Left atrial strain predicts postoperative atrial fibrillation in patients undergoing major orthopaedic surgery

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Abstract

**Background:** Atrial fibrillation (AF) is an arrhythmia that often occurred in patients after orthopaedic surgery; the presence of AF affects prognosis and prolongs hospitalization of these patients. Speckle tracking echocardiography (STE) is a new echocardiographic technique that has recently shown to predict the occurrence of AF. The aim of this study was to investigate left atrial (LA) function by STE in patients undergoing orthopaedic surgery and to correlate results with the incidence of post-operative AF.

**Methods:** One-hundred and fifteen patients (mean age 74±12 years), undergoing elective (n=39; 41.9%) or post-traumatic (n=54; 58.0%) orthopaedic surgery, were prospectively enrolled. Both conventional echocardiographic parameters and STE parameters were measured in all subjects the day before surgery. The occurrence of AF was monitored until discharge.

**Results:** Of 115 patients screened, 93 met eligibility criteria; 49 underwent hip surgery, 28 knee surgery and 16 surgery of the shoulder/elbow. All patients received a standard postoperative care. No major surgical complications were recorded. Postoperative AF occurred in 26 patients (27.9%). Among all clinical and echocardiographic variables analyzed, global PALS demonstrated the highest diagnostic accuracy (AUC of 0.88) and, with a cutoff value less than 15.3%, good sensitivity and specificity of 89% and 90%, respectively, to predict postoperative AF episodes. LA volume indexed and E/e’ ratio had lower diagnostic accuracy (AUC 0.70 and 0.49, respectively).

**Conclusions:** STE analysis of LA myocardial deformation could be considered a promising tool for the evaluation of AF risk prediction in patients undergoing orthopaedic surgery.

Introduction

The prevalence of atrial fibrillation (AF) is approximately 1.5-2% in the general population. About 70% of affected subjects are 65 and 85 years old. This arrhythmia is associated with a five-fold risk of stroke and three-fold incidence of congestive heart failure, and higher mortality. The occurrence of AF represents a common complication in patients undergoing major orthopaedic surgery and is often associated with prolonged hospitalization. In addition, AF leads to a worse prognosis, resulting in a higher morbidity and mortality. The high incidence of postoperative AF in orthopaedic surgery alerts the importance of identifying patients at higher risk.

Speckle tracking echocardiography (STE) is an echocardiographic technique that analyzes standard B-mode images for a semi-automated evaluation of myocardial deformation. Quantification of LA strain by speckle tracking has been recently proposed to analyze LA function, and has shown clinical potential utilities.

The aim of this study was to analyze LA deformation by STE in patients undergoing major orthopaedic surgery and correlate these parameters with the occurrence of post-operative AF.

Methods

**Study population**

One hundred and fifteen patients (mean age 74±12 years), undergoing elective (n=39; 41.9%) or post-traumatic (n=54; 58.0%) orthopaedic surgery, were prospectively enrolled. Exclusion criteria were: age<18 years old, non sinus rhythm, mechanical ventilation, severe mitral and/or aortic regurgitation, mitral and/or aortic stenosis, presence of prosthetic mitral and/or aortic valve, heart transplantation or a poor quality echocardiography imaging. All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients to be included in the study.

All patients underwent standard echocardiographic examination the day before surgery. Both standard echocardiographic parameters, and peak atrial longitudinal strain (PALS) were measured in all subjects. PALS values were obtained by averaging all segments measured in the 4- and 2-chamber views (global PALS). The occurrence of AF episodes was monitored until home discharge.
Table 1: Preoperative characteristics with subdivision into groups of postoperative atrial fibrillation (POAF) and sinus rhythm (no POAF).

<table>
<thead>
<tr>
<th></th>
<th>no POAF</th>
<th>POAF</th>
<th>HR</th>
<th>(95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>70.2 ± 12.1</td>
<td>77.1 ± 5.1</td>
<td>1.05</td>
<td>(1.03-1.06)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Female (%)</td>
<td>41.3</td>
<td>44.1</td>
<td>1.01</td>
<td>(0.99-1.02)</td>
<td>0.34</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>28.2 ± 7.1</td>
<td>29.5 ± 8.1</td>
<td>1.05</td>
<td>(0.95-1.07)</td>
<td>0.15</td>
</tr>
<tr>
<td>NYHA (1-4)</td>
<td>1.07 ± 1.1</td>
<td>1.30 ± 1.2</td>
<td>1.05</td>
<td>(1.02-1.07)</td>
<td>0.005</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>70</td>
<td>71</td>
<td>1.01</td>
<td>(0.99-1.02)</td>
<td>0.42</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>15</td>
<td>18</td>
<td>1.01</td>
<td>(0.99-1.01)</td>
<td>0.64</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>65</td>
<td>68</td>
<td>1.01</td>
<td>(0.99-1.02)</td>
<td>0.45</td>
</tr>
<tr>
<td>Smoking</td>
<td>29.6</td>
<td>35.2</td>
<td>1.04</td>
<td>(0.99-1.07)</td>
<td>0.14</td>
</tr>
<tr>
<td>Pulmonary disease (%)</td>
<td>12.2</td>
<td>19.2</td>
<td>1.07</td>
<td>(1.01-1.07)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 2: Preoperative echocardiographic variable

<table>
<thead>
<tr>
<th></th>
<th>no POAF</th>
<th>POAF</th>
<th>HR</th>
<th>(95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>76.2 ± 14.2</td>
<td>77.2 ± 16.1</td>
<td>1.01</td>
<td>(0.99-1.01)</td>
<td>0.66</td>
</tr>
<tr>
<td>End-diastolic LV diameter (mm)</td>
<td>48.2 ± 6.2</td>
<td>50.2 ± 7.9</td>
<td>1.01</td>
<td>(0.97-1.02)</td>
<td>0.32</td>
</tr>
<tr>
<td>LV mass index (g/m2)</td>
<td>127.2 ± 38.2</td>
<td>121.6 ± 37.4</td>
<td>0.97</td>
<td>(0.95-1.02)</td>
<td>0.42</td>
</tr>
<tr>
<td>LV Ejection Fraction (%)</td>
<td>57.6 ± 7.9</td>
<td>58.5 ± 7.9</td>
<td>1.00</td>
<td>(0.99-1.01)</td>
<td>0.75</td>
</tr>
<tr>
<td>LA volume indexed (ml/ m2)</td>
<td>42.6 ± 15.2</td>
<td>46.9 ± 17.1</td>
<td>1.02</td>
<td>(1.01-1.04)</td>
<td>0.05</td>
</tr>
<tr>
<td>Mitral E/A ratio</td>
<td>0.71 ± 0.41</td>
<td>0.79 ± 0.40</td>
<td>1.00</td>
<td>(0.99-1.01)</td>
<td>0.71</td>
</tr>
<tr>
<td>E/e’ ratio</td>
<td>12.1 ± 6.1</td>
<td>16.2 ± 7.1</td>
<td>1.03</td>
<td>(0.98-1.05)</td>
<td>0.08</td>
</tr>
<tr>
<td>PAPs (mmHg)</td>
<td>35.1 ± 11.6</td>
<td>39.2 ± 15.4</td>
<td>1.02</td>
<td>(0.98-1.06)</td>
<td>0.16</td>
</tr>
<tr>
<td>Global PALS (%)</td>
<td>34.6 ± 9.5</td>
<td>22.0 ± 7.1</td>
<td>1.09</td>
<td>(1.05-1.15)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Global PALS &lt; 15.3% (%)</td>
<td>41.1</td>
<td>91.6</td>
<td>7.76</td>
<td>(2.95-19.3)</td>
<td>&lt;0.0001</td>
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</table>

Standard echocardiography

The day before surgery, echocardiographic studies were performed using a high quality echocardiograph (Vivid 7, GE, USA). Subjects were studied in the left lateral recumbent position. Measurements of left ventricular (LV) and LA dimensions were made in accordance with current American Society of Echocardiography recommendations. LV ejection fraction was measured using the modified biplane Simpson’s rule. The ratio between peak early (E) and late (A) diastolic LV filling velocities and E wave deceleration time were determined by standard Doppler imaging. The timings of mitral and aortic valve opening and closure were defined by pulsed wave Doppler tracings of mitral inflow and LV outflow.

Speckle tracking

For speckle tracking analysis, apical four- and two-chamber views images were obtained using conventional two dimensional gray scale echocardiography, during breath hold with a stable ECG recording. Particular attention was given to obtain an adequate gray scale image, allowing reliable delineation of myocardial tissue and extracardiac structures. Three consecutive heart cycles were recorded and averaged. The frame rate was set between 60 and 80 frames per second. These settings are recommended to combine temporal resolution with adequate spatial definition, and to enhance the feasibility of the frame-to-frame tracking technique.

Recordings were processed using an acoustic-tracking software (Echo Pac, GE, USA), allowing off-line semi-automated analysis of speckle-based strain. LA endocardial surface was manually traced in both four- and two-chamber views by a point-and-click approach. An epicardial surface tracing was then automatically generated by the system, thus creating a region of interest (ROI). After manual adjustment of ROI width and shape, the software divided the ROI into 6 segments, and the resulting tracking quality for each segment was automatically scored as either acceptable or non-acceptable, with the possibility of further manual correction. Segments in which no adequate image quality could be obtained were rejected by the software and excluded from the analysis. Lastly, the software generated strain curves for each atrial segment.

In subjects with adequate image quality, a total of 12 segments were then analyzed. To trace the ROI in the discontinuity of LA wall corresponding to pulmonary veins and LA appendage, the direction of LA endocardial and epicardial surfaces at the junction with these structures was extrapolated. Peak atrial longitudinal strain (PALS) was calculated by averaging values observed in all LA segments (global PALS), and by separately averaging values observed in 4- and 2-chamber views (4- and 2- chamber average PALS). In patients in whom some segments were excluded because of the difficulty in achieving adequate tracking, PALS was calculated by averaging values measured in the remaining segments. (Figure 1) Reproducibility of PALS measurements has been assessed in our previous study 5.

Statistical analysis

Data are shown as mean ± SD. Inter- and intra-observer reproducibility was assessed by calculating variability coefficients. Reference values were expressed as mean ± SD and 5–95% percentile ranges. Comparisons were performed using the Student t test for paired data. A P value < 0.05 was considered statistically significant. Analyses were performed using the SPSS (Statistical Package for the Social Sciences, Chicago, Illinois) software Release 11.5.

Results

Of 115 patients screened, 93 met eligibility criteria during the study period: 49 underwent hip surgery, 28 knee surgery and 16 surgery of the shoulder/elbow. Five were excluded for severe mitral valve disease, 4 for poor echocardiographic window and 1 for severe aortic stenosis. All patients received a standard postoperative care (Table 1). No major surgical complications were recorded. Postoperative AF (POAF) occurred in 26 patients (27.9%). (Table 2)

Patients with POAF episodes were significantly older (No POAF patients 70.2±12.1, POAF 77.1±5.1, P<0.0001), presented higher prevalence of pulmonary disease (No POAF 12.2, POAF 19.2, p=0.01), higher E/e’ ratio (No POAF 12.1±6.1, POAF...
Among all clinical and echocardiographic variables analyzed, global PALS demonstrated the highest diagnostic accuracy (AUC of 0.88) and, with a cutoff value less than 0.326%, good sensitivity and specificity of 89% and 90%, respectively, to predict postoperative AF episodes. LA indexed volume and LA ratio and LA volume, global PALS (β=0.326, p < 0.0001) and age (β= 0.198, p < 0.0001) independently predicted the POAF episodes. Global PALS ratio was the strongest predictor, accounting for 66.3% of the total variability explained by the model.

Among all clinical and echocardiographic variables analyzed, global PALS demonstrated the highest diagnostic accuracy (AUC of 0.88) and, with a cutoff value less than 15.3%, good sensitivity and specificity of 89% and 90%, respectively, to predict postoperative AF episodes. LA volume indexed and E/e’ ratio had lower diagnostic accuracy (AUC 0.70 and 0.49, respectively). These findings suggest that global PALS can be a promising tool for the evaluation of LA subclinical dysfunction and passive deformation. STE analysis of LA myocardial deformation could be considered a promising tool for the evaluation of LA subclinical dysfunction in patients undergoing orthopaedic surgery, giving a potentially better risk stratification for the occurrence of postoperative AF.

Conclusions

STE analysis of LA myocardial deformation could be considered a promising tool for the evaluation of LA subclinical dysfunction in patients undergoing orthopaedic surgery, giving a potentially better risk stratification for the occurrence of postoperative AF.

Authors’ Contribution

RdV, AdG, RR, CdT were responsible for the collection of data; EB, anaesthesiologist, was responsible for the collection of intraoperative data. RdV drafted the manuscript; MC performed the statistical analysis; SM, MC and MF were responsible for the design of the study and revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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References