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ORIGINAL RESEARCH

Comparative Effectiveness of Various Radiofrequency Ablation Catheters in the Ablation of Typical Atrial Flutter

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ABSTRACT

Introduction: Although ablation of typical atrial flutter (AFL) can be easily achieved with radiofrequency energy (RF), no studies compare the effectiveness of different ablation catheters. Our study aimed to compare the efficacy of various types of ablation catheters in treating typical AFL.

Methods: We analyzed patients with AFL who underwent RF ablation by a single operator at our institution. Successful ablation was evidenced by a bidirectional conduction block (trans-isthmus conduction time $\geq$ 130 ms or double potentials $\geq$ 90 ms). Logistic regression was used to compare success rate and linear regression to compare lesion time.

Results: Out of 222 patients, only six did not meet the success criteria (2.7%). The catheters used were non-irrigated, large-tip, internally irrigated (Chili II Boston Scientific), and externally irrigated (non-force-sensing) catheters (Cool Path, Abbott). An externally irrigated force-sensing catheter (TactiCath, Abbott) was used with > 10 gm of force and (LPLD) setting (30 W– 45 °C– 60 s), and high-power short-duration (HPSD) setting (50 W– 43 °C – 12 s). No complications were encountered. The catheter type had no statistically significant association with ablation success. With the use of externally irrigated catheter with contract force-sensing and HPSD settings, statistically significantly shortening of lesion time was achieved 758.3 s, [CI – 1128.29, – 388.35 s] followed by LPLD by 419.0 s [CI – 808.49, – 29.47 s].

Conclusions: The typical atrial flutter radiofrequency ablation procedure had a high success rate, which was not influenced by the type of ablation catheter. Contact force ablation catheter and HPSD are associated with shorter total lesion time.

Keywords: Atrial flutter; Ablation; Irrigated catheter; Force sensing

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Key Summary Points

Why carry out the study?

No studies directly compare different ablation catheters for ablation of typical atrial flutter.

We are comparing the effectiveness of four different ablation catheters to assess success rates and procedural time.

What was learned from the study?

We found no difference in the effectiveness of achievement of successful lesion set. High-power short-duration strategy shortens the ablation time.

Based on the current set of data, evolving catheter technology has not resulted in substantial improvement in outcomes of typical atrial flutter ablation.

INTRODUCTION

Atrial flutter (AFL) is a common arrhythmia frequently and very effectively treated with catheter ablation. The overall incidence of AFL is approximately 88 per 100,000 person-years and increases with age [1]. Catheter ablation is a first-line treatment method. A meta-analysis of 21 studies examining atrial flutter success rate suggested a single procedure success of 92% and multiple procedure success rates of 97% [2]. Radiofrequency energy is commonly used, but cryoablation has also been employed [3]. The quest to develop better, safer, and faster ablation of atrial fibrillation techniques has resulted in new catheter development applicable to atrial flutter ablation. Although some randomized clinical trials have been published to assess the effectiveness of different large-tip catheters vs. irrigated catheters, they provided conflicting results [4, 5]. Furthermore, there are no comparative studies on force-sensing catheters and various ablation settings [5]. Therefore, we undertook a retrospective analysis of consecutive patients undergoing AFL ablation using different ablation catheters to assess the effectiveness of these catheters and different ablation settings in treating the AFL.

METHODS

Settings and Population

We included patients undergoing typical atrial flutter ablation as a standalone procedure in our institution from July 2007 to December 2021. Patients with missing data and demographic information were excluded. All procedures were done by a single operator using fluoroscopy and 3D mapping (using a different generations of the Ensite mapping system from Abbott, Minneapolis, MN, USA). Previously published criteria of ablation success were used [6]. Briefly, achievement of bidirectional isthmus conduction time $\geq$ 130 ms and the presence of double potentials at least 90 ms apart were considered an acute success. Lesion time was the total time of lesion creation.

Analysis

Baseline demographic data, including ethnicity, age, gender, past medical history, and medications use, were collected.

We classified the ablation catheters into the following categories: non-irrigated 8 and 10 mm, (Blazer II Boston Scientific, Marlborough, MA, USA), internally irrigated 4 mm (Chili II, Boston Scientific, Marlborough, MA, USA), externally irrigated 4 mm (Cool Path, Abbott, Minneapolis, MN, USA), and externally irrigated force-sensing 3.5 mm (TactiCath, Abbott, Minneapolis, MN, USA). For non-irrigated catheters, power was set to 70–100 W and maximum temperature of 60 °C, and typically a 60-s application; for internally irrigated catheters, settings were power of 30 W and temperature of 43 °C; externally irrigated catheter for low-power long-duration (LPLD) settings were power of 30 W and temperature of 45 °C or for high-power short-duration (HPSD), power of

50 W and temperature of 43 °C, and 12 s in duration. With force-sensing catheters, lesions were applied with force ranging from 10–20 g. The RF application was made point-by-point in a contiguous fashion. The gaps in the ablation line were most often identified during coronary sinus pacing and ablation catheter mapping. In some cases, the gaps were identified with high-density activation mapping.

Statistical Analysis

Our study compared different catheters in terms of success rate and lesion time. We used logistic regression to compare the success rate between other catheters and linear logistic regression to compare lesion time. The non-irrigated large-tip catheter was the reference point. All statistical analyses were performed using statistical software R version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). The study has received a waiver of consent from the Institutional Review Board of SUNY Downstate Health Sciences University study 1650721-1. The study was performed in accordance with the Helsinki Declaration of 1964 and its later amendments.

RESULTS

We identified a total of 222 patients during the study period. The mean age of the population was 72 (± 14) years old, and 50% were females. Patient characteristics are summarized in Table 1.

Figure 1 shows the breakdown of the catheter used. The most common catheters used were contact force catheters with the two settings (HPSD and LPLD).

Were we unable to achieve a bidirectional block in only six patients (2.7%), despite employing multiple catheter/sheath configurations. For patients with sinus rhythm, the mean pre-ablation clockwise and counterclockwise times were 55.32 s and 55.67 s, respectively. Conduction time increased after ablation to an average clockwise conduction time of 146.8 s and a counterclockwise time of 147.9 s.

The type of catheter used did not affect the success rate (p value > 0.9). We could not identify factors associated with ablation failure due to the low incidence of unsuccessful cases. Lesion time for non-irrigated catheters was 1162.8 s. Compared with the non-irrigated catheter, the contact force catheter was significantly associated with a shorter lesion time by 629.92 s (− 993.59, − 266.25). When the different settings of contact force catheters were compared with the different types of catheters,

Table 1 General characteristics of the population studied

	Total (N = 222)
Age	
Mean (SD)	72 (± 14)
Sex	
Female	111 (50%)
Male	111 (50%)
Race	
Black	191 (86%)
White	27 (12%)
Native American	1 (0%)
Missing	3 (1.4%)
DM	92 (41%)
HTN	157 (71%)
HLD	71 (32%)
CAD	46 (21%)
CKD	78 (35%)
CHF	85 (38%)
Afib	51 (23%)
Stroke	12 (5%)
COPD	27 (12%)
OSA	9 (4%)

DM diabetes mellitus, *HTN* hypertension, *HLD* hyperlipidemia, *CAD* coronary artery disease, *CKD* chronic kidney disease, *CHF* congestive heart failure, *Afib* atrial fibrillation, *COPD* chronic obstructive pulmonary disease, *OSA* obstructive sleep apnea

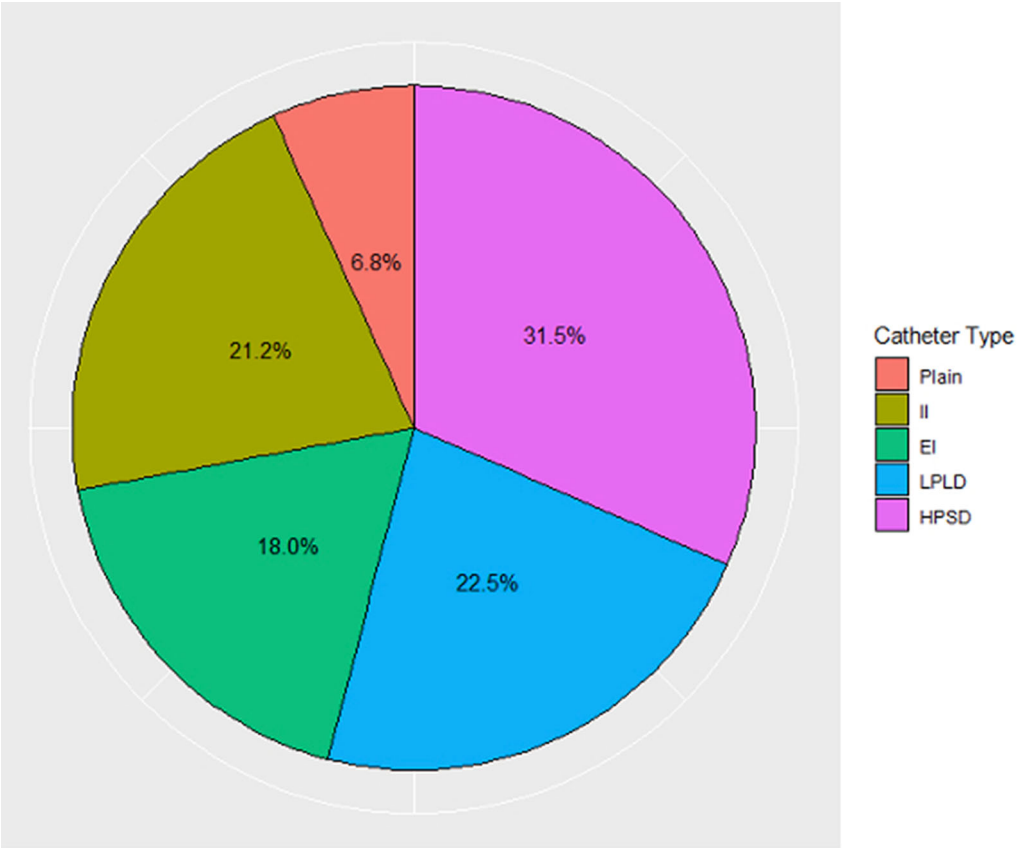

Fig. 1 Type of catheter used

the HPSD had the shortest lesion time, followed by the LPLD (Table 2).

DISCUSSION

Our study indicates that HPSD lesions applied with force-sensing catheters achieve the bidirectional CTI block in the shortest time. Our data also show that externally irrigated catheters with force sensing can accomplish a set of effective lesions faster than non-irrigated and internally irrigated catheters.

Our data suggest similar acute effectiveness of all catheters in achieving CTI block. Past studies comparing the efficacy of gold, platinum-iridium, and externally irrigated-tip catheters showed mixed results, with either equivalency of effectiveness and an advantage with gold-tip catheters and irrigated catheters, in the acute success of the procedure [7, 8].

Table 2 Lesion time as compared to the plain catheter

Catheter	Lesion time	*P* value
(Intercept)	1162.786 [825.46, 1500.112]	0
II	− 210.863 [− 604.101, 182.375]	0.292
EI	− 276.434 [− 672.47, 119.601]	0.17
LPLD	− 418.976 [− 808.487, − 29.466]	0.035
HPSD	− 758.322 [− 1128.29, − 388.354]	0

II internal irrigation, *EI* external irrigation, *LPLD* low-power long-duration, *HPSD* high-power short-duration

Furthermore, the reported rate of failure to achieve CTI block of 5% with gold and platinum-iridium-tip catheters was similar to our data. The success of 8-mm and 10-mm-sized catheter tips has been demonstrated in multiple

trials over the past 10 years. A study performed by Ventura et al. confirmed this by showing successful ablation using 8-mm catheter tips in patients resistant to ablation using 4-mm catheter tips [8]. Shorter procedure times are reported with the larger-tip ablation catheters than standard 4- or 5-mm-tip ablation catheters, with comparable or greater efficacy, no significant increase in complications, and improved quality of life. Larger-tip ablation electrodes do require the use of higher-power radiofrequency generators up to 100 W. A study comparing the efficacy of 8- and 10-mm ablation catheters and high energy (100 W) showed that the actual number of ablations required (i.e., 10 vs. 14) as well as total lesion time was less for the 10-mm-tip catheter, however with almost 7% failure to achieve CTI block [9]. However, it is not unusual to experience difficulty in delivering full power during those ablations due to inadequate catheter cooling, particularly in areas of CTI indentations where blood flow is restricted.

Irrigated-tip catheter technology was designed to cool the electrode tip, prevent excessive temperatures at the electrode tip–tissue interface, and thus allow continued delivery of RF current into the surrounding tissue. This ablation system creates larger and deeper ablation lesions and minimizes steam pops and thrombus formation. Compared to small-tip catheters, irrigated-tip ablation catheters require fewer lesions to achieve CTI block and shorten the procedure [10].

Irrigated catheters can be divided into open and closed types of irrigation. In open irrigation, there are holes in the tip of the catheter through which (typically) normal saline is pumped. Closed-irrigation catheters have a system within the tip that allows 5% glucose solution to pass through the interior and then be removed. Yokoyama et al. compared a closed-irrigation catheter (Chilli®, Boston Scientific, Natick, MA, USA) versus an open-irrigation catheter (ThermoCool) for RF lesion morphology and depth, thrombus formation, and occurrence of steam pops in a dog model [11]. It was found that the resultant ablation lesion was similar to closed- and open-irrigated electrodes yet more thrombus formation on the electrode with closed irrigation [12]. Our data confirm the equivalent performance of closed- and open-irrigated catheters in AFL ablation.

HPSD was designed to limit resistive heating and therefore produces less collateral tissue damage while achieving similar success [13–16]. In a single non-randomized study, HPSD ablation resulted in a shortened ablation time, as seen in our study [17, 18]. We have not seen a reduction in the number of lesions needed to achieve CTI block, as typically, HPSD ablation creates similar size lesions to traditional irrigated catheter ablation [13].

We could not identify factors associated with ablation failure due to the low incidence of inability to achieve CTI block. Typical predictors of failed ablation are previous atrial fibrillation and presence of complex congenital heart disease (transposition of great arteries, systemic ventricle dilation) [18]. Previous data suggest that HPSD helps achieve CTI block in all patients [17, 19].

The observational nature of the design limits our study. Nevertheless, the presence of a single operator performing the procedure eliminates some of the bias that might be present with multiple operators, even in a randomized study. We do not believe that operator's experience has influenced the outcomes, as we do not see differences between non-irrigated catheters and internally and externally irrigated catheters (as the latter were available more recently). Having the ability to objectively assess the force exerted by the catheter during ablation is certainly advantageous as evident in our data set. Beyond this feature of the mapping software, we do not believe that different versions of the mapping system have significantly affected outcomes in this study.

CONCLUSIONS

Our data strongly suggest that the HPSH technique coupled with a force-sensing catheter is the most efficacious modality for AFL circuit ablation. Furthermore, disappointingly, technological advances in ablation catheters design do not seem to be translating to improved efficacy of the ablation procedures.

Author Contributions. Study design was completed by Adam S. Budzikowski. Data collection was completed by Asher Gorantla, Mahmoud Alsaiqali, Johnathan Francois, and Shruthi Sivakumar. Data analysis was completed by Mahmoud Alsaiqali, Leonall Freytes-Santiago, Ahmad Jallad, and Adam S. Budzikowski. Manuscript writing was completed by Adam S. Budzikowski, Asher Gorantla, and Mahmoud Alsaiqali.

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Data Availability. Data linked to this study can be found at https://doi.org/10.5061/dryad.ghx3ffbs2.

Declarations

Conflict of Interest. Asher Gorantla, Mahmoud Alsaiqali, Johnathan Francois, Shruthi Sivakumar, Leonell Freytes-Santiago, Ahmad Jallad, and Adam S. Budzikowski have nothing to disclose.

Ethical Approval. The study has received a waiver of consent from the Institutional Review Board of SUNY Downstate Health Sciences University study 1650721-1. The study was performed in accordance with the Helsinki Declaration of 1964 and its later amendments.

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