Predicting Patients’ Outcomes in Abdominal Wall Reconstruction Procedure

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Background
- A protrusion of abdominal tissue through a weak spot in the abdominal wall
  - Occurs at incision site of previous surgery
  - Caused by muscle weakness in abdomen
  - Smoking, obesity, and prior wound infections can increase risk
- Treatment Options and Impact:
  - Open ventral hernia repair: requires large, open incision; More than 50% result in recurrence
  - Laparoscopic ventral hernia repair: requires multiple smaller incisions; 13% to 24% complication rate
- Nonsurgical management: Watchful waiting and lifestyle changes; only viable if showing no symptoms
- Approximately 250,000 ventral hernia repairs performed each year

Concerns:
- Possible risk factors for wound complications reported:
  - Smoking, diabetes, obesity
  - Chronic steroid use and prolonged operation time
  - Surgery-specific factors (e.g., incision site, incision location)

Currently, there is no clear consensus on factors most contributing to post-op wound complications

Purpose
- Our goal is to develop a predictive model to
  - Identify the most contributing factors to wound complications following ventral hernia surgery
  - Stratify patients based on their outcomes

Data
- 102 patients’ data collected over 49 months from 8/11 to 9/15 at Halifax Health in Daytona Beach, FL
- 73 total parameters recorded:
  - 23 patient characteristics (e.g. Age, BMI)
  - 37 intra-operative factors (e.g. OR Time, Incision Location)
  - 13 post-operative outcomes (e.g. Recurrence, Wound Complications)
- 29 total wound complications (nine major, seven moderate, 13 minor)

Methodology
- Built models using Random Forest
  - Very robust for datasets with high ratio of parameters to observations
  - Ensemble method
  - Uses bagging and random variable selection
  - Aggregates classification trees to predict response
  - Reveals the most contributing factors
  - Objective evaluation using leave-one-out cross-validation

We observed poor classification accuracy when applied directly

Parameter Elimination (PE) Algorithm
- Recursive parameter elimination approach that iteratively reduces number of parameters
- Balancing to assure equal representation of the two classes of the response variable
- Parameter selection based on Gini index

Algorithm:
1. downsample with respect to the response variable to generate balanced dataset 2. while number of parameters in model is greater than zero do
3. build RF using the balanced dataset \( \rightarrow \) RandomForest
4. identify the least important parameter using Gini index \( \rightarrow \) ParameterSelection
5. for each patient in dataset do
6. exclude the patient from the dataset and build RF for remaining patients in the dataset
7. use RF to predict the response variable for the excluded patient
8. determine if the predicted values match the ground truth or not for the excluded patient \( \rightarrow \) CV
9. end for
10. calculate cross validation error by summing over the total number of incorrect predictions, divided by 100 and create a contingency matrix
11. remove the least important parameter previously identified \( \rightarrow \) ParameterSelection
12. end while

Best Model
- Executed PE algorithm 25 times to account for variations in each execution
- Nine-parameter models found to have highest F1 score out of all 60 n-parameter models

Results

<table>
<thead>
<tr>
<th>Predicted +</th>
<th>Predicted -</th>
</tr>
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<tbody>
<tr>
<td>Condition +</td>
<td>3 (TP) 63 (FP) 24 (FN)</td>
</tr>
<tr>
<td>Condition -</td>
<td>17 (FP) 56 (TN)</td>
</tr>
<tr>
<td>F1 Score = 55% Sensitivity = 83% Specificity = 93%</td>
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Purpose
- Most important contributing parameters:
  - BMI
  - Age
  - OR Time
  - Wound Infection in Past
  - Number of Prior Abdominal Operations
  - Intra-Op Hernia Defect Size
  - Intra-Op Mesh Size
  - Pre-Op Emotional Complexity
  - Number of Prior Hernia Recurrences

Discussion
- Surprisingly, smoking did not show up as one of the main contributing factors to complications, despite anecdotal references in the literature and physicians’ intuition
- Inform physicians and patients of the controllable factors and provide insights on the non-controllable factors
- Better understanding of risks and treatment options to inform physicians and patients to pave the way for shared decision making