Catheter ablation has become a standard therapy in the treatment of atrial fibrillation (AF). Although many different ablation strategies have been proposed and are currently applied, all ablation procedures share 1 commonality in their necessity for the use of fluoroscopy to visualize catheters. Heavy reliance on the use of live x-ray for ablation procedures was alleviated in the 1990s with the advent of 3-dimensional (3D) electroanatomical mapping systems that helped to significantly reduce radiation time and dose. Integration of cardiac imaging using MRI and computed tomography was shown to further reduce fluoroscopy exposure during ablation procedure.1 More recently, a new technology for catheter visualization called the MediGuide technology (St Jude Medical Inc, St Paul, MN) has been introduced that can further facilitate reduction in radiation exposure.2,3 Details have been previously described.4,5 Briefly, single-coil sensors embedded in the catheter tip can be accurately localized by an electromagnetic field. Information about the 3D position and orientation of the tools is then transferred to the fluoroscopy system and is used to visualize the catheter tip in a virtual biplanar view projected on 2 prerecorded cineloops. It has been previously shown that the application of the MediGuide technology can lead to a significant reduction in fluoroscopy burden by using diagnostic catheters in atrial flutter4 and by using both diagnostic and ablation catheters in several supraventricular tachycardias3 and AF.7 There may be concerns that the application of the nonfluoroscopic catheter visualization (NFCV) technology may increase procedural risks in the absence of the catheter shaft visualization and catheter localization that is solely based on the location of the catheter tip. We evaluated any possible role of this new technology on procedure-related complications using a registry of all AF ablations performed at our institution using NFCV.

Methods

Patients
Between May 2012 and February 2014, all patients undergoing AF ablation supported by NFCV technology were included in a prospective registry. In addition to baseline characteristics of patients (age, gender, body mass index, left atrial and left ventricular dimensions), and comorbidities, data and complications within the first 3 months were recorded. Between May 2012 and February 2014, a total of 375 patients underwent atrial fibrillation ablation using nonfluoroscopic catheter visualization technology. The patients were predominantly men (68%); the majority were ablated for the first time (71%); left atrium was 43±6 mm; and left ventricular function was normal (59±9%). The median ablation procedure time was 135 (113–170) minutes, median fluoroscopy time 2.8 (1.5–4.4) minutes, and median radiation dose 789 (470–1466) cGy*cm². Regression analysis demonstrated a significant decrease of fluoroscopy time, dose, and procedure time. To confirm the result and show overall changes, the initial 50 cases (group 1) to the last 50 cases (group 2) of the series were compared: fluoroscopy time decreased from 6.0 (4.1–10.3) minutes in group 1 to 1.1 (0.7–1.5) minutes in group 2 and radiation dose from 2363 (1413–3475) to 490 (230–654) cGy*cm², respectively. Ten patients (2.7%) experienced complications: 5 cardiac tamponades (1.4%), 4 pseudoaneurysms (1.1%), and 1 stroke (0.3%).

Conclusions—Atrial fibrillation ablation using the nonfluoroscopic catheter visualization technology is safe with a rate of complications of 2.7%. Procedure time (135 minutes) is not prolonged. A dramatic reduction in fluoroscopy time and dose was achieved.

Key Words: atrial fibrillation ■ fluoroscopy
sex, comorbidities, and AF history), procedural data such as procedure time, fluoroscopy time, fluoroscopy dose, ablation time, ablation concept, and periprocedural anticoagulation regimen were analyzed. All complications during the usual 48-hour in-hospital follow-up were recorded and analyzed. Long-term complications with late presentations were also followed at a 3-month clinical visit.

Technology Description

The NFCV system consists of 3 components: (1) a transmitter generating a 3D electromagnetic field; (2) a small single-coil sensor (<1 mm³) assembled within an intracardiac device such as a conventional decapolar electrophysiology catheter (MediGuide-enabled Livewire; St Jude Medical Inc) or an ablation catheter (Safire DUO, MediGuide-enabled, and CoolPath DUO, MediGuide-enabled; St Jude Medical Inc); and (3) a magnetic field reference sensor attached to the patient’s chest.2,3 The transmitter is integrated in the fluoroscopy detector of a conventional x-ray imaging system (Siemens Artis, Erlangen, Germany), aligning the fluoroscopy space with the 3D magnetic field. The sensor-equipped electrophysiology catheters can be either visualized on fluoroscopy or tracked nonfluoroscopically by the electromagnetic field. The first step in a typical NFCV ablation procedure is to record 2 short fluoroscopy loops (3 seconds each), which are then used to nonfluoroscopically visualize the position and orientation of the catheter tips within the conventional x-ray environment. It is important to note that the projection on the fluoroscopy loops does not require any active registration steps. Two compensation algorithms are in place to account for primary and secondary organ movements. In particular, the system uses ECG leads to compensate for changes in the heart rate, and the reference sensor allows compensation for the respiratory and patient movements. Therefore, patient movement or secondary organ motion because of changes in respiratory pattern or arrhythmias do not influence the stability of catheter tip visualization.

Ablation Procedure

All procedures were performed by 6 different operators experienced with >300 conventional AF procedures. All cases started with a recording of cine-loops in right anterior oblique (15°–20°) and left anterior oblique (45°–55°). Because all patients were ablated in deep analgesiation, we used femoral arterial access to monitor the blood pressure invasively. Three venous access lines were created for 2 MediGuide-enabled diagnostic catheters placed in the coronary sinus and the right ventricular apex and a long steerable sheath (Agilis; St Jude Medical Inc).1 In most cases, 1 transseptal access was used to achieve isolation of the ventricular apex and a long steerable sheath (Agilis; St Jude Medical Inc). Catheter navigation in the left atrium was exclusively performed by manipulation of the steerable sheath. The registry includes the first patient to be ablated on commercial availability of MediGuide-enabled ablation catheters (Safire DUO or CoolPath DUO) in May 2012. The workflow in the first 75 patients involved acquiring left atrial angiographies using an injection of 60 mL of contrast dye into the pulmonary artery. Subsequently, we changed this approach to a direct injection of contrast dye via the long transseptal sheath into both superior pulmonary veins to obtain more direct anatomic information (Figure 1). An electroanatomical mapping system (EnSite Velocity, version 4.0.1; St Jude Medical Inc) in combination with a 3D reconstructed 256-slice computed tomography was used in all patients to facilitate the procedure.11 A temperature probe was inserted (Sensitherm; St Jude Medical Inc) to ensure intrasophageal temperatures <39°C. In case 41°C was exceeded, a fluoroscopy was performed to rule out severe mucosal damage.12

Pulmonary vein isolation (PVI) was used as the first cornerstone of the ablation strategy. Patients presenting with AF at the time of the procedure were cardioverted electrically to verify complete antral isolation by pacing maneuvers.26 After achieving PVI, a voltage map of the left atrium was created to determine the subsequent ablation strategy. No further ablations were performed regardless of left atrial diameter or the clinical presentation if normal endocardial voltage of >0.5 mV was observed throughout the atrium and no stable left-sided atrial tachycardias were inducible. If low-voltage areas were identified, a substrate modification strategy was used using pace- and ablative techniques. Ablation of cavotricuspidal isthmus was only done if typical atrial flutter was induced by the pacing protocol or typical atrial flutter was documented on Holter ECG.

The anticoagulation regimen included vitamin K antagonists (VKAs) aiming at an international normalized ratio (INR) of 2 to 3 on the day of the procedure and direct oral anticoagulants (DOACs) that were paused for 24 hours before the procedure and reinitiated 6 hours after ablation. The DOAC and nontherapeutic VKA patients received 5000 U of heparin before the transseptal puncture, with the overall dose in all patients after the transseptal puncture being 100 U/kg. The target for activated clotting time was 250 to 350 seconds. After the procedure, heparin was antagonized in all patients with a maximum of 10000 U of protamine.

Statistics

For the primary outcome, data from the entire cohort were used in a linear regression analysis with 95% confidence interval shown. In this regression analysis, the number of procedures is an ordinal variable, which was treated as continuous. Furthermore, a confirmatory comparison was made between 2 subgroups of patients: group 1 (novice phase; patients 1–50) and group 2 (experienced phase; patients 325–375). Most continuous variables are presented as means±SD and highly skewed variables as median with the first and third quartiles (25%–75%). Categorical variables are expressed as number and percentage of patients. The differences between continuous values were assessed using an unpaired 2-tailed Student t test for normally distributed continuous variables, a Mann–Whitney test for skewed variables, and a χ² test for nominal variables. P values >0.05 were considered nonsignificant. All analyses were performed using SPSS for Windows, release 18.0 (SPSS Inc, Chicago, IL).

Figure 1. Ablation of atrial fibrillation using MediGuide. Left: right anterior oblique (RAO) view (21°). Middle: left anterior oblique (LAO) view (44°). Markers were added for RSPV (green), RIPV (red); LSPV (blue) and LIPV (brown) using pulmonary vein angiographies for LSPV (LAO) and RIPV (RAO). The coronary sinus catheter is visualized both by conventional fluoroscopy and MediGuide (yellow tip). Additional markers show SVC (pink ring) and IVC ostium (blue ring). The ablation catheter tip is MediGuide-visualized at the anterior ridge of LSPV. Right: Visualization of the ablation catheter in the 3-dimensional mapping system. Intrasophageal temperature probe is used (green). IVC indicates inferior vena cava; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; RIPV, right inferior pulmonary vein; RSPV, right superior pulmonary vein; and SVC, superior vena cava.
Table 1. Patient Baseline Characteristics for the Patients Treated With the Nonfluoroscopic Catheter Tracking System

<table>
<thead>
<tr>
<th></th>
<th>All 375</th>
<th>First 50</th>
<th>Last 50</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>60±10</td>
<td>60±11</td>
<td>60±8</td>
<td>NS</td>
</tr>
<tr>
<td>Male sex</td>
<td>255 (68%)</td>
<td>35 (68%)</td>
<td>34 (68%)</td>
<td>NS</td>
</tr>
<tr>
<td>Paroxysmal atrial fibrillation</td>
<td>169 (45%)</td>
<td>24 (48%)</td>
<td>21 (42%)</td>
<td>NS</td>
</tr>
<tr>
<td>Arterial hypertension</td>
<td>250 (68%)</td>
<td>32 (65%)</td>
<td>38 (76%)</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>33 (9%)</td>
<td>5 (10%)</td>
<td>4 (8%)</td>
<td>NS</td>
</tr>
<tr>
<td>Structural heart disease</td>
<td>78 (21%)</td>
<td>8 (16%)</td>
<td>13 (26%)</td>
<td>NS</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>59±9</td>
<td>60±7</td>
<td>55±10</td>
<td>NS</td>
</tr>
<tr>
<td>Left atrial diameter, mm</td>
<td>42±6</td>
<td>42±6</td>
<td>42±7</td>
<td>NS</td>
</tr>
<tr>
<td>Anticoagulation with DOAC</td>
<td>221 (59%)</td>
<td>27 (55%)</td>
<td>39 (77%)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Data are given for the overall population, group 1 (first 50 patients) and group 2 (last 50 patients). P>0.05 is considered nonsignificant (NS). DOAC indicates direct oral anticoagulant; and LVEF, left ventricular ejection fraction.

Results

From May 2012 to February 2014, 375 AF ablation procedures were performed using NFCV technology. Complete follow-up data were available for 320 of 365 patients (88%).

The included patients were predominantly men (68%) and 60±10 years of age (Table 1). They presented with comorbidities such as arterial hypertension (68%) and diabetes mellitus (9%). The left ventricular function was decreased (<50%) in 45 patients (12%) and the left atrial diameter was significantly enlarged (>45 mm) in 117 patients (31%). The dominant clinical manifestation of the arrhythmia was paroxysmal in 169 (45%) and persistent in 149 (40%), and long-standing persistent in 73 (19%) patients. In 266 (71%) cases, the procedure was the patient’s first ablation. Of the remaining 109 (29%) patients, 67 (21%) had their previous ablation(s) at other hospitals, whereas 42 (39%) had been previously ablated at our institution. Oral anticoagulation was maintained using VKA in 154 (41%) such that the mean INR on the day of the intervention was 2.2±0.34. In 221 (59%) patients, DOACs were used. Of 221 (64%) of the DOAC patients, 142 received dabigatran (usually 2×150 mg per day), 75 (34%) received rivaroxaban (usually 1×20 mg per day), and 4 (2%) apixaban (2×5 mg per day). During the observational period, a significant change was identified: in group 1 (the first 50 patients), only 27 of 50 (55%) were anticoagulated with direct anticoagulants, whereas in group 2 (last 50 patients), 39 of 50 (77%) patients were on DOAC therapy.

Despite the fact that the majority of patients presented with persistent or long-standing persistent AF (55%), additional modification of left atrial substrate was performed only in 87 (24%) patients. In 54 of 375 (15%) cases, ablation of the cavitricuspidal isthmus was added to the ablation concept because typical atrial flutter occurred or was inducible during the procedure. Complete PVI was achieved in 371 (99%) patients. Uncontrollable rise of the intraesophageal temperature despite energy reduction to <20 W precluded complete PVI in the other 4 cases. The mean procedure time was 145±45 minutes with an ablation time of 42±19 minutes (Table 2). The median fluoroscopy time of 2.8 (1.5–4.4) minutes and fluoroscopy dose of 789 (470–1466) cGy*cm² were observed in the entire population. A significant learning curve was observed in regression analysis: the regression coefficient for fluoroscopy time was –0.015 (–0.017 to –0.011), for fluoroscopy dose –5.36 (–6.3 to –4.4), and for procedure time –0.13 (–0.16 to –0.08). This was confirmed when comparing the first and last 50 patients. In particular, group 1 exhibited a fluoroscopy time of 6.0 (4.1–10.3) minutes, which was significantly reduced to 1.1 (0.7–1.5) minutes (P<0.001) in group 2 (Figure 2A). A significant decline was also observed in fluoroscopy dose (group 1: 2363 [1413–3475] cGy*cm²; group 2: 490 [230–654] cGy*cm²; P<0.001; Figure 2B). Lastly, procedure time was also significantly reduced from 169±49 minutes in group 1 to 128±39 minutes in group 2 (P<0.001) (Figure 2C). Efficacy was not the primary subject to our analysis; therefore, no routine Holter monitoring was performed in those patients. The rate of Re-Do procedures within a follow-up of 14±7 months as an indirect marker for efficacy was 20 of 375 (5.3%) patients, which is comparable to our conventional procedures.

Seven-day Holter monitoring at 6 months was available for 80 of 375 (21%) patients only: recurrences of AF or atrial tachycardia >30 seconds were found in 19 of 80 (24%); 61 of 80 (76%) were in stable sinus rhythm; in only 2 of 80 (2.5%), antiarrhythmic drug treatment was delivered at 6 months after ablation.

Complications

In 375 patients ablated for AF using the MediGuide technology, a total of 10 complications (2.7%) were observed. In 9 (90%) cases, the complication was diagnosed within the first 48 hours after the procedure. The remaining complications of femoral pseudoaneurysm were detected during clinical visits after 3 months and were addressed with a conservative treatment at another hospital (manual compression with no residual flow). The most frequent complication was a pericardial effusion leading to tamponades that required pericardiocentesis in 5 patients (1.4%). The tamponades occurred in the case of 3 different operators, 3 patients on DOAC (170, 500, 700), and 2...
patients with INRs of 2.3 and 2.35 on VKA (220, 300 mL). We observed a total of 4 pseudoaneurysms of the femoral artery in 2 patients on VKA (INRs of 2.8 and 0.9) in which case the patients received enoxaparin, and 2 patients on novel oral anticoagulant treatment. Three of these cases were successfully treated with manual Doppler-guided compression, whereas 1 patient required a surgical intervention (VKA, INR 2.83). Lastly, 1 stroke occurred 30 hours after the procedure (novel oral anticoagulants) with a left-sided hemiparesis, which was resolved with conservative treatment after 48 hours without sequelae (Table 3). We did not observe any phrenic nerve pulsy, pulmonary vein stenosis, or atrioesophageal fistula in these 375 patients.

**Discussion**

Several studies have recently shown that the application of NFCV technology is associated with a significant reduction in fluoroscopy time and dose. This was also shown for AF ablations in a cohort 80 patients. The reported studies, however, included only a limited number of patients (10–80), leading to concerns regarding the safety profile of this technology having not been addressed. In this registry, 375 consecutive ablation procedures using the NFCV technology were analyzed. We were able to show that in a nonselected cohort of patients with only 45% paroxysmal AF and 29% repeat ablations, the effects of the new technology on fluoroscopy reduction could be confirmed. Overall, the median fluoroscopy time was 2.8 (1.5–4.4) minutes in all patients and only 1.1 (0.7–1.5) minutes in the last 50 patients of this series. Concerning overall radiation exposure for the patient, computed tomographic scans have to be added to the dose delivered during the ablation.

More importantly, the complication rate was comparable to previously published data. Although we observed that 2.7% of patients had a complication, Dagres et al reported a 3.9% complication rate in 1000 AF ablations based on their single-center experience in 2009, and Cappato et al revealed complication rates of 4.5% and 3.6% in worldwide surveys. In these surveys, the rate for cardiac tamponade ranged from 0.9% to 1.3%. In our data, cardiac tamponade was the most frequent complication (1.3%) followed by complications related to venous access (fistula or arterial pseudoaneurysms) in 0.8%. The rate of tamponade is comparable with our daily experience from >7000 AF ablations (1–1.5%). Four fifth of tamponades occurred in the first 150 cases, whereas only one fifth was registered in the last 225 cases, reflecting a learning curve especially when combining steerable sheath with NFCV technology. Only 1 complication related to vascular access did not occur within the first 48 hours after the procedure, and as such, no late-onset pericardial effusion was observed as described previously by Cappato et al.

Fifty-five percent of patients received DOAC therapy in group 1 of our analysis (May 2012 to November 2012). This proportion increased to 77% in the last 50 patients considered in this study (November 2013 to February 2014). The complications potentially related to the anticoagulation regimen were seen in both VKA (INRs of 2.8 and 0.9) and DOAC groups. In this relatively small cohort of patients, interruption of DOAC therapy 24 hours before the ablation procedure is likely as safe as nondiscontinued VKA therapy. This is in line with results from a recent study reporting that uninterrupted DOAC therapy in AF ablation procedures is as safe as uninterrupted VKA therapy.

Despite the fact that the majority of patients presented with persistent or long-standing persistent AF, additional substrate modification was performed only in 24% of patients. According to our database from >3000 patients, ≈10% of patients presenting with paroxysmal AF show abnormal findings in endocardial voltage mapping and only 40% of persistent AF patients (unpublished data). The 24% of patients with
additional lesions reflects that we report on a real-world cohort. This approach is adapted to the findings of Verma et al.\(^\text{18}\) who showed that the presence of atrial scar revealed by endocardial voltage mapping is associated with impaired outcomes. The same findings were confirmed using MRI-based quantification of atrial scar by Mahnkopf et al.\(^\text{20}\) Additional ablation of the cavitricuspid isthmus was performed in 15% of patients only if typical flutter was inducible or documented in the ECG.

A learning curve of 5 to 10 procedures has been previously described in using the NFCV technology.\(^\text{6,7}\) In AF ablation, in particular, \(\approx\)50 patients were needed in the initial experience before the workflow was fully optimized and the radiation exposure was reduced to reach the stable final level. Starting with optimal workflow using currently available software and catheters, the learning curve should be in the range of 25 procedures.

**Limitations**

This study has the inherent limitations of a registry, and prospective randomized studies are needed to confirm the findings. Because efficacy was not primarily addressed, we did not perform Holter monitoring in all patients, but only in a small subset of 80 patients. The observed improvements may be an overestimate for unexperienced operators because the participating interventionists were highly experienced operators (\(\approx\)300 conventional AF ablations). During the study period, a total of \(\approx\)3000 PVIs were performed at our institution. Although there may have been an underlying bias in the selection of patients undergoing NFCV ablation procedures, the baseline characteristics reflect a real-world scenario with predominantly persistent AF patients and structural heart disease in a large number of patients.

**Conclusions**

In this real-world cohort of patients, we were able to demonstrate that AF ablation procedures can be performed fast (mean procedure time of 150 minutes) and safely (complication rate of 2.7%) using the new NFCV system. Addition of the NFCV technology to a 3D mapping system results in a reduction of fluoroscopy time to 3.4 minutes and a reduction of fluoroscopy dose to 1017 cGy*cm\(^2\). There is a learning curve of \(\approx\)25 patients in using the system.

### Table 3. Complications in 375 Atrial Fibrillation Ablation Procedures

<table>
<thead>
<tr>
<th>Patient#</th>
<th>Type of Complication</th>
<th>Age</th>
<th>Sex</th>
<th>Onset of Complication</th>
<th>Anticoagulation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Tamponade</td>
<td>46</td>
<td>Male</td>
<td>End of procedure</td>
<td>DOAC</td>
<td>Resolved after pericardiocentesis (500 mL)</td>
</tr>
<tr>
<td>20</td>
<td>Tamponade</td>
<td>53</td>
<td>Male</td>
<td>1 h after procedure</td>
<td>VKA, INR 2.3</td>
<td>Resolved after pericardiocentesis (300 mL)</td>
</tr>
<tr>
<td>41</td>
<td>Pseudoaneurysm</td>
<td>35</td>
<td>Male</td>
<td>12 h after procedure</td>
<td>DOAC</td>
<td>Resolved after manual compression</td>
</tr>
<tr>
<td>62</td>
<td>Pseudoaneurysm</td>
<td>71</td>
<td>Female</td>
<td>8 h after procedure</td>
<td>VKA, INR 2.84</td>
<td>Resolved after surgical intervention</td>
</tr>
<tr>
<td>108</td>
<td>Tamponade</td>
<td>57</td>
<td>Male</td>
<td>2 h after procedure</td>
<td>DOAC</td>
<td>Resolved after pericardiocentesis (170 mL) and surgical intervention</td>
</tr>
<tr>
<td>126</td>
<td>Pseudoaneurysm</td>
<td>47</td>
<td>Male</td>
<td>3 d after procedure</td>
<td>DOAC</td>
<td>Resolved after pericardiocentesis (700 mL) and surgical intervention</td>
</tr>
<tr>
<td>146</td>
<td>Tamponade</td>
<td>68</td>
<td>Female</td>
<td>End of procedure</td>
<td>DOAC</td>
<td>Resolved after pericardiocentesis (700 mL) and surgical intervention</td>
</tr>
<tr>
<td>149</td>
<td>Pseudoaneurysm</td>
<td>58</td>
<td>Female</td>
<td>12 h after procedure</td>
<td>VKA plus enoxaparin, INR 0.9</td>
<td>Resolved after manual compression</td>
</tr>
<tr>
<td>257</td>
<td>Tamponade</td>
<td>67</td>
<td>Female</td>
<td>End of procedure</td>
<td>VKA, INR 2.35</td>
<td>Resolved after pericardiocentesis (220 mL)</td>
</tr>
<tr>
<td>337</td>
<td>Stroke</td>
<td>62</td>
<td>Male</td>
<td>30 h after procedure</td>
<td>DOAC</td>
<td>Resolved without sequelae</td>
</tr>
</tbody>
</table>

DOAC indicates direct oral anticoagulant; INR, international normalized ratio; and VKA, vitamin K antagonist.

**Disclosures**

S. Rolff, T. Gaspar, and S. Richter received modest lecture fees by St Jude Medical; P. Sommer, C. Piorkowski, and G. Hindricks received modest lecture fees and are advisory board members by St Jude Medical. The other authors report no conflicts.

**References**

Complex ablation procedures such as ablation of atrial fibrillation or ventricular tachycardias are now the standard of care for the treatment of these arrhythmias. However, these ablation procedures continue to be performed under fluoroscopic guidance with underestimated risks associated with exposure to ionizing radiation for patients, physicians, and nurses. The concept behind a nonfluoroscopic catheter visualization system is to display the catheter in a virtual biplanar fluoroscopy. In this setup, a sensor in the catheter tip is first localized by an electromagnetic field, and the position and orientation information is used to display the catheter tip on the background of 2 prerecorded fluoroscopy loops. Using this system, it has been previously demonstrated that fluoroscopy time and dose in supraventricular tachycardia cases such as typical atrial flutter, atrioventricular nodal re-entry tachycardia, or Wolff–Parkinson–White syndrome could be significantly reduced. In the current analysis, data from 375 consecutive patients who were ablated for atrial fibrillation using this technology are presented. With comparable outcomes to the conventional approach, these complex procedures were performed with <3 minutes of fluoroscopy exposure and, therefore, a reduction of 70% to 90% was achieved. The primary finding of this analysis indicates that despite an incomplete visualization of the catheter shaft, no increases in complication rates were observed and an overall complication rate of 2.7% was recorded. These data, therefore, suggest that even complex procedures such as ablation of atrial fibrillation can be safely performed using this new technology for nonfluoroscopic visualization of the catheters. This technological step forward may help to reduce the risk for adverse side effects of life-long radiation exposure in interventional electrophysiology.
Nonfluoroscopic Catheter Visualization in Atrial Fibrillation Ablation: Experience From 375 Consecutive Procedures
Philipp Sommer, Sascha Rolf, Christopher Piorkowski, Thomas Gaspar, Yan Huo, Carlos Piedra, Sergio Richter, Andreas Bollmann, Arash Arya and Gerhard Hindricks

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