**SUPPLEMENTAL MATERIAL**

**SUPPLEMENTAL METHODS**

*Patient Selection*

We designed our study to include incisional hernias. Due to the switch from ICD-9 to ICD-10 on October 1, 2015 both sets of codes were used. We began by selecting ‘incisional hernia’ ICD codes. Because coding can be incorrect, we also reviewed other abdominal wall hernia codes (‘umbilical’, ‘parastomal’, ‘other ventral’) by random audit of a selection of patient records to determine the sensitivity and specificity for capturing incisional hernias. From an initial list of 34 abdominal wall hernia ICD codes, the following ICD-9 diagnosis codes were used for encounters prior to October 1, 2015: 552.29, 553.20, 553.21, 552.21, 553.29, 552.20, 551.29, 551.21, 551.20, 553.0, and the following ICD-10 diagnosis codes were used for encounters after October 1, 2015: K43.2, K46.9, K43.9, K43.6, K43.0, K43.1, K43.7. (*Supplemental Table 2*). On manual review we observed that at our institution a majority (60-70%) of patients with a ‘ventral hernia’ ICD code have an incisional hernia. To maximize the sensitivity and accuracy of capturing all incisional hernias, we elected to include these ventral hernia codes. Overall, this strategy excluded >90% of non-incisional ventral hernias (umbilical, epigastric, parastomal, spigelian and lumbar).

To assess the performance of our identification of patients with incisional hernias using our 17 selected ICD-9/ICD-10 diagnosis codes, multiple audits were performed. First, an audit was performed on 100 randomly-selected patients from our entire study population utilizing the 17 selected ICD codes in order to ascertain the false discovery rate. Of these, 81 had incisional hernias, while the remaining 19 had either a primary, parastomal, internal, or hiatal hernia. Second, a similar audit was performed again on the entire patient dataset using the 17 unselected ICD-9/ICD-10 diagnosis codes to obtain the false omission rate. This resulted in only 8 incisional hernias out of 100 patients that were screened. The sensitivity of our selection of patients with incisional hernias thus was 91%, the specificity was 83%, and the overall accuracy was 86.5%.

Next, we examined a random selection of 100 patients from the 23,022 patients who underwent initial NOM to examine the accuracy of the denominator for the incidence calculations. The patients in this group all contributed to the total number of patient-years. Of the 100 patients audited, 74% had a true incisional hernia; the remaining consisted of: 8 patients with a misdiagnosis (i.e. patients whose follow-up surgical evaluation or radiologic imaging showed no evidence of a hernia), 6 with inguinal hernias, 5 with primary umbilical hernias, 3 with parastomal hernias, 2 with hiatal hernias, and 2 with primary epigastric hernias. Lastly, we reviewed the charts of all 540 patients with an incarceration event. This revealed 483 patients (89%) who had a true incisional hernia. Of the 57 (11%) without an incisional hernia, 43 had primary umbilical hernias, 7 had Spigelian hernias, 4 had parastomal hernias, and 3 had primary epigastric hernias.

We hypothesized that, especially among patients with incisional hernias, very few patients with a history of prior surgery and abdominal pain would be ‘underdiagnosed’ with e.g. a diagnosis of ‘abdominal pain’, as this patient population is highly likely to undergo CT imaging with identification of the hernia. We reviewed our cohort of hernia patients to identify those patients with a diagnosis of abdominal pain (ICD-9: 789.00, ICD-10 R10.9) that precedes an ICD diagnosis of incisional hernia. This would represent a potential situation in which a hernia was miscoded and missed initially. This occurred in only 66 of 30,998 patients (0.2%). Also, none of the 800 patients in whom an incarceration event established the hernia diagnosis had a prior diagnosis of abdominal pain, indicating their hernia was not previously miscoded as ‘abdominal pain’.

While the use of big data allows for exploration of a large population of patients, screening by ICD codes is associated with certain limitations which have previously been outlined by others1,2. Although a small proportion of patients in our group were not found to have a ventral hernia, the vast majority had a true incisional hernia with the remainder mostly displaying non-incisional but ventral abdominal hernias. Manual audit of the charts confirms the veracity of our cohort and confirms that we have captured almost all of the patients with an incisional hernia diagnosis within our system.

*Assessment of outcomes*

 The primary outcome for non-operative management was acute incarceration. Patients were censored if death without an incarceration event occurred, or if they underwent late elective repair. For the remainder of the cohort, we assumed successful NOM until the end of the study period. To verify the appropriateness of this assumption, we randomly sampled 100 patients from our cohort and found that only 1 patient did not have any encounter after the date of diagnosis. 77% had a clinical encounter beyond the end of the study period. Of the remaining 22 patients, median time from date of diagnosis to most recent clinical encounter was >2 yrs. Although the above argumentation shows that the effect of this assumption can be considered small, it caused an overestimation of total number of years of follow-up resulting in a slight underestimation of the true risk of incarceration.

*Clinical Prediction Rule*

The decision tree was constructed using Python 3.7.3 (Python Software Foundation), Numpy 1.16.43, Pandas 0.24.24, and Sklearn 0.21.25 packages. Hyperparameters were limited to 4 layers and 4 leaf nodes. Optimal hyperparameters were found by grouped 10-fold cross-validation making sure that the patients from multiple imputations did not cross between training and testing. This process was repeated 100 times with new imputations and the mode for each hyperparameters was selected. The optimal hyperparameters were then used to determine the best tree structure. The analysis was run 100 more times and the most common tree structure was selected.

**SUPPLEMENTAL REFERENCES**

1. Fawcett N, Young B, Peto L, et al. ‘ Caveat emptor ’ : the cautionary tale of endocarditis and the potential pitfalls of clinical coding data — an electronic health records study. *BMC Med*. 2019;17:1–15.

2. O’Malley KJ, Cook KF, Price MD, et al. Measuring diagnoses: ICD code accuracy. *Health Serv Res*. 2005;40:1620–1639.

3. Oliphant TE. A guide to NumPy (Vol. 1).

4. McKinney W. Data structures for statistical computing in python. 2010;51–56.

5. Pedregosa F, Varoquax G, Gramfort A, et al. Scikit-learn. *J Mach Learn Res*. 2011;12:2825–2830.

**SUPPLEMENTAL TABLES**

**Supplemental Table 1.**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Odds ratio  | 95% Confidence Interval | P-value |
| Age (years)* <40
* 40-49
* 50-59
* 60-69
* 70-79
* ≥80
 | Reference0.840.88 0.991.322.43 | Reference0.76, 0.930.80, 0.970.90, 1.091.19, 1.472.11, 2.80 | Reference0.001<0.010.85<0.001<0.001 |
| Female Gender | 0.79 | 0.74, 0.83 | <0.001 |
| Race* Caucasian
* African American
* Asian
 | Reference1.351.28 | Reference1.21, 1.510.67, 2.48 | Reference<0.0010.46 |
| Smoking status* Never smoker
* Current smoker
* Former smoker
 | Reference0.901.0 | Reference0.84, 0.970.93, 1.07 | Reference<0.010.97 |
| BMI (kg/m2)* <30 (normal or overweight)
* ≥30 (obese)
 | Reference0.95 | Reference0.89, 1.02 | Reference0.14 |
| Median income (dollars)* Q1 (0-41921)
* Q2 (41922-49844)
* Q3 (49845-59427)
* Q4 (59428-111636)
 | Reference0.810.820.80 | Reference0.75, 0.880.76, 0.890.73, 0.87 | Reference<0.001<0.001<0.001 |

**Supplemental Table 1. Predictors of Early Elective Repair versus Non-operative Management.** Multinomial logistic regression analysis was performed to determine predictors of patients selecting for Non-Operative Management over Early Elective Repair. Data are reported as odds ratios with 95% confidence intervals with corresponding p values. BMI (body mass index), Q (quartile).

**Supplemental Table 2.**

|  |  |  |
| --- | --- | --- |
| **ICD-9 Code** | **Code Description** | **Selection for Study** |
| 551.1 | Umbilical hernia with gangrene | No |
| 552.1 | Umbilical hernia with obstruction | No |
| 551.20 | Ventral hernia, unspecified, with gangrene | Yes |
| 551.29 | Other ventral hernia with gangrene | Yes |
| 552.20 | Ventral, unspecified, hernia with obstruction | Yes |
| 552.29 | Other ventral hernia with obstruction | Yes |
| 553.20 | Ventral, unspecified, hernia without mention of obstruction or gangrene  | Yes |
| 553.29 | Other ventral hernia without mention of obstruction or gangrene | Yes |
| 551.21 | Incisional ventral hernia, with gangrene | Yes |
| 552.21 | Incisional ventral hernia with obstruction | Yes |
| 553.21 | Incisional hernia without mention of obstruction or gangrene | Yes |
| 551.8 | Hernia of other specified sites, with gangrene | No |
| 551.9 | Hernia of unspecified site, with gangrene | No |
| 552.8 | Hernia of other specified sites, with obstruction | No |
| 552.9 | Hernia of unspecified site, with obstruction | No |
| 553.8 | Hernia of other specified sites without mention of obstruction or gangrene | No |
| 553.9 | Hernia of unspecified site without mention of obstruction or gangrene | Yes |
|  |  |  |
| **ICD-10 Code** | **Code Description** | **Selection for Study** |
| K42.0 | Umbilical hernia with obstruction, without gangrene | No |
| K42.1 | Umbilical hernia with gangrene | No |
| K43.0 | Incisional hernia with obstruction, without gangrene | Yes |
| K43.1 | Incisional hernia with gangrene | Yes |
| K43.2 | Incisional hernia without obstruction or gangrene | Yes |
| K43.3 | Parastomal hernia with obstruction, without gangrene | No |
| K43.4 | Parastomal hernia with gangrene | No |
| K43.5 | Parastomal hernia without obstruction or gangrene | No |
| K43.6 | Other and unspecified ventral hernia with obstruction, without gangrene | Yes |
| K43.7 | Other and unspecified ventral hernia with gangrene | Yes |
| K43.9 | Ventral hernia without obstruction or gangrene | Yes |
| K45.0 | Other specified abdominal hernia with obstruction, without gangrene | No |
| K45.1 | Other specified abdominal hernia with gangrene | No |
| K45.8 | Other specified abdominal hernia without obstruction or gangrene | No |
| K46.0 | Unspecified abdominal hernia with obstruction, without gangrene | No |
| K46.1 | Unspecified abdominal hernia with gangrene | No |
| K46.9 | Unspecified abdominal hernia without obstruction or gangrene | Yes |

**Supplemental Table 2. ICD codes of non-inguinal abdominal wall hernia diagnosis.** From an initial list of 34 ICD codes, 17 codes were selected in order to screen patients for inclusion within the study. ICD-9 codes were utilized for patients presenting before October 1, 2015 and ICD-10 codes were utilized thereafter.

**SUPPLEMENTAL FIGURE LEGEND**

**Supplemental Figure 1. Schematic depicting patient allocation into outcome groups.** This flowchart details how the large dataset was strategically mined to classify patients to the correct treatment and outcome groups.

**Supplemental Figure 1**

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