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RAPID COMMUNICATION

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Meta-analysis of ultrasound-guided vs conventional vascular access for cardiac electrophysiology procedures

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Abstract

Background: Vascular complications are common during invasive cardiac electrophysiology procedures. This meta-analysis compares outcomes following ultrasound and nonultrasound-guided vascular access for these procedures.

Methods: PubMed, Embase and Cochrane 01/01/1980-30/09/2018 were searched for relevant studies to meta-analyse.

Results: Seven studies (6269 patients) were included. Pooled rates and odds ratio(95% confidence interval) for ultrasound and nonultrasound subgroups were 1.2% vs 3.0%, 0.32 (0.21-0.49) for all vascular complications, with less hematomas and arterial punctures but similar arteriovenous fistulas, pseudoaneurysms or retroperitoneal bleeds.

Conclusion: Ultrasound guidance had less complications due to less hematoma and arterial puncture, and is generally recommended for electrophysiology procedures.

KEYWORDS

arrhythmia, catheter ablation, electrophysiology, ultrasound, vascular access

1 | INTRODUCTION

Invasive cardiac electrophysiology procedures have risen significantly over the last decade.[1,2] It is well-established as curative for some arrhythmias, reducing burden and symptoms in others, and for selected patients with both atrial fibrillation and heart failure, potentially improving clinical outcomes including survival.[1,3] Periprocedural complications occur in 2%-10% of these procedures, where vascular complications are most common.[1,4,5] Ultrasound guidance for central vascular access has gained popularity over recent years but are rarely studied for invasive electrophysiology procedures.[6,7] We meta-analysed the rates of vascular complications following cardiac electrophysiology procedures with ultrasound guidance vs a conventional nonultrasound approach for vascular access.

2 | METHODS

Electronic databases Pubmed, Medline, Embase and Cochrane were searched from 1 January 1980 to 30 September 2018 for relevant studies and abstracts. The search terms used were "ultrasound", "vascular" or "access" or "percutaneous", and "catheter ablation" or "electrophysiology". Original randomised trials and observational studies reporting vascular bleeding complication rates for both ultrasound-guided and conventional nonultrasound-guided access of electrophysiological procedures for any arrhythmias are included.

Data pertaining to study design, patient characteristics and outcomes of all included studies were then extracted. Review Manager Version 5.3 (Cochrane Collaboration, Oxford, England) was used. Pooled odds ratios (OR) with 95% confidence intervals (95% CI) and

Forrest Plots were performed. We used random effects modeling to account for potential heterogeneity in study methodology and patient characteristics. Heterogeneity of studies was assessed using I^2 and publication bias using Funnel Plots for each outcome pooled. *P*-value less than .05 was deemed statistically significant and all tests were two-tailed.

3 | RESULTS

The search yielded 229 articles, for which 41 duplicate studies and 173 unrelated studies were excluded after initial screening. Upon review of 15 full-text articles, 4 were reviews and 2 were meta-analyses without original data, and 2 were single-arm.[8–14] This resulted in seven studies being included for meta-analysis, listed in Table 1. There was one randomised trial and six observational studies, totaling 6269 patients.

Forrest plots are illustrated in Figure 1A-F. Ultrasound guidance had a significantly lower rate of composite vascular complications 1.2% vs 3.0%, OR 0.32 (95% CI 0.21-0.49), $P < .001$; local hematoma 0.3% vs 1.4%, 0.20 (0.09-0.42), $P < .001$; and inadvertent arterial puncture 6.4% vs 20.4%, OR 0.25 (0.11-0.57). There were no statistically significant differences in the rates of pseudoaneurysm, arteriovenous fistula formation and retroperitoneal bleed ($P > .05$) although events were rare with either strategy (pooled rates <0.5%). No significant heterogeneity or publication bias was identified for all outcomes. The findings did not differ if only atrial fibrillation studies were meta-analysed.[8,10,12,14]

4 | DISCUSSION

Vascular complications are the commonest adverse event following invasive cardiac electrophysiology procedures, and rates vary based on the type of arrhythmia treated.[1,5] We found that ultrasound guidance for vascular access in these procedures was associated with reduction by two-thirds in composite vascular complications and consistent across all studies.[9–14] The main strength of ultrasound is the ability to visualise vascular structures; in this setting, both the femoral vein and artery, as well as their size, depth and optimal route of access, rather than based on anatomical landmarks and palpation only. This explains the lower rate of inadvertent arterial punctures, and potentially lower risk of perforating the posterior venous wall, both of which could lead to hematomas.

Although we did not find statistically significant differences between the two access approaches for the rates pseudoaneurysm, arteriovenous fistula formation and retroperitoneal hematoma, the event rates of these major complications were extremely low, making the analysis underpowered. These events, particularly retroperitoneal bleeding, often require active management including blood transfusion, interventional radiology procedures, and occasionally vascular surgery. They are potentially fatal and inevitably

TABLE 1 Characteristics of included studies

Author/year	Design	Timeframe of procedures	Centers	Country	Cohort	Group	N	Age (years)	Male
Tanaka-Esposito (2013)[8]	Retrospective cohort 2 phases	January 2005-December 2006 July 2008-May 2010	1	United States	Atrial fibrillation	Conventional Ultrasound	1909 1511	62.9 63.1	63% 60%
Errahmouni (2014)[9]	Retrospective cohort Historic controls	April 2012-October 2012 November 2012-June 2013	1	Monaco	All arrhythmias	Conventional Ultrasound	150 150	Not reported	79% 77%
Wynn (2014)[10]	Prospective cohort 2 phases	May 2012-September 2012 October 2012-February 2013	1	United Kingdom	Atrial fibrillation	Conventional Ultrasound	146 163	58.7 59.1	68% 74%
Rodriguez (2015)[11]	Prospective Cohort	Not reported	1	Spain	All arrhythmias	Conventional Ultrasound	12 24	57 58	61% 49%
Dussault (2016)[12]	Retrospective cohort	January 2010-October 2015	1	United States	Atrial fibrillation/ Atrial flutter	Conventional Ultrasound	757 439	65.4 64.2	67% 64%
Sharma (2016)[13]	Prospective Cohort 2 phases	October 2014-May 2015 June 2015-January 2016	1	United States	All arrhythmias	Conventional Ultrasound	349 340	65.4 64.2	42% 83%
Yamagata (2018)[14]	Randomised trial	March 2016-November 2016	4	Czech Republic Japan	Atrial fibrillation	Conventional Ultrasound	160 159	61.2	72%

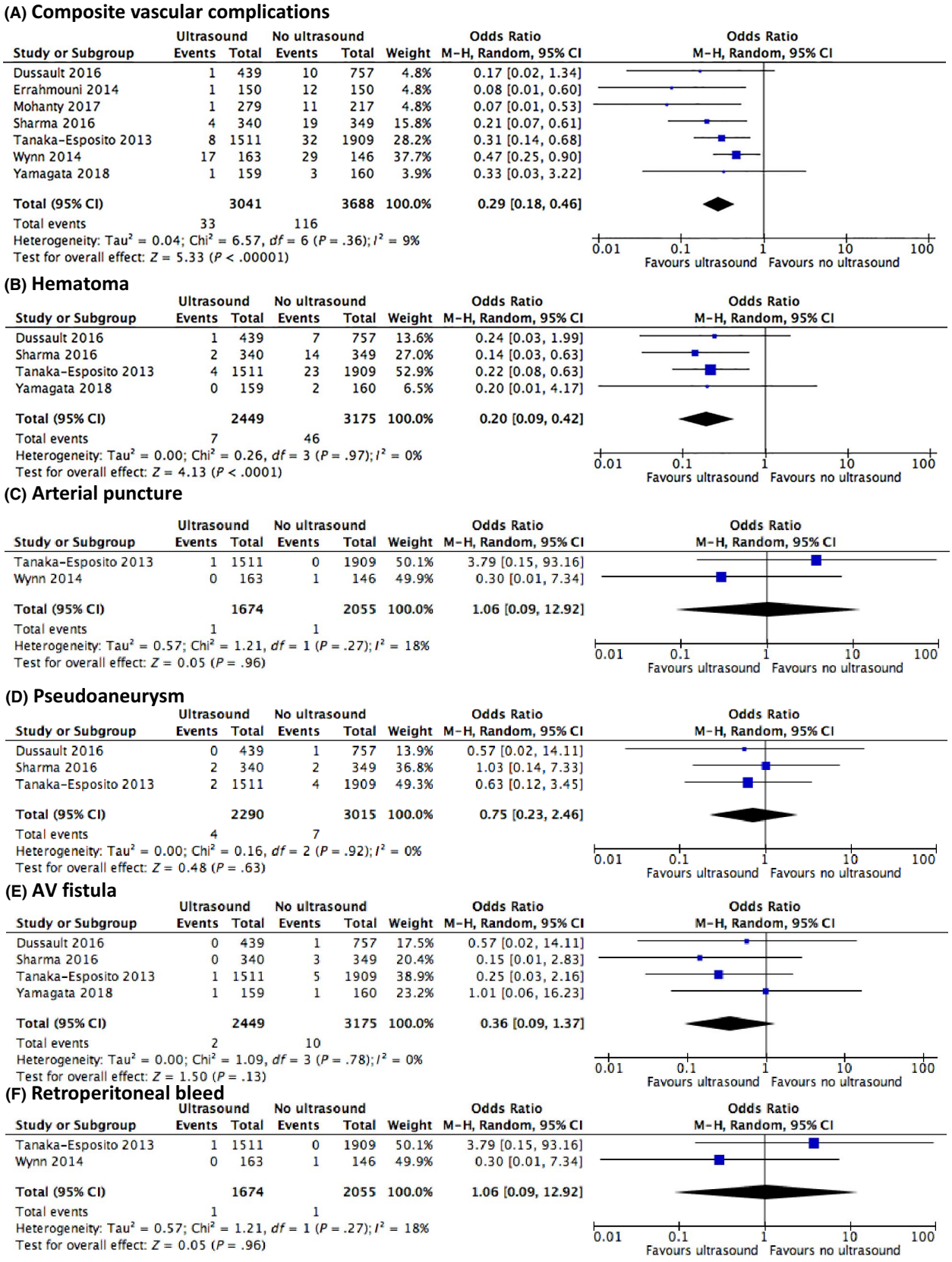

FIGURE 1 Forrest plots of pooled outcomes (A) composite vascular complications, (B) hematoma, (C) arterial puncture, (D) arteriovenous fistula, (E) pseudoaneurysm and (F) retroperitoneal bleed

lead to prolonged hospital stay. The low event rate is reassuring in the current era where an increasing number of electrophysiology procedures are undertaken with uninterrupted periprocedural anticoagulation.[1] Pseudoaneurysms and arteriovenous fistula formation were in fact numerically lower in the ultrasound group ($P > .05$), so the lack of significant differences for major vascular complications does not go against recommendations for routine ultrasound use.

Pitfalls in using ultrasound for vascular access on a routine basis need to be considered.[6,15] There is cost associated with ultrasound machines, including having one readily available, and it requires another staff member to be present to operate it. Although puncture time may initially be lengthened, this tends to shorten with experience and may ultimately be a faster strategy for obtaining vascular access in experienced hands.[8,11] Additional training would be required for some operators, however, this is a useful and important skill, and routine application helps the operator attain the competency required for cases of varying complexity. Case complexity is often realized only after failed attempts for access where vascular spasm and hematoms may have developed complicating further visualisation and compromising patient safety. We therefore recommend having ultrasound available for all electrophysiology laboratories and at the discretion of operator, with encouraged use.

This meta-analysis had some limitations. Only one study was randomised, whilst other observational studies had inherence biases that may influence outcomes. These include differences in baseline characteristics such as anticoagulation regimen, bleeding history and body mass index. Ultrasound guidance may in clinical practice be reserved for those with difficult access using the conventional approach, although this would only strengthen the differences in our findings. There were some differences in study design, patient characteristics and endpoint definitions, as well as risk of publication bias although neither was significant in our analysis. As patient-level data were not available, subgroup and multivariable analyses could not be conducted. Some outcomes were very rare and so their analysis underpowered, but does present all the available comparative data in the literature to date. None of the studies evaluated the cost-effectiveness of the use of ultrasound.

In summary, rates of vascular complications were significantly lower for ultrasound-guided access strategy. These differences were driven primarily by reductions in minor complications such as local hematoma and inadvertent arterial puncture, while major and potentially fatal complications such as retroperitoneal hematoma had very low event rates to show statistically significant difference. These data suggest that routine ultrasound-guided vascular access for invasive cardiac electrophysiology procedures is generally recommended.

CONFLICTS OF INTEREST

Authors declare no conflict of interests for this article.

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