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Short communication

Safety and cost-effectiveness of same-day complex left atrial ablation

Hejie He\textsuperscript{a,d}, Sushma Datla\textsuperscript{a}, Nicholas Weight\textsuperscript{a}, Sidra Raza\textsuperscript{a}, Thomas Lachlan\textsuperscript{a,d}, Bashar Aldhoon\textsuperscript{b}, Sandeep Panikker\textsuperscript{a}, Tarv Dhanjal\textsuperscript{a,d}, Shamil Yusuf\textsuperscript{a}, William Foster\textsuperscript{b}, Sajad Hayat\textsuperscript{a,c}, Faizel Osman\textsuperscript{a,d,*}

\textsuperscript{a}Department of Cardiology, University Hospitals Coventry and Warwickshire NHS Trust, Clifford Bridge Road, Coventry CV2 2DX, UK
\textsuperscript{b}Department of Cardiology, Worcestershire Royal Hospital, Charles Hastings Way, Worcester WR5 1DD, UK
\textsuperscript{c}Department of Adult Cardiology Heart Hospital, Hamad Medical Corporation, Doha, Qatar
\textsuperscript{d}Warwick Medical School, University of Warwick, Gibbet Hill Road, Coventry CV4 7HL, UK

\textbf{Article info}

\textbf{Abstract}

\textbf{Background:} Catheter ablation for complex left-atrial arrhythmia is increasing worldwide with many centres admitting patients overnight. Same-day procedures using conscious sedation carry significant benefits to patients/healthcare providers but data are limited. We evaluated the safety and cost-effectiveness of same-day complex left-atrial arrhythmia ablation.

\textbf{Method:} Multi-centre retrospective cohort study of all consecutive complex elective left-atrial ablation procedures performed between January 2011 and December 2019. Data were collected on planned same-day discharge versus overnight stay, baseline parameters, procedure details/success, ablation technology, post-operative complications, unplanned overnight admissions/outcomes at 4-months and mortality up to April 2020. A cost analysis of potential savings was also performed.

\textbf{Results:} A total of 967 consecutive patients underwent complex left-atrial ablation using radiofrequency (point-by-point ablation aided by 3D-mapping or PVAC catheter ablation with fluoroscopic screening) or cryoballoon-ablation (mean age: 60.9 ± 11.6 years, range 23-83 yrs., 572 (59\%) females). The majority of patients had isolation of pulmonary veins alone (n = 846, 87\%) and most using conscious-sedation alone (n = 921, 95\%). Of the total cohort, 414 (43\%) had planned same-day procedure with 35 (8\%) admitted overnight due to major (n = 5) or minor (n = 30) complications. Overall acute procedural success-rate was 96\% (n = 932). Complications in planned overnight-stay/same-day cohorts were low. At 4-month follow-up there were 62 (6.4\%) readmissions (femoral haematomas, palpitation, other reasons); there were 3 deaths at mean follow-up of 42.0 ± 27.6 months, none related to the procedure. Overnight stay costs £350; the same-day ablation policy over this period would have saved £310,450.

\textbf{Conclusions:} Same-day complex left-atrial catheter ablation using conscious sedation is safe and cost-effective with significant benefits for patients and healthcare providers. This is especially important in the current financial climate and Covid-19 pandemic.

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1. Introduction

Complex left-atrial catheter ablation is frequently performed for atrial fibrillation (AF) and atypical atrial flutter/atrial tachycardia. These procedures involve trans-septal puncture and patients are routinely kept overnight to observe for possible complications [1]. Overnight-stay has higher costs compared with same-day procedures. Studies evaluating same-day catheter ablation for AF [2,3] and catheter ablation more widely [4] have suggested same-day ablation is safe, effective [5] and has significant cost-savings for healthcare providers [6–8]. Same-day ablations may benefit patients/healthcare providers by reducing logistic constraints on hospital resources, especially in the current financial climate and Covid-19 pandemic, the latter making overnight hospital-stay challenging. We previously reported same-day standard catheter ablation was safe and cost-effective [6] but data on complex left-atrial ablation are limited. We started performing same-day complex left-atrial ablations in 2016 and wanted to evaluate the safety and efficacy of this policy. We also performed a cost-analysis of potential savings possible by adopting this same-day ablation policy.

2. Methods

This was multi-centre retrospective cohort study of all consecutive elective complex left-atrial ablations performed at University Hospital Coventry, Rugby St-Cross Hospital and Worcester Royal Hospital, UK between January 2011 and December 2019. Data were collected on
baseline demographics, procedure details, ablation technology (Pulmonary Vein Ablation Catheter [PVAC], 28 mm Arctic-Front Advance Cryoballoon with Ablieve mapping catheter [both Medtronic Inc., USA], Carto 3 with Lasso mapping catheter or PentaRay mapping catheter [Biosense Webster Inc., USA], Velocity/Precision with Optima or HD-Grid mapping catheter [Abbott Medical, USA]), ablation success, post-operative complications, outcome at 4-months and mortality. Study approval was obtained from our Research and Audit Department. All procedures were performed by an Electrophysiologist using local anaesthesia (LA) [1% lidocaine] and conscious sedation (midazolam, 0.1 mg/kg intravenously/maximum15mg) with fentanyl pain relief (25μg boluses/maximum200mcg); very few were under general anaesthesia (GA).

Our protocol for same-day complex left atrial ablation started in January 2016 for cryoballoon ablations and June 2017 for 3D-radiofrequency (RF) point-by-point ablations with contact-force sensing. We included all consecutive patients requiring left-atrial ablation (needing trans-septal puncture from outset) chronologically from these dates. Where possible those living further away from the hospital were listed earlier than those living closer to allow timely discharge. Age and geography were not specifically used to exclude patients; exceptions to same-day discharge were allowed on the day at the operator’s discretion. Those on vitamin K antagonists (mostly warfarin) had to have therapeutic INRs for at least 1 month pre-op and an INR on the day of between 2 and 3.5. Patients taking a direct oral anticoagulant (DOAC) included those on Dabigatran/Rivaroxaban/Apixaban/Edoxaban; those on once-daily DOACs took their last dose ~20 h pre-procedure, those on twice-daily DOACs took their last dose ~10 h pre-procedure. No trans-oesophageal echocardiography (TOE) was performed in any patient unless the INR was sub-therapeutic on the day or within 3 weeks pre-op. All patients had baseline blood tests and group/save samples taken in pre-op clinic as per our hospital protocol. On admission to Cardiology Day Unit (CDU) patients had their consent confirmed and a point-of-care international normalized ratio (if on warfarin) and peripheral venous access sited. Our procedure protocol details and after-care are shown in Supplement 1.

Patients were anticoagulated pre-procedure with arrhythmia mechanism and ablation strategy formulation in accordance with published guidelines [9]. Unilateral femoral-venous access was performed for PVAC/cryoballoon and bilateral for 3D-RF cases. Duration of 3D-RF application was determined by Force-Time-Integral [10], Lesion-Size-Index [11] or Ablation-Index [12]. A transthoracic echocardiogram (TTE) was performed in all immediately post-procedure with repeat 2–3 h later; protamine 50 mg was administered post-op and femoral haemostasis achieved using digital manual pressure or a ‘figure-of-8’ (Z) suture [13] using the same-day protocol.

Details of immediate (≤4 h post-procedure) and short-term (>4 h – 24 h) complications were collected in addition to need for overnight-stay and readmissions at 4-months post-ablation, as well as mortality up to April 2020. The cost of monitored overnight-stay was obtained and potential savings of adopting the same-day ablation policy during the study period calculated.

2.1. Statistical analysis

All data were analysed using Statistical Package for Social Sciences (SPSS), version 26.0 (IBM, Chicago, Illinois). Continuous variables were expressed as mean ± standard deviation (SD) and nominal data as number and percentage. We compared categorical variables using Chi-squared test and continuous variables using the independent t-test.

3. Results

A total of 967 patients underwent complex left-atrial ablation (mean age: 60.9 ± 11.6 years; 572 [59%] female). The majority were performed using LA and conscious sedation only (n = 921, 95%); the commonest...

**Fig. 1.** Evolution of Left Atrial Ablation Technology used over the study period.
Table 1

| Demographics | Total n = 967 | Same Day n = 553 | Overnight n = 414 | P-value |
|--------------|--------------|------------------|-------------------|---------|
| Age mean ± SD | 60.9 ± 11.6 | 62.8 ± 12.1 | 59.7 ± 11.0 | <0.001 |
| Age Range | 23–83 | 26–83 | 23–83 | n/a |
| Female n (%) | 572 (59) | 227 (55) | 345 (83) | 0.020 |
| Underlying Heart Disease n (%) | None Identified | 726 (75) | 297 (72) | 429 (78) | 0.020 |
| Ischaemic Heart Disease | 39 (4) | 13 (3) | 26 (5) | 0.225 |
| Hypertensive Heart Disease | 42 (4) | 34 (8) | 9 (2) | <0.001 |
| Valvular Heart Disease | 15 (2) | 10 (2) | 5 (1) | 0.059 |
| Hypertrophic Cardiomyopathy | 12 (1) | 6 (1) | 6 (1) | 0.610 |
| Dilated Cardiomyopathy | 26 (3) | 15 (4) | 11 (2) | 0.195 |
| Other Cardiomyopathy | 32 (3) | 20 (5) | 12 (2) | 0.022 |
| Other Heart Disease | 16 (2) | 9 (2) | 7 (1) | 0.271 |
| Mixed Disease | 10 (1) | 6 (1) | 4 (1) | 0.268 |
| Unspecified | 48 (5) | 4 (1) | 44 (8) | <0.001 |
| Arrhythmia pre procedure | Paroxysmal AF | 620 (64) | 267 (65) | 353 (64) | 0.794 |
| Persistent AF | 268 (28) | 114 (28) | 155 (28) | 0.884 |
| Long-standing persistent AF | 61 (6) | 26 (6) | 36 (7) | 0.773 |
| Other Atrial Arrhythmia | 105 (11) | 72 (17) | 33 (6) | 0.935 |
| No. of previous ablations n (%) | 1 | 102 (11) | 30 (7) | 73 (13) | 0.002 |
| 2 | 10 (1) | 1 (0.2) | 9 (2) | 0.035 |
| 3 | 2 (0.2) | 1 (0.2) | 1 (0.2) | 0.835 |
| Type of Ablation Procedure n (%) | AF Ablation – PVI/SOCA/WACA | 846 (88) | 388 (94) | 458 (83) | <0.001 |
| Left Atrial Tachycardia (Re-entrant, Focal, Atrial Flutter) | 15 (2) | 6 (1) | 9 (2) | 0.828 |
| Combined AF and Other Procedures | 105 (11) | 20 (5) | 85 (15) | <0.001 |
| Local anaesthesia (LA) only | 22 (2) | 14 (3) | 8 (1) | 0.046 |
| LA + Conscious Sedation (including Fentanyl/Diazepam/Midazolam) | 906 (94) | 393 (95) | 514 (93) | 0.207 |
| General Anaesthetic | 38 (4) | 7 (2) | 31 (6) | 0.011 |
| Antiocoagulation n (%) | None | 3 (0.3) | 2 (0.5) | 1 (0.2) | 0.402 |
| Bridging LMW Heparin | 256 (26) | 179 (43) | 77 (14) | <0.001 |
| Uninterrupted Vitamin K antagonist | 410 (42) | 87 (21) | 324 (59) | <0.001 |
| Uninterrupted DOAC | 297 (31) | 146 (35) | 151 (27) | 0.007 |
| Ablation Technology n (%) | PVAC | 114 | 0 | 114 | <0.001 |
| RF/3D Mapping | 489 | 88 | 401 | <0.001 |
| Cryoballoon | 347 | 313 | 35 | <0.001 |
| Cryo + 3D | 16 | 13 | 3 | 0.002 |
| Procedure Duration | Mean Procedure Time (mins) | 159.8 | 146.2 | 169.2 | <0.001 |
| Mean Ablation Energy Time (mins) | 19.8 | 12.0 | 25.7 | <0.001 |
| ± 22.6 | ± 15.2 | ± 25.4 | |
| Externar Cardioversion n (%) | None | 578 (60) | 254 (61) | 324 (59) | 0.361 |
| AF/AT External | 386 (40) | 159 (38) | 228 (41) | 0.351 |
| AF/AT Device | 2 (0.2) | 1 (0.2) | 1 (0.2) | 0.836 |
| Acute Procedure Success n (%) | Complete Success | 932 (96) | 400 (97) | 533 (96) | 0.850 |
| Partial Success | 28 (3) | 13 (3) | 15 (3) | 0.690 |
| Failed | 6 (0.6) | 1 (0.2) | 5 (0.9) | 0.195 |

**b. Immediate/short-term complications, readmissions at 4 month follow-up and mortality.**

| Demographics | Total n = 967 | Same Day n = 553 | Overnight n = 414 | P-value |
|--------------|--------------|------------------|-------------------|---------|
| Major Immediate (≤4 h) | n = 16 | n = 5 | n = 11 | 0.345 |
| Vascular Injury/Bleed requiring Surgical Intervention | 2 | 1 | 1 |  |
| Percutaneous Ablation requiring Drain | 10 | 1 | 9 |  |
| Stroke | 2 | 1 | 1 |  |
| Hypotension requiring ITU support (Severe vasovagal) | 1 | 1 | 0 |  |

The asterisk denotes significant differences between unilateral versus bilateral venous-puncture (1.7% vs 1.8%, p = 0.7 respectively). Overall complications were no different between cryoballoon versus 3D-RF (4.0% vs 5.0%, p = 0.49 respectively) or
GA versus conscious-sedation (2.6% vs 4.7%, p = 0.54 respectively) cases.

Of those discharged same-day, none developed complications within 24 h that would otherwise have been detected by overnight-stay. There were 86 (20.8%) unplanned overnight admissions, of which 34 were for immediate/short-term complications (as above), 25 admitted at operator discretion and 27 for non-procedure related reasons (late-finish, medication-dispensing delays). There were 3 deaths at mean follow-up of 42.0 ± 27.6 months, none related to ablation.

Overnight-stay, excluding any other procedures, costs ~$500 (£350). Our same-day policy over this period resulted in 327 patients (413 minus 86 unforeseen admissions) discharged same-day resulting in a $163,500 (£114,450) cost-saving. However, if the same-day policy was applied to all during the study period (excluding 79 who had post-procedure complications) $443,500 (£310,450) could have been saved.

4. Discussion

Same-day complex left-atrial catheter ablation, performed using pain relief and conscious sedation, is safe and associated with few complications with a minority requiring overnight-stay or hospital readmission. Data on same-day complex left-atrial ablations are limited [3,7,8] with many centres admitting patients overnight, which has inherent cost-implications and is associated with significant risk given the Covid-19 pandemic [14]. Performing same-day complex left atrial ablation can help mitigate risk of Covid-19 transmission and reduce cost-burden on healthcare providers worldwide.

We previously reported standard same-day ablation was safe/cost-effective [6]; applying the same principles to complex left-atrial ablation could have significant benefits. Opel et al. [8] demonstrated safe and successful same-day AF cryo-ablation. Utilising a same-day strategy for all left-atrial ablations irrespective of ablation technology could significantly reduce logistic constraints on hospitals, especially given the increasing volume of such cases being performed worldwide [9]. This is even more important with the high demand for inpatient beds by services such as Acute Medicine, resulting in elective procedure cancellations and delays. In our study 20% same-day patients had unplanned overnight-stay, with the majority not due to a complication. This was likely related to the initiation phase of the same-day protocol, with operators initially being over-cautious, and logistics constraints caused by late finishes/patients living further away. These considerations can limit implementation of the same-day policy but are not insurmountable with careful planning/experience.

Overall we noted low complications and high acute procedural success. Most immediate and short-term complications were femoral haematomas/bleeding (n = 37, 3.8%) and only 5 (0.5%) needed surgical intervention. Interestingly, lack of use of TOE did not appear to confer disadvantage as our stroke/transient ischaemic attack rate was very low although we did not screen for silent-strokes as this is less experience plays in patient safety [9].

4.1. Study limitations

We had no data on morbidity at longer-term follow-up. Additionally, it is possible some may have developed minor complications (e.g. small groin-haematomas) that may have resolved spontaneously before 4-month follow-up and for which the patient may not have sought medical advice. This could result in under reporting of minor complications. Also, certain arrhythmias (such as left-atrial tachycardia) were limited in number. Our study was non-randomised with no control group. Also, our historical overnight-stay comparison group has limitations given the advances in technology/procedural-care that have occurred during the study time-period.

5. Conclusions

Complex same-day left atrial ablation is safe, cost-effective and has significant benefits for patients and healthcare providers. This is particularly important in the current climate when hospitals are facing enormous challenges, both clinical and financial.

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Declaration of Competing Interest

None to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jjccard.2020.09.066.

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