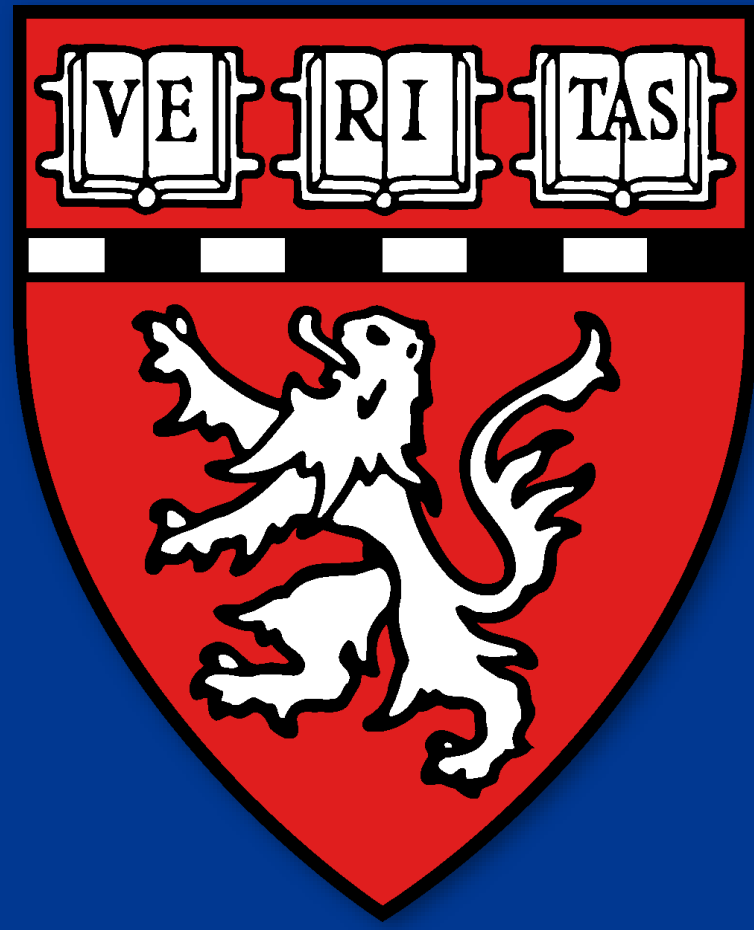




Predicting Neuraxial Analgesia Failure: A Retrospective Model Development Study



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Background

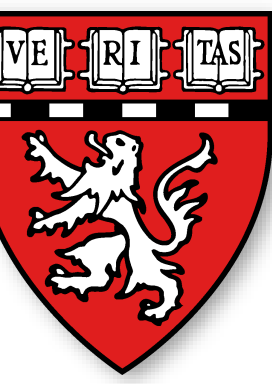
Labor neuraxial catheter failure rate: 5-15%
Decreased maternal satisfaction
Decreased patient safety
Prior studies limited by:
Single-institution data sets
Missing data

Known Risk Factors for Failure

Patient Factors	Procedural Factors	Post-Placement Factors
Age	Epidural > CSE/DPE	Dwell time
BMI	Intrathecal catheter	Breakthrough pain
Nulliparity	Non-OB subspecialist	Clinician boluses

No existing predictive models for catheter failure

Hypothesis: We can accurately predict neuraxial catheter failure



Methods



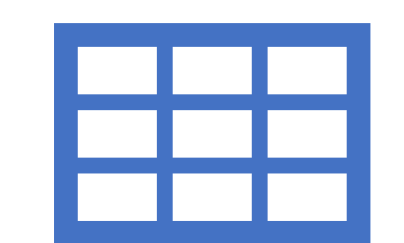
Study Design

Retrospective cohort
8 large hospitals in Northeast
Data from 2015 to 2024
Labor neuraxial catheters



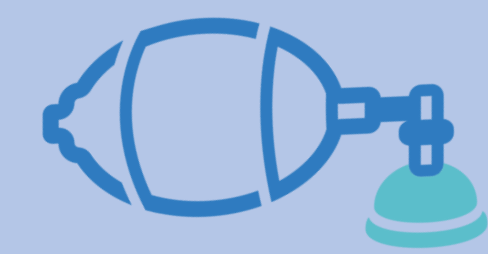
Study Population

80,435 unique patients
104,825 catheters
5,284 failures



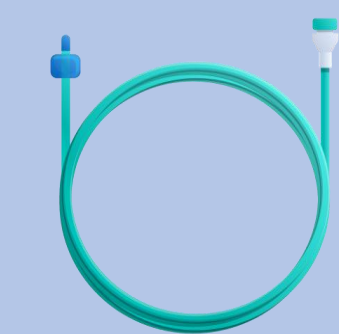
Data Included

86 features
Demographics,
comorbidities, vitals, notes



Catheter Failure Definition

Catheter replacement
Spinal for cesarean delivery
General anesthesia for cesarean delivery

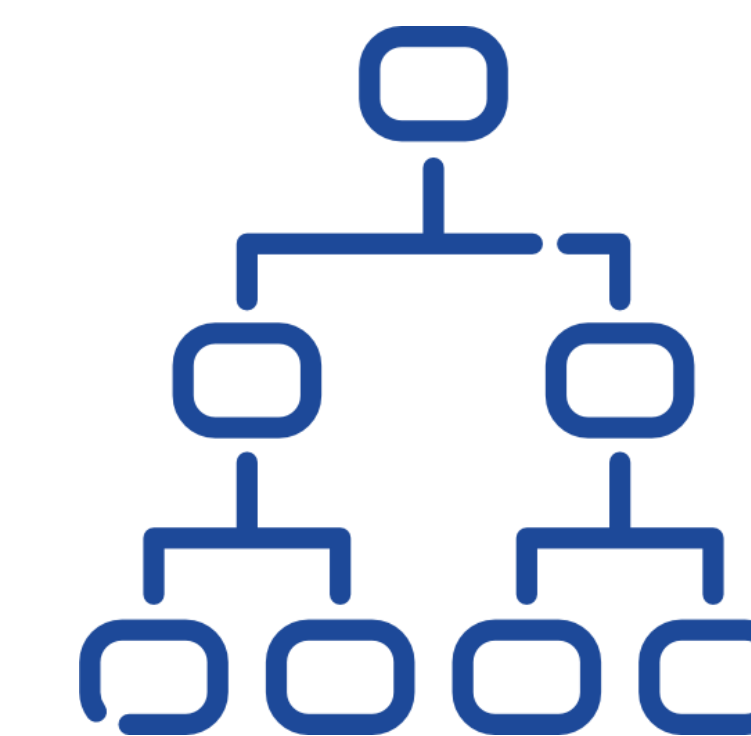
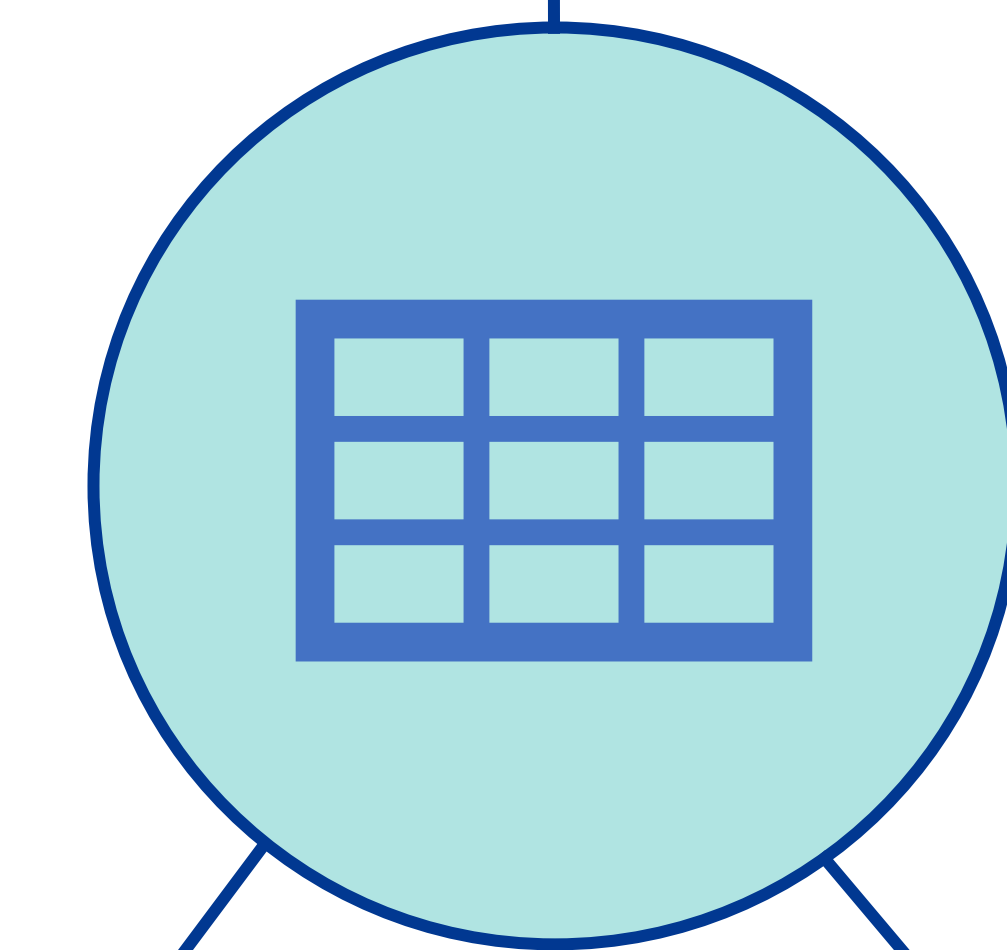


Provider Experience Definition

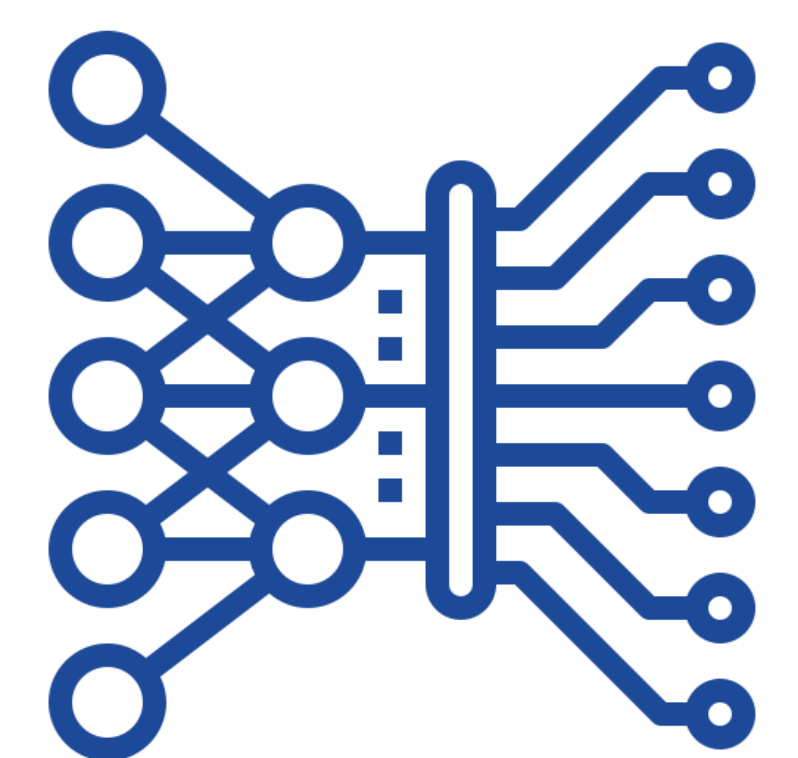
Number of prior catheters:
Low: 0 – 39
Moderate: 40 – 399
High: 400+

Machine Learning Models

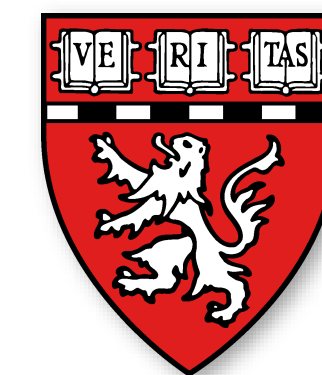
Logistic regression



Ensemble
decision trees



Deep neural
network



Results I

Patient Factors

Procedural Factors

Significant protective factors

Not significant

Significant risk factors

Delivery at our obstetric teaching hospital (vs other)

Parity (per birth)

Time from ROM to placement (per hour)

Prior catheters across all encounters (per catheter)

Gestational Age (per week)

Maternal age (per year)

History of high risk pregnancy (vs not)

Cephalic fetal presentation (vs other)

Back pain (vs none)

BMI > 40 *and* scoliosis (vs not both)

Multiple gestation (vs not)

Intrauterine fetal demise

Scoliosis (vs none)

Scoliosis or other back problems (vs none)

All socioeconomic advantages (vs not all)

Current high risk pregnancy (vs not)

Prior failed catheters in prior encounters (per failure)

Max OB-CMI score prior to placement (per unit)

Any psychosocial risk factors (vs none)

Weight of neonate (per kg)

Posterior or transverse fetal position (vs other)

History of Cesarean section (vs not)

Max pain score prior to placement (per unit 0-10)

BMI (per kg/m²)

Prior failed catheters in this encounter (per failure)

Induced labor (vs not)

OR 0.64 (0.60 - 0.69)

OR 0.83 (0.78 - 0.89)

OR 0.87 (0.79 - 0.96)

OR 0.88 (0.81 - 0.96)

OR 0.93 (0.87 - 1.00)

OR 0.96 (0.90 - 1.02)

OR 0.97 (0.91 - 1.04)

OR 0.98 (0.92 - 1.03)

OR 0.99 (0.93 - 1.06)

OR 1.00 (0.96 - 1.04)

OR 1.00 (0.95 - 1.06)

OR 1.01 (0.96 - 1.06)

OR 1.01 (0.96 - 1.07)

OR 1.01 (0.95 - 1.08)

OR 1.03 (0.98 - 1.09)

OR 1.04 (0.98 - 1.10)

OR 1.06 (1.01 - 1.12)

OR 1.06 (1.01 - 1.12)

OR 1.08 (1.03 - 1.14)

OR 1.12 (1.05 - 1.20)

OR 1.13 (1.08 - 1.18)

OR 1.14 (1.08 - 1.21)

OR 1.15 (1.09 - 1.21)

OR 1.18 (1.10 - 1.25)

OR 1.20 (1.14 - 1.26)

OR 1.22 (1.15 - 1.29)

Odds Ratio (99.9% confidence interval)

Minimally experienced attending anesthesiologist (vs moderately experienced)

No attending anesthesiologist (vs moderately experienced)

Depth to loss of resistance (per cm)

Dural puncture epidural (vs conventional epidural)

Number of placement attempts (per attempt)

Squared difference between observed LOR and BMI-predicted LOR (per cm²)

Paresthesias present during placement (vs none)

Less experienced resident (vs no resident)

Highly experienced attending anesthesiologist (vs moderately experienced)

Highly experienced resident (vs no resident)

Intrathecal catheter (vs conventional epidural)

OR 0.53 (0.43 - 0.64)

OR 0.79 (0.63 - 1.00)

OR 0.93 (0.79 - 1.08)

OR 0.95 (0.89 - 1.02)

OR 1.02 (0.86 - 1.20)

OR 1.05 (1.00 - 1.10)

OR 1.06 (1.02 - 1.11)

OR 1.08 (1.03 - 1.13)

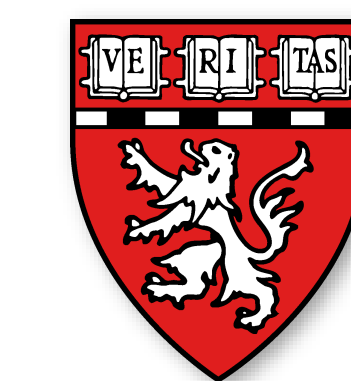
OR 1.22 (1.06 - 1.41)

OR 1.25 (1.09 - 1.42)

OR 1.35 (1.17 - 1.55)

OR 4.70 (1.90 - 11.58)

OR (99.9% CI)



Results II and Conclusions

Model Performance (AUROC)
XGBoost: 0.70
Random forest: 0.70
Logistic regression: 0.68
Deep neural network: 0.62

Conclusions

Identified expected and unexpected risk factors
Models achieved moderate performance
Data restricted to pre/intra-placement

***The Future:
Dynamic prediction,
integrated into care***

L&D Catheter
Dashboard:

High risk

Low risk

Location	G/P	GA	MEM	DILI, EFF, Sta	Last Eval	Pre Note?	ANS	Mallamp	Difficult	Pit
L04-1	1/0	40w1d		5 / 100 / -1	0m	✓	🔍	III		
L08-1	1/0	40w5d	Artificial	10 / 100 / ...	0m	✓	🔍	I		📄
L09-1	1/0	39w2d				✓		II		📄
L10-1	1/1	39w4d	Spontan...		3h 25m	✓	🔍	II		📄
L11-1	5/2	39w0d				❌				
L14-1	7/4	39w2d				❌				
L16-1	1/1	37w2d	Artificial			✓		II		📄
L17-1	1/0	32w3d	Spontan...	1 / 80 /		✓		II		
L19-1	2/0	34w1d			14m	✓	🔍	III		📄
L20-1	2/1	39w6d	Spontan...		4h 37m	✓		II		📄
L21-1	1/0	40w5d	Spontan...		2h 8m	✓	🔍	I		📄
L22-1	2/0	40w3d		4 / 70 / -1	10m	✓	🔍			