Predicting Patients’ Outcomes in Abdominal Wall Reconstruction Procedure

Danika Dorris, Anahita Khojandi, Ph.D., Department of Industrial and Systems Engineering, University of Tennessee
Bruce Ramshaw, M.D., University of Tennessee Graduate School of Medicine

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

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
  - Reduces overfitting of data

- Objective evaluated the model 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

- Executed PE algorithm 25 times to account for variations in each execution

Best Model

- Nine-parameter models found to have highest F1 score out of all 60 n-parameter models

Results

- F1 Score = \( \frac{2TP}{2TP + FP + FN} \)
- Sensitivity = \( \frac{2TP}{2TP + FN} \)
- Specificity = \( \frac{TP + FN}{FP + TN} \)

1. No Parameter Selection and No Balancing

<table>
<thead>
<tr>
<th>Condition +</th>
<th>Condition -</th>
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</thead>
<tbody>
<tr>
<td>Predicted +</td>
<td>3 (TP)</td>
</tr>
<tr>
<td>Predicted -</td>
<td>2 (FP)</td>
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<tr>
<td>F1 Score = 18%</td>
<td>Sensitivity = 10%</td>
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2. Parameter Selection and No Balancing

<table>
<thead>
<tr>
<th>Condition +</th>
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<tbody>
<tr>
<td>Predicted +</td>
<td>13 (TP)</td>
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<tr>
<td>Predicted -</td>
<td>5 (FP)</td>
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<tr>
<td>F1 Score = 55%</td>
<td>Sensitivity = 45%</td>
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3. No Parameter Selection and Balancing

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<tbody>
<tr>
<td>Predicted +</td>
<td>22 (TP)</td>
</tr>
<tr>
<td>Predicted -</td>
<td>23 (FP)</td>
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<tr>
<td>F1 Score = 59%</td>
<td>Sensitivity = 76%</td>
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4. Parameter Selection and Balancing

<table>
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<tbody>
<tr>
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<td>24 (TP)</td>
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<tr>
<td>Predicted -</td>
<td>17 (FP)</td>
</tr>
<tr>
<td>F1 Score = 69%</td>
<td>Sensitivity = 83%</td>
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Discussion

- 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

- 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