Reduction of fluoroscopy duration in radiofrequency ablation obtained by the use of a non-fluoroscopic catheter navigation system

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Aims Radiofrequency (RF) ablation requires placement of several catheters at critical positions. The catheters are positioned with fluoroscopy, resulting in a significant radiation exposure. We have investigated to what degree an intracardiac navigation system reduces the fluoroscopy duration in different groups of routine RF ablations.

Methods and results The fluoroscopy time was evaluated in 365 consecutive routine RF ablations, performed between 2002 and 2005. An intracardiac navigation system (LocaLisa, Medtronic) was used from 2003. The data were prospectively entered into a database and subsequently retrieved, and the procedures classified as being performed with fluoroscopy only or with the aid of the LocaLisa system. After introduction of the LocaLisa system, the median fluoroscopy time decreased from 24 to 10 min in the 141 atrioventricular nodal re-entry tachycardia (AVNRT) ablations and from 43 to 28 min in the 71 atrial flutter (AFl) ablations (P,0.005 for both). In the 145 Wolff-Parkinson-White (WPW) ablations, a decrease from 27 to 23 min was observed (P = 0.03). The decrease in AVNRT and AFl, but not in WPW, was associated with the introduction of the LocaLisa system.

Conclusion The use of the LocaLisa system during RF ablations significantly reduced the fluoroscopy time in AVNRT and AFl ablations, by a median of 58% and 46%, respectively.

KEYWORDS Radiofrequency ablation; Non-fluoroscopic mapping system; Radiation exposure

Introduction

Radiofrequency (RF) ablation requires placement of several catheters at critical positions within the heart. The catheters were originally positioned and monitored with fluoroscopy only. The procedures are associated with a significant radiation exposure to the patients and the staff. Non-fluoroscopic navigation and mapping systems have subsequently been developed, allowing more precise placement of the catheters. The most widely used systems are the Carto (Biosense Webster, Diamond Bar, CA, USA), EnSite NavX (St Jude Medical, St Paul, MN, USA), and LocaLisa (Medtronic, Minneapolis, MN, USA). The former also have mapping capabilities, whereas the latter is a simpler navigation system. In addition, these systems offer the potential for reducing the radiation exposure associated with the procedures. For LocaLisa, this has been studied in several smaller studies. The use of EnSite NavX was associated with a significant reduction in radiation exposure in a recent prospective study of PV-isolation. We have investigated the procedure time and fluoroscopy time during RF ablations before and after the introduction of the LocaLisa intracardiac navigation system in consecutive ablations of the most common supraventricular tachycardias.

Methods

The RF ablations of Wolff-Parkinson-White (WPW), atrioventricular nodal re-entry tachycardia (AVNRT), and atrial flutter (AFl), performed at our centre between January 2002 and December 2005 were evaluated. The procedures during the entire period were performed by four operators (with 10, 4, 3, and 1 years of ablation experience at the start of the data collection). From November 2003, the procedures were routinely performed with the aid of the LocalLisa system. Catheters were placed from the left and right groin. In all three types of procedure, diagnostic catheters were placed in the right ventricular apex, the His-position, and the coronary sinus. A Halo-catheter was placed in the right atrium in the AFl procedures. In AVNRT, AFl, and WPW with right-sided accessory pathways, an ablation catheter was placed in the right atrium. Left-sided accessory pathways were approached by the transseptal technique in 75% of the procedures and by the
retrograde aortic technique in 25%. The ablation result was evaluated 30 min after the last RF application. The criteria for acute success in WPW, AVNRT, and AFI procedures were absence of delta wave and retrograde conduction block in the accessory pathway, non-inducibility of tachycardia, and bi-directional conduction block through the cavo-tricuspid isthmus, respectively. At the end of the procedure, the procedure time (calculated by the operator) and fluoroscopy time (obtained by a timer reading) were prospectively entered into a database.

For the present analysis, the numerical data were retrieved from the database and the reports from all the procedures were reviewed. Each procedure was classified with respect to the procedure date as being performed with fluoroscopy only or with the aid of the LocaLisa system. It was desirable to differentiate an abrupt change that may be attributable to the introduction of LocaLisa, from a non-specific more gradual change. For this purpose, we divided each of the classes (i.e. fluoroscopy only and with LocaLisa) into two equally sized groups, thus obtaining subgroups ‘Fluoroscopy-early’, ‘Fluoroscopy-late’, ‘LocaLisa-early’, and ‘LocaLisa-late’ (Figures 1 and 2). An attempt was also made to estimate the effect of LocaLisa in ablations of differing complexity. The procedures were divided with respect to their duration into short and long by dichotomization at the median procedure duration and the fluoroscopy time was analyzed separately in each group.

Results

Data from 365 procedures performed during the period were analyzed: 149 WPW procedures (61 fluoroscopy only, 88 with LocaLisa) on 130 patients, 145 AVNRT procedures (58 fluoroscopy only, 87 with LocalLisa) on 141 patients, and 71 AFI procedures (33 fluoroscopy only, 38 with LocalLisa) on 58 patients. Fluoroscopy data were missing in four WPW and in one AVNRT procedures.

Background findings

The median fluoroscopy time in the entire study was for WPW procedures 24 min (17–35), for AVNRT 14 min (8–28), and for AFI 33 min (21–49). The median procedure duration was 150 min (120–180) in WPW, 120 min (105–150) in AVNRT, and 158 min (130–192) in AFI. In all three types of procedure, the patients ablated with fluoroscopy only and the patients ablated with the LocalLisa system showed an adequate matching with respect to age and gender. The median age was 44 (31–56) vs. 44 (32–57) years in WPW, 53 (39–66) vs. 54 (45–66) years in AVNRT, and 58 (53–67) vs. 59 (53–66) years in AFI (\(P > 0.5\) for all three comparisons). The percentage of men was 61 vs. 64% for WPW (\(P > 0.5\)), 33 vs. 45% for AVNRT (\(P = 0.15\)), and 76 vs. 79% for AFI (\(P > 0.5\)).

The success rates in the WPW, AVNRT, and AFI procedures were 87, 93, and 73%, respectively. No significant difference in success rate was seen between the patients ablated with fluoroscopy only and the patients ablated with the LocaLisa. (The success rate in AFI, however, rose to 90% in mid-2005, after increasing the power output and switching to irrigated-tip catheters.) Three cases of complete heart block requiring pacemakers occurred in the AVNRT group (one in the
fluoroscopy only and two in the LocaLisa group). No heart block requiring a pacemaker was seen in AFl- and WPW-ablations. One tamponade each occurred in AVNRT before and after the introduction of LocaLisa. In WPW, one asymptomatic pericardial puncture and one late sterile pericarditis were seen. No tamponade occurred in AFl. (After the change to irrigated-tip catheters and increase in power output in AFl, we experienced three popping events, with no further consequences.) Other complications in the WPW group were one transient ischaemic attack and one self-terminating ventricular flutter, induced by catheter manipulation and in the AVNRT group one late pulmonary embolus.

**Changes associated with LocaLisa**

The findings are summarized in Table 1. In the AVNRT ablations, the median fluoroscopy time for each procedure decreased from 24 to 10 min; in the AFl ablations it decreased from 43 to 23 min ($P < 0.0005$ for both comparisons). The decrease was present in the long, as well as in the short procedure groups. For AVNRT, the median fluoroscopy time decreased from 15 to 9 min in the short procedure group ($P = 0.009$) and 38 to 15 min in the long procedure group ($P < 0.0005$). For AFl, the decrease was from 34 to 16 min in the short group and 68 to 36 min in the long group ($P < 0.0005$ for both comparisons).

In WPW ablations, the median fluoroscopy time decreased from 27 to 23 min ($P = 0.03$). In the analysis with respect to the procedure duration, the median of the short procedures decreased from 20 to 17 min ($P = 0.04$). The corresponding change in the long procedures was non-significant (39 to 31 min, $P = 0.08$).

In AVNRT and AFl ablations, the decrease was associated with the introduction of the LocaLisa system (Figure 1). No such association was visible in WPW (Figure 2). The median procedure duration in AVNRT decreased from 140 to 120 min ($P = 0.02$). No significant change was observed in the procedure times for WPW and AFl (Table 1, 150 vs. 145 min and 150 vs. 160 min, $P = n.s.$ for both comparisons).

**Table 1**  Fluoroscopy duration and procedure duration in the patients ablated with fluoroscopy-only and with the aid of LocaLisa

<table>
<thead>
<tr>
<th></th>
<th>WPW</th>
<th>P</th>
<th>AVNRT</th>
<th>P</th>
<th>AFl</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td><strong>Fluoroscopy time (min)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoroscopy only</td>
<td>27 (18–43)</td>
<td>0.03</td>
<td>24 (14–39)</td>
<td>$&lt;0.0005$</td>
<td>43 (31–66)</td>
<td>$&lt;0.0005$</td>
</tr>
<tr>
<td>With LocaLisa</td>
<td>23 (16–33)</td>
<td></td>
<td>10 (7–17)</td>
<td></td>
<td>23 (16–38)</td>
<td></td>
</tr>
<tr>
<td><strong>Procedure time (min)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoroscopy only</td>
<td>150 (130–190)</td>
<td>0.15</td>
<td>140 (115–168)</td>
<td>0.02</td>
<td>150 (133–189)</td>
<td>$&gt;0.5$</td>
</tr>
<tr>
<td>With LocaLisa</td>
<td>145 (120–180)</td>
<td></td>
<td>120 (100–150)</td>
<td></td>
<td>160 (130–200)</td>
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Values are stated as median (interquartile range).
Discussion

In our comparatively large series of 365 consecutive procedures, the use of the LocalLisa system during RF ablations greatly reduced the fluoroscopy duration in AVNRT- and AFL-ablations, by a median of 58% and 46%, respectively. The relative decrease was similar in the long and in the short procedures. The absolute benefit of decreased radiation for the individual patient was thus greater in the long and presumably more complex procedures. The decrease seems to be abrupt and associated with the introduction of the LocalLisa system (Figure 1). It is, therefore, less probable that this decrease was due to a general learning curve effect. The rather small simultaneous decrease in procedure duration also speaks against this possibility. Two other studies describe a similar fluoroscopy time reduction in AFL procedures, whereas no significant difference was found in another smaller study. In contrast, the decrease in WPW ablations was small, gradual over time, and more consistent with a general improvement in the ablation technique than with the introduction of the LocalLisa system. A previous, smaller study describes no decrease in the fluoroscopy duration in WPW ablations.

Ablations of AVNRT and AFL are presumably heavily dependent on good spatial orientation and visual control of the catheter, because of the homogeneous and anatomically defined nature of the substrate. The use of a catheter navigation system in these ablations may, therefore, more directly decrease the fluoroscopy time. In the heterogeneous group of WPW procedures, the placing of the ablation catheter is mainly guided by the signal. Here, a decrease in fluoroscopy time may rather be due to a continuous improvement in multiple factors, such as a general ability to manipulate the catheters in difficult positions and interpret the signals.

The underlying technology in the LocalLisa system is the same as in EnSite NavX, but LocalLisa does not offer the mapping possibilities. These are, however, not necessary in the bulk of routine cases. The incremental cost associated with each investigation using a non-fluoroscopic system is large for Carto and EnSite NavX, whereas it is negligible for LocalLisa. The latter thus offers the advantage of a decreased radiation exposure in a majority of routine investigations described in this article, which would not be considered for Carto or EnSite NavX. Further refinement of the LocalLisa system software, allowing for more advanced mapping would be highly desirable. Unfortunately, this development has apparently been suspended by the manufacturer.

The procedure durations in our patients were relatively long. This may be attributable to a rather conservative approach and extensive standard catheter setup as described above. We did not observe any great changes in the procedure times after the introduction of the LocalLisa system. This is in accordance with previously published findings. The probable reason is that the time involved in obtaining vascular access, placing of the diagnostic catheters, initial tachycardia provocation, and final evaluation of the therapy is not altered by the use of a navigation system.

Limitations

The study is a retrospective analysis of our database on ablation procedures. The variables were nevertheless coded prospectively at the time of each procedure. The procedure times were manually defined at the end of the procedure and, thus, less exact than the fluoroscopy times that were obtained by reading of a timer.

The operators differ with respect to procedure durations and use of fluoroscopy, but no matching of procedures with respect to the operators was performed. The mix of operators and the technique involved did, however, not change during the studied time period. No direct measurements of the radiation doses were available. The radiation dose will vary between individual patients with the same fluoroscopy time, because of the automatic exposure adjustment and the use of varying aperture size. All the investigations were, however, performed with the same X-ray equipment and the studied groups seem reasonably well matched. We therefore assume that in a group-wise comparison, equivalent exposure times correspond to equivalent radiation doses.

Conclusion

The introduction of a non-fluoroscopic navigation system was associated with a significant decrease in fluoroscopy duration for AVNRT and AFL ablations. During the studied time period, the fluoroscopy duration also decreased in WPW ablations. This decrease was, however, not associated with the introduction of the navigation system.

References