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Systematic Review

Efficacy and Safety of High-power Short-duration Radio Frequency Ablation in the Treatment of Atrial Fibrillation: A Meta-analysis of Prospective Study

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Abstract

Background: Radiofrequency ablation is a critical therapeutic method used in the management of atrial fibrillation (AF). This study systematically evaluates the effectiveness and safety of two catheter radio frequency ablation approaches: high-power short-duration (HPSD) and traditional low-power long-duration (LPLD), in treating AF. **Methods**: Four databases were searched for prospective studies (eight cohort studies and three randomised controlled trials) that evaluated the effect of HPSD treatment on AF recurrence, occurrence rate of complications and procedural time in patients with AF from the establishment of the databases to March 2023. We utilised RevMan 5.20 and Stata 11.0 statistical software to conduct a meta-analysis, and publication bias was assessed using funnel plots and Egger's test. The effect estimates were synthesised as relative risks (RRs) or standardised mean differences (SMDs) along with their corresponding 95% confidence intervals (CIs). **Results**: A total of 536 relevant studies were retrieved, and 11 prospective studies were collected. The combined value of the estimated effect of HPSD versus LPLD treatment on AF recurrence in patients with AF had an RR of 0.59 (95% CI: 0.45–0.78; $p < 0.001$), the effects of HPSD versus LPLD treatment on procedural time in patients with AF had an SMD of –1.17 (95% CI: –1.56– –0.77; $p < 0.001$), and the effect of HPSD versus LPLD treatment on oesophageal thermal injury in patients with AF had an RR of 0.84 (95% CI: 0.22–3.28; $p = 0.80$). Notably, the estimated combined effects of HPSD and LPLD on other major complications (steam pop) in patients with AF had an RR of 0.57 (95% CI: 0.22–1.47; $p = 0.24$). **Conclusions**: HPSD is more effective than traditional LPLD and has a lower AF recurrence rate after surgery. Meanwhile, HPSD treatment can improve surgical efficiency and has a shorter procedural time than LPLD treatment.

Keywords

radio frequency ablation; atrial fibrillation; efficacy; complication; meta-analysis

Introduction

Atrial fibrillation (AF) is one of the most common tachyarrhythmia. The crude prevalence rate of AF is 2.3% in China and has shown regional differences. The elderly population is strong associated with the onset and progression of cardiovascular conditions, such as AF [1]. Given that AF can lead to multiple disabling and fatal complications, standardised treatment methods that reduce burden on patients with AF are needed [2,3]. Radio frequency ablation is one of the important methods for the catheter ablation of AF. Pulmonary vein isolation (PVI) is a crucial radio frequency ablation technique used to treat AF by isolating electrical conduction between the pulmonary veins and the atrium [3,4]. The recovery of pulmonary venous electrical conduction after PVI is considered the primary cause of AF recurrence and radio frequency ablation failure. In the past, surgeons had often used methods requiring low output power and long discharge time, and thus the surgical and fluoroscopy times were long. These methods not only are inefficient but also result in a high incidence of complications [5]. High-power short-duration (HPSD) ablation can effectively shorten the operation time and improve the single loop isolation rate but might increase in the incidence of surgical complications [6,7].

As the most important factor of ablation damage, the relationship between ablation power and ablation efficiency has emerged as a prominent area of research. Nilsson *et al.* [8] attempted to increase the ablation power to 45 W and shorten the ablation time in radio frequency ablation in 2006. Since then, novel radio frequency ablation strategies for HPSD have been widely used in animal models and clinical studies. Compared with the traditional low-power long-duration (LPLD) strategy, the HPSD strategy can generate shallow and large-area damage by increasing

the impedance of a damaged core and reducing damage caused by conduction heat generation. The results of studies on the efficacy of radio frequency ablation of HPSD for AF are inconsistent. Thus, the present study included the recent studies comparing HPSD and traditional LPLD strategies for the catheter ablation of AF, and we conducted a meta-comparison of multiple endpoints in terms of effectiveness, safety and surgical efficiency of the two strategies to provide a reference for the selection of catheter ablation strategies for AF. In addition, we statistically analysed the recurrence rate of postoperative AF and the recurrence rate of AF or atrial tachycardia (atrial tachycardia) to explore the heterogeneity of efficacy in patients with AF. The specific process of radio frequency ablation is shown in Fig. 1.

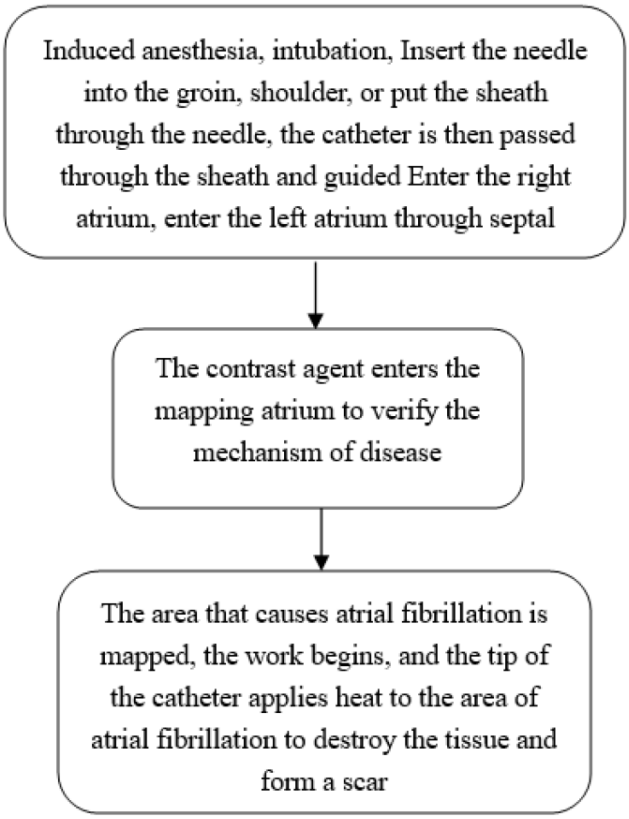

Fig. 1. Specific process of radio frequency ablation.

Materials and Methods

The methods of this meta-analysis were applied by PRISMA guidelines [9]. The main and abstract checklist of PRISMA were completed (**Supplementary Material**).

Search Strategy

Four databases, namely, PubMed, Cochrane Library, Web of Science database and Medline, were accessed, and the search strategy was as follows: (Atrial Fibrillations OR Fibrillation, Atrial OR Fibrillations, Atrial OR Auricular Fibrillation OR Auricular Fibrillations) AND (Ablation, Radiofrequency OR Ablation, Radiofrequency OR Ablation, Radio Frequency OR Radio-Frequency Ablation OR Ablation, Radio-Frequency). Studies published until March 2023 were retrieved. Concurrently, we manually searched the references of relevant reviews in the four databases to ensure that no articles were omitted, and the prospective original studies published in the literature were statistically reviewed.

Study Selection

Studies which meet the following criteria were identified by an information specialist utilising the PICO framework [10]: (1) randomised clinical trial (RCT) evaluating the effect of HPSD on AF and atrial tachycardia/atrial flutter (AT/AFL) recurrence, occurrence rate of complications and procedural time and published from the database to March 2023; (2) the study patients in original article were clinically diagnosed as AF; (3) studies employed LPLD treatment as control group; (4) original articles contents should include accurately comprehensive statistical data, including sample size, number of AF and AT/AFL recurrence, occurrence rate of complications and procedural time. The exclusion criteria were (1) non-clinical study; (2) incomplete literature data; (3) repeated reports of literature; (4) absence of clear outcome observation indicators. Only English language articles were applied.

Literature Quality Evaluation and Data Extraction

According to the same inclusion and exclusion criteria, the studies were completed by two reviewers independently. In the event of a disagreement, the two reviewers discussed and negotiated with a third participant to reach a resolution. We aimed to extract the following data: the number of HPSD and LPLD groups, outcomes (AF and AT/AFL recurrence, occurrence rate of complications and procedural time), name of the first author and the time of publication.

We used the Newcastle Ottawa Scale [11] to assess the methodological quality of the included papers. The evaluation criteria covered several aspects, including adequate case definition, representativeness of cases, selection of controls, definition of controls and ascertainment of exposure, and the same method for ascertainment was used for both cases, controls, and non-response rate.

For the RCTs, we evaluated their quality and methodology by using the Jadad scale, which assigns a high score (total score of 7) to trials with rigorous methodological designs.

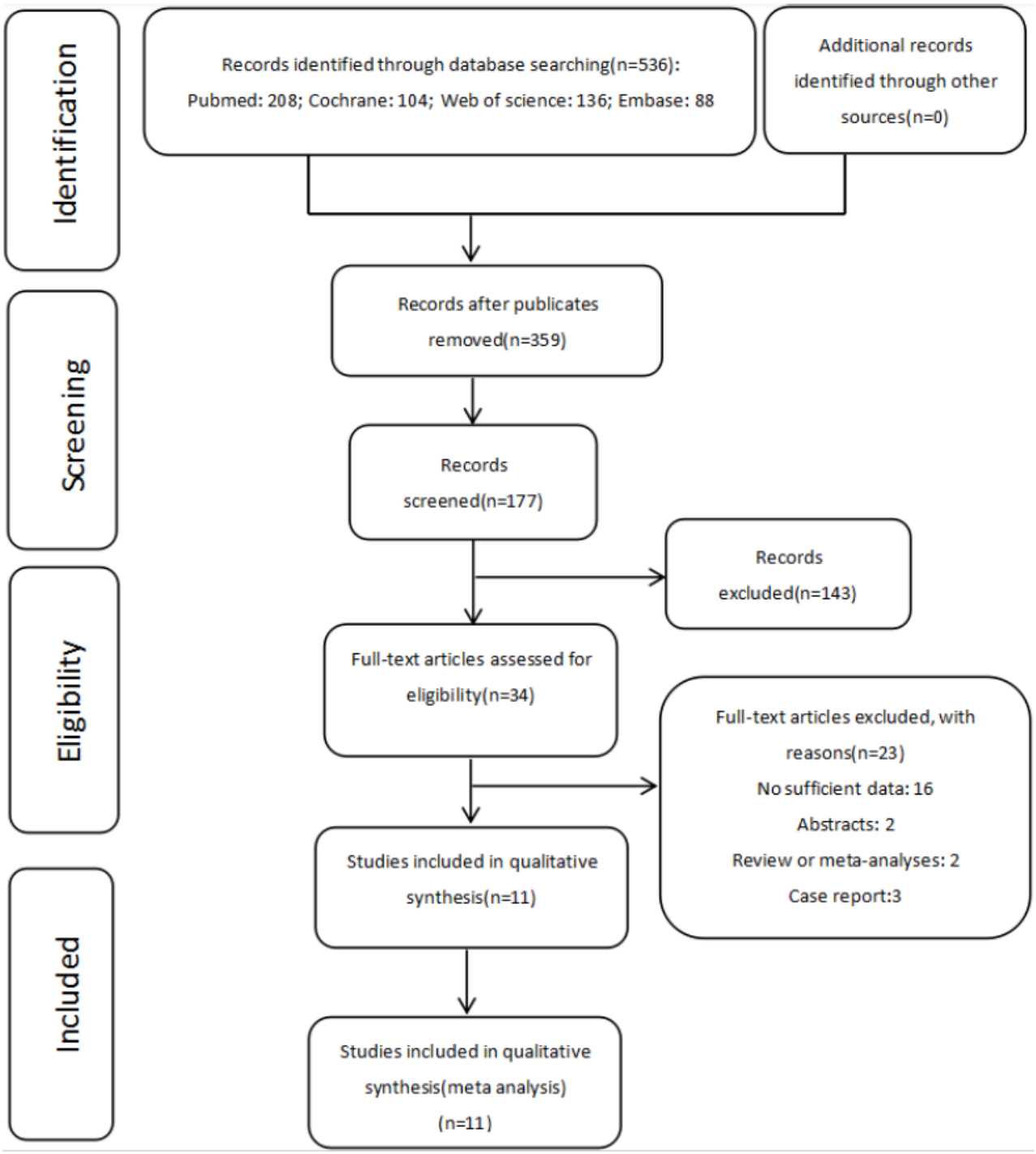

Fig. 2. Flowchart of the literature search and study selection.

Statistical Analysis

RevMan 5.20 software (Cochrane Collaboration, London, UK) was used in meta-analysis. The effect estimates were pooled using relative risk (RR) or standardised mean difference (SMD) with 95% confidence interval (95% CI). The heterogeneity of the studies collected in this meta-analysis was calculated using Q-test and I^2-test. When $p > 0.100$ and $I^2 < 50\%$, which indicated low heterogeneity across the included studies, the fixed effect model was used to combine merged RR or SMD with 95% CI; otherwise, a random-effects model was employed. For the sensitivity analysis of heterogeneity and subgroup analysis of factors that may cause heterogeneity, Funnel plot and forest plots were made by using RevMan 5.20 software. Subsequently, Egger's test and Begg test were performed using Stata software (version11.0, Stata Corp., College Station, TX, USA) to detect publication bias.

Table 1. Basic information of the included literature.

First author & year	Nation	Study design	No. of cases		Type of atrial fibrillation	Ablation parameters		Mapping tools	Follow-up time
			HPSD	LPLD		HPSD	LPLD		
Castrejón-Castrejón S 2020 [12]	Spain	Cohort study	48	47	I–IIa indication for ablation of paroxysmal or persistent AF	50 W 60 W, 10 g, 7–10 s, AI: 350–450	30 W, 30 s, AI: –	CARTO 3/EnSite	3 months
Ejima K 2020 [13]	Japan	Cohort study	60	60	PAF	50 W, 3–5 s	25–40 W, 5–10 s	CARTO 3	12 months
Kottmaier M 2020 [14]	German	Cohort study	97	100	PAF	70 W, 5–7 s	30–40 W, 20–40 s	EnSite	3 months
Kumagai K 2020 [15]		RCT	80	80	AF	50 W, 5 s, CF $<$10 g	20–40 W, 30 s	CARTO 3	6 months
Okamatsu H 2019 [16]	Japan	Cohort study	20	20	AF	30–50 W, AI: 250–400 g	20–40 W, AI: 250–400 g	CARTO 3	12 months
Pambrun T 2019 [17]	France	Cohort study	50	50	PAF	40–50 W, 8.5 $\pm$ 0.8 s	25–30 W, 15.7 $\pm$ 2.3 s	CARTO 3	12 months
Shin DG 2020 [18]	Korea	RCT	50	50	AF	30–50 W, $\leq$20 s	25–30 W, 30–40 s	CARTO 3	12 months
Wielandts JY 2021 [19]	Belgium	RCT	48	48	AF	45 W, 13–17 s	35 W, 26–37 s	CARTO 3	12 months
Yavin HD 2020 [20]	USA	Cohort study	112	112	AF	45–50 W, 8–15 s	20–40 W, 20–30 s	CARTO 3	1.2 years
Berte B 2019 [21]	Switzerland	Cohort study	80	94	AF	35–45 W, 20–25 s	30 W, 30 s	CARTO 3	6 months
Kaneshiro T 2020 [22]	Japan	Cohort study	101	170	AF	45–50 W, 10–30 s	20–30 W, 10–30 s	CARTO 3	12 months

HPSD, high-power short duration; LPLD, low-power long duration; RCT, randomised controlled trial; W, power; s, ablation time; CT, conventional power; AI, ablation index.

Table 2. Study quality assessment based on the Newcastle Ottawa Scale.

Author, Year	Selection				Comparability of cases and controls on basis of design of analysis	Outcome			Score
	Adequate Case Definition	Representative of Cases	Selection of Controls	Definition of Controls		Ascertainment of Exposure	Same Method of Ascertainment for Cases and Controls	Non-Response Rate	
Castrejón-Castrejón S 2020 [12]	Yes	Yes	Yes	Yes	No	No	Yes	No	5
Ejima K 2020 [13]	Yes	Yes	Yes	Yes	No	No	No	Yes	4
Kottmaier M 2020 [14]	Yes	Yes	Yes	Yes	No	No	Yes	No	5
Okamatsu H 2019 [16]	Yes	Yes	Yes	Yes	No	No	Yes	No	5
Pambrun T 2019 [17]	Yes	Yes	Yes	Yes	No	Yes	Yes	No	6
Yavin HD 2020 [20]	Yes	Yes	No	Yes	No	Yes	Yes	No	5
Berte B 2019 [21]	Yes	Yes	No	Yes	No	Yes	Yes	No	5
Kaneshiro T 2020 [22]	Yes	Yes	No	Yes	Yes	Yes	Yes	No	6

Table 3. Detailed quality assessment of RCT studies by using Jadad score.

References	Randomisation	Concealment of allocation	Double blinding	Description of withdrawals and dropouts	Total Jadad Score
Kumagai K 2020 [15]	1	1	0	1	3
Shin DG 2020 [18]	2	1	0	1	4
Wielandts JY 2021 [19]	2	1	0	1	4

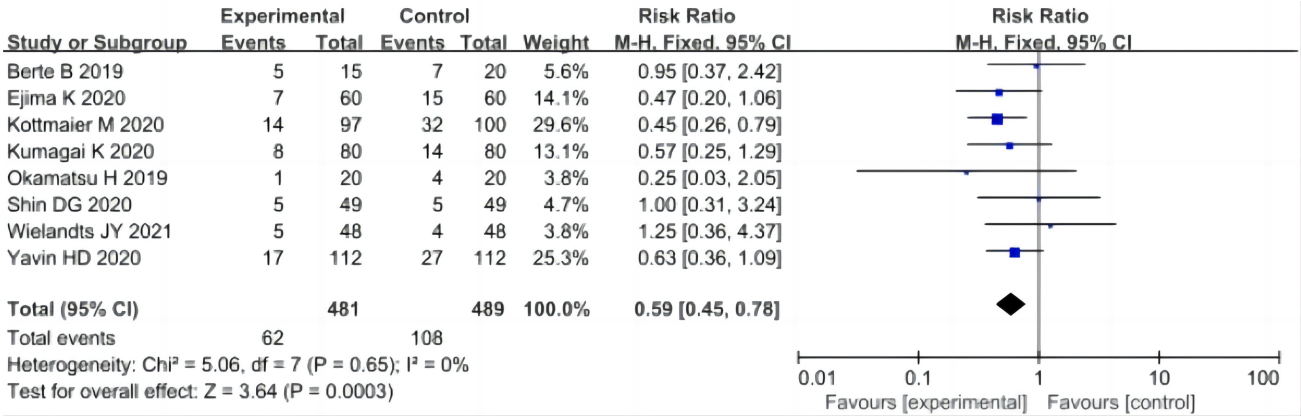

Fig. 3. Forest plot of the effect of high-power short-duration (HPSD) *vs.* low-power long-duration (LPLD) treatment on AF recurrence in patients with AF. The heterogeneity test result was (Q = 5.06; $p = 0.65$; $I^2 = 0\%$). The combined value of the estimated effect was (RR = 0.59; 95% CI: 0.45–0.78; $p < 0.001$). AF, atrial fibrillation; RR, relative risk; CI, confidence interval.

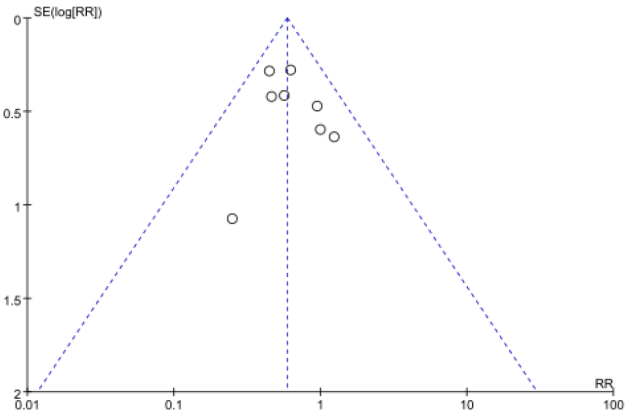

Fig. 4. Funnel plot of the effect of HPSD *vs.* LPLD treatment on AF recurrence in patients with AF.

Results

Study Characteristics and Quality Assessment

A total of 536 relevant articles were retrieved using the inclusion and exclusion criteria: 208 from Pubmed, 104 from the Cochrane Library, 136 from Web Science and 88 from Embase. After duplicates, titles and abstracts were excluded, 11 prospective [12–22] cloning studies were included, which examined 746 cases in the HPSD group and 831 in the LPLD group. All the included studies evaluated the effects of HPSD on AF and AT/AFL recurrence, occurrence rate of complications and procedural time in patients with AF. The flowchart of the literature screening is illustrated in Fig. 2. The basic information for each included study is demonstrated in Table 1 (Ref. [12–22]). The outcome of cohort study quality assessment using the Newcastle Ottawa Scale showed that the quality of the enrolled studies was moderate, with a score of 3–7, and the outcomes of the RCTs using the Jadad score showed that the quality of enrolled studies was moderate with a score of 3–4. The Newcastle Ottawa Scale is presented in Table 2 (Ref. [12–14,16,17,20–22]), and the Jadad scores for the included literature are provided in Table 3 (Ref. [15,18,19]).

Heterogeneity Test and Estimated Effect Analysis of AF Recurrence

A total of 10 original studies reported AF recurrence. The heterogeneity test result of the effect of HPSD treatment on AF recurrence revealed a Q of 5.06 ($p = 0.65$; $I^2 = 0\%$). The degree of heterogeneity of the studies was small, and thus the fixed effect model was used. The combined RR value of the estimated effect was 0.59 (95% CI: 0.45–0.78; $p < 0.001$). The sensitivity analysis suggested that the elimination of the original studies had no effect on the pooled effect size. Figs. 3,4 provide the forest and funnel plots, respectively.

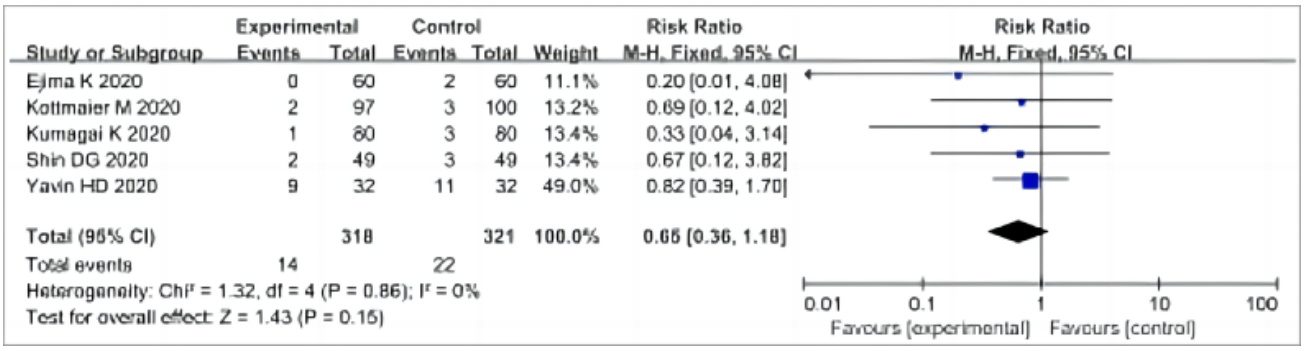

Fig. 5. Forest plot of the effect of HPSD *vs.* LPLD treatment on atrial tachycardia/atrial flutter (AT/AFL) recurrence. The heterogeneity test result revealed a Q of 1.32 ($p = 0.86$; $I^2 = 0\%$). The combined value of the estimated effect revealed an RR of 0.65 (95% CI: 0.36–1.18; $p = 0.15$).

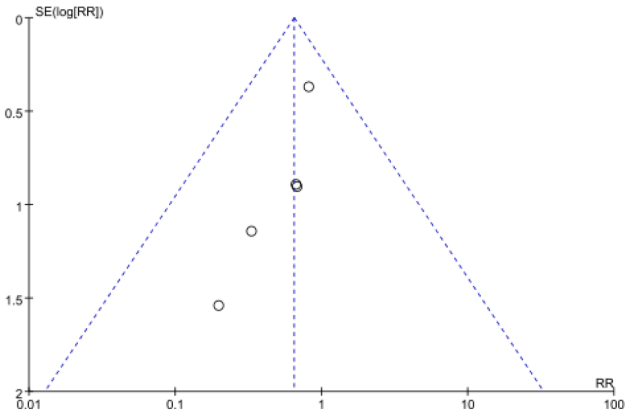

Fig. 6. Funnel plot of the effect of HPSD *vs.* LPLD treatment on AT/AFL recurrence in patients with AF.

Heterogeneity Test and Estimated Effect Analysis of AT/AFL Recurrence

Five original studies were reported AT/AFL recurrence. The heterogeneity test result of the effect of HPSD *vs*. LPLD treatment on AT/AFL recurrence revealed a Q of 1.32 ($p = 0.86$; $I^2 = 0\%$). The degree of heterogeneity of the studies was small, and thus a fixed-effects model was used. The combine RR value of the estimated effects was 0.65 (95% CI: 0.36–1.18; $p = 0.15$). The sensitivity analysis suggested that the elimination of either original study had no effect on the pooled effect size. Figs. 5,6 are forest and funnel plots, respectively.

Heterogeneity Test and Estimated Effect Analysis of Procedural Time and Subgroup Analysis

The operative times in eight original studies were summarised. The heterogeneity test result of the effect of HPSD versus LPLD treatment on procedural time in patients with AF revealed a Q of 42.22 ($p < 0.001$; $I^2 = 83\%$). The degree of heterogeneity of the studies was not small, and thus a random-effects model was used. The combined value of the estimated effects showed an Weighted mean difference (WMD) of –24.62 (95% CI: –30.78– –18.47; $p < 0.001$). The sensitivity analysis indicated that the original studies of Berte *et al*. [21] and Shin DG [18] were potential sources of heterogeneity and considerably reduced the total surgery time in the HPSD group compared with the LPLD group (WMD = –22.09; 95% CI: –[27.10–17.9]; $I^2 = 67\%$; $p < 0.00001$). After subgroup analysis, the total operation time in the HPSD group (WMD = –25.86; 95% CI: –[41.61–10.10]; $I^2 = 93\%$; $p = 0.001$; 45 W < 70 W; WMD = –22.09; 95% CI: –[27.10–17.09]; $I^2 = 67\%$; $p < 0.00001$). Fig. 7, Fig. 8 (Ref. [18,21]) and Fig. 9 are the forest, subgroup analysis forest and funnel plots, respectively.

Heterogeneity Test and Estimated Effect Analysis of Complications of Oesophageal Thermal Injury (ETI)

Three original studies have documented oesophageal thermal damage. The heterogeneity test result of the effect of HPSD *vs*. LPLD treatment on ETI in patients with AF was (Q = 9.20; $p = 0.01$; $I^2 = 78\%$). It was considered that the heterogeneity among the studies was not small, so random effect model was used in analysis. The combined value of the estimated effect was (RR = 0.84; 95% CI: 0.22–3.28; $p = 0.80$). The sensitivity analysis suggested that the elimination of either original study had no effect on the pooled effect size. Figs. 10,11 are forest plot and funnel plot, respectively.

Heterogeneity Test and Estimated Effect Analysis of Other Major Complications (Steam Pop)

The heterogeneity test result of the effect of HPSD *vs*. LPLD treatment on other major complications in patients with AF revealed a Q of 3.95 ($p = 0.56$; $I^2 = 0\%$). The degree of heterogeneity of the studies was small, and thus a fixed-effects model was used. The combined RR value of the estimated effect was 0.57 (95% CI: 0.22–1.47; $p = 0.24$). Figs. 12,13 provide the forest and funnel plots, respectively. The sensitivity analysis suggested that the elimination of either original study had no effect on the pooled effect size.

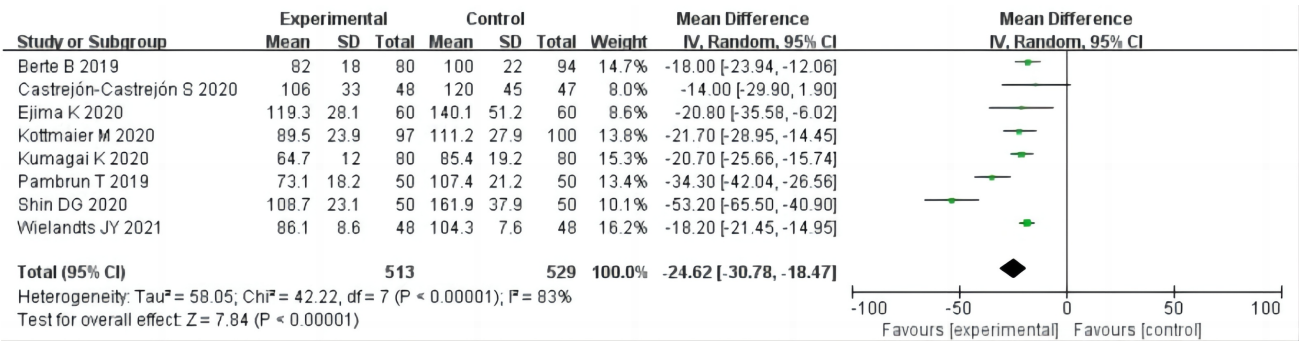

Fig. 7. Forest plot of the effect of HPSD *vs.* LPLD treatment on procedural time in patients with AF. The heterogeneity test result was (Q = 42.22; $p < 0.001$; $I^2 = 83\%$). The combined value of the estimated effect was [Mean difference (MD)= –24.62; 95% CI: –30.78– –18.47; $p < 0.001$].

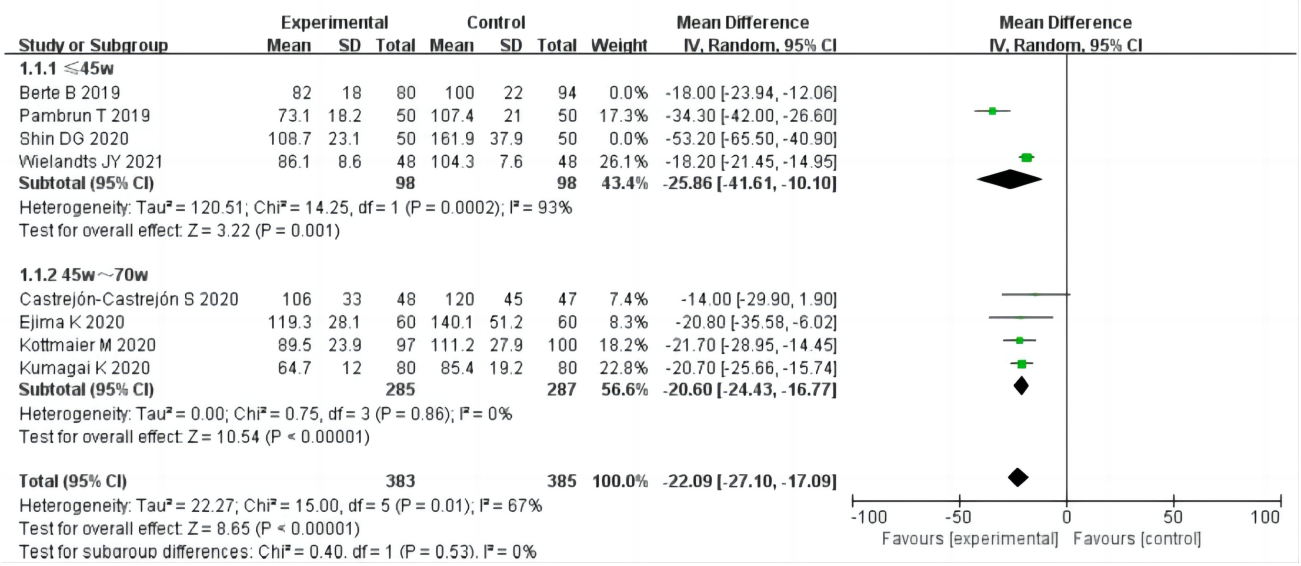

Fig. 8. Forest plot of the effects of HPSD *vs.* HPSD, from 45 w and 45 to 70 w. The original studies of Shin *et al.* [18] and Berte *et al.* [21] were removed from the Figure.

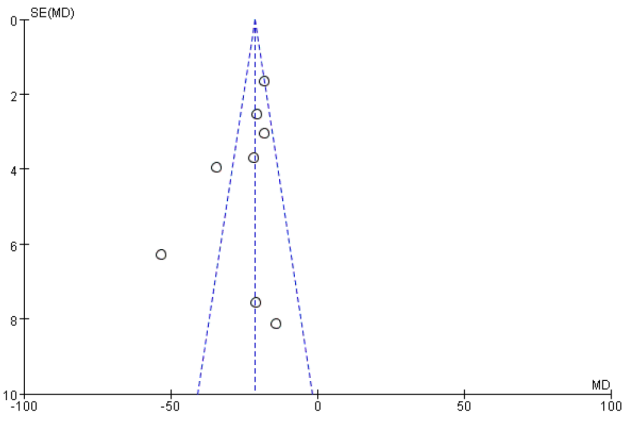

Fig. 9. Funnel plot of the effect of HPSD *vs.* LPLD treatment on procedural time in patients with AF.

Bias Analysis

The funnel plot showed that all points were evenly distributed and symmetrical for the outcomes of AF and AT/AFL recurrence and occurrence rate of complications. However, the funnel plot showed that all points were not symmetrical for procedural time. The results of the Egger's test were as follows: $p = 0.428$, 0.354, 0.526, 0.628 for AF and AT/AFL recurrence, ETI, and major complications, respectively,suggesting the absence of publication bias and the results were credible. The Begg test results were as follows: $p = 0.300$, 0.256, 0.427, 0.597, 0.597, respectively, further establishing that no bias occurred.

Discussion

This study enrolled recent relevant studies to evaluate the effectiveness, safety and surgical efficiency of HPSD

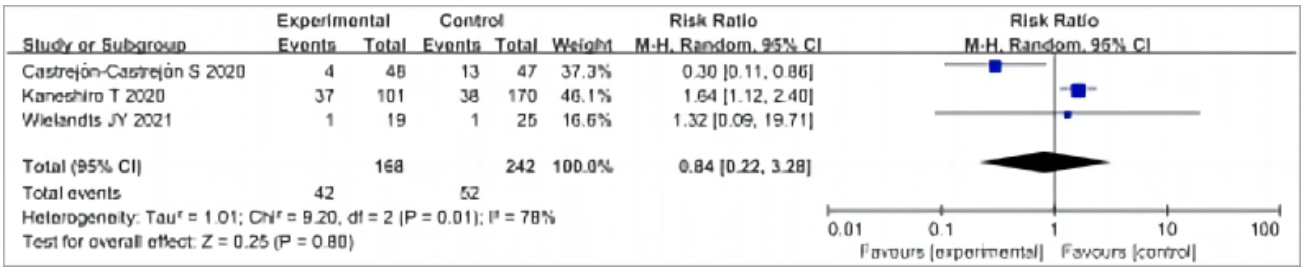

Fig. 10. Forest plot of the effect of HPSD *vs.* LPLD treatment on oesophageal thermal injury (ETI) in patients with AF. The heterogeneity test result was (Q = 9.20; p = 0.01; I^2 = 78%). The combined value of the estimated effect was (RR = 0.84; 95% CI: 0.22–3.28; p = 0.80).

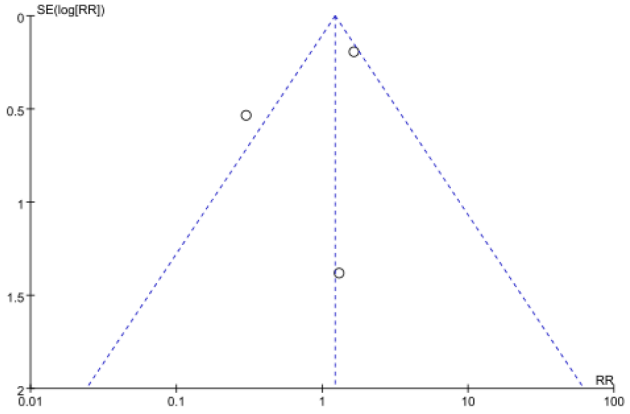

Fig. 11. Funnel plot of the effect of HPSD *vs.* LPLD treatment on ETI in patients with AF.

versus traditional LPLD strategies for AF. In addition, this meta-analysis refined the efficacy endpoints of postoperative AF and AF/tachycardia recurrence rates, reducing the heterogeneity of underlying diseases in different patients and accurately describing the efficacy of HPSD strategies in different arrhythmia diseases. Heterogeneity occurred because of differences in the characteristics of patients, treatment options, or lifestyles. We found that radio frequency ablation of AF using the HPSD strategy is superior to traditional strategies in terms of effectiveness, specifically manifested by a low recurrence rate of AF after surgery. HPSD radio frequency ablation strategy for AF is safe, similar to the LPLD strategy, although the procedural time of HPSD strategy is superior to that of the LPLD strategy.

The mechanism of radio frequency ablation in the treatment of AF is to cause thermal damage to a specific location of the left atrium, isolating the electrical conduction between the pulmonary veins and the atrium and playing a role in the treatment of AF [23–25]. High-quality transmural injury is one of the key factors for reducing the postoperative recurrence of AF [26–28]. Power is a parameter that is intuitive and easy to adjust during radio frequency ablation, and thus many researchers have attempted to adjust power to improve the therapeutic effect of radio frequency ablation. Bourier *et al*. [29] discovered through a computer model that the energy generated in the HPSD group (50 W) for 11–13 s was equal to the damage caused by the LPLD group (30 W) in 30 s and can be generated within 11–13 s. The reason was that the HPSD radio frequency settings can be derived from lesion metric indices. Through computer simulation, one study found that damage caused by high-power short-range radio frequency ablation was larger but shallower than that caused by traditional LPLD strategies. This simulation result was partially confirmed in the isolated heart tissue. Bhaskaran *et al*. [30] reported that the HPSD group (50 or 60 W/5 s) caused similar damage to the traditional LPLD group (40 W/30 s) in myocardial tissues, and the ultrahigh-power group (70 W/5 s and 80 W/5 s) caused extensive damage. Yavin *et al*. [20] applied ultrahigh-power radio frequency ablation (90 W/4 s) to the atria of pigs and found that this strategy can produce large and shallow damage.

The above studies suggested that increasing the power of radio frequency ablation is theoretically feasible. Subsequently, the HPSD strategy has been incorporated into the clinical radio frequency ablation of AF. This study confirmed the feasibility of the HPSD strategy in the radio frequency ablation of AF. In all included original studies, 100% of patients in the HPSD group successfully completed PVI. This study confirmed that the HPSD strategy is superior to the traditional LPLD strategy in terms of effectiveness for AF ablation; that is, the probability of occurrence of AF after surgery was lower. Therefore, our study suggested that the HPSD strategy was feasible and had better effects than the traditional LPLD strategy. In recent years, ultrahigh-power (70–90 W) short-term strategies have been used for the radio frequency ablation of AF [14]. Although the ultrahigh-power strategy was used in this study, an in-depth subgroup analysis of the original studies was difficult because of the limited number of these studies and which was only performed on the basis of operative time and power. Therefore, whether increased power can improve therapeutic effect should be confirmed.

One of the potential advantages of the HPSD strategy is its safety, especially for the thermal injury of the oesophagus caused by radio frequency ablation. The posterior wall of the left atrium is adjacent to the oesophagus.

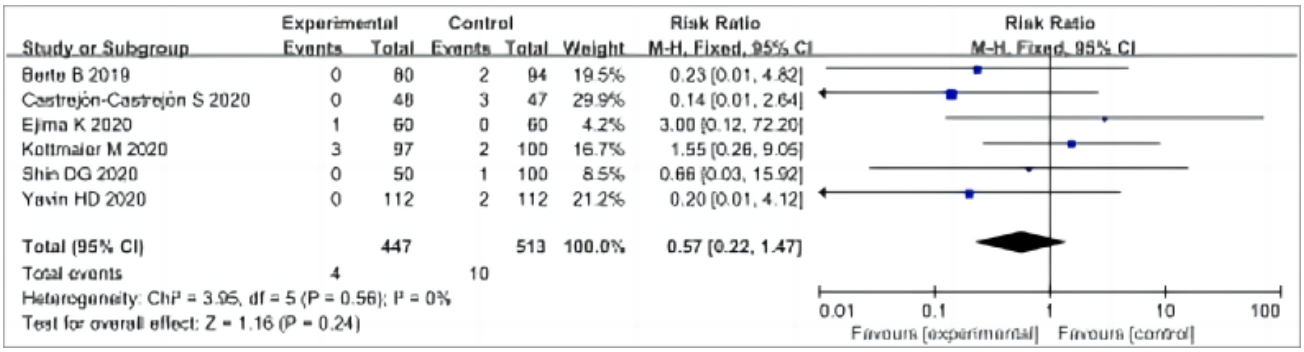

Fig. 12. Forest plot of the effect of HPSD *vs.* LPLD treatment on other major complications in patients with AF. The heterogeneity test result revealed a Q of 3.95 (p = 0.56; I^2 = 0%). The combined RR value of the estimated effect was 0.57 (95% CI: 0.22–1.47; p = 0.24).

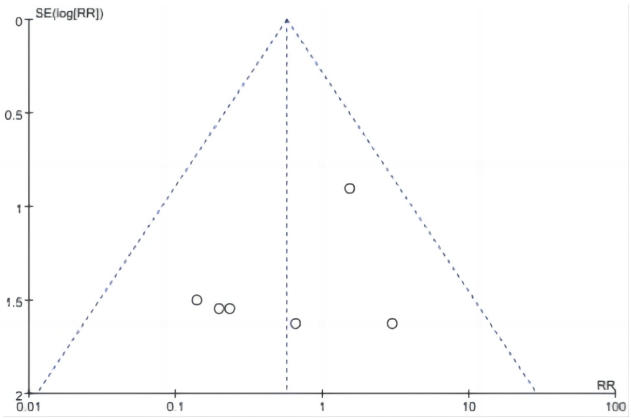

Fig. 13. Funnel plot of the effect of HPSD *vs.* LPLD treatment on other major complications in patients with AF.

Owing to individual differences in the course of the oesophagus, the shortest distance from the endocardium to the oesophageal wall is 3.5%. The distance between the endocardium and the oesophagus at the opening of the pulmonary vein ranges from 3 mm to 13.5 mm [31,32]. The safe and effective range of ablation of the posterior wall of the atrium is narrow, and thus the radio frequency ablation of the intima corresponding to the weak connective tissue between the atrium and the oesophagus (mostly the posterior wall) may cause varying degrees of oesophageal thermal damage [33]. The HPSD strategy produces broad and shallow lesions that can theoretically reduce oesophageal injury. Our comprehensive study found no significant difference in the incidence of oesophageal injury between the HPSD and LPLD groups. Notably, some surgeons actively reduce power during the ablation of the posterior wall structure of the left atrium. For example, Leo *et al.* [34] used 20 W power in the LPLD and HPSD groups during posterior wall ablation, and Lee *et al.* [35] used 25 W. Reduced posterior wall ablation power may explain why no difference in oesophageal damage was found between the HPSD and LPLD groups. The HPSD group seemed to outperform the LPLD group. For example, in the study by Francke *et al.* [36], 97 patients in the HPSD group experienced 13 cases of oesophageal injury. However, except for one deep ulcer, the oesophageal lesions in the HPSD group were all small and superficial ulcers, whereas two cases in the LPLD group were deep ulcers. Leo *et al.* [37] conducted real-time monitoring of oesophageal temperature by using temperature detectors during radio frequency ablation, specifying 39 °C as the alarm temperature; they found that the number of times the temperature in the oesophagus reached the alarm temperature during radio frequency ablation in the LPLD group was higher than that in the HPSD group (p = 0.026). As HPSD ablation is based on impedance thermal damage, in the myocardial tissue in a short time completely wall without increasing the deep tissue damage. LPLD ablation mainly depends on conduction heat damage and does not completely increase the probability of AF recurrence. A long ablation period may cause damage to deep adjacent tissues, and LPLD ablation affects catheter stability, which in turn affects the ablation effect.

The included studies exhibited significant statistical variability in procedural time, reflecting considerable inconsistency in terms of protocol. The limitations of this study were as follows: (1) Only two of the original studies included were RCTs or randomised nonblind controlled studies, whereas the rest were observational cohort studies; (2) Owing to differences in power, ablation time, contact pressure, ablation index (AI), transmission wall ablation index (LSI) and other settings and operational differences between each surgeon, difference in procedural time was found among the studies; (3) Various radio frequency ablation methods with different proportions were included in various studies, such as PVI and linear ablation based on PVI, posterior wall box ablation, and tricuspid isthmus ablation for atrial flutter, resulting in the heterogeneity of the original studies; (4) Some endpoints may have publication bias.

In summary, in the treatment of AF with radio frequency ablation, the HPSD strategy is more effective than the traditional LPLD strategy and results in a lower AF re-

currence rate after surgery. The HPSD strategy is as safe as the LPLD strategy, and no significant difference in the incidence of oesophageal injury has been found between the HPSD and LPLD groups. Moreover, the HPSD strategy can improve surgical efficiency and has a shorter procedural time than the LPLD strategy. The shortened time of HPSD ablation indicates that it can reduce the time of wearing lead clothing, relieve the long-term load damage, reduce physical injury caused by X-ray exposure to medical staff and patients and reduce the risk of anaesthesia and discomfort during long-term ablation. However, in future studies, other indicators, such as PVI time and acute pulmonary vein conduction recovery rate, should be validated.

Conclusions

HPSD is more effective than traditional LPLD and has a lower recurrence rate of postoperative AF. Meanwhile, HPSD treatment can improve surgical efficiency and have a shorter operation time than LPLD treatment.

Availability of Data and Materials

No data was used for the research described in the article.

Author Contributions

GM and WZ designed the research study. GM and WZ performed the research. GM analyzed the data. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.59958/hsf.6853.

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