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Anterior-Posterior versus anterior-lateral electrodes position for electrical cardioversion of atrial fibrillation: A meta-analysis of randomized controlled trials

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A R T I C L E I N F O

Keywords:
Cardioversion
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Electrode position

A B S T R A C T

Background: The optimal electrodes position for elective direct current (DC) cardioversion of patients with atrial fibrillation (AF) remains uncertain.

Methods: An electronic search of MEDLINE, EMBASE and COCHRANE databases was performed through March 2022 for randomized trials that examined the outcomes of anterior-posterior (AP) versus anterior-lateral (AL) electrodes position during cardioversion of (AF). The main outcome was the success rate of cardioversion. Data were pooled using random effects model.

Results: The final analysis included 10 RCTs with a total of 1677 patients. There was no difference in the rate of successful cardioversion between the AP versus AL groups (86.6 vs 87.9 %; RR 1.00; 95 % Confidence Interval (CI) 0.95 to 1.06**).** Subgroup analysis by the shock waveform showed no significant interaction between monophasic and biphasic waveforms ($P_{intercation} = 0.23$). meta-regression analyses showed no effect modification of primary outcome according to body mass index ($p = 0.15$), left atrial diameter ($p = 0.64$), valvular heart disease ($p = 0.34$), lone AF ($p = 0.58$), or the duration of AF ($p = 0.70$). There was no significant difference between the AP and AL electrode position groups in successful cardioversion at low energy (RR 0.94; 95 % CI 0.74 to 1.19), the number of the delivered shocks (standardized mean difference [SMD] −0.03; 95 % CI −0.32 to 0.26) or the mean energy of the delivered shocks (SMD −0.11 and 95 % CI −0.30 to 0.07). There was lower transthoracic impedance with AP versus AL electrode position (SMD −0.28; 95 %CI −0.47 to −0.10).

Conclusion: Meta-analysis of randomized data showed no difference between AP and AL electrode positions in the success rate of DC cardioversion of AF. Either AP or AL electrode positions should be acceptable approaches for elective DC cardioversion of patients with AF.

1. Introduction

Atrial Fibrillation (AF) is the most common cardiac arrhythmia seen in clinical practice. [1,2] Direct current (DC) cardioversion of AF is commonly indicated either on emergent basis for unstable patients, or on elective basis in patients planned for rhythm control strategy. [3]

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Hence, establishing efficacious and safe cardioversion approaches are of clinical importance. Several factors have been established to predict the success of DC cardioversion, including patient related factors such as left atrial size and duration of AF. The vector of DC cardioversion, determined by electrode and paddle positions, has been proposed as an important factor in determining success of the procedure. [4] The anterior-posterior (AP) and anterior-lateral (AL) electrode positions are the most common positions in practice and the most thoroughly studied. [5] Several randomized control trials (RCTs) have evaluated the comparative efficacy for AP versus AL positions during cardioversion of AF, with mixed results. [6–12] Most recently Schmidt et al. conducted a multicenter trial and demonstrated superior efficacy for AL positioning in DC cardioversion of AF using biphasic shock waveform. [4] However, many of the conducted RCTs were underpowered to detect the true efficacy of electrode positioning on outcomes of DC cardioversion. Hence, we sought to conduct a systematic review and *meta*-analysis including RCTs that evaluated the efficacy of AP versus AL electrode position in DC cardioversion of AF.

2. Methods

2.1. Data sources and search strategy

We performed a computerized search of MEDLINE, EMBASE and Cochrane databases through March 2022, using the terms 'atrial fibrillation', 'Electrode Position' and 'cardioversion', separately and in combination, to identify all RCTs that evaluated the outcomes with AP versus AL electrode position during cardioversion of AF. English language restriction was applied during our search. A similar search strategy was done for abstracts of the major scientific sessions (American Heart Association, American College of Cardiology, Heart Rhythm Society and European Society of Cardiology) between March 2020 up to March 2022. Furthermore, we screened the bibliographies of the retrieved articles and **ClinicalTrials.gov** to search for any relevant studies not retrieved through the initial search. The current systematic review and *meta*-analysis was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and meta-Analyses) guidelines. [13] **(Supplemental Table 1).** Prospective PROSPERO registration has been submitted for the current analysis **(ID 328784).**

2.2. Selection criteria

We included RCTs that examined the outcomes of AP versus AL electrode positioning during cardioversion of AF. Included studies must have reported the success rate of cardioversion among the study groups. We excluded non-randomized studies.

2.3. Data extraction

The study details, interventions, patients' characteristics, endpoints and other study characteristics were extracted by 2 independent investigators (M.E and D.G). Discrepancies among investigators were resolved by consensus.

2.4. Outcomes

The primary outcome of the study was success in cardioversion of AF, as defined per each study. Other outcomes included success of cardioversion at low shock energy (defined as monophasic shock $\leq$ 200 J or biphasic shock $\leq$ 120 J), number of received shocks, mean transthoracic impedance and mean shock energy.

2.5. Assessment of the quality of the included studies

The Cochrane risk of bias criteria were adopted for evaluating the quality of the included studies, including the following criteria: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting and other sources of bias. [14] Accordingly studies were labeled to be of low, unclear or high risk of bias.

2.6. Statistical analysis

Due to anticipated heterogeneity in the included studies, data were pooled using the random-effects model. Statistical heterogeneity across studies was assessed using I^2 statistics. Low degree of heterogeneity was defined by I^2 statistic value < 25 %, moderate degree by I^2 statistic value 25–50 % and high degree by I^2 statistic value > 50 %. [15] Outcome measures for categorical values were reported using risk ratios (RR) and for continuous variables using standardized mean differences (SMD). Pre-specified subgroup analysis for the primary outcome was conducted according to monophasic or biphasic shock waveform for cardioversion. meta-regression analyses were conducted using confidence level 95 %, to evaluate the effect modification in the primary outcome based on body mass index, duration of AF, lone AF, left atrial diameter and presence of valvular heart disease. Publication bias was assessed by inspection of funnel plot symmetry. P-values were considered statistically significant if < 0.05. Statistical analyses were conducted using RevMan 5.0 software (Cochrane Collaboration, Oxford, UK).

3. Results

The study selection process is outlined in Fig. 1**.** The final analysis included 11 RCTs with a total number of 1677 patients [4,6–12,16,17]; of whom 831 patients underwent cardioversion with AP electrode position and 846 patients underwent electrical cardioversion with AL electrode position. The characteristics of included studies appear in Table 1. Two trials were multicenter trials [4,9] and the remaining trials were done in singles centers. The AP electrode position in most of the included trials involved placements of electrodes at the right sternal border and left infrascapular regions, except for Schmidt et al. [4], where it involved positioning at the left parasternal and left lower scapular region (3). The AL electrode position involved electrode positioning at the cardiac apex and right infraclavicular region in the included trials. In five trials, electrical cardioversion was done using biphasic shock waveform [4,9,12,17], while in the remaining trials electrical cardioversion was done using monophasic shock waveforms. [6–8,10,11,16] The quality of included trials is outlined in **Supplemental Table 2.** The patients' characteristics appear in Table 2. The weighted mean age of patients was 63.8 years and proportion of men was 68 %. The pattern of AF in the included studies was mostly persistent AF, while Schmidt et al. also included patients with paroxysmal AF for about 20 % of their population. [4] The classification of AF was not clarified in studies by Mathew et al. and Brazdzionyte et al. [10,12] The use of anti-arrhythmic medications varied across the included studies, and is outlined in Table 3**.**

3.1. Primary outcome

The success of AF cardioversion was reported in all included RCTs **(Supplemental Table 3).** There was no difference in the rate of successful cardioversion of AF among the AP versus AL electrode position groups. ((86.6 vs 87.9 %; RR 1.00; 95 % Confidence Interval (CI) 0.95 to 1.06, $I^2 = 69$ %) (Fig. 2**).** Inspection of funnel plot symmetry suggested no publication bias **(Supplemental Figure 1).** meta-regression analyses showed no effect modification of primary outcome according to body mass index (p = 0.15), left atrial diameter (p = 0.64), valvular heart disease (p = 0.34), lone AF (p = 0.58), or the duration of AF (p = 0.70). Subgroup analysis according to the shock waveform showed no significant interaction between monophasic and biphasic waveforms ($P_{intercation} = 0.23$) **(Supplemental Figure 2).**

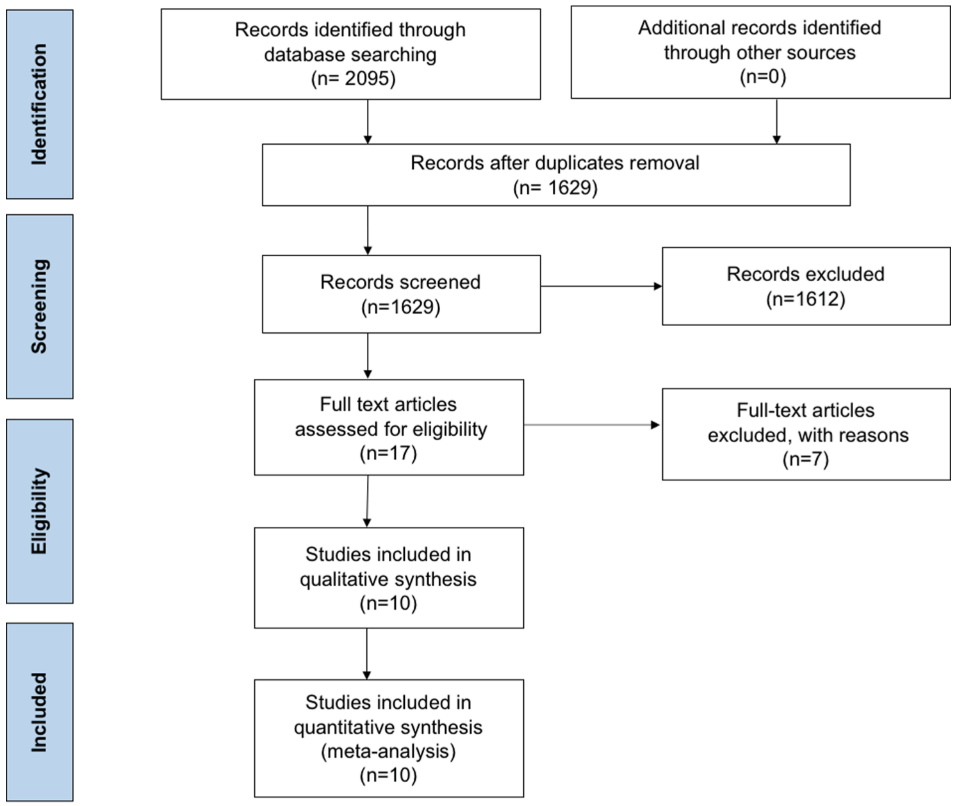


Fig. 1. Study flow sheet.

Table 1
Characteristics of the included Trials.

Study	Year of publication	Single/ Multicenter	APGroup (n)	AL Group (n)	Waveform of DC Shock	Definition of successful DCCV	The Sequence and escalation of the delivered DC shocks
Botto et al	1999	Single	150	151	Monophasic	Interruption of AF > 10 s	Initial 3 J/kg then 4 J/kg, with maximum 360j then 4 J/kg alternate/ crossover paddles position
Mathew et al	1999	Single	45	45	Monophasic	Restoration of sinus rhythm	100 J then 200 J then 300 J then 360 J if SR was not achieved cross over with alternate paddle position with 360 J
Alp et al	2000	Single	29	30	Monophasic	Restoration of sinus rhythm based on 12 Lead EKG within 30mniutes or more after DCCV	360 J then cross over with alternate paddle position with 360 J to achieve SR
Kirchhof et al	2002	Single	52	56	Monophasic	Restoration of sinus rhythm or conversion to organized atrial rhythm	50 J then 100 J then 200 J then 300 J then 360 J, then cross over with alternate paddle position 360 J
Chen et al	2003	Single	39	31	Monophasic	Restoration and maintenance of sinus rhythm for ≥ 60 min	100 J then 150 J then 200 J then 300 J, maximum 360 J
Vogiatzis et al	2009	Single	30	32	Monophasic	Restoration of sinus rhythm	200 J,then 300 J then 360 J
Walsh et al	2005	Multicenter	144	150	Biphasic	Restoration and maintenance of sinus rhythm for ≥ 30 s	70-J then 100 J then 150 J then 200 J, then cross over with alternate paddle position 200 J to achieve SR
Siaplaouras et al	2005	Single	60	63	Biphasic	Restoration of sinus rhythm	120 J then 150 J then 200 J then another DC with 200 J
Brazdzionyte et al	2006	Single	48	55	Biphasic	Restoration of sinus rhythm, with at least one P wave within 30 s	UA
Schmidt et al	2021	Denmark	234	233	Biphasic	Restoration of sinus rhythm in first minute after shock	100 J then 150 J then 200 J then 360 J till restoration of SR

AP:Anterior-posterior, AL:Anterior-lateral, DC:Direct Current cardioversion,AF:Atrial Fibrillation,HD:Hemodynamic,SR:Sinus Rthym,LA:Left atriuam,UK:United Kindgom,HT:Heart,CHF:Congestive heart failure,K:Potassiusm,AC:Anticougulation,R:Right,L:Left.

3.2. Secondary outcomes

Success of cardioversion at low energy was reported in 6 trials. There was no significant difference between the AP and AL electrode position groups in successful cardioversion at low energy (51.3 % vs 58.5 %; RR 0.94; 95 % CI 0.74 to 1.19). The Number of the delivered shocks was reported in 5 trials, and no difference was observed between the AP and AL electrode position groups (SMD −0.03; 95 % CI −0.32 to 0.26). The mean energy of the delivered shocks was reported in 6 trials and there was no observed difference among both groups (SMD −0.11 and 95 % CI

Table 2
The baseline characteristics of the enrolled patients.

Trials	Age(yr) Mean age (SD)	Male sex (%)	BMI(kg/ m2) BMI (SD)	HTN % Percentage	CAD % Percentage	CM % Numbers	Mean AF duration (months)	Lone AF % Percentage	Paroxysmal AF(%) Percentage	Persistent AF(%) Percentage	LA diameter (mm) Diameter (standard deviation)
	AP/ AL	AP/ AL	AP/ AL	AP/ AL	AP/ AL	AP AL	AP/ AL	AP/ AL	AP/ AL	AP/ AL	AP/ AL
Botto et al	62(11)/ 62(12)	59/62	NA	27 /27	12 / 9	11/ 10	3.2/ 3.06	21/ 21	0/ 0	100/ 100	45(6)/44(6)
Mathew et al	65.5(10) in the whole group	66.66 in both groups	26.5 (5.3)/ 27.5 (4.9)	21 in the whole group	21 in the whole group	NA	13.3/ 14.7	NA/NA	NA/ NA	NA/ NA	48.4(9.8)/ 48.9(7.2)
ALP et al	66.8(7.9)/ 67.8(8.1)	75.86/ 63.33	NA	37.93/ 16.66	10.34/ 20	NA	7.75/ 5.75	NA/ NA	0/ 0	100/ 100	47.2(7.5)/ 49.2(14.9)
Kirchhof et al	62(2)/ 58 (2)	73.07/ 78.57	27(4)/ 27(4)	56/ 39	25/ 25	13/ 23	5/ 4*	23/ 27	0/ 0	100/100	51(7)/ 49(6)
Chen et al	57.6 (10.1)/ 59.1 (14.7)	69.2/ 64.5	25.2 (4.7)/ 25.3 (4.6)	38.5/ 32.3	7.7/ 3.2	17.9/ 16.1	25.9/23.8	2.7/ 16.1	0/ 0	100/ 100	40.2(6.2)/ 40.8(7.1)
Vogiatzis et al	61.6(7.2)/ 60.1(8.6)	65.6/ 65.6	26.8 (3.8)/ 25.9(40)	13.5/12.5	20/ 12.5	6.7/ 6.3	1.6/1.7	60/ 50	0/ 0	100/ 100	44.3(8.7)/ 41.2(9.9)
Walsh et al	66(14)/67 (10)	64/63	29(5)/ 28(5)	52/ 38	39/ 31	NA	6.5/ 4.75	10/ 14	5/ 3	58/ 62	46(6)/ 47(8)
Siaplaouras et al	67(10)/ 66(10)	67/ 75	27.7(4)/ 28.2(5)	44/ 28	16/ 25	5/ 17	3/ 3.8	12/ 12	0/ 0	100/ 100	49(7)/ 48(7)
Brazdzionyte et al	62.31 (10.37)/ 63.84 (11.67)	60.4/ 65.5	29.91 (5.16)/ 29.55 (4.78)	38.5/ 32.3	NA	NA	14.6 % >6ms/ 9.1 %> 6ms	NA	NA/ NA	NA/ NA	45.81 (5.08)/ 45.87(5.35)
Schmidt et al	68.9(9.3)/ 68.7(9.5)	67.52/ 66.9	28.9 (5.4)/ 28.8 (5.8)	65/ 64	12/ 12	23/ 29	5/ 9*	NA	22/ 18	78/ 82	NA

Abbreviations of table 3: SD = standard deviation; BMI = body mass index; HTN = Hypertension; CAD = coronary artery disease; CM = Cardiomyopathy, AP = anterior-posterior; AL = anterior-.
* Data are medians.

Table 3
The use of antiarrhythmic medications before cardioversion.

Trials	Class I AAT(%)	Class II AAT(%)	Class III AAT(%)*	Class IV AAT(%)	Digitalis (%)	Amiodarone(%)
	AP/ AL	AP/ AL	AP/ AL	AP/ AL	AP/ AL	AP/ AL
Botto et al	15/ 20	0/0	4/ 5	0/ 0	0/ 0	46/ 41
Mathew et al	NA/ NA	NA/NA	NA/NA	NA/NA	NA/NA	NA/NA
ALP et al	55.17/ 46.66	NA/NA	3.44/ 3.33	0/ 6.66	37.93/ 50	20.68/ 26.66
Kirchhof et al	13/ 16	50/ 57	19/ 25	25/ 7	69/ 63	15/ 21
Chen et al	0/0	20.5/ 22.6	0/ 0	17.9/ 12.9	0/0	64.1/ 58.1
Vogiatzis et al	0/ 0	50/ 50	0/ 0	16.7/ 25	46.7/ 56.3	0/ 0
Walsh et al	8/9	59/ 59	4/ 3	NA/ NA	39/ 42	10/ 9
Siaplaouras et al	5/ 5	48/ 30	15/ 21	0/ 2	3/ 6	27/ 30
Brazdzionyte et al	NA/ NA	NA/ NA	NA/ NA	NA/ NA	NA/ NA	NA/ NA
Schmidt et al	1/ 2	76/ 83	NA/ NA	NA/ NA	14/ 18	13/ 17

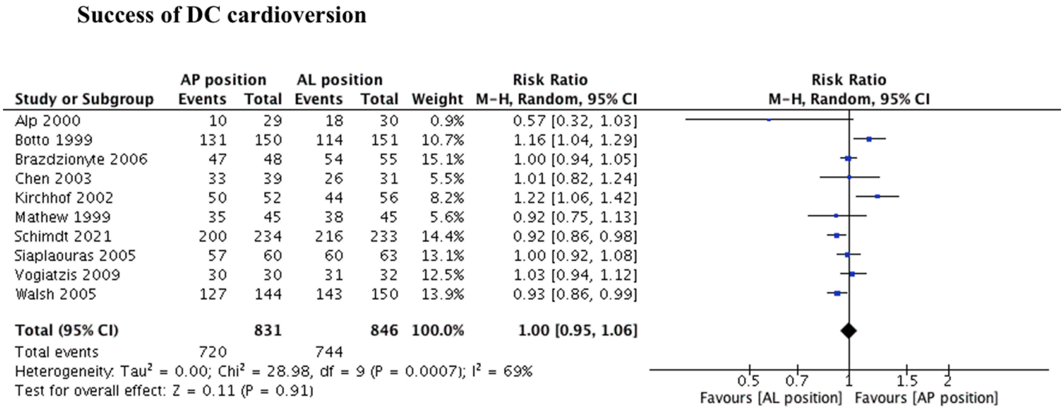
Abbreviations of table 5; NA = not available, AP = anterior-posterior; AL:anterior-lateral, AAT = Antiarrthymic medications.
* Not including amiodarone.

−0.30 to 0.07). Transthoracic impedance was reported in 3 trials. There was lower transthoracic impedance with AP versus AL electrode position (SMD −0.28; 95 %CI −0.47 to −0.10) (Fig. 3).

4. Discussion

In this metanalysis of 10 RCTs including 1677 patients, we evaluated the efficacy of AP versus AL electrode position during cardioversion of AF. The salient findings of this analysis are: 1) there was no difference in the success rate of AF cardioversion among the AP versus AL electrode position groups; 2) there were no differences among the AP and AL electrode position groups in successful cardioversion at low energy, number of received shocks, or mean shock energy; 3) AP electrode position was associated with lower mean transthoracic impedance during AF cardioversion compared with AL position; 4) exploratory analyses suggested no significant effect modification according to shock waveform, body mass index, left atrial diameter, lone AF or the duration of AF.

The ideal electrode/paddle position for DC cardioversion of AF remains uncertain. AP and AL electrode positions have been the most adopted positions in clinical practice and evaluated in multitude of studies. Some practical considerations might render the AL electrode position more favorable, such as faster application in emergent cases, or during electrophysiologic procedures (AF ablation or pacemaker implantation). [4] Data from randomized studies have yielded mixed results regarding the comparative efficacy of each position DC

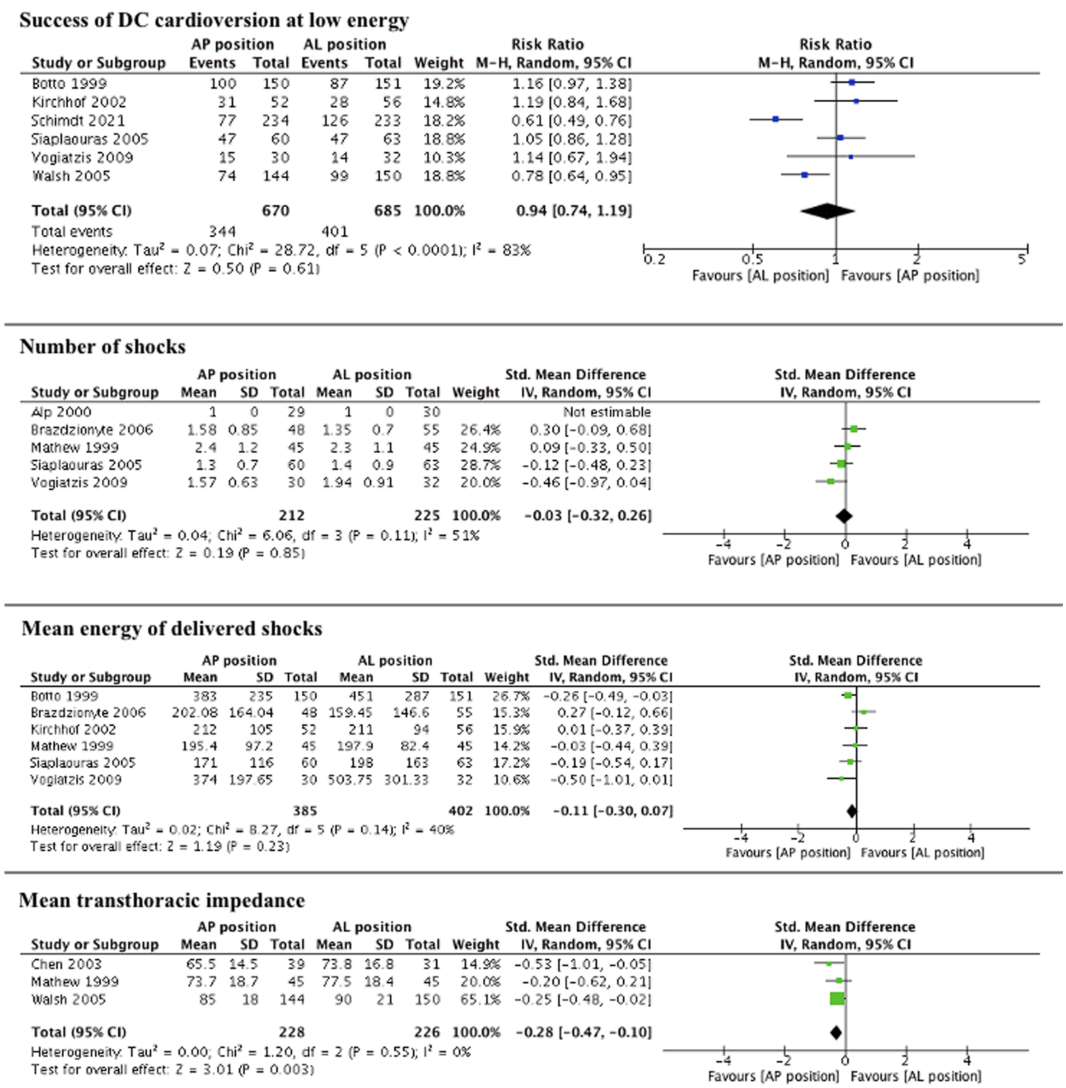


Success of DC cardioversion

Study or Subgroup	AP position Events	AP position Total	AL position Events	AL position Total	Weight	Risk Ratio M-H, Random, 95% CI
Alp 2000	10	29	18	30	0.9%	0.57 [0.32, 1.03]
Botto 1999	131	150	114	151	10.7%	1.16 [1.04, 1.29]
Brazdzionyte 2006	47	48	54	55	15.1%	1.00 [0.94, 1.05]
Chen 2003	33	39	26	31	5.5%	1.01 [0.82, 1.24]
Kirchhof 2002	50	52	44	56	8.2%	1.22 [1.06, 1.42]
Mathew 1999	35	45	38	45	5.6%	0.92 [0.75, 1.13]
Schimdt 2021	200	234	216	233	14.4%	0.92 [0.86, 0.98]
Siaplaouras 2005	57	60	60	63	13.1%	1.00 [0.92, 1.08]
Vogiatzis 2009	30	30	31	32	12.5%	1.03 [0.94, 1.12]
Walsh 2005	127	144	143	150	13.9%	0.93 [0.86, 0.99]
Total (95% CI)		**831**		**846**	**100.0%**	**1.00 [0.95, 1.06]**
Total events	720		744			

Heterogeneity: Tau² = 0.00; Chi² = 28.98, df = 9 (P = 0.0007); I² = 69%
Test for overall effect: Z = 0.11 (P = 0.91)

Fig. 2. Forest plot for success of DC cardioversion with AP versus AL electrode position.



Success of DC cardioversion at low energy

Study or Subgroup	AP position Events	AP position Total	AL position Events	AL position Total	Weight	Risk Ratio M-H, Random, 95% CI
Botto 1999	100	150	87	151	19.2%	1.16 [0.97, 1.38]
Kirchhof 2002	31	52	28	56	14.8%	1.19 [0.84, 1.68]
Schimdt 2021	77	234	126	233	18.2%	0.61 [0.49, 0.76]
Siaplaouras 2005	47	60	47	63	18.8%	1.05 [0.86, 1.28]
Vogiatzis 2009	15	30	14	32	10.3%	1.14 [0.67, 1.94]
Walsh 2005	74	144	99	150	18.8%	0.78 [0.64, 0.95]
Total (95% CI)		**670**		**685**	**100.0%**	**0.94 [0.74, 1.19]**
Total events	344		401			

Heterogeneity: Tau² = 0.07; Chi² = 28.72, df = 5 (P < 0.0001); I² = 83%
Test for overall effect: Z = 0.50 (P = 0.61)

Number of shocks

Study or Subgroup	AP Mean	AP SD	AP Total	AL Mean	AL SD	AL Total	Weight	Std. Mean Difference IV, Random, 95% CI
Alp 2000	1	0	29	1	0	30		Not estimable
Brazdzionyte 2006	1.58	0.85	48	1.35	0.7	55	26.4%	0.30 [−0.09, 0.68]
Mathew 1999	2.4	1.2	45	2.3	1.1	45	24.9%	0.09 [−0.33, 0.50]
Siaplaouras 2005	1.3	0.7	60	1.4	0.9	63	28.7%	−0.12 [−0.48, 0.23]
Vogiatzis 2009	1.57	0.63	30	1.94	0.91	32	20.0%	−0.46 [−0.97, 0.04]
Total (95% CI)			**212**			**225**	**100.0%**	**−0.03 [−0.32, 0.26]**

Heterogeneity: Tau² = 0.04; Chi² = 6.06, df = 3 (P = 0.11); I² = 51%
Test for overall effect: Z = 0.19 (P = 0.85)

Mean energy of delivered shocks

Study or Subgroup	AP Mean	AP SD	AP Total	AL Mean	AL SD	AL Total	Weight	Std. Mean Difference IV, Random, 95% CI
Botto 1999	383	235	150	451	287	151	26.7%	−0.26 [−0.49, −0.03]
Brazdzionyte 2006	202.08	164.04	48	159.45	146.6	55	15.3%	0.27 [−0.12, 0.66]
Kirchhof 2002	212	105	52	211	94	56	15.9%	0.01 [−0.37, 0.39]
Mathew 1999	195.4	97.2	45	197.9	82.4	45	14.2%	−0.03 [−0.44, 0.39]
Siaplaouras 2005	171	116	60	198	163	63	17.2%	−0.19 [−0.54, 0.17]
Vogiatzis 2009	374	197.65	30	503.75	301.33	32	10.6%	−0.50 [−1.01, 0.01]
Total (95% CI)			**385**			**402**	**100.0%**	**−0.11 [−0.30, 0.07]**

Heterogeneity: Tau² = 0.02; Chi² = 8.27, df = 5 (P = 0.14); I² = 40%
Test for overall effect: Z = 1.19 (P = 0.23)

Mean transthoracic impedance

Study or Subgroup	AP Mean	AP SD	AP Total	AL Mean	AL SD	AL Total	Weight	Std. Mean Difference IV, Random, 95% CI
Chen 2003	65.5	14.5	39	73.8	16.8	31	14.9%	−0.53 [−1.01, −0.05]
Mathew 1999	73.7	18.7	45	77.5	18.4	45	20.0%	−0.20 [−0.62, 0.21]
Walsh 2005	85	18	144	90	21	150	65.1%	−0.25 [−0.48, −0.02]
Total (95% CI)			**228**			**226**	**100.0%**	**−0.28 [−0.47, −0.10]**

Heterogeneity: Tau² = 0.00; Chi² = 1.20, df = 2 (P = 0.55); I² = 0%
Test for overall effect: Z = 3.01 (P = 0.003)

Fig. 3. Forest plot for success of DC cardioversion at low energy, mean number of shocks, mean energy of delivered shocks and mean *trans*-thoracic impedance with AP versus AL electrode position.

cardioversion of AF. Two metanalyses have been previously published in 2014 attempting to answer similar questions. Kirkland et. al. primarily explored the potential benefit of AP vs AL positioning on successful conversion to normal sinus rhythm after administration of the first shock in patients with AF. [5] Zhang et. al. similarly tested whether AP vs AL positioning facilitates cardioversion success for atrial fibrillation. [18] In contrast to the above *meta*-analyses, ours included a recent large randomized controlled trial by Schmidt et al. [3] Despite the addition of Schmidt et al., a study that demonstrated benefit of AL positioning, our pooled analysis failed to show superiority of either positioning. Our results align well with that of Kirkland and Zhang et al. for our primary end point. Zhang et al. found that AP positioning in patients with a left atrium diameter < 45 mm and lone AF might create benefit; however, our updated analyses showed no similar interaction between left atrial diameter or lone AF and success of cardioversion. [3] Nevertheless, indexed left atrial volumes represent a more accurate measurement of left atrial geometry, and the lack of such data precluded more granular analysis for the interaction between left atrial geometry and success of cardioversion in AP versus AL electrode positions. A *meta*-analysis by Salah et al. evaluated success of DC cardioversion of AF among AP vs AL electrode position, but only included studies using biphasic shock waveform. [19] Their analysis included 6 RCTs and showed higher success rate with AL versus AP electrode positioning. In our analysis, we have included the totality of available randomized data, (10 RCTs), with higher analytical power compared to priro *meta*-analyses. Moreover, we explored the interaction between monophasic and biphasic shock waveform using subgroup analysis, and while there was a signal for higher success rate with biphasic shockwave forms, this did not reach statistical analysis (Pinteraction = 0.26).

It has historically been believed that the AP configuration would deliver a superior shock vector. [7] Additionally, when transthoracic impedance is lower, a greater amount of current may be able to be delivered to the myocardium increasing the chance of a return to normal sinus rhythm. Our study did demonstrate that transthoracic impedance is lower in the AP position, however it did not demonstrate a difference in success between the two positions. The lack of a clinical difference that mirrors the theoretical difference is likely due to the magnitude of current that actually traverses the heart. Lerman and Deale found that a very small proportion of current delivered (~4%) actually depolarized the heart. The remainder of the current would go through parallel pathways such as the thoracic cage and lung. Thus, if a relatively small amount of current is delivered to the heart itself, any potential benefits of AP vs AL positioning would be attenuated via these additional anatomic factors. [20,21].

The current *meta*-analysis comprises the totality of randomized data evaluating the efficacy of AP versus AL electrode position in AF cardioversion. Our results showed no significant difference in the success rate, number of shock or mean energy required for cardioversion between the AP and AL electrode positions. Collectively, our result results emphasize that electrode position is not a significant determinant for success of elective DC cardioversion, and AP or AL positions are appropriate approaches.

The current analysis has some limitations. First, there was considerable degree of heterogeneity in some of the study outcomes. We have adopted a random effects model to mitigate the effects of such heterogeneity. Second, the lack of patient-level data precluded more granular analyses regarding outcomes of certain subgroups of patients. Third, certain data were not available in some of the included studies, such as outcomes according to body habitus, left atrial geometry and comorbidities. Also, there were not enough data to conduct further detailed analyses for outcomes according to the protocol used, or according to type of shock use. Fourth, the study was limited by some variation in the definition of the primary endpoint across the included studies. Finally, the current study focused on evaluating outcomes of electrode positioning among patients undergoing elective cardioversion, so our results cannot be extrapolated to critical patients who require cardioversion.

5. Conclusion

In this *meta*-analysis of randomized clinical trials, there was no difference between AP and AL electrode positions in the success rate of DC cardioversion of AF There were also no differences in success rate at low shock energy, number of shocks or mean energy required for cardioversion between the AP and AL electrode positions. Either AP or AL electrode positions should be acceptable approaches for elective DC cardioversion of patients with AF.

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Compliance with Ethical Standards.

This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of Competing Interest

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Data availability.

All data generated or analyzed during this study are included in this published article/as supplementary information files.

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Appendix A. Supplementary data

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