Incremental prognostic value of fully-automatic machine-learning based global circumferential strain during a stress CMR exam

T. Pezel¹, P. Garot², S. Toupin³, F. Sanguineti², T. Hovasse³, T. Unterseeh³, T. Chitibo³, A.J. Jacob⁴, I. Borgohain⁴, P. Sharma⁴, S. Champagne², J. Garot²

¹Hospital Lariboisiere, Paris, France
²Cardiovascular Institute Paris-Sud (ICPS), Massy, France
³Siemens Healthcare France, MRI, Saint Denis, France
⁴Siemens Healthineers, Digital Technologies and Innovation, Princeton, United States of America

Funding Acknowledgements: None.

Background: Left ventricular global circumferential strain using cardiovascular magnetic resonance (CMR) is an accurate indicator to predict cardiovascular events. Although several studies have shown the excellent prognostic value of stress CMR, the prognostic value of stress global circumferential strain (sGCS) remains unknown.

Purpose: To investigate the prognostic value of sGCS for predicting cardiovascular events using a fully automatic machine learning algorithm without human correction in consecutive patients referred for stress CMR.

Methods: Between 2016 and 2018, all consecutive patients referred for stress CMR were included and followed for the occurrence of major adverse cardiovascular events (MACE), defined by cardiovascular death or nonfatal myocardial infarction (MI). A fully automatic machine learning algorithm was trained and validated on unseen CMR studies (MAGNETOM Aera and Skyra, Siemens Healthcare, Erlangen, Germany) to assess the sGCS from short-axis cine images at stress. The algorithm combines multiple deep learning networks for detection and segmentation with an active contours approach. Cox regressions were performed to determine the prognostic value of sGCS.

Results: Among 2,906 consecutive patients who underwent stress CMR, the automatic sGCS was successfully computed in 2,859 (98.4%) patients (68% male, mean age 64±12 years). A total of 256 (8.8%) MACEs were observed during a median (IQR) follow-up period of 4.5 (3.7-5.3) years. Using Kaplan-Meier analysis, sGCS and the presence of inducible ischemia were significantly associated with the occurrence of MACE (hazard ratio, HR: 1.12 [95% CI, 1.08-1.17]; and HR: 8.48 [95% CI, 6.05-11.91], both p<0.001; respectively). After adjustment for traditional risk factors, inducible ischemia and late gadolinium enhancement (LGE), sGCS was an independent predictor of a higher incidence of MACE (adjusted HR: 1.12 [95% CI, 1.05-1.20]). Finally, sGCS showed an incremental prognostic value to predict MACE compared to a multivariable model including traditional risk factors, the presence of inducible ischemia and LGE (C-statistic improvement: 0.05, p=0.007; NRI=0.169; IDI=0.097; both p<0.001).

Conclusions: Automatic sGCS has an incremental prognostic value to predict MACE above traditional risk factors, and other stress CMR parameters.
Survival curves
### Incremental Prognostic Value

**Table:**

<table>
<thead>
<tr>
<th>Model</th>
<th>C-index</th>
<th>NRI</th>
<th>IDI</th>
<th>P-value for all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1 (Clinical)</td>
<td>0.606</td>
<td>Reference</td>
<td>Reference</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Model 2 (Clinical + LVEF)</td>
<td>0.785</td>
<td>0.406</td>
<td>0.061</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Model 3 (Clinical + LVEF + stress GCS)</td>
<td>0.870</td>
<td>0.538</td>
<td>0.108</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

**Figure:**

- **Chi Square:**
  - Model 1 (Clinical): 7.20
  - Model 2 (Clinical + LVEF): 53.9
  - Model 3 (Clinical + LVEF + stress GCS): 98.6

- **P-values:**
  - Chi Square: p < 0.001
  - C-index: p < 0.001 for all
  - NRI: p < 0.001 for all
  - IDI: p < 0.001 for all