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External Validation of the HERNIAScore: An Observational Study

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Abstract

Background—The HERNIAScore is a ventral incisional hernia (VIH) risk assessment tool that utilizes only preoperative variables and predictable intraoperative variables. The aim of this study was to validate and modify, if needed, the HERNIAScore in an external dataset.

Study Design—This was a retrospective observational study of all patients undergoing resection for gastrointestinal malignancy 2011–2015 at a safety-net hospital. Primary outcome was clinical postoperative VIH. Patients were stratified into low, medium, and high risk based on HERNIAScore. A Revised HERNIAScore was formed with the addition of prior abdominal surgery as a categorical variable. Cox regression of incisional hernia with stratification by risk class was performed. Incidence rates of clinical VIH formation within each risk class were also calculated.

Results—247 patients were enrolled. On Cox regression, in addition to the three variables of the HERNIAScore (BMI, incision length, and COPD), prior abdominal surgery was also predictive of VIH. The Revised HERNIAScore demonstrated improved predictive accuracy for clinical VIH. While the original HERNIAScore effectively stratified the risk of developing an incisional radiographic VIH, the Revised HERNIAScore provided a statistically significant stratification for both clinical and radiographic VIHs in this patient cohort.

Conclusion—We have externally validated and improved the HERNIAScore. The Revised HERNIAScore utilizes BMI, incision length, COPD, and prior abdominal surgery to predict risk of post-operative incisional hernia. Future research should assess methods to prevent incisional hernias in moderate-to-high risk patients.

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INTRODUCTION

Ventral incisional hernias (VIH) are a common iatrogenic complication following abdominal surgery. The prevalence of clinically diagnosed VIH following abdominal surgery ranges from 0 to 33 percent, with substantial variation cited among different studies (1, 2, 3). The prevalence of occult VIH, or hernias noted on radiographic imaging but not on clinical exam, is believed to be twice that of clinically apparent hernias. The clinical significance of these occult hernias, however, remains unknown.

Various models have been published to predict a patient's risk of VIH formation following abdominal surgery. The majority of models, however, use post-operative variables that limit their use for patient counseling and in implementing pre-operative or intra-operative interventions (1, 2, 4, 5, 6, 7). The HERNIAScore is a VIH risk assessment tool that utilizes only preoperative variables and predictable intra-operative variables: body mass index (BMI), chronic obstructive pulmonary disease (COPD), and incision length (laparoscopic, extended laparoscopy, or laparotomy) (8). This score was developed and internally validated among patients receiving a wide variety of abdominal surgeries of varying specialties among a Veterans Affairs population. The primary outcome in this previous study for model development, presence of hernia, was determined through clinical exam with on-demand radiographic imaging (8). Before incorporating the model into practice management guidelines, the HERNIAScore requires validation in separate cohorts. We also believed that we could further refine the model by studying an additional cohort and adding previous abdominal surgery as a categorical variable.

The aims of this study were as follows: 1) To determine the prevalence of radiographic and clinical preoperative and postoperative ventral hernias in a population of patients undergoing resection for gastrointestinal malignancy, and 2) to validate and modify (if necessary) the HERNIAScore in an external dataset.

METHODS

This was a retrospective observational study. Following institutional review board approval, all patients undergoing resection for gastrointestinal malignancy from January 2011 to December 2015 at a single safety-net hospital (Lyndon Baines Johnson Hospital in Houston, Texas) were included. This study population was chosen because a large proportion of these patients have both preoperative and postoperative computed tomography (CT) scanning. Inclusion criteria were (1) patients undergoing abdominal operation for gastrointestinal malignancy with a midline abdominal incision, and (2) patients with documented preoperative and postoperative CT scans. Strengthening the Reporting of Observational Studies in Epidemiology guidelines were followed (9).

Patient demographics, comorbidities, intraoperative data, and postoperative data were obtained through the electronic medical record and defined in accordance with the National Surgical Quality Improvement Project (NSQIP) or European Hernia Society guidelines (10, 11). Three blinded, independent, and trained abstractors assessed CT scans for a ventral hernia utilizing a standardized method of reviewing CT scans that has previously been

validated (12). The preoperative CT scan closest to the operative date and the most recent postoperative CT scan with no intervening reoperation were chosen for analysis. The index operation was defined as the gastrointestinal cancer resection. An operation was coded as extended laparoscopic if it included an extended extraction site (ie laparoscopic colectomy, hand-assisted colectomy). For extended laparoscopic operations, patients underwent sutured closure with interrupted or figure-of-8 polyglactin 910 sutures. For laparotomies, patients underwent sutured closure with running 0-polydioxanone sutures.

Primary outcome was clinical postoperative VIH. Secondary outcomes included radiographic postoperative VIH and preoperative ventral hernia. A radiographic ventral hernia was defined as any ventral abdominal wall gap visible by imaging (11). The original HERNIAScore utilizes laparotomy, extended laparoscopy, chronic obstructive pulmonary disease (COPD), and body mass index (BMI) as categorical variables. Thus, a patient is assigned 4 points if he has undergone laparotomy; 3 points if he has undergone extended laparoscopy; 1 point if he has COPD; and 1 point if his BMI is equivalent to or greater than 25 kg/m². Maintaining the recommendations of the authoring paper, Hernia Class I (low risk) consisted of patients having a HERNIAScore 0 to 3; Hernia Class 2 (medium risk) consisted of HERNIAScore 4 to 5; and Hernia Class 3 (high risk) consisted of HERNIAScore 6 points (8).

To assess the need for refinement of the HERNIAScore model, a Cox regression was performed with the new dataset. The Revised HERNIAScore was developed by rounding each hazard ratio to the nearest integer minus one.

Univariate analysis was performed using the appropriate test (t-test or Mann-Whitney U for continuous data and Pearson's chi square for categorical data). In order to determine if the 3 risk strata defined by the HERNIAScore and the Revised HERNIAScore corresponded to differences in time to VIH formation (external validation), Cox regression of incisional hernia with stratification by risk class was performed. The efficacy of stratification by hernia formation was also assessed via incidence rates of clinical and radiographic VIH within each HERNIAScore and Revised HERNIAScore risk class. As this sample examined all patients satisfying the inclusion criteria during this time period, no power calculations were performed. STATA Version 14 (StataCorp, College Station, TX) was used for statistical analysis.

RESULTS

A total of 247 patients were enrolled and followed for a median (range) of 21.4 (0.4–66.1) months. Nine patients had had prior ventral hernia repair. Half of all patients had a ventral hernia noted on radiographic imaging prior to (145/247, 58.7%) and following (114/247, 46.2%) the index operation. Of patients with preoperative and postoperative ventral hernias, 2/3s were occult and 1/3s were clinically apparent.

Following index gastrointestinal surgery, approximately half of all patients developed an occult or clinical hernia (radiologic 114/247, 46.2%, clinical 36/247, 14.6%). Patients who developed an occult or clinical hernia differed significantly from patients who did not

develop a post-operative hernia with regards to gender (male no hernia 57.1% versus clinical or occult hernia 44.7%, $p=0.035$), prior abdominal surgery (no hernia 31.6% versus clinical or occult hernia 45.6%, $p=0.016$), and follow-up duration (no hernia median 16.8 months, interquartile range 8.3–32.2 versus clinical or occult hernia median 25.1 months, interquartile range 13.9–39.2, $p=0.005$). Other preoperative, surgical, and postoperative variables evaluated did not statistically differ between study groups (Tables 1, 2, and 3).

On cox regression, an additional predictive variable was identified, prior abdominal surgery (Table 4). The Revised HERNIAScore was developed in which low risk was designed 0 to 6.9 points; medium risk 7.0 to 9 points; and high-risk equal to or greater than 9 points. The original HERNIAScore effectively predicted and stratified the risk of developing a post-operative radiographic, but not clinical, VIH (Figure 1 and 2). Only radiographic VIH occurrence significantly differed per HERNIAScore class (Table 5). The Revised HERNIAScore was associated with improved and statistically significant stratification for both clinical and radiographic incisional hernias (Table 5, Figures 3 and 4).

DISCUSSION

We have improved and validated the HERNIAScore for both clinically apparent and radiographic VIH in an external dataset. The original HERNIAScore was developed and validated in a veteran population undergoing a wide variety of abdominal surgeries with an outcome of either clinical or radiographic hernia. Our new model incorporates the features of the original model, distinguishes clinical from radiographic hernias, and adds prior abdominal surgery. Our HERNIAScore models remain important scoring systems because they are among the few, if not only, models to include only preoperative and easily predictable intraoperative factors. Other scoring systems evaluate additional preoperative factors (chemotherapy, age, gender, thickness of subcutaneous fat, malnutrition, tobacco use, liver disease, ostomy reversal, acute gastrointestinal inflammatory process), operative factors (wound class, blood transfusion, suture type, continuous versus interrupted suture), and postoperative factors (surgical site infection) (1, 2, 4, 6, 7). These other scoring systems either use variables that are difficult to obtain or variables that cannot be easily determined prior to the operation.

Multiple studies have alluded to an association between prior abdominal surgeries and incisional hernia risk (7, 13). Our inclusion of prior abdominal surgeries to strengthen our original HERNIAScore is therefore not unexpected and is consistent with previous literature. The univariate analysis of our own data in the present study also reflects meaningful differences in this variable between patients who did and did not develop an incisional hernia.

A large proportion (approximately half) of our patient sample had radiographic hernias that were observed prior to and following the index operation. The prevalence of radiographic hernias before and after abdominal surgery is substantial. Our rates of incisional hernia (42.9% of patients at 60 months) may be higher than those described by previous literature (14, 15, 16, 17) due to our considerably longer follow-up duration than that of other studies (60 months); our examination of both radiographic and clinical hernias, as opposed to only

clinical; and our high-risk population. The patient sample utilized for this paper is largely comprised of uninsured, Medicaid-receiving, or vulnerable individuals seeking care at a safety-net institution (18). This group comprises 27 million people (19), or 8.5% of the US population. Prior studies have suggested that the prevalence of radiographic primary ventral hernias and radiographic VIH is significantly greater than that of clinically apparent hernias. However, the clinical significance of occult hernias remains unknown. No matter the reasoning, our detected high rate of radiographic hernias does align with some prior studies (20, 21). A study utilizing high- resolution ultrasound, for example, to determine the prevalence of paraumbilical hernias among adult patients in a tertiary care hospital presenting for non-abdominal wall complaints detected an approximately 25% rate (22). Our data, in light of high incisional hernia rates, highlights the need for preoperative risk modification and operative intervention for high-risk patients.

While preoperative radiographic hernias were not associated with radiographic or clinical incisional hernias in the current patient cohort, we have previously found preoperative radiographic hernias to be associated with radiographic incisional hernias in patients without prior abdominal surgery (23). Our current patient sample differed from our previous studies in that it now included patients with and without previous abdominal surgery.

Limitations of this study include power and small sample size. However, even with our limited data size, we were still able to show that the Revised HERNIAScore distinguished patients into 3 separate groups, utilizing outcomes of either clinical or radiographic hernia, based on risk, supporting the strength of the model.

By demonstrating the stratification of patients of an external dataset into 3 distinct categories using the Revised HERNIAScore, we have shown that this prediction model is generalizable. Future steps should include the validation of the Revised HERNIAScore in other patient populations as well as the development of strategies to prevent hernia formation in high- risk patients. Such strategies may include prehabilitation programs that emphasize weight loss, suturing techniques, or prophylactic mesh.

CONCLUSIONS

Radiographic hernias may be observed in approximately half of patients undergoing a gastrointestinal cancer resection preoperatively and postoperatively. We have modified and validated the HERNIAScore for clinically apparent and radiographic VIH among this patient population in which patients receive 1 point for a BMI greater than or equal to 25; 1 point for COPD; 5 points for extended laparoscopy; 6 points for laparotomy; and 3 points for previous abdominal surgery. Future research should determine the clinical significance of occult hernias as well as assess methods to prevent incisional hernias in patients in the moderate- and high-risk Revised HERNIAScore classes.

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Figure 1.

Cox proportional hazards regression model, stratified by HERNIAScore (Outcome: Clinical Hernia)

Figure 2.
Cox proportional hazards regression model, stratified by HERNIAScore (Outcome: Radiographic Hernia)

Figure 3.
Cox proportional hazards regression model, stratified by Revised HERNIAScore (Outcome: Clinical Hernia)

Figure 4.
Cox proportional hazards regression models, stratified by Revised HERNIA score (Outcome: Radiographic Hernia)

Table 1

Preoperative Variables of the Patient Sample

Variable	Postoperative			P Value
	No hernia (n=133)	Occult hernia * (n=78)	Clinical hernia (n=36)	
Age, mean (SD)	55.9 (11.1)	56.4 (9.2)	56.8 (10.2)	0.201
Gender, male, n (%)	76 (57.1)	39 (50.0)	12 (33.3)	0.038
Ethnicity, n (%)				0.679
Hispanic	62 (46.6)	31 (39.7)	16 (44.4)	
Black	48 (36.1)	27 (34.6)	12 (33.3)	
Other	23 (17.3)	20 (25.6)	8 (22.2)	
BMI, mean (SD)	28.2 (6.9)	28.1 (7.0)	28.5 (7.1)	0.950
ASA, n (%)				0.918
1,2	26 (19.5)	17 (21.8)	7 (19.4)	
3,4	107 (80.5)	61 (78.2)	29 (80.6)	
Tobacco use, n (%)	26 (19.5)	18 (23.1)	8 (22.2)	0.818
COPD, n (%)	2 (1.5)	6 (7.7)	1 (2.8)	0.065
Diabetes mellitus, n (%)	34 (25.6)	21 (26.9)	8 (22.2)	0.866
Prior abdominal surgery, n (%)	42 (31.6)	29 (37.2)	23 (63.9)	0.002
Albumin, Mean (SD)	3.5 (0.8)	3.6 (0.6)	3.7 (0.6)	0.010
Hemoglobin, A1C, mean (SD)	6 (2.1)	6.2 (2.3)	6.2 (1.8)	0.682
Cancer Stage , n (%)				0.602
0	0	1 (1.3)	1 (2.8)	
1	14 (10.5)	6 (7.7)	3 (8.3)	
2	37 (27.8)	21 (26.9)	12 (33.3)	
3	50 (37.6)	29 (37.2)	13 (36.1)	
4	28 (21.1)	20 (25.6)	4 (11.1)	
Chemotherapy, n (%)				0.531
None	42 (31.6)	21 (26.9)	14 (38.9)	
Pre- only	5 (3.8)	7 (9.0)	2 (5.6)	
Post- only	59 (44.4)	30 (38.5)	14 (38.9)	
Pre- and Post-	27 (20.3)	20 (25.6)	6 (16.7)	
Preoperative radiographic ventral hernia, n (%)	78 (58.6)	42 (53.8)	25 (69.4)	0.290

* Occult hernia: Hernia noted on radiological imaging but not clinical exam.

ASA, American Association of Anesthesiologists; SSI, surgical site infection

Table 2

Operative Variables of the Patient Sample

Variable	No hernia (n=133)	Occult hernia [*] (n=78)	Clinical hernia (n=36)	p Value
Surgery, n (%)				0.419
Laparoscopic	20 (15.0)	10 (12.8)	2 (5.6)	
Extended laparoscopic	46 (34.6)	24 (30.8)	10 (27.8)	
Open	67 (50.4)	44 (56.4)	24 (66.7)	
Emergency Surgery, n (%)	16 (12.0)	10 (12.8)	3 (8.3)	0.778
Intraoperative blood transfusion, n (%)	6 (4.5)	4 (5.1)	2 (5.6)	0.958

* Occult hernia: Hernia noted on radiological imaging but not clinical exam.

ASA, American Association of Anesthesiologists; SSI, surgical site infection

Table 3

Postoperative Variables of the Patient Sample

Variable	No Hernia (n=133)	Occult hernia* (n=78)	Clinical hernia (n=36)	p Value
SSI, n (%)	14 (10.5)	8 (10.3)	9 (25.0)	0.051
Surgical repair of VIH that occurred after index operation, n (%)	0	2 (2.6)	13 (36.1)	<0.001
Follow-up,months,median (IQR)	16.5 (8.2–31.7)	22.0 (12.2–32.7)	34.6 (16.9–44.7)	<0.001

* Occult hernia: Hernia noted on radiological imaging but not clinical exam.

ASA, American Association of Anesthesiologists; SSI, surgical site infection; VIH, ventral incisional hernia

Table 4

Multivariable Cox Regression Analyses: Main Analysis of Current Cohort with Prior and Revised HERNIAScore

Variable	Original HERNIAScore (development cohort) (n=428) [†]		Revised HERNIAScore (current cohort) (n=247)	
	Hazard ratio	95% CI	Hazard ratio	95% CI
BMI ≥ 25 kg/m ²	1.7	1.0–2.9	1.3	0.6–2.7
COPD	2.4	1.4–3.8	1.4	0.2–10.3
Surgery				
Extended laparoscopy	4.0	2.1–7.7	2.6	0.6–11.9
Open	4.8	2.6–8.7	2.8	0.7–12.1
Prior abdominal surgery	N/A	N/A	1.9	1.0–3.8
Formula	HERNIAScore = 1*(BMI greater than or equal to 25) + (1*COPD) + (3*extended laparoscopy) + (4*laparotomy)		Revised HERNIAScore = 1*(BMI greater than or equal to 25) + (1*COPD) + (5*extended laparoscopy) + (6*laparotomy) + (3*prior abdominal surgery)	

[†]Data for development cohort obtained from Goodenough et al, 2015 (8).

Extended laparoscopy, operations involving an extended extraction site (ie laparoscopic colectomy, hand-assisted colectomy)

Table 5

Predictive Score for and Actual Rate of Clinical Ventral Incisional Hernia After Abdominal Surgery

Variable	Risk level, %			p Value
	Low	Moderate	High	
Original HERNIAScore				
Development risk group (n=428) *				
Clinical VIH (n=70)	6.8	23.2	50.0	<0.001
Internal validation risk group (n=197) *				
Clinical VIH (n=23)	2.0	19.6	75.0	<0.001
External validation (current study) risk group (n=247)				
Clinical VIH (n=36)	5/60 (8.3)	30/183 (16.4)	1/4 (25.0)	0.258
Radiographic (n=114)	23/60 (38.3)	79/183 (43.2)	4/4 (100.0)	0.054
Revised HERNIAScore				
Clinical VIH (n=36)	7/101 (6.9)	8/73 (11.0)	21/73 (28.8)	<0.001
Radiographic VIH (n=114)	38/101 (37.6)	26/73 (35.6)	42/73 (57.5)	0.011

VIH, ventral incisional hernia

* Data for development and internal validation cohorts obtained from Goodenough et al, 2015 (8).