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Machine Learning Approach for the Prediction of Hernia Recurrence, Postoperative Complication, and 30-Day Readmission After Abdominal Wall Reconstruction

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Disclosures

The authors have nothing to disclose

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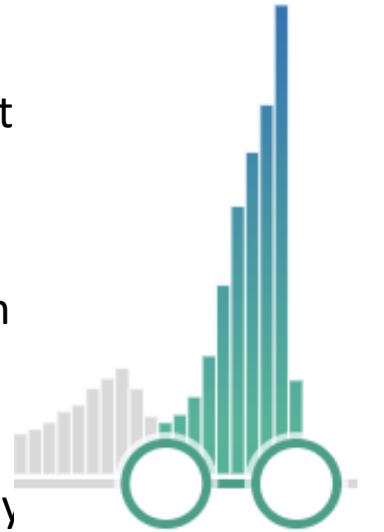
Introduction

- Artificial intelligence (AI) is an evolving field and has become a popular subject within and out scientific community.
- There was a 7000% increase in published manuscripts on Artificial Intelligence and surgery on from 2016 to 2022.
- The terms Machine Learning (ML), Deep learning (DL) and Artificial Intelligence (AI) are highly but not interchangeable.
- AI is focused on automating tasks that would be performed by humans while ML and DL are specific methods of achieving automation.
- Machine learning is a subfield of AI in which a computer is able to perform tasks with no previous instructions



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ORIGINAL ARTICLE

Machine learning, deep learning and hernia surgery. Are we pushing the limits of abdominal core health? A qualitative systematic review

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- 13 studies – 2020 – 2023
- Abdominal wall imaging
- Identification of surgical steps
- Predicting outcomes

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Table 1 Characteristics of the included studies

Author	Year	Country	Sample size	Hernia type	Type of machine learning used
Ayuso et al	2023	USA	510 CT scans	midline ventral hernia	image-based DLM
Choi et al	2023	USA	279	Umbilical and incisional	Logistic regression, neural networks, gradient boosting ma- chine, random forest, gradient boosted trees, CART, KNN and support vector machines
Cui et al	2021	Japan, China	35 patients	Inguinal hernia	CNN
Elhage et al	2023	Netherlands, UK, USA	369 patients	Ventral hernia	8-layer CNN
Gao et al	2021	USA	148,214	Inguinal hernia	ANN
Hassan et al	2022	USA	725 patients	ventral hernia	support vector machine, decision tree, generalized linear model, multiple adaptive regression splines, KNN, single hidden layer artificial neural network, random forest, and extreme gradient boosting
McAuliffe et al	2022	USA	9,685 patients	incisional hernia	SVM
O'Brien et al	2020	USA	96,435 surgeries	Inguinal and ventral hernia	NNR
Ortenzi et al	2023	USA	619 videos	Inguinal hernia	VTN, LSTM network
Takeuchi et al	2022	France	119 videos	Inguinal hernia	TeCNO + HMM
Yan et al	2023	China	11,305 patients	Inguinal hernia	LR, RF, SVM, GBT, TabNet
Zang et al	2023	USA	209 videos	Inguinal hernia	ResNet
Ortega et al	2023	France	600,016 patients	Incisional hernia	Binary splitting decision tree

Deep Learning Models, classification and regression trees, K nearest neighbors, convolutional neural network, 8-layer convolutional neural network, artificial neural networks, Support Vector Machine, Neural networking regression, Video transformer network, Long Short-Term Memory network, Temporal convolutional network, Hidden Markov Model, Residual neural networks

Table 2 Outcomes of the included studies

Author	Findings
Abdominal wall imaging	
Ayuso et al	Conventional DLMs were less effective for predicting both mesh infection and pulmonary failure. Conventional DLMs had higher accuracy and specificity but lower sensitivity for predicting mesh infection and pulmonary failure
Elhage et al	DLM performed better to predict surgical complexity when compared with six expert AWR surgeons. DLM was successful in predicting SSI
Inguinal Hernia Surgical steps	
Cui et al	Identified and labeled vas deferens using a CNN model during LIHR
Ortenzi et al	High accuracy of the algorithm in recognizing surgical steps
Takeuchi et al	High accuracy to identify unilateral or bilateral TAPP. System was able to monitor surgery progress and improve OR efficiency
Zang et al	High accuracy in determining surgical steps of Robotic IHR
Predicting outcomes	
Hassan et al	high mean accuracy rates of 85% (95% CI 80% to 90%), 72% (95% CI 64% to 80%), and 84% (95% CI 77% to 90%) for predicting recurrence, SSOs, and 30-day readmission
O'Brien et al	ML regression model that was able to identify long-term hernia associated skin and soft tissue infection
Choi et al	LR performed best in identifying factors related to increased likelihood of developing hernia after surgery
McAuliffe et al	ML identified widening of the rectus complex, increased visceral volume and body wall skeletal muscle atrophy as factors associated with IH
Ortega et al	Binary splitting decision tree algorithm identified laparotomy and age $\geq$ 40 years old as predictors factors of IH
Gao et al	No difference between ANN and LR for predicting morbidity, readmission and mortality after IHR
Yan et al	ML models Identified predictors of VTE after IHR

Incisional Hernia, Logistic regression, Artificial Neural Network, Convoluted Neural Network, Operating Room, Machine Learning, Venous Thromboembolism, Confidence Interval, Surgical Site Occurrence, Deep Learning Model, Abdominal Wall reconstruction, Laparoscopic Inguinal Hernia repair, Transbadominal Preperitoneal, Inguinal Hernia Repair

Objective

to develop, validate, and evaluate:

machine learning (ML) algorithms

for predicting complications (Surgical Site Infection, Surgical Site Occurrence, Readmission, Reoperation, ED Visit) after AWR

using the Abdominal Core Health Quality Collaborative (ACHQC) database

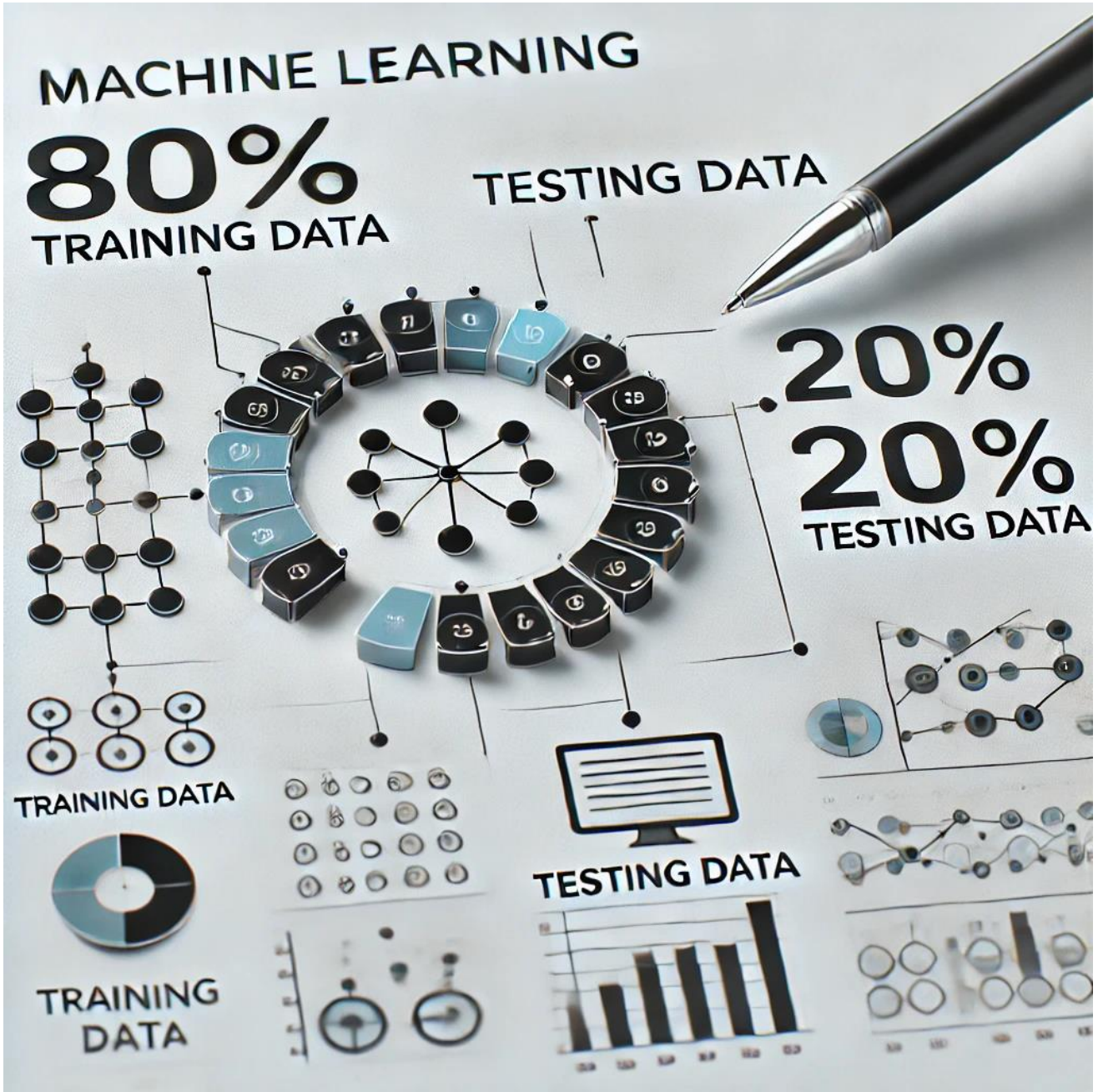
Outcomes of interest

Primary outcomes: SSI an SSO at 30 days

Secondary outcomes: readmissions, Length of stay, reoperation at 30 days

Inclusion criteria

- Incisional or primary ventral surgical procedure.
- 30 day follow up complete..
- Elective cases.
- Wound class: Clean or Clean-contaminated.
- Synthetic mesh
- Operative approach: Open, Laparoscopic, Robotic.
- Midline hernia classification: M1, M2, M3, M4, or M5.
- Excluded patients with concomitant procedures.



VENTRAL HERNIA RESAIR

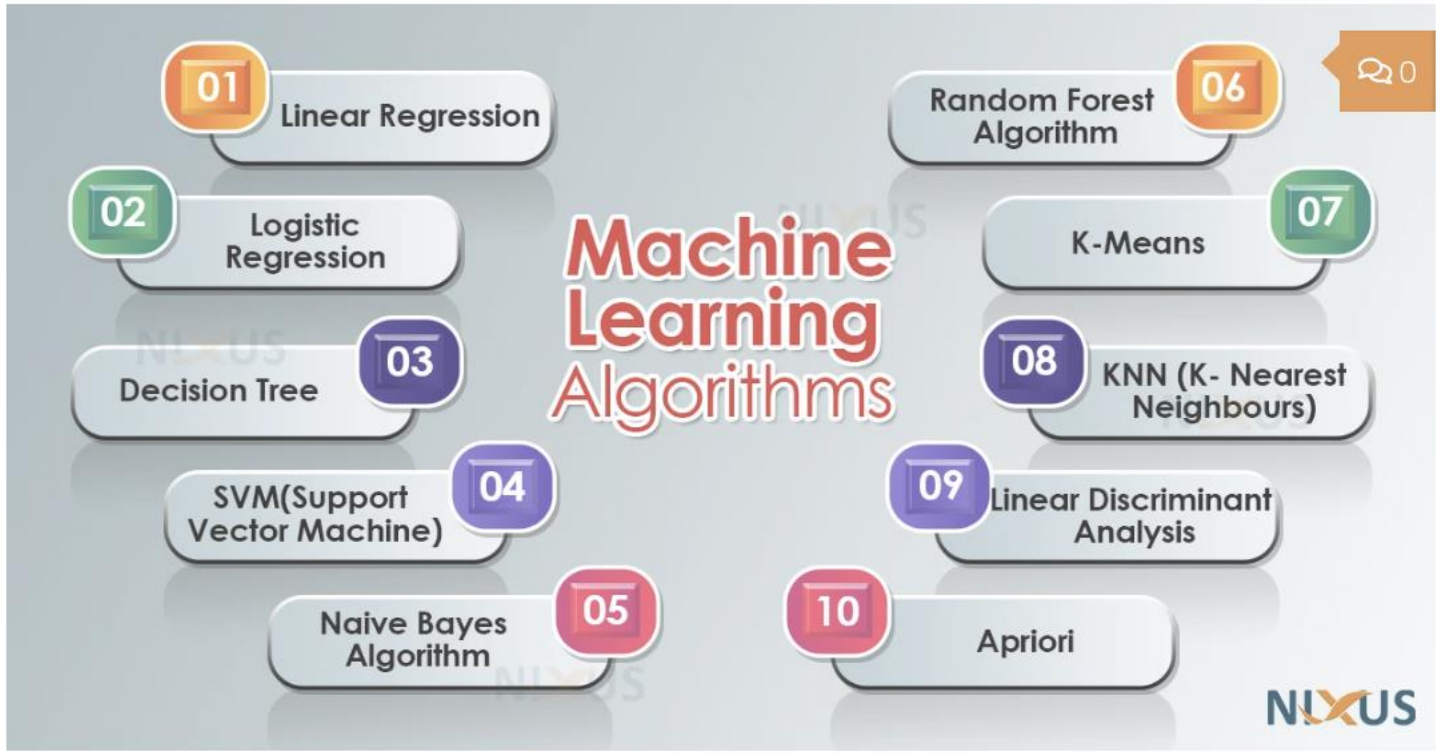
VENTRAL HERNIA RESAIR

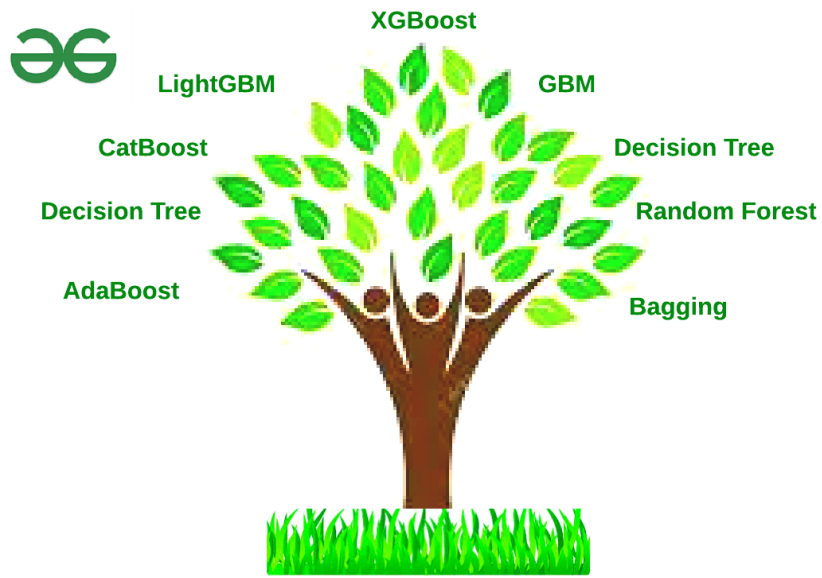
80%

18,065 patients

4,517

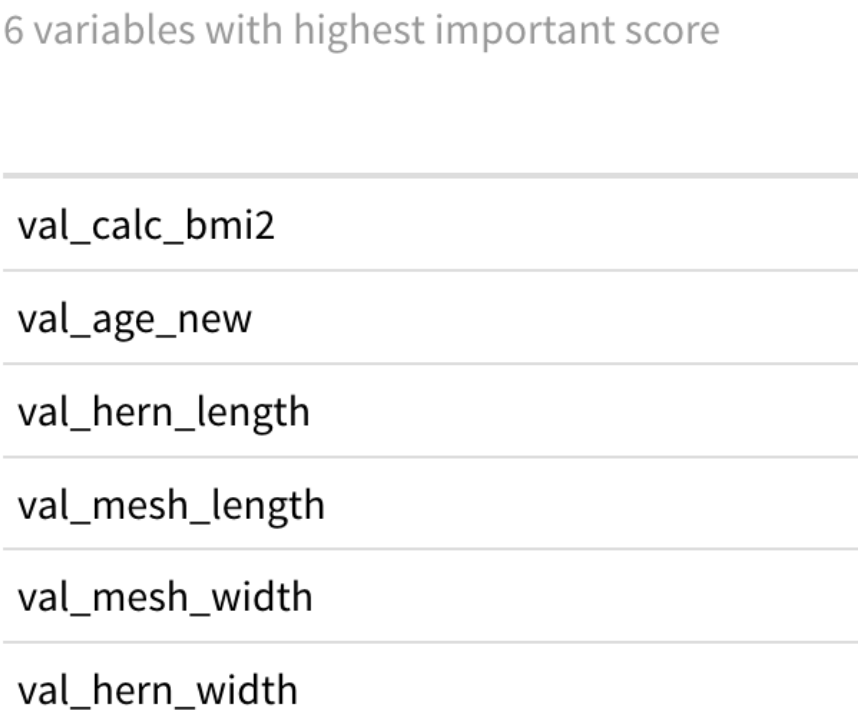
Testing data


Machine Learning Algorithms
01 Linear Regression
02 Logistic Regression
03 Decision Tree
04 SVM(Support Vector Machine)
05 Naive Bayes Algorithm
06 Random Forest Algorithm
07 K-Means
08 KNN (K- Nearest Neighbours)
09 Linear Discriminant Analysis
10 Apriori
NIXUS


XGBoost
LightGBM
GBM
CatBoost
Decision Tree
Decision Tree
Random Forest
AdaBoost
Bagging

Random Forest for 30-day SSO

- Report on 30-day SSO because it has the most “Yes” answers compared with the other 30-day outcome variables.
- The machine learning will have better results when it can train with more “Yes” responses.
- Worked well in the training data, with only 2 misclassifications.
- The test data, only 18 of the 346 yes were correctly predicted.



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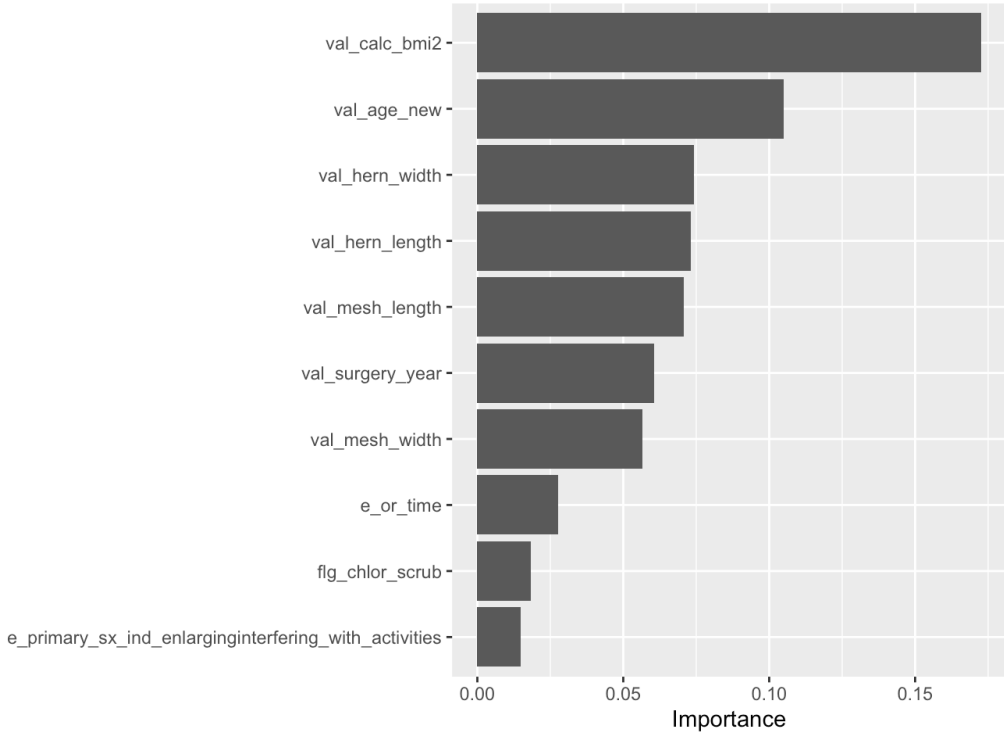
Extreme Gradient Boosting (xgBoost) for 30-day SSO

- Only correctly classified 137 yesses out of the 1073 total yesses in the training data.
- The result was much worse in the test data, where only 2 of 138 yesses were correctly predicted.
- The importance plot shows the 10 variables with the highest importance, with BMI having the most.



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WORK IN PROGRESS

Next steps

- Different machine learning model type
- More specific set of variables (less skewed)
- A machine learning model – LASSO:
- Will shrink regression coefficients to zero for variables that are not impactful to our prediction

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Future and challenges of ML and abdominal wall surgery

- Abdominal wall surgery is a common operation worldwide
- AI would be helpful in identifying the right surgical technique or if surgery would be the correct treatment option.
- In addition, ML may be able to predict challenging hernia repairs which should be referred to a specialized tertiary center.

Conclusions

- ML has reshaped the surgical field as it focus on learning relationships and patterns between variables, images and video.

- The use of ML for abdominal wall reconstruction has been shown to be a promising tool for predicting outcomes and identifying factors that could lead to postoperative complications

Thank you!

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