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## The cost of preventable comorbidities on wound complications in open ventral hernia repair

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### ABSTRACT

**Background:** Patients with complex ventral hernias may benefit from preoperative optimization. This study evaluates the financial impact of preventable comorbidities (PCM) in elective open ventral hernia repair.

**Methods:** In this single institution prospectively collected data from 2007-2011, hospital charges (included all hernia-related visits, interventions, or readmissions) and wound-related complications in patients with PCM—diabetes, tobacco use, and obesity—were compared to patients without such risks using standard statistical methods.

**Results:** Within the study period, there were 118 patients with no PCM; of those, 33 had complications, and 85 did not. In the 131 patients with two or more PCM, 81 had complications; 89 of 251 patients had complications in the group with only 1 PCM; groups with PCM were significantly more likely to have complications compared to the no PCM group (62% versus 35.4% versus 28%,  $P < 0.05$ ). The majority of the patient population was female (57.2%) with a mean age of 57.8 y (range, 22-84 ys), and median defect size was 150 cm<sup>2</sup> (interquartile range, 50-283 cm<sup>2</sup>). Body mass index was higher in PCM group with complications than in PCM without complications (40 versus 36 kg/m<sup>2</sup>,  $P < 0.05$ ). For patients with complications, the average hospital charges were \$80,660 in the PCM group compared to \$55,444 in the no PCM group ( $P = 0.038$ ). Hospital charges in those with PCM without complications compared to no PCM with complications were equivalent (\$65,453 versus \$55,444,  $P = 0.55$ ). Even when no complications occurred, patients with PCM incurred higher charges than No PCM for inpatient (\$61,269 versus \$31,236,  $P < 0.02$ ), outpatient (\$4,185 versus \$552,  $P < 0.04$ ), and total hospital charges (\$65,453 versus \$31,788,  $P < 0.001$ ). Those patients without complications but with a single PCM incurred larger charges than those with no PCM during follow-up (\$3578 versus \$552,  $P = 0.04$ ), but there was no difference in hospital or overall total charges ( $P > 0.05$ ). Interestingly, patients without complications, both hospital (\$38,333 versus \$61,269,  $P = 0.02$ ) and total charges (\$41,911 versus \$65,453,  $P = 0.01$ ) were increased for patients with 2+ PCM compared to those with only a single PCM. If complications occurred, no difference between the single PCM group compared to the two or more PCM groups existed for hospital, follow-up, or overall charges ( $P > 0.05$ ).

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Conclusions: Patients with PCM undergoing open ventral hernia repair are more likely to have complications than patients without comorbidities. Patients with PCM generate higher hospital charges than those without PCM even when no complications occur; furthermore, the more PCM, the patient has the more significant the impact. Interestingly, patients with multiple PCM and no complications had equivalent hospital costs compared to patients with no PCM and with complications. Aggressive risk reduction may translate into significant savings. Preoperative preparation of patients before elective surgery is indicated.

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## Introduction

Ventral hernia repairs are common with an annual incidence up to 360,000 repairs performed with an estimated total cost of \$3.2 billion and the second most common cause for readmission.<sup>1-3</sup> As recurrence rates are becoming more consistent in the literature, other factors, such as quality of life and wound-related complications, have become important quality outcome measures for hernia repair. Focus on outcomes, together with the evaluation of factors affecting outcomes, has brought forward the importance of preoperative patient optimization in attempts to prevent what can be costly specifically for ventral hernia repair which is a leading cause of readmission.<sup>3</sup>

Comorbidities effect on outcomes is a popular topic in hernia research. Krapta et al.<sup>4</sup> showed that patients undergoing open repair for grade II hernias had a 16% increased risk of developing a surgical site occurrence (SSO) when they had comorbidities such as chronic obstructive lung disease, diabetes, a smoking history, or were obese.

Any cigarette smoking can negatively impact healing, and even from a single cigarette, cutaneous blood flow recovers more slowly in smokers as it is reduced 38.1% compared to 28.1% reduction in nonsmokers.<sup>5,6</sup> Tobacco use alone carries a 2.49 relative risk of wound complications (95% confidence interval [CI], 1.91-3.26,  $\leq 0.05$ )<sup>7</sup> and has been supported internationally after logistical regression analysis making it a statistically significant risk factor for a wound-related events after ventral hernia repair ( $P = 0.022$ ).<sup>8</sup> Although smokers have an increase adjusted odds ratio (OR) 1.8 times for superficial skin infections (SSI), it is similarly seen that nonsmokers had a reduced risk of SSI with an adjusted OR of 0.4 for that of nonsmokers.<sup>9</sup> Smoking has repetitively demonstrated to have significant impact of surgical outcomes, and cessation can be effective in reducing such risk.<sup>10</sup>

Obesity is becoming a worldwide epidemic. Patients who are obese often have medical comorbidities, are more difficult to operate on, have compromised tissue healing, increased wound complications, and increased intra-abdominal pressure.<sup>11</sup> The literature supporting obesity as risk factor for SSO and SSI is extensive. Increased incidence of hernia recurrence with a rising body mass index (BMI) has been well documented as well.<sup>12-16</sup> The pooled relative risk of obesity impacting wound healing is a 1.6-time increased risk compared to nonobese patients.<sup>16</sup> In laparoscopic repairs, patients with BMI >40 had a four times greater hernia recurrence.<sup>17</sup> Furthermore, for BMI over 26, there is an odds ratio of increase risk of wound complication of 1.08 per BMI point.<sup>14</sup>

This same effect is seen by the American Heart Association to incrementally increase sick days, medical claims, and overall health care costs.<sup>18</sup>

Diabetes, also considered a preventable comorbidity, whether requiring oral antiglycemic control or insulin dependence, both result in a 20% increase in wound complications (OR, 1.22 and 1.23 respectively,  $P < 0.025$ ).<sup>19</sup> Many other studies validate the effect of diabetes on ventral hernia repairs,<sup>13,20,21</sup> and some research has identified diabetes as independently associated with delayed wound healing (OR = 1.62, CI = 1.14-2.35,  $P \leq 0.05$ ).<sup>20</sup> In a recent study evaluating combined results from national outcome registries of Nationwide Inpatient Sample (NIS) and American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), patients who underwent open ventral hernia repair that had diabetes had a 13.7% risk of major complication compared to 8.8% for nondiabetics ( $P < 0.0001$ ); the effect was even more profound of a difference for those with uncomplicated controlled diabetes of 12.6% compared to those with complicated uncontrolled diabetes at 23.3% ( $P < 0.0001$ ) and increasing length of stay as well as overall inpatient charges.<sup>22</sup>

Minimizing preoperative risks such as severity of patient comorbidities may considerably affect patient outcomes and cost related to hernia repair. Little information exists on evaluating the outcomes of patient optimization in terms of its financial impact. Herein, this study looks at patients with multiple preventable comorbidities (PCM) of diabetes, tobacco use, or obesity versus those patients without such risk factors. Therefore, our aim was to evaluate the economic bearing of PCM during elective, open ventral hernia repair with the intent of proposing preoperative intervention as an area of medicine with significant opportunity to improve patient outcomes and decrease the financial burden of the healthcare system.

## Methods

### Study design

#### Inclusion and exclusion criteria

After obtaining institutional review board approval, a prospectively collected surgical outcomes database was reviewed from 2007-2011 in standards of HIPAA compliance. Patients were at least 18 years, had a ventral hernia requiring an open repair, and consented for the study. Patients were required to have the diagnosis of at least two of the three comorbidities

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