Development and Validation of a Risk-Stratification Score for Surgical Site Occurrence and Surgical Site Infection after Open Ventral Hernia Repair

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BACKGROUND: Current risk-assessment tools for surgical site occurrence (SSO) and surgical site infection (SSI) are based on expert opinion or are not specific to open ventral hernia repairs. We aimed to develop a risk-assessment tool for SSO and SSI and compare its performance against existing risk-assessment tools in patients with open ventral hernia repair.

STUDY DESIGN: A retrospective study of patients undergoing open ventral hernia repair (n = 888) was conducted at a single institution from 2000 through 2010. Rates of SSO and SSI were determined by chart review. Stepwise regression models were built to identify predictors of SSO and SSI and internally validated using bootstrapping. Odds ratios were converted to a point system and summed to create the Ventral Hernia Risk Score (VHRS) for SSO and SSI, respectively. Area under the receiver operating characteristic curve was used to compare the accuracy of the VHRS models against the National Nosocomial Infection Surveillance Risk Index, Ventral Hernia Working Group (VHWG) grade, and VHWG score.

RESULTS: The rates of SSO and SSI were 33% and 22%, respectively. Factors associated with SSO included mesh implant, concomitant hernia repair, dissection of skin flaps, and wound class 4. Predictors of SSI included concomitant repair, dissection of skin flaps, American Society of Anesthesiologists class $\geq$3, wound class 4, and body mass index $\geq$40. The accuracy of the VHRS in predicting SSO and SSI exceeded National Nosocomial Infection Surveillance and VHWG grade, but was not better than VHWG score.

CONCLUSIONS: The VHRS identified patients at increased risk for SSO/SSI more accurately than the National Nosocomial Infection Surveillance scores and VHWG grade, and can be used to guide clinical decisions and patient counseling. (J Am Coll Surg 2013;217:974–982. © 2013 by the American College of Surgeons)

Ventral hernia repairs are among the most common general surgery procedures, with more than 350,000 performed in the United States each year.[1] A myriad of wound complications can occur after open ventral hernia repair (OVHR). These events are cumulatively called surgical site occurrences (SSO) and are thought to be related to patient and surgical factors. Specifically, SSO includes surgical site infection (SSI), seroma and hematoma formation, wound dehiscence, and fistula formation.[2] Surgical site occurrence after OVHR can lead to chronic mesh infection and hernia recurrence, both of which can lead to reoperation and increased risk of subsequent complications.

Recognizing the grave consequences of SSO, earlier efforts have been made to identify risk factors for SSO to guide patient counseling of postoperative risks and to facilitate outcomes reporting for OVHR; yet there are several limitations to each of the existing risk-assessment tools. For example, the Ventral Hernia Working Group (VHWG) categorizes patients into 4 grades that predict the risk of SSO. Patients classified as grade 1 have a "low risk" of complications and includes patients with no

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Abbreviations and Acronyms

ASA = American Society of Anesthesiologists
AUC = area under the receiver operating characteristic curve
BMI = body mass index
NNIS = National Nosocomial Infection Surveillance
OR = odds ratio
OVHR = open ventral hernia repair
SSI = surgical site infection
SSO = surgical site occurrence
VHRS = Ventral Hernia Risk Score
VHWG = Ventral Hernia Working Group

history of wound infection. Grade 2 describes "comorbid" patients who are smokers, diabetic, obese, immunosuppressed, or have COPD. Patients who have "potentially contaminated" hernias are considered grade 3, and these patients have earlier wound infections, stomas, or had "violation of the gastrointestinal tract." Grade 4 patients with infected mesh or septic dehiscence are considered "infected." Based on the hernia grade, the authors propose a plan for the appropriate use of synthetic vs biologic mesh. However, the VHWG grading system was based on expert opinion after literature review rather than on direct patient data.[2]

The VHWG model was later modified into a 3-tier system by Kanters and colleagues.[3] Although this study was performed on patient data, the authors adapted the original VHWG and omitted certain hernia characteristics and variations in operative technique that might influence the rate of postoperative complications. Important hernia-related factors, such as presence of an incarcerated hernia, concomitant surgery, acute presentation, and surgery-related factors, such as operative time, use of drains, and extent of tissue dissection, can also affect SSO and SSI rates. Finally, the National Nosocomial Infection Surveillance (NNIS) Risk Index is a well-accepted risk-assessment tool, but was created to predict the risk of SSI after surgical procedures in general and has not been validated for ventral hernia repairs or SSO specifically.[4] To our knowledge, there is currently no validated risk-assessment tool based on direct patient data to evaluate the risk of SSO or SSI after OVHR.

Therefore, the goals of the current study were to identify factors associated with SSO and SSI for patients undergoing OVHR, develop prognostic risk-assessment scores for SSO and SSI, and compare their performance against existing risk-assessment tools. We hypothesize that risk-assessment scores derived from direct patient data and specific to open ventral hernias will outperform existing paradigms.

METHODS

We conducted a retrospective cohort study on all consecutive patients undergoing OVHR by the general surgery service at the Michael E DeBakey Veterans Affairs Medical Center from 2000 through 2010. Institutional Review Board approval was obtained. Patients were divided into 2 groups based on presence of SSO. We adopt a previously established definition to identify SSO: SSI at 30 days, seroma, hematoma, wound dehiscence, or formation of a fistula, as determined from review of the electronic medical records by trained chart abstractors or clinicians.[2,3] All abstractors were trained on a data dictionary before chart review, and a quality check was performed that entailed a random selection of 10% of all cases that were then reviewed in total by the senior author. To determine the presence of SSI, we used the guidelines described by the Center for Disease Control and Prevention.[5] Seromas were recorded if the patient had radiographic evidence of fluid collection or clinical evidence of a seroma.

Patient demographic, clinical, and intraoperative data were also abstracted from the medical records. Demographic data included age, race, and sex. Clinical factors included body mass index (BMI), history of diabetes mellitus, insulin use, benign prostatic hypertrophy, steroid use, history of cancer, current smoker, alcohol use disorder, and American Society of Anesthesiologists (ASA) score. Surgical factors included earlier SSI, earlier ventral hernia repair, earlier abdominal surgery, earlier mesh implant, and NNIS score. Hernia characteristics included whether the hernia was primary or incisional; whether the procedure was elective or acute; whether the hernia repair was concomitant, incarcerated, and/or recurrent; and hernia defect area. Incisional hernias were defined as hernias that formed in the location of a previous incision.[6] Concomitant hernia repairs were defined as those repaired during a procedure for another surgical indication. Hernia defect area was approximated using the formula for an ellipse. Intraoperative factors collected included wound class, duration of operation, use of preoperative antibiotics, mesh implantation, type of mesh, dissection techniques, and use of drains. Fascial flaps were defined as an incision made on the fascia to facilitate medial advancement, such as "relaxing fascial incision, component separation, Chevrel technique," noted in the operative dictation. The creation of skin flaps was defined as a maneuver that dissected the skin and subcutaneous tissue off of the anterior abdominal wall fascia.

Secondary outcomes included length of stay, admission to the ICU, urinary tract infection, pulmonary infection, ileus, 30-day readmission, reoperation, hernia recurrence,

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