Predicting adverse outcomes of cardiac surgery with the application of artificial neural networks

Peng SY, Peng SK. *Anaesthesia*, 2008, 63, 705-713.

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**Background:**
Preoperative patient and surgical factors are useful to predict perioperative adverse outcomes including mortality. The prediction abilities help to triage surgical versus non-surgical therapy. The prediction scores also help to compare the quality of care between various providers and surgeons. The Parsonnet score predicts post cardiac surgical mortality and was derived from logistic regression of large international statistics. Logistic regression models the probability of event as a linear function of a set of predictor variables. The artificial neural network is a computational model that adapts to the flow of information during the learning (ANN) phase in a nonlinear fashion.

**Methods:**
952 anonymized adult cardiac surgical patient records during a three year period were retrospectively studied. Preoperative and postoperative information was noted with operationalized definitions of demographic and outcome data. Logistic regression (backward stepwise regression with selection by univariate analysis p<0.2) and ANN models were built with a training set of 637 patients. The remaining 315 patients formed the validation set. The Parsonnet score was derived for the training set both for morbidity and mortality. ANN training was tested to see if the outcome was predicted correctly. The error difference was calculated and back-propagated through the network to adjust the connection weights to more closely match the input and output data. This model was then tested with the validation set. Sensitivity, specificity, accuracy and the area under the receiver operating characteristic (ROC) curve were estimated for the Parsonnet, logistic regression model and ANN model.

**Results:**
The in-hospital mortality and major morbidity rates in the training set were 10.2% and 46.6%.
There was no statistical difference between the three models to predict the in-hospital mortality. However, the ANN model predicted morbidity significantly better than the other two models.

**Discussion:**
ANN predicted morbidity better than the other models. This is a useful model to discriminate the lengths of stay and utilization of hospital resources. This is a single center study and needs external validation. It is useful to model complex relationships between preoperative patient and surgical factors and outcomes. This can be compared to human brain recognizing the patterns during repeated exposure. Since ANN has limitless abilities to predict with various models, the final model does have similar limitations to that of logistic regression. The impressive feature of ANN is the nonlinear association between the patient and surgical factors on outcome.

<table>
<thead>
<tr>
<th>Scores (mortality/morbidity)</th>
<th>Accuracy</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANN</td>
<td>83.8 / 79</td>
<td>81.1 / 71.9</td>
<td>84.2 / 85.8</td>
<td>0.87 / 0.85</td>
</tr>
<tr>
<td>Logistic regression</td>
<td>87.9 / 74.3</td>
<td>67.6 / 67.3</td>
<td>90.7 / 80.9</td>
<td>0.85 / 0.79</td>
</tr>
<tr>
<td>Parsonnet score</td>
<td>78.4 / 68.6</td>
<td>78.4 / 53.6</td>
<td>78.4 / 82.7</td>
<td>0.82 / 0.73</td>
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</tbody>
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