Advancing Post-Surgical Care: Machine Learning Prediction of Red Blood Cell Transfusion After Elective Aortic Surgery

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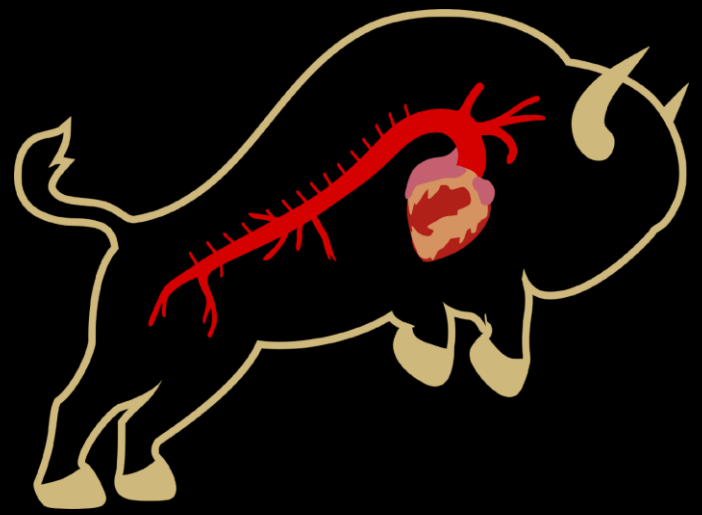
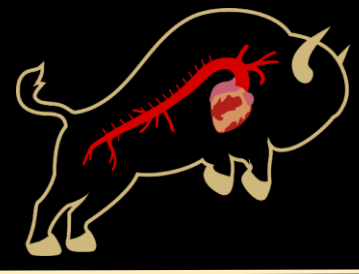
No disclosures



Introduction



- Post-operative transfusion in cardiac surgery has been linked to adverse post-operative outcomes

- Machine learning models for red blood cell (RBC) transfusion have not been applied to aortic surgery

Aim

- Develop a machine learning model to predict need for post-operative transfusion in elective aortic surgery
- Assess feature value to determine impact on risk of red blood cell transfusion

Methods

- Retrospective review of aortic database for all patients who underwent elective aortic surgery from 2009 to 2022
- Patients divided into training (70%) and testing (30%) sets with eXtreme gradient boosting (XGBoost) models
- Included 64 input parameters
  - 24 demographic characteristics
  - 8 pre-operative, 32 intraoperative variables
- Assess model performance and accuracy with area under receiver operating curve (AUC-ROC) and precision with area under precision recall curve (AUC-PR, mean average precision)
  - Determine model performance depending on aortic procedure
- Perform feature analysis to determine impact of input parameters

Results

- 543 total patients included in analysis
  - Majority male, Caucasian, aneurysmal pathology, hemiarch replacement
- 265 patients (48.8%) received post-operative RBC transfusion

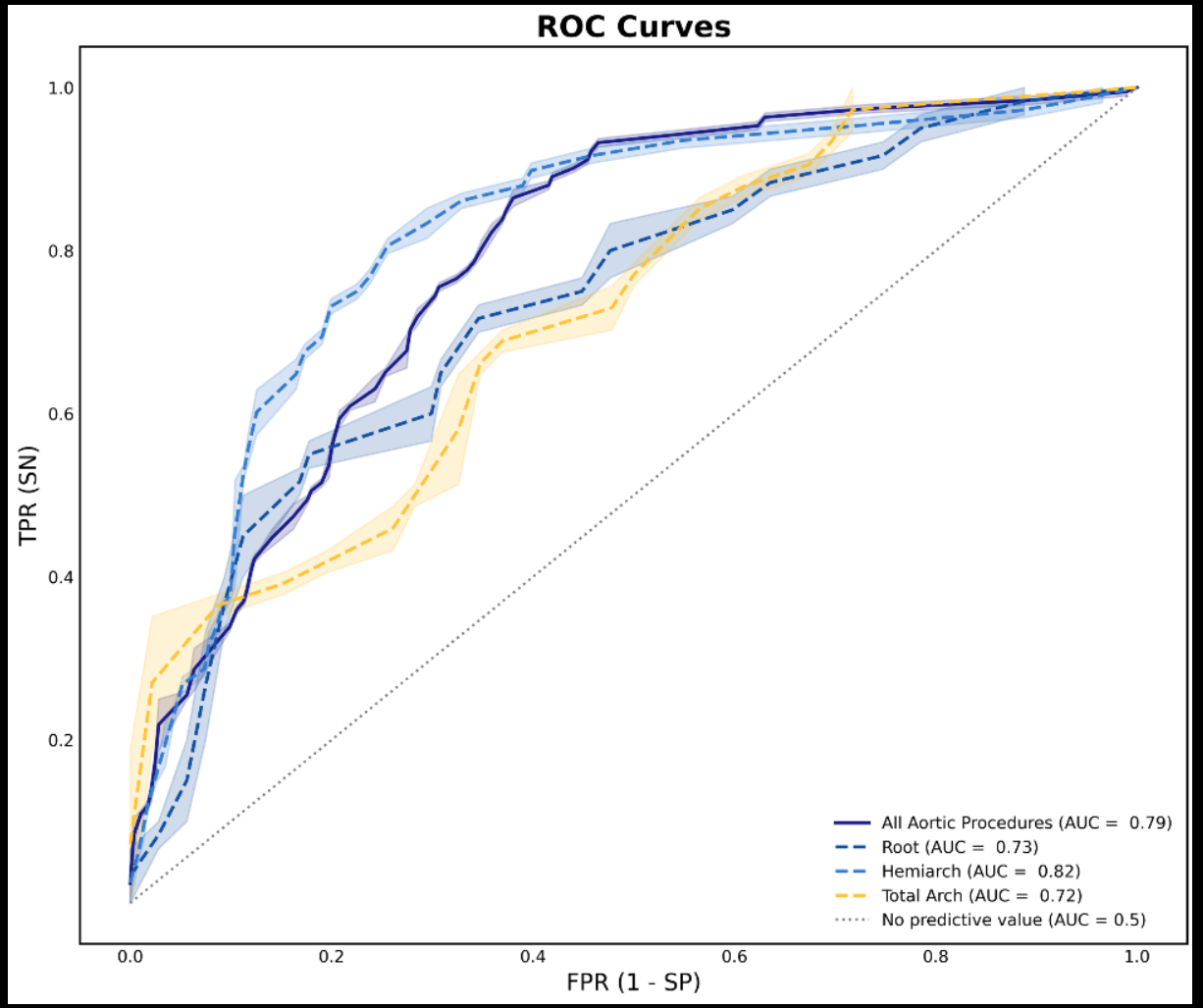
Age	59 ± 14
Male	399 (73.5%)
BMI	28 ± 6
Baseline Systolic BP	131 ± 19
Baseline Diastolic BP	76 ± 13
Race	
Caucasian	435 (80.1%)
African American	35 (6.4%)
Asian	11 (2.0%)
Hispanic	47 (8.7%)
Other	15 (2.8%)
Comorbidities	
No Comorbidities	20 (3.7%)
Dyslipidemia	209 (38.5%)
HTN	355 (65.4%)
Smoking	129 (23.8%)
Diabetes	54 (9.9%)
Renal Disease	51 (9.4%)
PVD	16 (2.9%)
Obesity	179 (33.0%)
CVA	39 (7.2%)
Liver Disease	6 (1.1%)
Pulmonary Disease	130 (23.9%)
CAD	91 (16.8%)
Afib	38 (7.0%)
Autoimmune Disease	10 (1.8%)
Surgical History	
No Hx of CT Surgery	335 (61.7%)
Hx of Sternotomy	108 (19.9%)
Hx of Aortic Surgery	83 (15.3%)
Number of Sternotomies	110 (20.3%)
Aortic Presentation	
Aneurysm	474 (87.3%)
Dissection	62 (11.4%)
Dissection – Malperfusion	2 (0.4%)
Thrombus	5 (0.9%)
Infection	3 (0.6%)
Friable	1 (0.2%)
Baseline Labs	
Creatinine	1 ± 1
HbA1c	6 ± 1
Hemoglobin	14 ± 2
Platelets	219 ± 64
INR	1 ± 0

Procedure Type	
Root	211 (38.9%)
Hemiarch	414 (76.2%)
Total Arch	111 (20.4%)
Operative Urgency	
Elective	543 (100%)
Adjunctive Procedure	
No Adjunctive Structural Procedure	106 (19.5%)
Aortic Valve Repair	49 (9.0%)
Aortic Valve Replacement	151 (27.8%)
Mitral Valve Repair	8 (1.5%)
Mitral Valve Replacement	5 (0.9%)
Tricuspid Valve Repair	3 (0.6%)
Tricuspid Valve Replacement	0 (0.0%)
PFO Closure	15 (2.8%)
Aortic Annulus Enlargement	5 (0.9%)
Afib Procedure	23 (4.2%)
CABG	38 (7.0%)
Operative Variables	
Nadir Bladder Temperature	27 ± 2
CPB Time	156 ± 59
Aortic Cross-Clamp Time	102 ± 48
Circulatory Arrest Time	13 ± 11
OR CPB Nadir Hemoglobin	9 ± 2
Circulatory Arrest Protection	
Straight HCA	6 (1.1%)
RCP	42 (7.7%)
SACP via Axillary	43 (7.9%)
SACP via Innominate	241 (44.4%)
Direct Innominate	2 (0.4%)
Innominate, Left Carotid	16 (2.9%)
Intraoperative Blood Products	
Intraoperative # RBC Units	2 ± 3
Intraoperative # FFP Units	3 ± 4
Intraoperative # PLT Units	1 ± 1
Intraoperative # Cryo Units	0 ± 1

Results

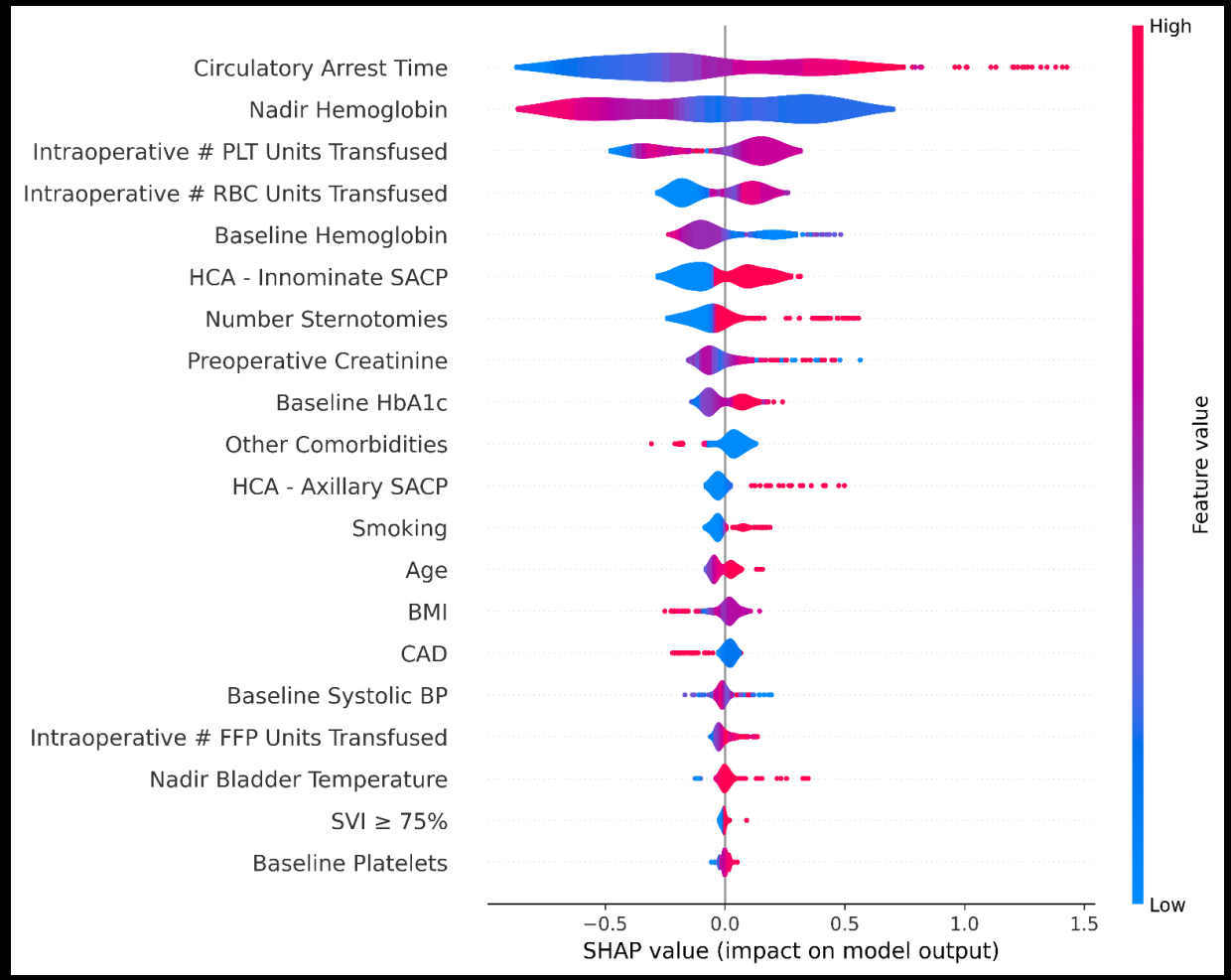
- XG boost model demonstrated excellent accuracy (AUC-ROC 0.79, AUC-PR 0.56)

- By procedure:
  - Root (AUC-ROC 0.73)
  - Hemiarch (AUC-ROC 0.82)
  - Total Arch (AUC-ROC 0.72)



Results: Feature Impact & Value

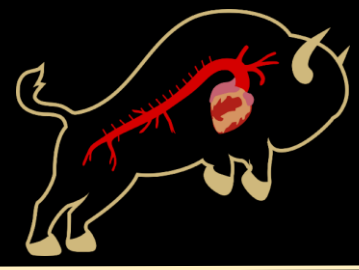
- Provides insight into model decision making
- Increased Risk:
  - Extended circulatory arrest
  - Lower pre-operative, nadir hemoglobin
  - Antegrade cerebral protection
  - More intraoperative transfusion of platelets or RBC
  - Prior sternotomy
- Less impact seen by FFP transfusion, bladder temperature, CPB time, thrombocytopenia, social vulnerability (SVI)



Interpreting Violin plot:

- Descending order of impact on model (highest=most impact)
- Color indicates variable value (for categorical variables, yes=high)

Conclusions



- Machine learning model demonstrated excellent performance in predicting patients who would receive post-operative RBC transfusion after elective aortic surgery
  - Strong performance in procedure subsets
- Extended circulatory arrest, usage of antegrade cerebral perfusion, baseline anemia and intraoperative bleeding strongest predictors
- Baseline thrombocytopenia, length of cardiopulmonary bypass, nadir bladder temperature not as impactful

Questions???