Apixaban in patients at risk of stroke undergoing atrial fibrillation ablation

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Aims

It is recommended to perform atrial fibrillation ablation with continuous anticoagulation. Continuous apixaban has not been tested.

Methods and results

We compared continuous apixaban (5 mg b.i.d.) to vitamin K antagonists (VKA, international normalized ratio 2–3) in atrial fibrillation patients at risk of stroke as a prospective, open, multi-centre study with blinded outcome assessment. Primary outcome was a composite of death, stroke, or bleeding (Bleeding Academic Research Consortium 2–5). A high-resolution brain magnetic resonance imaging (MRI) sub-study quantified acute brain lesions. Cognitive function was assessed by Montreal Cognitive Assessment (MoCA) at baseline and at end of follow-up. Overall, 674 patients (median age 64 years, 33% female, 42% non-paroxysmal atrial fibrillation, 49 sites) were randomized; 633 received study drug and underwent ablation; 335 undertook MRI (25 sites, 323 analysable scans). The primary outcome was observed in 22/318 patients randomized to apixaban, and in 23/315 randomized to VKA (difference 0.38% [90% confidence interval (CI) -4.0%, 3.3%], non-inferiority P = 0.0002 at the pre-specified absolute margin of 0.075), including 2 (0.3%) deaths, 2 (0.3%) strokes, and 24 (3.8%) ISTH major bleeds. Acute small brain lesions were found in a similar number of patients in each arm [apixaban 44/162 (27.2%); VKA 40/161 (24.8%); P = 0.64]. Cognitive function increased at the end of follow-up (median 1 MoCA unit; P = 0.005) without differences between study groups.

Conclusions

Continuous apixaban is safe and effective in patients undergoing atrial fibrillation ablation at risk of stroke with respect to bleeding, stroke, and cognitive function. Further research is needed to reduce ablation-related acute brain lesions.

Keywords

Atrial fibrillation • Ablation • Anticoagulation • Bleeding • Stroke • Brain MRI

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Introduction

Catheter ablation is an effective\textsuperscript{1–3} and increasingly used component of rhythm control therapy to improve symptoms in patients with atrial fibrillation.\textsuperscript{4–6} Atrial fibrillation ablation is associated with a risk of stroke and major bleeding.\textsuperscript{4–6} Continuous oral anticoagulation using vitamin K antagonists (VKA) such as warfarin can reduce the risk of embolic events to <1% when combined with peri-procedural heparin.\textsuperscript{7} Therefore, continuous oral anticoagulation is recommended in patients undergoing atrial fibrillation ablation.\textsuperscript{4,6,7} One randomized trial comparing rivaroxaban to warfarin in 218 patients found similar bleeding rates with rivaroxaban compared to warfarin: 21/114 (18.4%) patients with bleeding on rivaroxaban, 18/104 (17.3%) patients with bleeding on VKA, one patient with stroke.\textsuperscript{8} Another trial randomizing 635 atrial fibrillation ablation patients to dabigatran or VKA found 59/318 (18.6%) patients with bleeding on dabigatran, 54/317 (17%) patients with bleeding on VKA, and one patient with transient ischaemic attack.\textsuperscript{9} Continuous apixaban has not been compared to VKA in atrial fibrillation ablation patients.

Atrial fibrillation ablation, unlike other ablation procedures, has been associated with declining cognitive function 90 days after the procedure, raising concerns about peri-procedural protection of the brain.\textsuperscript{10,11} Furthermore, acute brain lesions without corresponding neurological symptoms are detected in ca. 25% of patients undergoing atrial fibrillation ablation by high-resolution diffusion-weighted brain magnetic resonance imaging (MRI), a sequence that detects acute cytotoxic brain oedema.\textsuperscript{12–15} Cognitive function and acute brain lesions have not been evaluated in controlled clinical trials of patients undergoing atrial fibrillation ablation.

Objectives

Therefore, we conducted a randomized trial comparing continuous apixaban to continuous VKA therapy in patients at risk of stroke undergoing atrial fibrillation ablation, including assessment of cognitive function in all patients and MRI-detected brain lesions in a sub-study.

Trial design

Anticoagulation using the direct factor Xa inhibitor apixaban during Atrial Fibrillation catheter Ablation: comparison to VKA therapy (AXAFA – AFNET 5) was an investigator-initiated, prospective, parallel-group, randomized, open, blinded outcome assessment study.

Table 1  Inclusion and exclusion criteria of the AXAFA – AFNET 5 trial

| Inclusion                                                                 | Exclusion                                                                 |
|--------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Non-valvular atrial fibrillation (ECG-documented) with a clinical indication for catheter ablation | Any disease that limits life expectancy to <1 year                        |
| Clinical indication to undergo catheter ablation on continuous anticoagulant therapy | Participation in another clinical trial, either within the past 2 months or still ongoing |
| Presence of at least one of the CHADS\textsubscript{2} stroke risk factors\textsuperscript{a} | Previous participation in AXAFA                                             |
| Age ≥ 18 years                                                           | Pregnant women or women of childbearing potential not on adequate birth control: only women with a highly effective method of contraception (oral contraception or intra-uterine device) or sterile women can be randomized |
| Provision of signed informed consent                                      | Breastfeeding women                                                        |
|                                                                          | Drug abuse or clinically manifest alcohol abuse                           |
|                                                                          | Any stroke within 14 days before randomization                             |
|                                                                          | Concomitant treatment with drugs that are strong dual inhibitors of cytochrome P450 3A4 (CYP3A4) and P-glycoprotein (P-gp) or strong dual inducers of CYP3A4 and P-gp |
|                                                                          | Valvular AF (as defined by the focused update of the ESC guidelines on AF, i.e. severe mitral valve stenosis, mechanical heart valve). Furthermore, patients who underwent mitral valve repair are not eligible for AXAFA |
|                                                                          | Any previous ablation or surgical therapy for AF                          |
|                                                                          | Cardiac ablation therapy for any indication (catheter-based or surgical) within 3 months prior to randomization |
|                                                                          | Clinical need for ‘triple therapy’ (combination therapy of clopidogrel, acetylsalicylic acid, and oral anticoagulation) |
|                                                                          | Other contraindications for use of VKA or apixaban                        |
|                                                                          | Documented atrial thrombi <3 months prior to randomization                |
|                                                                          | Severe chronic kidney disease with an estimated glomerular filtration rate (GFR) < 15 mL/min |

\textsuperscript{a}Stroke or TIA, age ≥ 75 years, hypertension, defined as chronic treatment for hypertension, estimated need for continuous antihypertensive therapy or resting blood pressure > 145/90 mmHg, diabetes mellitus, symptomatic heart failure (NYHFA ≥ II)
comparing continuous apixaban therapy to VKA therapy. Details of the study design have been published.\textsuperscript{16} AXAFA – AFNET 5 was conducted in Europe and North America. The trial sponsor was AFNET, Münster, Germany (www.kompetenznetz-vorhofflimmern.de). AXAFA – AFNET 5 was designed by the steering committee in cooperation with AFNET and conducted in accordance with the declaration of Helsinki and the International Conference on Harmonization Good Clinical Practice Guidelines (ICH-GCP). The protocol was approved by ethics review boards at all institutions. The Clinical Research Institute (CRI, Munich, Germany) executed the study in cooperation with the steering committee and the sponsor. Data collection and entry were performed using the MARVIN\textsuperscript{16–18} eCRF system.\textsuperscript{16–18} An independent steering committee and an independent data and safety monitoring board guided the trial. All serious adverse events were adjudicated by an independent endpoint review committee blind to study group and international normalized ratio (INR) values. The Duke Clinical Research Institute served as the statistical core and performed the statistical analyses for the trial. The authors vouch for the accuracy and completeness of the data and for the fidelity of the trial to the protocol. This manuscript was written by the authors.

**Study population**

AXAFA – AFNET 5 enrolled patients scheduled for a first atrial fibrillation ablation. Patients had at least one established stroke risk factor (age \( \geq 75 \) years, heart failure, hypertension, diabetes, or prior stroke). The full inclusion and exclusion criteria have been published (see Table 1).\textsuperscript{16}

**Treatment**

At baseline, clinical parameters, stroke risk, heart rhythm, symptoms, quality-of-life (EQ5D, SF-12,\textsuperscript{1} and Karnofsky performance status\textsuperscript{18}), and cognitive function [Montreal Cognitive Assessment Test (MoCA)\textsuperscript{19}] were assessed. Patients were randomized in a ratio of 1:1 to apixaban or VKA therapy. Randomization was stratified by study site and AF type (paroxysmal vs. persistent or long-standing persistent). The randomization scheme was generated via a computer programme using permuted block of a random size.

**Apixaban**

Patients randomized to apixaban received 5 mg b.i.d. throughout the study period. The apixaban dose was reduced to 2.5 mg b.i.d. if two or more of the following characteristics were present: age \( \geq 80 \) years, body weight \(< 60 \) kg, or serum creatinine level \( \geq 1.5 \) mg/dL (133 \( \mu \)mol/L).\textsuperscript{16,20} Apixaban was continued during the ablation procedure without interruption, including on the morning of ablation. Continuous anticoagulation in this group was defined as having taken all but one apixaban dose per week based on pill count.

**Figure 1** CONSORT diagram of the AXAFA – AFNET 5 study.
**Vitamin K antagonist**

Patients randomized to VKA were treated using the locally used VKA, e.g. warfarin, phenprocoumon, or acenocoumarol,

prescribed and dispensed following local routine. Vitamin K antagonist therapy was monitored by INR measurements; a minimum of three INR measurements was mandatory prior to ablation. The last INR prior to ablation needed to be 1.8 or higher. The time in the therapeutic range was calculated by the Rosendaal method. Continuous anticoagulation in this group was defined by therapeutic INR (INR $\geq 2$) in all INR measurements 30 days prior to catheter ablation.

All patients underwent follow-up visits at the time of the ablation procedure and 3 months after ablation. At the ablation visit, continuous anticoagulation for at least 30 days prior to ablation was assessed and an ECG performed. Transoesophageal echocardiography could be used following local practice. Interrupted anticoagulation required rescheduling of the ablation for 30 days unless (i) atrial thrombi were excluded by transoesophageal echocardiogram and (ii) effective anticoagulation was demonstrated prior to starting the ablation procedure by either taking at least two doses of apixaban (patients randomized to apixaban), or by an INR value $\geq 1.8$ (patients randomized to VKA).

**Figure 2** (A) Cumulative primary outcome events since randomization until 90 days after randomization at full scale (upper panel) and magnified (lower panel) in the ablation set. (B) Cumulative primary outcome events starting from ablation until 90 days after ablation at full scale (upper panel) and magnified (lower panel). VKA, vitamin K antagonist therapy.
randomized to VKA). A heparin bolus (100 IU/kg body weight) was required prior to or directly after transseptal puncture. The ablation procedure followed local practice and current guidelines. The protocol encouraged pulmonary vein isolation, the use of irrigated tip catheters, and flushing of all left atrial sheaths. Activated clotting time (ACT) was kept >300 s throughout the procedure. Activated clotting time measurements, details of the ablation technology used, delivered energy, procedure time, rhythm at beginning and end of procedure, and the need for cardioversion during the procedure were collected. An echocardiogram (transthoracic or intracardiac) was mandated directly after ablation to detect pericardial effusion.

At the 3 month visit, cognitive function and quality-of-life were reassessed, a 24 h Holter ECG was performed, and study medication was returned. A final phone call to assess serious adverse events was performed 30 days after discontinuation of study drug.

**Magnetic resonance imaging sub-study**

Centres participating in the MRI sub-study (n = 25) offered brain MRI to all eligible study patients. A brain MRI was performed within 48 h after the ablation procedure. The MRI sequences were designed to detect all acute brain lesions, and to differentiate acute from chronic lesions. An imaging chart defined the MRI and adjudication workflow and brain MRI requirements (Supplementary material online, Table S2). The following MRI sequences were used: T2*-weighted imaging to screen for intracranial haemorrhage, diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) maps (post-processed) to
assess acute brain infarction, and fluid-attenuated inversion recovery (FLAIR) to investigate the age of brain lesions.14,15 Diffusion-weighted imaging was conducted using a slice thickness of 2.5–3 mm (high-resolution DWI) to enhance the sensitivity of MRI for small lesions.14,15 Images failing the immediate quality check were repeated whenever feasible. All images were independently analysed by two experienced neuro-radiologists blinded to treatment allocation.

Study outcomes

The primary outcome measured from randomization was the composite of all-cause death, stroke, or major bleeding among modified intention-to-treat (mITT) population, defined as all randomized patients who received study drug and underwent catheter ablation. Safety was assessed in all randomized patients receiving study drug (safety population). Sensitivity analyses were performed in all randomized patients (ITT). Another sensitivity analysis compared events during the peri-ablation period defined from ablation to 7 days after the procedure.9 Major bleeding was defined according to the Bleeding Academic Research Consortium (BARC >_2).23 All bleeding events were centrally adjudicated according to the BARC, ISTH, and TIMI classifications.23,24

Secondary outcomes included time from randomization to ablation (ITT population), nights spent in hospital after ablation, ACT during ablation (summarized as median, 25th, 75th percentiles, and number of ACT measurements within the target range), all bleeding events, tamponade, need for transfusion, and changes in quality-of-life and cognitive function compared to baseline. In the MRI sub-study, the prevalence and number of MRI-detected acute brain lesions were compared between groups.

Adverse events

All serious adverse events were collected, defined as adverse events that caused or prolonged hospitalization, caused disability or incapacity, were life-threatening, resulted in death or were important medical events. In addition, pregnancy, overdose, and cancer diagnosed after randomization were defined as serious adverse events. As AXAFA – AFNET 5 compared approved anticoagulants within their indications, non-serious adverse events were generally not reported, but those of special interest were defined and assessed. These comprised ablation-related complications including non-serious bleeding. The protocol encouraged brain imaging in patients who developed neurological abnormalities after the ablation procedure. All events from randomization to 3 months after index ablation procedure or to premature study termination were analysed.

Statistical analysis

We estimated that a total of 650 patients (325 per group) were needed to detect a pre-specified margin of 7.5% (absolute difference) with 80% power using upper one-sided 95% confidence interval (i.e. two-sided 90% CI) with 3% attrition rate. The Farrington and Manning score test was used to compute sample size and power. The primary non-inferiority hypothesis was tested in the ablation population (mITT) using the method of Farrington and Manning score test with the pre-specified absolute margin of 0.075. In addition, a time-to-event analysis using Cox proportional hazards model with a relative margin of 1.44 was conducted. A multivariable Cox proportional hazards model controlling for the baseline risk factors of age, sex, weight, type of atrial fibrillation, and the CHADS2 factors was conducted. Changes in quality-of-life and cognitive function were assessed.
## Table 2  Clinical characteristics of the AXAFA – AFNET 5 ablation population

|                                | All patients | Apixaban  | VKA       |
|--------------------------------|--------------|-----------|-----------|
|                                | n = 633      | n = 318 (n = 317) | n = 315 (n = 127 warfarin, n = 102 phenprocoumon, n = 86 acenocoumarol) |
| Age (years)                    |              |           |           |
| Median age (q1, q3)            | 64 (58.70)   | 64 (57.70) | 64 (58.70) |
| Female sex                     | 209 (33%)    | 100 (31%) | 109 (35%) |
| Weight (kg)                    |              |           |           |
| Median weight (q1, q3)         | 87.0 (77.0, 99.3) | 88.0 (77.0, 100.0) | 86.6 (76.0, 98.0) |
| Median body mass index (q1, q3) | 28.3 (25.3, 31.6) | 28.4 (25.5, 31.3) | 28.2 (25.2, 31.9) |
| Concomitant conditions, stroke risk factors, and CHA2DS2-VASc score |           |           |           |
| CHA2DS2-VASc score, mean (SD)  | 2.4 (1.2)    | 2.4 (1.2) | 2.4 (1.2) |
| CHA2DS2-VASc score, median (q1, q3) | 2 (2, 3)    | 2 (1, 3)  | 2 (2, 3)  |
| Hypertension (n)               | 571 (90.2%)  | 283 (89.0%) | 288 (91.4%) |
| Median systolic blood pressure (q1, q3) | 138.0 (125.0, 150.0) | 137.0 (125.0, 149.5) | 140.0 (125.0, 152.0) |
| Median diastolic blood pressure (q1, q3) | 82.0 (76.0, 90.0) | 82.0 (75.0, 91.0) | 82.0 (77.0, 90.0) |
| NYHA I                         | 62 (9.8%)    | 30 (9.4%) | 32 (10.2%) |
| NYHA II                        | 126 (19.9%)  | 67 (21.1%) | 59 (18.7%) |
| NYHA III                       | 24 (3.8%)    | 11 (3.5%) | 13 (4.1%) |
| NYHA IV                        | 0            | 0         | 0         |
| Diabetes mellitus              | 76 (12.0%)   | 41 (12.9%) | 35 (11.1%) |
| Prior stroke or transient ischaemic attack | 47 (7.4%)   | 24 (7.5%) | 23 (7.3%) |
| Age ≥ 75 years                 | 56 (8.8%)    | 28 (8.8%) | 28 (8.9%) |
| Age 65–74 years                | 240 (37.9%)  | 122 (38.4%) | 118 (37.5%) |
| Vascular disease, defined as coronary artery disease, peripheral artery disease, or carotid disease | 83 (13.1%) | 41 (12.9%) | 42 (13.3%) |
| Valvular heart disease         | 73 (11.5%)   | 39 (12.3%) | 34 (10.8%) |
| Mitral valve disease (moderate or more) | 20          | 15        | 5         |
| Aortic valve disease (moderate or more) | 6           | 3         | 3         |
| Confirmed coronary artery disease | 77 (12.2%)  | 39 (12.3%) | 38 (12.1%) |
| Chronic obstructive lung disease | 39 (6.2%)   | 21 (6.6%) | 18 (5.7%) |
| Clinical history of major bleeding | 13 (2.1%)  | 10 (3.1%) | 3 (1.0%)  |
| Concomitant medical therapy n (%) | 633         | 318       | 315       |
| Amiodarone                     | 102 (16.1%)  | 49 (15.4%) | 53 (16.8%) |
| Dronedarone                    | 13 (2.1%)    | 3 (0.9%)  | 10 (3.2%) |
| Flecainide                     | 125 (19.7%)  | 59 (18.6%) | 66 (21.0%) |
| Propafenone                    | 16 (2.5%)    | 8 (2.5%)  | 8 (2.5%)  |
| Sotalol > 160 mg/day           | 16 (2.5%)    | 7 (2.2%)  | 9 (2.9%)  |
| ACE inhibitor or angiotensin receptor blocker | 388 (61.3%) | 192 (60.4%) | 196 (62.2%) |
| Calcium channel antagonists    | 147 (23.2%)  | 72 (22.6%) | 75 (23.8%) |
| Diuretics                      | 221 (34.9%)  | 120 (37.7%) | 101 (32.1%) |
| Antanginal medication           | 2 (0.3%)     | 0         | 2 (0.6%)  |
| Antidiabetic medication        | 63 (10.0%)   | 32 (10.1%) | 31 (9.8%) |
| Statins                        | 231 (36.5%)  | 111 (34.9%) | 120 (38.1%) |
| Platelet inhibitors or non-steroidal anti-inflammatory agents | 30 (4.7%) | 11 (3.5%) | 19 (6.0%) |
| Beta blockers                  | 451 (71.2%)  | 230 (72.3%) | 221 (70.2%) |
| Digoxin or digitoxin           | 26 (4.1%)    | 17 (5.3%) | 9 (2.9%)  |
| Last INR before ablation (n)   | 531 (83.9)   | 217 (68.2%) | 314 (99.7%) |
| Mean (SD)                      | 1.9 (0.7)    | 1.2 (0.3)  | 2.3 (0.5) |
| Median (q1, q3)                | 2.0 (1.1, 2.4) | 1.1 (1.0, 1.2) | 2.3 (2.0, 2.6) |

Continued
Table 2  Continued

| Quality-of-life at baseline | All patients | Apixaban | VKA |
|----------------------------|--------------|----------|-----|
| SF-12 physical component, n (%) | 44.6 (37.7, 51.4), n = 597 | 43.5 (38.1, 51.3), n = 301 | 45.2 (37.6, 51.5), n = 296 |
| SF-12 mental component n (%) | 598 (94.5%) | 301 (94.7%) | 297 (94.3%) |
| Karnofsky scale | 90 (80, 90) | 80 (80, 90) | 90 (80, 90) |

| Cognitive function [Montreal Cognitive Assessment (MoCA)] at baseline | All patients | Apixaban | VKA |
|---------------------------|--------------|----------|-----|
| Median MoCA(q1, q3) | 27.0 (25.0, 29.0), n = 618 | 27.0 (25.0, 29.0), n = 313 | 27.0 (25.0, 29.0), n = 305 |
| MoCA < 26 | 188 (30.4%) | 93 (29.7%) | 95 (31.1%) |

| Modified EHRA scale at baseline | All patients | Apixaban | VKA |
|---------------------------------|--------------|----------|-----|
| mEHRA I | 40 (6.3%) | 18 (5.7%) | 22 (7.0%) |
| mEHRA IIa | 164 (25.9%) | 76 (23.9%) | 88 (27.9%) |
| mEHRA IIb | 205 (32.4%) | 107 (33.6%) | 98 (31.1%) |
| mEHRA III | 208 (32.9%) | 110 (34.6%) | 98 (31.1%) |
| mEHRA IV | 16 (2.5%) | 7 (2.2%) | 9 (2.9%) |

| Ablation information | All patients | Apixaban | VKA |
|----------------------|--------------|----------|-----|
| Atrial fibrillation pattern | | | |
| Paroxysmal atrial fibrillation | 367 (58.0%) | 189 (59.4%) | 178 (56.5%) |
| Persistent or long-standing persistent atrial fibrillation | 266 (42.0%) | 129 (40.6%) | 137 (43.5%) |

| Time from randomization to ablation (days) | All patients | Apixaban | VKA |
|-------------------------------------------|--------------|----------|-----|
| Mean (SD) | 38.0 (27.3) | 36.9 (27.6) | 39.1 (27.0) |
| Median (q1, q3) | 35.0 (20.0, 50.0) | 34.0 (18.0, 48.0) | 36.0 (21.0, 52.0) |

| Rhythm at start of ablation | All patients | Apixaban | VKA |
|-----------------------------|--------------|----------|-----|
| Number of patients | 633 | 318 | 315 |
| Sinus rhythm | 434 (68.6%) | 212 (66.6%) | 222 (70.6%) |
| Atrial fibrillation | 180 (28.4%) | 98 (30.8%) | 82 (26.0%) |
| Atrial flutter | 12 (1.9%) | 3 (0.9%) | 9 (2.8%) |
| Pacing | 7 (1.1%) | 5 (1.6%) | 2 (0.6%) |
| Other | 0 (0%) | 0 (0%) | 0 (0%) |

| Type of ablation | All patients | Apixaban | VKA |
|-----------------|--------------|----------|-----|
| Pulmonary vein isolation, n (%) | 571 (90.2%) | 288 (90.6%) | 283 (89.8%) |
| Pulmonary vein isolation plus other ablation, n (%) | 59 (9.3%) | 29 (9.1%) | 30 (9.5%) |
| Other ablation without pulmonary vein isolation | 3 (0.5%) | 1 (0.3%) | 2 (0.6%) |
| Transoesophageal echocardiography prior to ablation | 549 (86.7%) | 269 (84.6%) | 280 (88.9%) |
| Total duration of ablation procedure (min), Median (q1, q3) | 135 (110, 175) | 136 (110, 175) | 135 (105, 172) |

| Ablation energy source | All patients | Apixaban | VKA |
|------------------------|--------------|----------|-----|
| Radiofrequency | 402 (63.5%) | 207 (65.1%) | 195 (61.9%) |
| Cryoablation | 186 (29.3%) | 92 (28.9%) | 94 (29.8%) |
| Other | 45 (7.1%) | 19 (6.0%) | 26 (8.3%) |

| Abnormal blood parameters | All patients | Apixaban | VKA |
|---------------------------|--------------|----------|-----|
| Red blood cell count Abnormal | 65/618 (10.5%) | 32/311 (10.3%) | 33/307 (10.7%) |
| Platelet count abnormal | 35/625 (5.6%) | 20/315 (6.3%) | 15/310 (4.8%) |
| ALT abnormal | 75/612 (12.3%) | 39/307 (12.7%) | 36/305 (11.8%) |
| Bilirubin abnormal | 38/596 (6.4%) | 14/297 (4.7%) | 24/299 (8.0%) |

Number of patients with valid information (n (%)) is only given when values were missing. BD, twice daily dosing; SD, standard deviation; q1, q3 are 25th and 75th percentiles, respectively; VKA, vitamin K antagonist.
Results

Trial participants
AXAFA – AFNET 5 randomized 674 patients across 49 sites in 9 countries from February 2015 to April 2017. Overall, 633 patients took study drug and underwent atrial fibrillation ablation (mITT, ablation set, Figure 1). Demographic and clinical characteristics were well balanced between groups (Table 1). Transoesophageal echocardiography was used in 549/633 (86.7%) patients. All or all but one apixaban doses per week were taken by 307/318 (97%) patients randomized to apixaban in the ablation set. The median time in therapeutic range in the 315 patients randomized to VKA in the ablation set was 84% (71, 97%). Time from randomization to ablation was not different between study groups (Table 1).

Primary outcome
Primary outcome events (BARC 2–5 bleeding, stroke, or death) were observed in 22/318 (6.9%) patients randomized to apixaban, and in 23/315 (7.3%) patients randomized to VKA therapy in the ablation set. Four events were classified as TIMI major bleeding, and 24 events are ISTH major bleeding (Table 3). Two patients died: one patient randomized to VKA, female, age 70, hypertensive, last blood pressure 156/76, last INR 2.6, underwent pacemaker implantation 8 days after ablation and experienced a massive intracerebral haemorrhage. Another patient randomized to apixaban, male, age 69, with paroxysmal atrial fibrillation, hypertension, heart failure, diabetes, and chronic obstructive lung disease, was found dead in his bed 19 days after ablation without identifiable cause of death upon autopsy. Two patients randomized to apixaban had a stroke. Both had persistent AF and underwent transoesophageal echocardiogram. One patient, male, age 63, hypertensive, ACT 236–398 s, developed slurred speech with matching MRI lesion on the day of radiofrequency pulmonary vein isolation that fully resolved. Another patient, male, age 52, ACT 301–400 s, hypertensive, developed weakness of the right arm with paraesthesia of the right leg after cryoballoon pulmonary

Table 3 Primary outcomes in the AXAFA – AFNET 5 trial (ablation set), including details of the type of bleeding

| Outcome                                      | All patients       | Apixaban          | VKA               |
|----------------------------------------------|--------------------|-------------------|-------------------|
| Patients with primary endpoint: composite of all-cause death, stroke or major bleeding | 45/633 (7.1%)      | 22/318 (6.9%)     | 23/315 (7.3%)     |
| Death                                        | 2 (0.3%)           | 1 (0.3%)          | 1 (0.3%)          |
| Stroke or TIA                                | 2 (0.3%)           | 2 (0.6%)          | 0                 |
| Major bleeding (BARC 2–5)                    | 45 (7.1%)          | 20 (6.2%)         | 25 (7.9%)         |
| Bleeding requiring medical attention (BARC 2) | 24 (3.8%)          | 12 (3.7%)         | 12 (3.8%)         |
| Bleeding with haemoglobin drop of 30 to <50 g/L or requiring transfusion (BARC 3a) | 9 (1.4%)           | 5 (1.6%)          | 4 (1.3%)          |
| Intracranial haemorrhage (BARC 3b)           | 11 (1.7%)          | 3 (0.9%)          | 8 (2.5%)          |
| TIMI major bleeding (intracranial bleed, or bleeding resulting in a haemoglobin drop of ≥50 g/L, or bleeding resulting in death within 7 days) | 1 (0.2%)           | 0                 | 1 (0.3%, fatal)   |
| ISTH major bleeding                          | 4 (0.6%)           | 1 (0.3%)          | 3 (1%)            |
| Bleeding event by clinical type              |                    |                   |                   |
| Tamponade                                    | 7 (1.1%)           | 2 (0.6%)          | 5 (1.6%)          |
| Access site bleed                            | 27 (4.3%)          | 12 (3.8%)         | 15 (4.8%)         |
| Bleeding requiring transfusion of red blood cells | 3 (0.5%)           | 2 (0.6%)          | 1 (0.3%)          |
| Other major bleed                            | 7 (1.1%)           | 5 (1.6%)          | 2 (0.6%)          |

Shown are number of patients per group. Some patients had more than one event. BARC4 events were not observed in the study.

b.i.d., twice daily dosing.
Table 4  Secondary outcomes in the AXAFA – AFNET 5 trial (ablation set)

|                                | All patients | Apixaban 318 (n = 317) | VKA n = 315 (n = 127) |
|--------------------------------|--------------|------------------------|----------------------|
|                                | n = 633      | 5 mg BD, n = 1 2.5 mg BD | phenprocoumon, n = 86 |
| Time from randomization to ablation in days, median (q1, q3) | 35.0 (20.0, 50.0) | 34.0 (18.0, 48.0) | 36.0 (21.0, 52.0) |
| Nights spent in hospital after index ablation, median (q1, q3) | 3 (2, 5) | 2 (1, 5) | 3 (2, 7) |
| ACT during ablation in seconds, median (q1, q3) | 325.0 (285.0, 370.0) | 310.0 (273.0, 350.0) | 348.5 (304.0, 396.0) |
| Number of subjects with all ACT values in range (n (%)) | 234/631 (37.1%) | 73/316 (23.1%) | 161/315 (51.1%) |
| Number of subjects with at least one ACT value < 250 (n (%)) | 214/631 (33.9%) | 130/316 (41.1%) | 84/315 (26.7%) |
| Number of subjects with at least one ACT value < 300 (n (%)) | 397/631 (62.9%) | 243/316 (76.9%) | 154/315 (48.9%) |
| Number of bleeding events (n) | 118 | 54 | 64 |
| Patients without recurrence of atrial fibrillation (n (%)) | 434/619 (70.1%) | 217/311 (69.8%) | 217/308 (70.5%) |
| Quality-of-life | | | |
| SF-12 physical component score at end of study, median (q1, q3), n | 48.6 (42.0, 54.2), n = 564 | 48.4 (41.9, 54.2), n = 289 | 48.8 (42.2, 54.4), n = 275 |
| Change in SF-12 physical component score at end of study compared to baseline, median (q1, q3), n | 2.5 (-2.1, 8.1), n = 547, P < 0.001* | 2.4 (-2.2, 7.9), n = 280 | 2.8 (-2.0, 8.3), n = 267 |
| SF-12 mental component score at end of study, median (q1, q3), n | 54.4 (46.0, 58.6), n = 565 | 54.2 (45.8, 58.3), n = 290 | 54.5 (46.6, 59.7), n = 267 |
| Change in SF-12 mental component score at end of study compared to baseline, median (q1, q3), n | 1.2 (-3.2, 8.0), n = 548, P < 0.001* | 0.4 (-3.6, 8.0), n = 281 | 1.6 (-2.8, 8.3), n = 267 |
| Karnofsky score at end of study, median (q1, q3), n | 100 (90, 100), n = 619 | 100 (90, 100), n = 311 | 100 (90, 100), n = 308 |
| Change in Karnofsky score at end of study compared to baseline (Δ Karnofsky), median (q1, q3), n | 10 (0, 10), n = 619 | 10 (0, 10), n = 311 | 10 (0, 10), n = 308 |
| Cognitive function [Montreal Cognitive Assessment (MoCA)] | | | |
| Cognitive function at end of study (MoCA), median (q1, q3), n | 28.0 (26.0, 29.0), n = 607 | 28.0 (26.0, 29.0), n = 305 | 28.0 (26.0, 29.0), n = 302 |
| Abnormal MoCA at baseline (<26), n (%)) | 141 (23.2%) | 75 (24.6%) | 66 (21.9%) |
| Change in MoCA at end of study compared to baseline, median (q1, q3), n | 1.0 (-1.0, 2.0), n = 597, P < 0.001* | 0.0 (-1.0, 2.0), n = 301 | 1.0 (-1.0, 2.0), n = 296 |
| Change in patients with abnormal MoCA at end of study compared to baseline, n (%) | 141/607 (23.2%), -7.2%, P = 0.005* | 75/305 (24.6%) -5.1% | 66/302 (21.9%) -9.2% |

Number of patients with valid information (n (%)) is only given when values were missing. P-values marked by asterisks (*) indicate differences between baseline and end of follow-up measurements. Twice daily (b.i.d) dosing: q1 and q3 indicate 25th and 75th percentiles, respectively.

vein isolation that persisted beyond hospital discharge. Tamponade occurred in 2 (apixaban) and 5 (VKA) patients and was managed by pericardial drainage and administration of protamine and vitamin K. One patient with tamponade in each study group received blood transfusions. Anticoagulants were continued in five patients with tamponade, and paused for 4 days in one patient randomized to apixaban, and for 8 days in one patient randomized to VKA. All patients were discharged from hospital and attended the 3 months follow-up (n = 64) or an end of study visit (n = 1).

Apixaban was non-inferior to VKA based on the non-inferiority margin of 7.5% (a difference of -0.38%, 90% CI -4.0%, -3.3%, non-inferiority P = 0.0002). Apixaban was also non-inferior to VKA among all randomized patients as assessed by Cox proportional hazards model comparison between treatment groups using a relative non-inferiority margin of 1.44 (equivalent to 7.5% absolute; hazard ratio = 0.88, 90% CI 0.55, 1.41; P = 0.042, Figure 2). There was no statistical interaction between clinical stroke and bleeding risk factors and treatment groups (Figure 3).

Secondary outcome parameters

There was no difference in time to ablation or nights spent in hospital after the ablation between groups (Table 4). As expected, the last INR prior to ablation and ACTs achieved during ablation were lower...
in the patients randomized to apixaban (Table 4). Quality-of-life as assessed by the physical component of SF-12 $[+2.5 (-2.1, 8.1)$ units] and Karnofsky scale $[+10 (0, 10)]$ improved during the study without differences between study groups (Table 4). At least mild cognitive dysfunction was found in 188/619 (30.4%) of the patients at baseline (pre-defined as MoCA < 26, Table 2). At the end of follow-up, MoCA increased by a median of $+1.0 (-1.0, 2.0)$ unit without differences between study groups, and only 141/607 patients (7.2% fewer than at baseline) had mild cognitive impairment (Table 4).

**Magnetic resonance imaging sub-study**

Acute brain MRI was performed in 335 patients across 25 centres. Clinical characteristics of the sub-study population were not different from the main study population, with the exception of a lower median weight in patients undergoing MRI [85.0 kg (74.5, 96.0)] compared to non-MRI patients [90.0 kg (80.0, 103.0)]. Clinical characteristics were well balanced between MRI sub-study treatment groups. There were 323 analysable MRIs. Acute brain MRI lesions (Figure 4) were found in 44/162 (27.2%) patients randomized to apixaban, and in 40/161 (24.8%) patients randomized to VKA (P = 0.635), with very similar distribution of lesions between random groups (Table 5). Cognitive function at the end of follow-up was not different in patients with or without acute brain lesions (MoCA 27.1 ± 2.7 in 239 patients without MRI lesions, 27.1 ± 2.8 in 84 patients with MRI lesions, P = 0.91).

**Discussion**

AXAFA – AFNET 5 demonstrated that continuous anticoagulation with apixaban is a safe and effective alternative to VKA in patients at risk of stroke undergoing atrial fibrillation ablation. AXAFA – AFNET 5 observed four TIMI major bleeding events in 633 patients (0.6%, Table 3) compared to one event in 248 patients in VENTURE-AF (0.4%). AXAFA – AFNET 5 observed 24 patients with ISTH major bleeding events (3.8%, Table 3) compared to 27 events in 635 patients in RE-CIRCUIT (4.3%). The numerical differences in ISTH major bleeding rates between AXAFA – AFNET 5 [apixaban 10 patients (3.1%); VKA 14 patients (4.4%); Table 3] and RE-CIRCUIT [dabigatran 5 patients (1.6%); VKA 22 patients (6.9%)] could be due to chance variations in outcomes, differences in risk profile between the AXAFA – AFNET 5 and RE-CIRCUIT study populations, and due to the high time in therapeutic range in the VKA group in AXAFA – AFNET 5 (median TTR 84%). AXAFA – AFNET 5 included only patients with stroke risk factors, resulting in a mean CHA2DS2-VASc score of 2.4 and a population that was 4–5 years older than in the published controlled trials in atrial fibrillation ablation.1–3,8,9 Despite the higher stroke risk, we observed few strokes: AXAFA – AFNET 5 found 2 strokes in 633 patients (0.3%), compared to 1 stroke in 248 patients in VENTURE-AF (0.4%),6 and 1 TIA in 635 patients in RE-CIRCUIT (0.2%).9 Equally, mortality was low (0.3%) and similar to VENTURE-AF (0.4%),9 RE-CIRCUIT (0%),9 and the EORP AF ablation registry (0.2%).25
AXAFA – AFNET 5 included 86 patients on acenocoumarol and 102 patients on phenprocoumon, 186 patients (29%) undergoing cryoablation,3 and 84 patients undergoing atrial fibrillation ablation without transoesophageal echocardiography without safety signals, providing some reassurance that these common patterns of clinical practice can be used on continuous apixaban or VKA therapy.4–6,26

The secondary outcomes observed in AXAFA – AFNET 5 underpin the safety of continuous apixaban in atrial fibrillation ablation: time to ablation was not different between groups and quality-of-life and cognitive function improved equally in both study groups after ablation. High-resolution diffusion-weighted brain MRI detected acute brain lesions at the expected rate (4%25%)12,14,15 without differences between study groups. Continuous anticoagulation does not fully prevent acute brain lesions, which can be caused by debris dislodging from ablation wounds, air emboli, or small thrombi.27,28 Procedural improvements are desirable to reduce acute brain lesions during atrial fibrillation ablation.29 Further analyses of the AXAFA – AFNET 5 data set may shed more light on risk factors for acute brain lesions in patients undergoing AF ablation on continuous anticoagulation. One prior study found reduced cognitive function 90 days after atrial fibrillation ablation on interrupted warfarin therapy compared to baseline.10 Reassuringly, cognitive function improved at the end of AXAFA – AFNET 5 without differences between study groups.

**Limitations**

AXAFA – AFNET 5 was an open study, but with blinded outcome assessment. The non-inferiority margin was wide. The findings are consistent with prior studies with continuous dabigatran and rivaroxaban. While AXAFA – AFNET 5 was the first study comparing cognitive function after atrial fibrillation ablation in a controlled trial, the assessment was limited to global cognitive function. Differentiation between acute and chronic lesions was done by using an accepted combination of MRI sequences.14,15

**Conclusions**

Continuous apixaban therapy is a safe and effective alternative to VKA in patients at risk of stroke undergoing atrial fibrillation ablation with respect to stroke, major bleeding, cognitive function, and MRI-detected acute brain lesions.

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