Dynamic clinical prediction models for cardiac surgery

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History of clinical prediction models for cardiac surgery

- 1989: Parsonnet
- 1999: Additive EuroSCORE
- 2003: Logistic EuroSCORE
- 2008: STS Models
- 2012: EuroSCORE II
- Future: Where next?

Dominant European model for ~10 years
Procedure specific Multiple outcomes
What’s wrong with the *status quo*?

In April 2010, predicted mortality was **2.7 x** observed mortality.
Consequences

Logistic EuroSCORE

Recalibrated EuroSCORE (08/11)

Mortality rate

Number of procedures

Misrepresentation
<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do nothing</td>
<td>Develop a model (e.g. on 1-years data) and leave to run forever</td>
</tr>
<tr>
<td>Periodically refit model</td>
<td>Every, e.g. 1-year, independently refit the model</td>
</tr>
<tr>
<td>Rolling window</td>
<td>Fit model to a fixed window (e.g. 2-years) of data and then rolling the window incrementally (e.g. every 1-year)</td>
</tr>
<tr>
<td>Dynamic logistic regression</td>
<td>Exploit dynamic statistical models that can update in ‘real time’ (1-month) online</td>
</tr>
</tbody>
</table>

\(^a\) not an exhaustive list
‘Nuts & bolts’ of dynamic regression

- Described by McCormick et al. *Biometrics* 2012; 68:23-30 (with software)
- Assumes a state-space equation: $\beta_t = \beta_{t-1} + \delta$
  for risk factors (cf. log odds ratios)
- As each batch of new data arrives, model updates estimate of $\beta_t$ and its standard error using Bayesian statistics
- Assumptions made about $\delta$ and approximations in calculations
Strategy

• Focus on EuroSCORE risk factors
• Train all 3 models on 2001-02 clinical registry data for all adult cardiac surgery
• ‘Update’ models on 2002-11 clinical registry data
• Monitor model coefficients
Results
• 316,713 records
• 37 different hospital
• 120 months of clinical data (10 years)
Recent MI

Pulmonary hypertension

Emergency/salvage

Other than isolated CABG

Surgery on thoracic aorta

VSD

Time

Coefficient


No update
Piecewise recalibration (1-year)
Rolling 2-year window
Dynamic logistic regression
Piecewise recalibration (2-year)

Estimate

95% CI
### Intercept

<table>
<thead>
<tr>
<th>Coefficient Estimate</th>
<th>95% CI</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6.00</td>
<td>-5.75</td>
<td>No update</td>
</tr>
<tr>
<td>-5.75</td>
<td>-5.50</td>
<td>Rolling 2-year window</td>
</tr>
<tr>
<td>-5.50</td>
<td>-5.25</td>
<td>Piecewise recalibration (1-year)</td>
</tr>
<tr>
<td>-5.25</td>
<td>-5.00</td>
<td>Piecewise recalibration (2-year)</td>
</tr>
<tr>
<td>-5.00</td>
<td>-4.75</td>
<td>Dynamic logistic regression</td>
</tr>
</tbody>
</table>

**Graph Description:**
- **Y-axis:** Coefficient
- **Legend:**
  - Estimate
  - 95% CI
  - No update
  - Rolling 2-year window
  - Piecewise recalibration (1-year)
  - Piecewise recalibration (2-year)
  - Dynamic logistic regression
Conclusions

- Doing nothing is not an option
- A patient today does not have the same risk as 10 years ago
- Is it sensible to wait for EuroSCORE III?
- Dynamic regression is more methodologically complex and would require concerted effort to implement