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HIGH POWER SHORT DURATION VS LOW POWER LONG DURATION CATHETER ABLATION OF ATRIAL FIBRILLATION

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ABSTRACT

Backgrounds: *Atrial Fibrillation (AF) is a known common arrythmia, affecting around 33 million people worldwide. Catheter ablation is a safe and effective treatment for paroxysmal and persistent AF that are unresponsive to drug treatment. However, long procedural duration of AF ablation has raised the concern of radiation hazard and post-procedural complications. The high power short duration (HPSD) technique is an emerging method that has been introduced as an alternative to reduce procedural time of AF ablation.*

Objective: *This study attempts to review the safety and efficacy of HSPD compared to the conventional low power long duration (LPLD) ablation in AF patients.*

Method: *A search through PubMed, Science Direct, JSTORE, and clinicaltrial.gov was conducted. The keywords used were (catheter ablation OR radiofrequency OR pulmonary vein isolation) AND (atrial fibrillation) AND (high power short duration OR 50 W). The search was limited from 2006 to 2024. Risk of bias assessment was conducted through Newcastle-Ottawa Scale (NOS) assessment.*

Results: *Among 55,802 journals reviewed, we retrieved 10 journals that met the inclusion criteria. This study found that HPSD ablation results in either better or comparable efficacy in maintaining long term sinus rhythm post ablation. Additionally, there was no difference in safety for both HPSD and LPLD. We also recommend using esophageal temperature monitoring probe and adjusting energy delivery during posterior wall ablation to avoid injuring esophagus.*

Conclusion: *Our study concluded that HPSD ablation is a safe choice of treatment for drug-refractory paroxysmal or persistent AF with a noteworthy outcome compared to LPLD ablation.*

Keywords: *Atrial fibrillation, ablation, high power short duration, low power long duration*

BACKGROUNDS

Atrial Fibrillation (AF) is a known common arrythmia, affecting around 33 million people worldwide, a number that is expected to increase two-folds in the upcoming two or three decades (1). Catheter ablation is an emerging method that has been introduced as a safe and effective treatment for AF (1,2). It has been proposed as second-line treatment for paroxysmal AF and persistent AF that are unresponsive to drug treatment (3). Using a radio-frequency ablation (RFA) technique, the goal of the current AF ablation is to eliminate the atrial ectopic beat originating from the pulmonary vein (PV) (4). This technique uses a 3D-mapping system that enables depiction of PV anatomy followed by a single-tip catheter placement, usually inserted transseptally to the left atrium and then directed to isolate pulmonary vein circumferentially, around 10-15 mm away from the PV ostium (5).

Over the last few years, catheter ablation has shown a promising result with a success rate of 60-80% in eliminating paroxysmal AF (3). The success to AF ablation requires electrically isolating ablation scar, conventionally made by delivering a power of 25–35 W for 30–60 seconds per lesion which commonly referred to as the “low power long duration” (LPLD) ablation (6). However, in order to adequately isolate PV, normally a long procedural time is needed, nearing 4 hours. This long procedural time is associated with complications such as stroke, cardiac tamponade, pericardial effusion, and vascular complications (7). It also increases radiation exposure both for the patient and the operator, causing problems such as malignancy and genetic disease (8). Theoretically, longer duration is also associated with extensive lesion that may injure adjacent structures such as esophagus, phrenic nerve, and vagus nerve. Therefore, a study aimed to reduce this procedural time through increasing power while decreasing duration of ablation in order to generate the same energy during AF ablation. The study used 50–60 W for 5 seconds which is currently referred as the “high power short duration” (HPSD) ablation (9). This method was originally introduced in 2006 (6). Human studies have been done in the last decade in the aim to prove the safety and efficacy of HSPD ablation. HSPD was associated with shorter RFA time, PV isolation time, and overall procedural time while also maintaining arrhythmia-free rate on 12-month follow up (10). Although some study refers HSPD as a safe method (11,12), some raises valid concern regarding procedural complication that may arise such as esophageal thermal injury (ETI) (13). This study attempts to review the safety and efficacy of HSPD compared to the conventional low power long duration (LPLD) ablation in AF patients.

Material and Methods

A search through PubMed, Science Direct, JSTORE, and clinicaltrial.gov was conducted. The keywords used were (catheter ablation OR radiofrequency OR pulmonary vein isolation) AND (atrial fibrillation) AND (high power short duration OR 50 W). The search was limited from 2006 to 2024. Inclusion criteria included: (1) a comparison study between HPSD and LPLD ablation; (2) with human subjects undergoing catheter ablation for paroxysmal or persistent AF as indicated; (3) evaluating either the safety or efficacy of HPSD and LPLD ablation. Study is excluded if written in non-English language. Risk of bias assessment was conducted through Newcastle-Ottawa Scale (NOS) assessment (14).

Result

Among 55,802 journals reviewed, we retrieved 10 journals that met the inclusion criteria (Fig. 1). Characteristics of each included study are presented in Table 1.

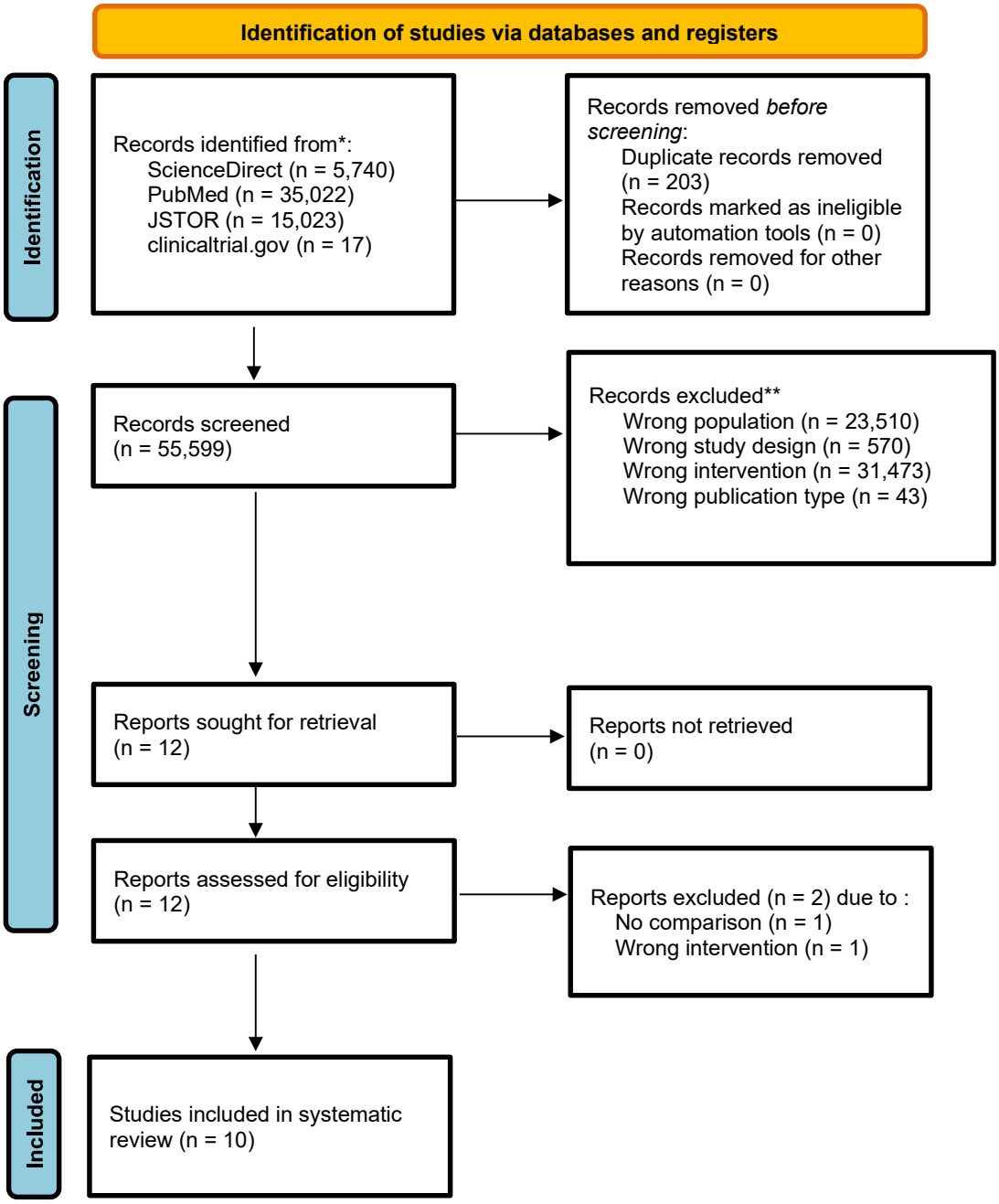

Fig. 1 Prisma Flow Diagram

Table 1. Characteristics of Study

No	Title	Author (year)	Study Design	Population	Exclusion criteria	Sample Size	Intervention	Follow-up Duration	Study Outcome(s)
1	Higher power short duration vs. lower power longer duration posterior wall ablation for atrial fibrillation and oesophageal injury outcomes: a prospective multi-centre randomized controlled study (Hi-Lo HEAT trial)	Chieng et al. (2023)	Randomized Controlled Trial	Eighty-eight patients with paroxysmal AF (AF lasting <7 days) and persistent AF (AF lasting ≥7 days) undergoing their first catheter RF ablation procedure were recruited then randomized 1:1 to HPSD or LPLD posterior wall (PW) ablation groups	Patients with long-standing persistent AF, AF secondary to an obvious reversible cause, severe valvular heart disease, severe renal/liver impairment, severe gastro-oesophageal reflux disease, and hypertrophic cardiomyopathy	88	In HPSD group, the power was set at 40W. In the LPLD ablation group, power was set at 25 W. In both groups, ablation was terminated when either of the following occurred: (i) AI of 400 or LSI of 4 was achieved, or (ii) luminal oesophageal temperature exceeded ≥38°C, or there was a steep rise of >1°C within 5 s.	At 3, 6, and 12 months post ablation	(1) Incidence of ETI in the HPSD and LPLD groups (2) Freedom from AF after single procedure of antiarrhythmi drug at 12 months; (3) Acute procedural outcomes.
2	High-Power Short-Duration vs Low-Power Long-Duration Ablation for Pulmonary Vein Isolation: A Substudy of the AWARE Randomized Controlled Trial	Joza et al. (2024)	Randomized Controlled Trial	Included subjects were 398 patients symptomatic and drug refractory patients with paroxysmal AF	NM	398	HPSD was defined as a power setting of ≥ 40 W. Operators using the HPSD approach were permitted to use RF energy from 40 to 50 W and energy delivery duration ranging from 5 to 15 seconds during ablation. LPLD was defined as a power of ≤ 35W in anterior, inferior, and superior aspects of the PV antra.	At 3-, 6-, and 12-months post ablation	(1) One-year recurrence of any atrial arrhythmia lasting ≥ 30 seconds, detected using three 14-day ambulatory continuous ECG monitoring. (2 Procedural an safety endpoints

							A maximum power of 25 watts was permitted along the posterior wall of the LA.		
3	Low complication rates using high power (45-50 W) for short duration for atrial fibrillation ablations	Winkle et al. (2019)	Prospective cohort study	A total of 10,284 patients undergoing AF ablation for standard clinical indications at 4 experienced ablation centers from September 2006 through November 2017	NM	10,284	AF ablation at power of 45–50 W for short durations of 5–15 seconds in the left atrium other than on the posterior wall. On the posterior wall, some operators used 45–50 W for 2–10 seconds, and others reduced RF power to 35 W and increased the duration of energy delivery to 20 seconds.	up to 30 days post ablation	(1) Procedura fluoroscopy, and total RF times. (2) Acute complications including: death, stroke, PV stenosis, phrenic nerve paralysis, atrioesophage fistulas, steam pops, and catheter char.
4	Efficacy and Safety of High-Power Short-Duration Radiofrequency Catheter Ablation of Atrial Fibrillation	Park et al. (2021)	Prospective cohort study	A total of 1,260 patients in the Yonsei AF Ablation Cohort Database who underwent a de novo AF catheter ablation. Patients were categorized into two groups: HPSD-RF and conventional power RF. After propensity score matching: 315 in 50~60W HPSD group vs. 945 in the	(1) AF with rheumatic valvular disease, (2) significant structural heart disease other than left ventricular hypertrophy, and (3) a history of prior AF ablation or cardiac surgery	1260	For the conventional power RF ablation, power used was 25–35 W (30–35 W ablation for the anterior side of the LA and PVs and 20–25 W ablation for the posterior side of the LA and PV. For the HPSD-RF ablation, power used was 50-60 W ablation with 10~15 s for the anterior side of the	at 3, 12, and 24 months	This study investigated the procedura factors, complication rate, rhythm status, and 3-month heart rate variabilit (HRV) throug Holter monitoring between the two groups an subgroups.

				conventional power group.			LA and PVs and 40-50 W ablation with a reduced ablation time of <10 s for the posterior side of the LA and PVs for CPVI.		
5	Impact of high-power short-duration atrial fibrillation ablation technique on the incidence of silent cerebral embolism: a prospective randomized controlled study	Chen et al. (2023)	Randomized Controlled Trial	100 patients who (1) have documented, symptomatic AF, (2) are scheduled to undergo their first catheter ablation procedure for AF, (3) are between the ages of 18 and 80 years, and (4) are willing and able to provide informed consent.	(1) moderate to severe valvular heart disease, (2) CI for anticoagulant, (3) CI for hDWI, (4) ischemic stroke (5) acute coronary syndrome, (6) left atrial appendage occlusion device or septal occlusion device, (7) LA diameter ≥ 55 mm, (8) conditions prevent cognitive assessment, (9) pregnant, breastfeeding, or planning to become pregnant during the study	100	For patients in the HPSD group, RF energy was adjusted to 50 W, using the novel STSF catheter, while for patients in the conventional group, RF energy was adjusted to 30–35 W, using the ST catheter.	at 24-72 hours post procedure, 3 and 6 months during outpatient clinic follow-up	Primary outcome was incidence of new silent cerebral embolism detected by post-procedural hDWI within the 24–72 h after ablation. The secondary outcomes wer the safety endpoints during the procedure and at the 3-month follow-up, including cognitive impairment and the overal complication rate.

6	Better Outcomes in High-Power Short-Duration Compared to Low-Power Long-Duration Atrial Fibrillation Ablation in One-Year Follow-Up	Vassallo et al. (2020)	Retrospective cohort study	144 patients submitted to first time AF ablation	NM	144	In the HPSD ablation technique; in the posterior wall; atrial roof; and atrial flutter (if indicated); power of RF generator was 45 W for no more than 6 seconds. On the anterior wall, the power was 50 W. For LPLD; the RF applications lasted no more than 30 seconds and power of 20 W in the posterior wall and 30 W elsewhere including in the cases of atrial flutter.	12 months	Recurrence rate

7	Safety and effectiveness of very-high-power, short-duration ablation in patients with atrial fibrillation: Preliminary results	Mitrzak et al. (2022)	Retrospective cohort study	A total of 108 patients who were referred for their first catheter based AF ablation. The inclusion criteria included an age of at least 18 years and symptomatic paroxysmal or persistent AF.	Patients with a medical history of surgical or catheter ablation for AF	108	The vHPSD ablation (90 W, 4 s) was performed according to the Qmode+ algorithm. Meanwhile, in the control group the RF power output was 35 W with a target AI of > 400 at the posterior and inferior wall of the left atrium and > 550 at the remaining sites.	3 months post ablation	Freedom from AF at 3 month post-ablation
8	The effectiveness of a high output/short duration radiofrequency current application technique in segmental pulmonary vein isolation for atrial fibrillation	Nilsson et al. (2006)	Retrospective cohort study	Ninety consecutive patients (age 53±10 years, 66 men) who had undergone one segmental PV isolation of drug-refractory paroxysmal (59 patients) or persistent AF (31 patients) at the Rigshospitalet, Copenhagen University Hospital.	Patients with either: congenital heart disease, younger than 18 years, significant valve disease, left ventricular ejection fraction<20 %, NYHA class IV, and prior ablation for AF.	90	In the first 45 patients (Group 1), the RF power output was limited to 30 W, with a target temperature of maximal 50°C, and a preset duration of 120 s. In the last 45 patients (Group 2), the maximum power output was preset to 45 W, a target temperature	A mean follow-up of 15±7 months (range 5–25 months)	PV isolation time, mean fluoroscopy time, radiation dose, stable sinus rhythm follow-up, and the need of additional ant arrhythmic drugs post ablation

							of 55°C, and duration of 20 s.		
9	High-Power, Short-Duration Ablation under the Guidance of Relatively Low Ablation Index Values for Paroxysmal Atrial Fibrillation: Long-Term Outcomes and Characteristics of Recurrent Atrial Arrhythmias	Jin et al. (2023)	Prospective cohort study	A total of 943 patients who underwent RFA at Guangdong Provincial People's Hospital from July 2019 to March 2021. All the participants met the following criteria: (1) included patients' age ≥ 18; (2) patients with PAF refractory to medical therapy and undergoing initial catheter ablation.	(1) previous cardiac surgeries or/and AF ablations; (2) a history of rheumatic valvular disease and ischemic heart disease; (3) LA diameter > 55 mm; (4) patients who failed to complete the procedure due to complications.	943	In the HPSD group guided by AI, PVI was performed at 40–50 W. The output power of the mitral isthmus and posterior wall isolation were 40–50 W, tricuspid isthmus was 35 W, and that of the coronary sinus was 25 W. While in the conventional group without the guidance of AI, the power setting of PVs was limited to 35 W at the anterior wall, 25–35 W at the posterior wall, and 35–40 W in other segments. RF applications did not last more than 30 s.	at 1, 3, and 6 months, followed by 6-month intervals up to one year	(1) Early and late recurrenc of atrial arrhythmia (2 safety
10	Comparison of lesion characteristics between conventional and high-power short-duration ablation using contact	Chen et al. (2021)	Nonrandomized trial	Eighty patients with paroxysmal AF receiving CF ablation for AF	NM	80	Patients received CF with conventional energy setting (power control: 25–30 W, force–time integral =	mean follow-up period of 11 ± 1.4 months	(1) Optimal ablation lesion distribution; (2) ablation time; (3) recurrence rat

	force-sensing catheter in patients with paroxysmal atrial fibrillation						400 g s) or HPSD (power control: 40–50 W, 10 s, n = 40) ablation		

AF=atrial fibrillation; PAF= paroxysmal AF; HPSD=high power short duration; vHPSD=very high power short duration; LPLD=low power long duration; ETI=esophageal thermal injury; AI=ablation index; ECG=electrocardiogram; RF=radiofrequency; RFA=radiofrequency ablation; PV=pulmonary vein; PVI=pulmonary vein isolation; LA=left atrium; SCE=silent cerebral embolism; hDWI=high resolution diffusion-weighted magnetic resonance imaging; MoCA=Montreal Cognitive Assessment

Procedural Duration

All ten studies were in agreement that HPSD ablation notably reduced the overall procedural duration significantly compared to LPLD. This resulted in shorter fluoroscopy and radiofrequency application time also a lower radiation dose (11,12,15–22).

Efficacy

In the terms of this study, efficacy was defined as the success of pulmonary vein isolation (PVI) after ablation and freedom of AF recurrence during the follow-up period including the 3 months blanking period. Of all the included studies, eight described the efficacy of HPSD ablation compared to LPLD. Five studies were in agreement that HPSD ablation was superior in maintaining freedom of AF after ablation during one year follow up period (16,17,19) and three months follow up period (21). Nilsson et al. (2006) also found similar result albeit the data was presented only numerically (20). Meanwhile, Joza et al. (2024) and Park et al. (2021) found that HPSD ablation had similar efficacy to LPLD in maintaining freedom of AF recurrence during one year follow up period (12,18). Joza et al. (2024) added that HPSD ablation was better in maintaining sinus rhythm during the blanking period. However, Jin et al. (2023) disagreed and found that HPSD ablation was associated with higher recurrence rate within the blanking period of three months after ablation but had similar efficacy to LPLD in long term maintenance of sinus rhythm (23).

Safety

In this study, safety was determined from acute and long-term complications. Out of ten included studies, six investigated the safety of HPSD ablation compared to LPLD. All six studies were in agreement that HPSD had comparable safety to LPLD without any difference in both acute and long-term complications (11,12,15,17,18,23). The incidence of acute complications including: ETI, pericardial effusion, tamponade, stroke, PV stenosis, phrenic nerve paralysis, atrioesophageal fistulas, and death (11,17,18,23). Meanwhile, another frequent acute complication of AF, silent cerebral embolism (SCE) was evaluated by Chen et al. (2023) through Diffusion-weighted magnetic resonance imaging (DWI). The study revealed that within 24-72 hours after ablation there was no difference in the number of patients with cerebral lesions between groups receiving HPSD and LPLD ablation. The lesions created also did not differ significantly in the terms of number of lesions, lesion diameter, and volume. The study also revealed that there was no long term procedural complication difference such as cognitive performance between the two groups (15).

DISCUSSION

The HPSD ablation is marked by a high power delivery at 45–60 W for 10–15 seconds (shorter in the posterior area) or very high power at 90 W for less than 5 seconds (11,12,15–22). All studies were in agreement that HPSD ablation had either better or comparable long-term outcomes in maintaining sinus rhythm (12,16–21). Previous study described that HPSD ablation had a high rate of first-pass PVI and a low rate of reconnection (24). The importance of first-pass PVI is that it is associated with 2-year arrhythmia freedom alongside with lower rate of PV reconnection which is the underlying mechanism of AF recurrence (25). HPSD created more efficient lesion by limiting tissue edema through the creation of wider resistive heating area compared to the conventional LPLD ablation. Resistive heating area causes local temperatures rise more than 50°C resulting in an immediate, irreversible myocardial injury. Meanwhile, in LPLD ablation, resistive heating area is more narrow whereas conductive heating area extends circumferentially wider, causing potential reversible tissue damage (26).

The safety of HPSD is comparable to LPLD ablation. The posited mechanism is HPSD increases the resistive and reduces the conductive phase, resulting in shorter amount of time while avoiding injuring adjacent tissues. This suits the anatomy of left atrium (LA) with thinner posterior wall, thus sparring the adjacent tissue especially esophagus from damage (27). The concern was due to a slim distance between PV posterior wall and esophagus, approximately 2.6 mm (ranging from 1.4–6.0 mm) (28). Chieng et al. (2023) confirmed that HPSD had similar rate of ETI compared to LPLD. In addition, there was no significant difference in the incidence of pericardial effusion and tamponade, further confirming that HPSD is a safe choice (11,17,18,23). However, HPSD should be avoided in patients with enlarged LA diameter and those with short atrium-to-esophagus distance (<2 mm) as it increases the risk of ETI (28). Although still controversial, the use of esophageal temperature monitoring probe is a reasonable way to prevent ETI in patients receiving HPSD ablation. This monitoring use is a general agreement that has been recommended by the 2017 AF ablation consensus (29). To add, the use of multi-sensor instead of single sensor probe is associated with lower incidence of esophageal lesions (30). However, the use of esophageal temperature monitoring probe is not the sole way to prevent ETI, as energy delivery and contact force control should be taken into account during ablation. Ablation with the power of 25 W using direct visualisation within the duration of less than 5 seconds is recommended in the posterior wall to avoid ETI (28).

CONCLUSION

Our study concluded that HPSD ablation is a safe choice of treatment for drug-refractory paroxysmal or persistent AF with a noteworthy outcome compared to LPLD ablation.

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