Enhanced Prediction of Pacemaker Implantation Post-TAVI Using Pre-Procedural CTA, ECG, Device Characteristics, and Fluoroscopic Implant Depth

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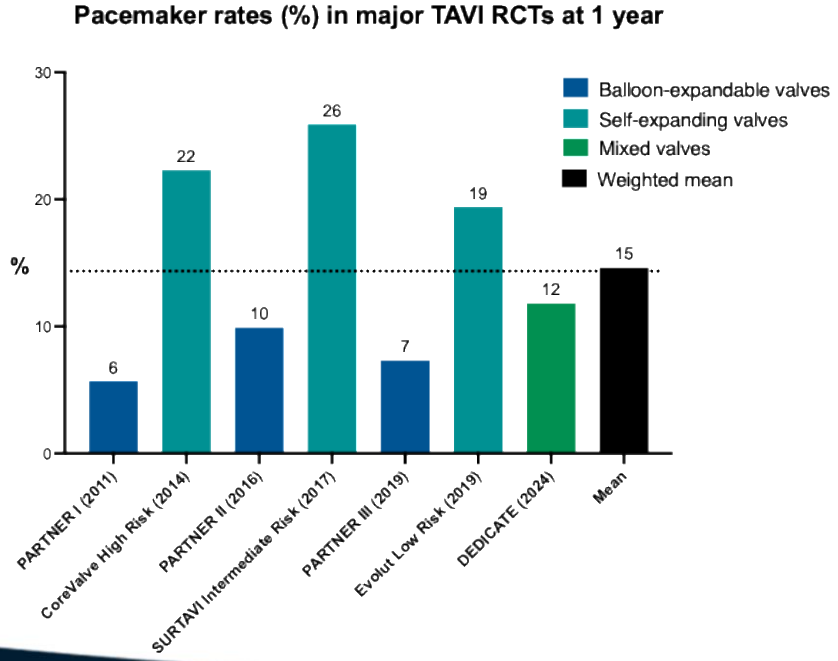
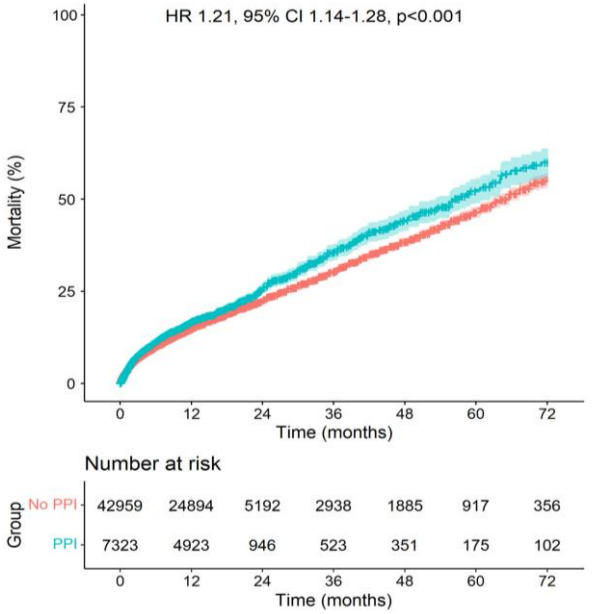
Disclosure of Relevant Financial Relationships

I, Jonathan Ciofani, DO NOT have any financial relationships to disclose.

Background: High-grade AV block is an important complication of TAVI





Sa et al. (2022) Europace

Anatomical and procedural risk factors for PPI

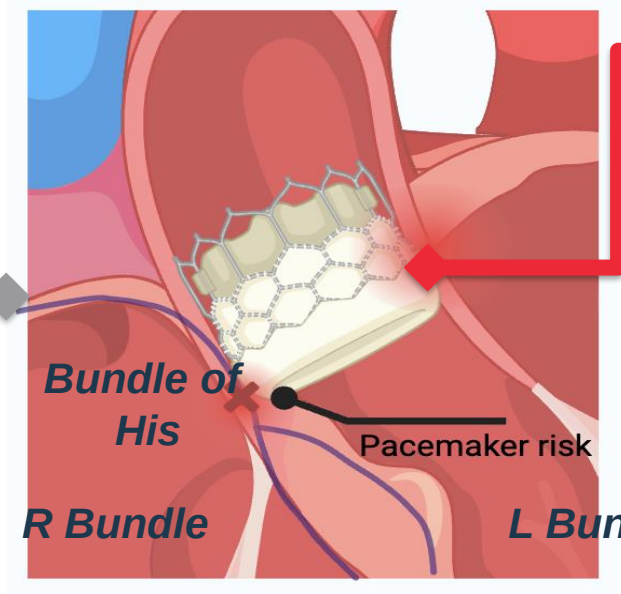
Anatomical

Membranous septum

Ca2+ volume & distribution

Bicuspid valves

Annular ellipticity



Procedural

Implant Depth

Self-expanding valves

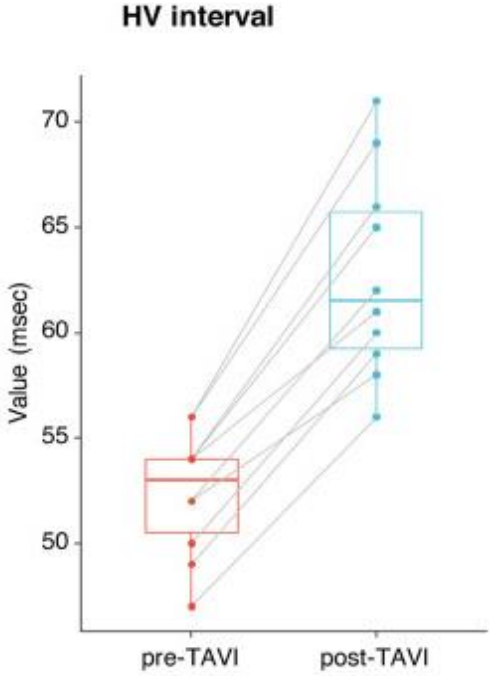
Valve Oversizing

Pre- or Post-Dilatation

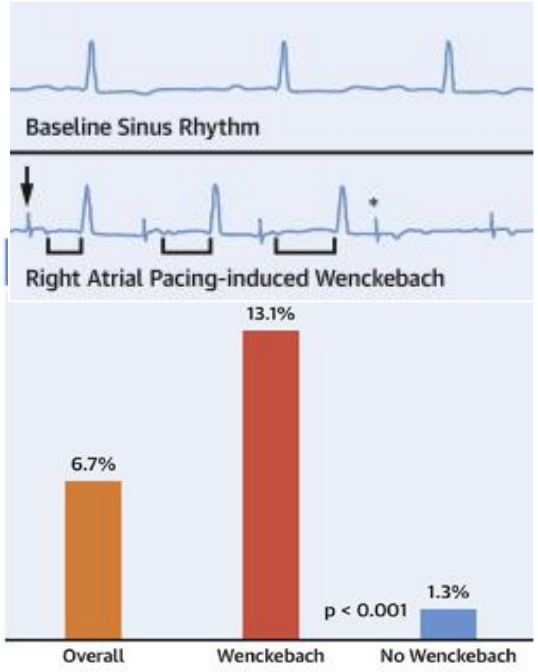
ECG and electrophysiology-based predictors

Pre-procedure
RBBB

Peri-procedure
Transient AV block



HV interval



Rapid atrial pacing

Rivard et al.
Heart Rhythm. 2015

Krishnaswamy et al.
JACC Cardiovasc. Interv. 2019

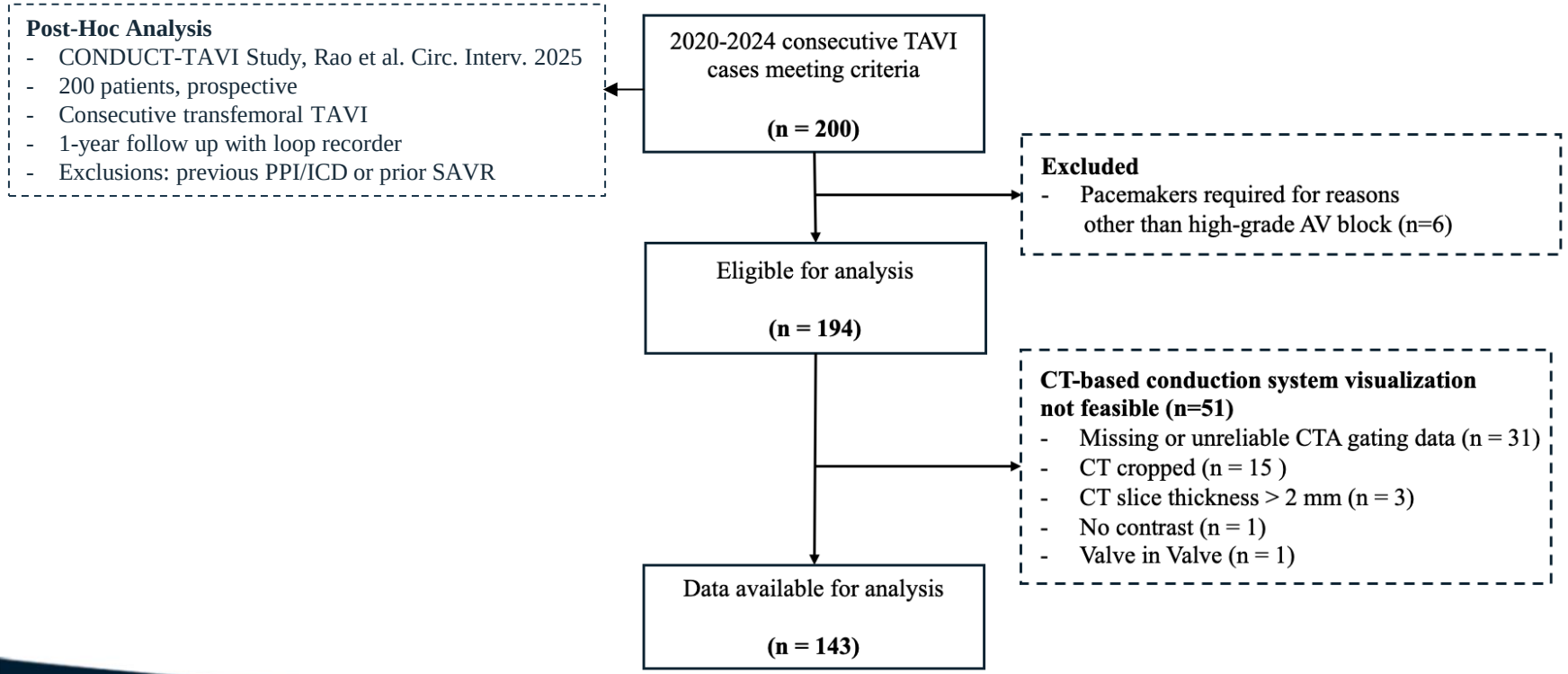
Knowledge Gaps

1. No accurate or reliable algorithm to predict PPI risk
2. Studies have examined risk factors individually, not collectively – high risk of intervariable confounding
3. Lack of studies predicting PPI risk up to 1-year
4. Need for more individualised, patient specific anatomical characterisation incorporating cardiac phase and circumferential orientation of the conduction axis

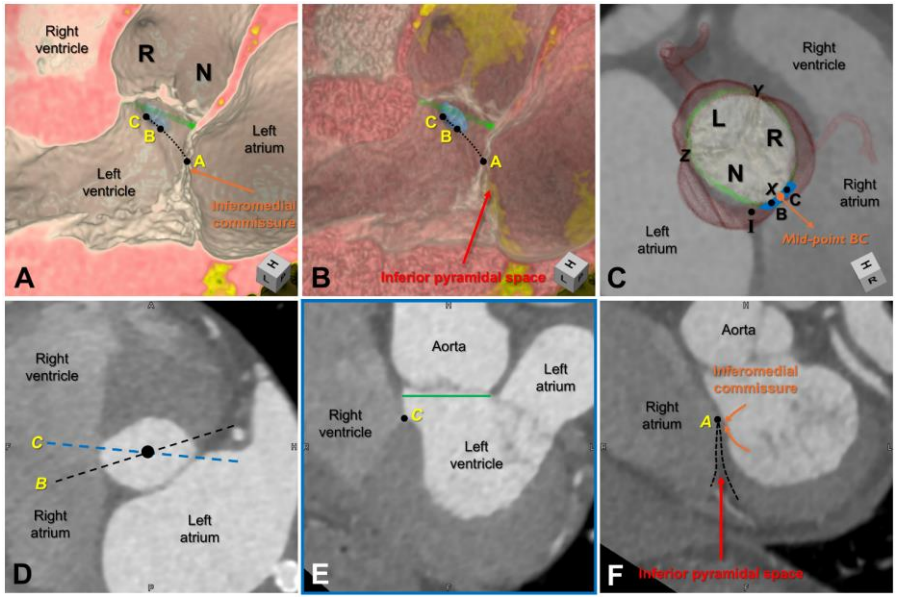
Aims

- This study sought to develop a model to predict PPI after TAVI by integrating pre-procedural computed tomography angiography (CTA) estimation of the conduction system with fluoroscopic implant depth and clinical factors

Methods


Post-Hoc Analysis
- CONDUCT-TAVI Study, Rao et al. Circ. Interv. 2025
- 200 patients, prospective
- Consecutive transfemoral TAVI
- 1-year follow up with loop recorder
- Exclusions: previous PPI/ICD or prior SAVR
2020-2024 consecutive TAVI cases meeting criteria
(n = 200)
Excluded
- Pacemakers required for reasons other than high-grade AV block (n=6)
Eligible for analysis
(n = 194)
CT-based conduction system visualization not feasible (n=51)
- Missing or unreliable CTA gating data (n = 31)
- CT cropped (n = 15)
- CT slice thickness > 2 mm (n = 3)
- No contrast (n = 1)
- Valve in Valve (n = 1)
Data available for analysis
(n = 143)

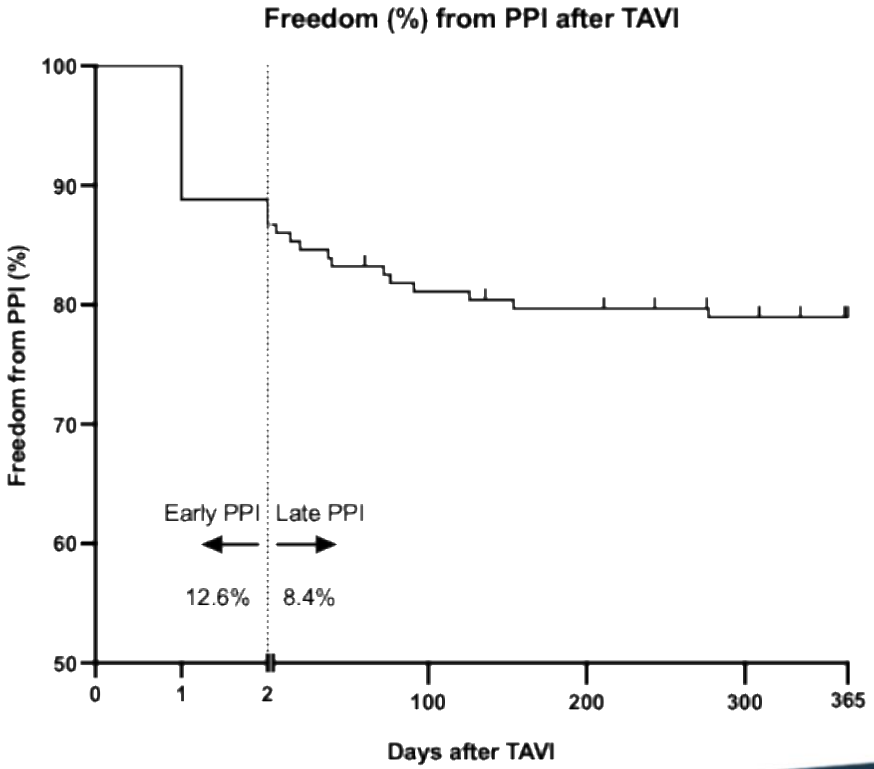
Methods – CTA based analysis
Identifying the AV-His-LBBB axis



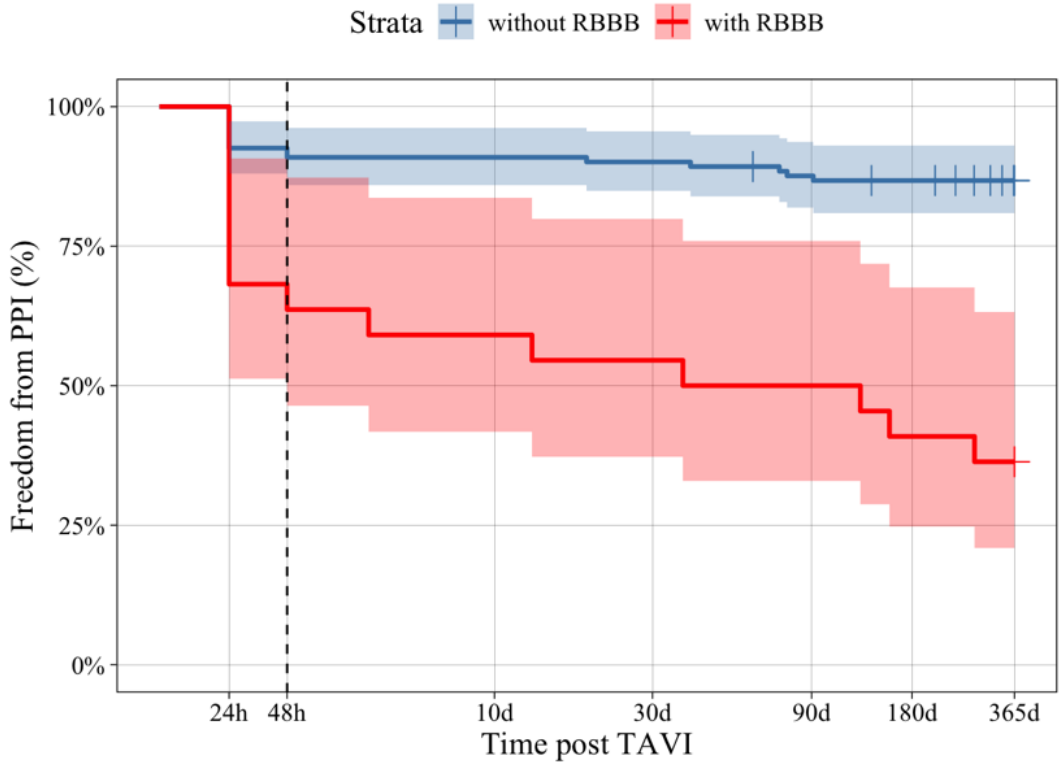
Variable	Significance
Point A **AV Node**	Inferomedial commissure of the mitral valve. Additionally, the apex of the hypoattenuated inferior pyramidal space used as marker.
Point B **His Bundle**	Posterior aspect of the inferior margin of the membranous septum.
Point C **LBB Origin**	Anterior aspect of the inferior margin of the membranous septum.
X to Mid-point BC	The angle from the centre of the annulus (short-axis – Image C) to the membranous septum (Midpoint BC)

Cohort Results

Variable	Median / n	IQR / %
Age (years)	83.0	[9.3]
Gender (Female)	47	37%
CTA assessed in systole	99	69%
RBBB	22	15%
Bileaflet valve	5	3%
Fluoroscopic Device Depth (mm)	3.7	[2.7]
Self-Expanding Mechanism	85	59%
Outcome: PPI Requirement	**30**	**21.0%**
Within 48h of TAVI	19	12.6%
Within 1y follow-up	11	8.4%



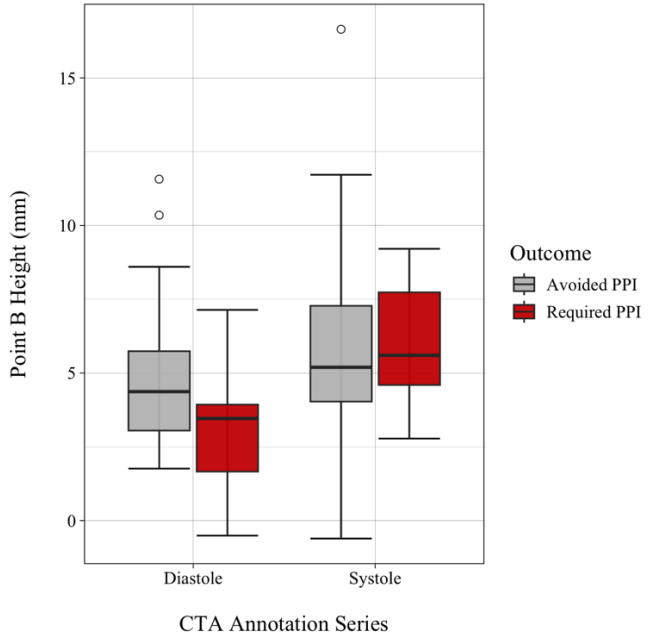
Baseline RBBB remains strongest predictor of PPI

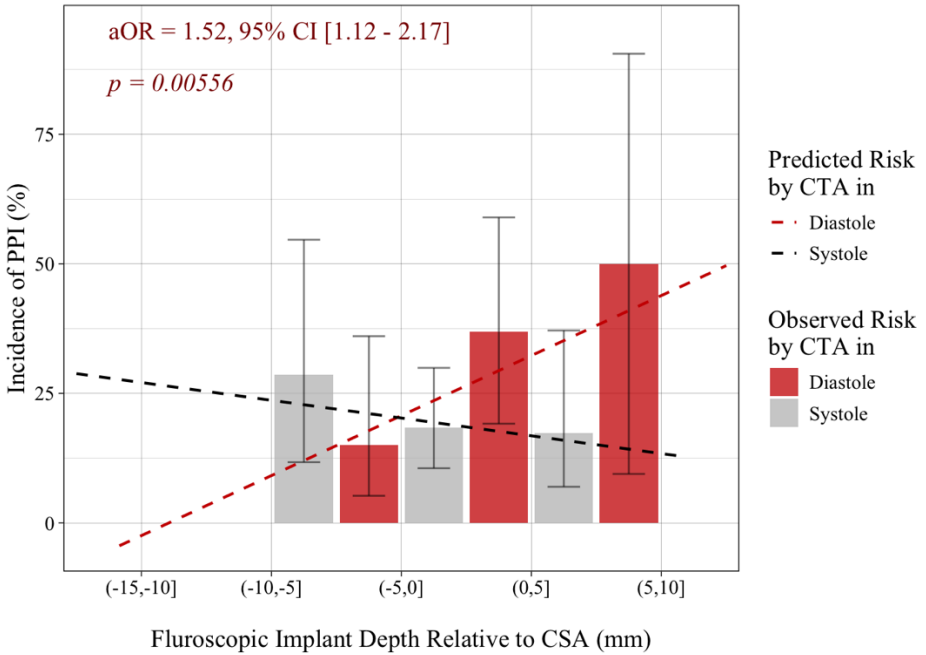


HR = 6.49 (3.16-13.4)
p<0.0001
For PPI at 1-year

The conduction axis position is dynamic through the cardiac cycle

Implant depth relative to His bundle in diastole more predictive of PPI





CSA = conduction system axis

Multivariable analysis
Final model

Term	aOR	95% CI	p value
Reference level*	1.00		
X-mid B-C angle (per 1° increase) *[rotational position of His Bundle]*	0.95	[0.91–0.99]	0.0122
RBBB pre-TAVI	14.0	[4.56–49.1]	<0.0001
†Device depth from Point B measured in diastole (per 1mm increase)	1.52	[1.12–2.17]	0.0056
†Device depth from Point B measured in systole (per 1mm increase)	0.97	[0.81–1.16]	0.7201
Oversizing of Self-expanding device (per 1 % increase)	1.07	[1.02–1.13]	0.0066
Oversizing of Balloon-expandable device (per 1 % increase)	1.07	[0.88–1.36]	0.4900

aOR=adjusted odds ratio

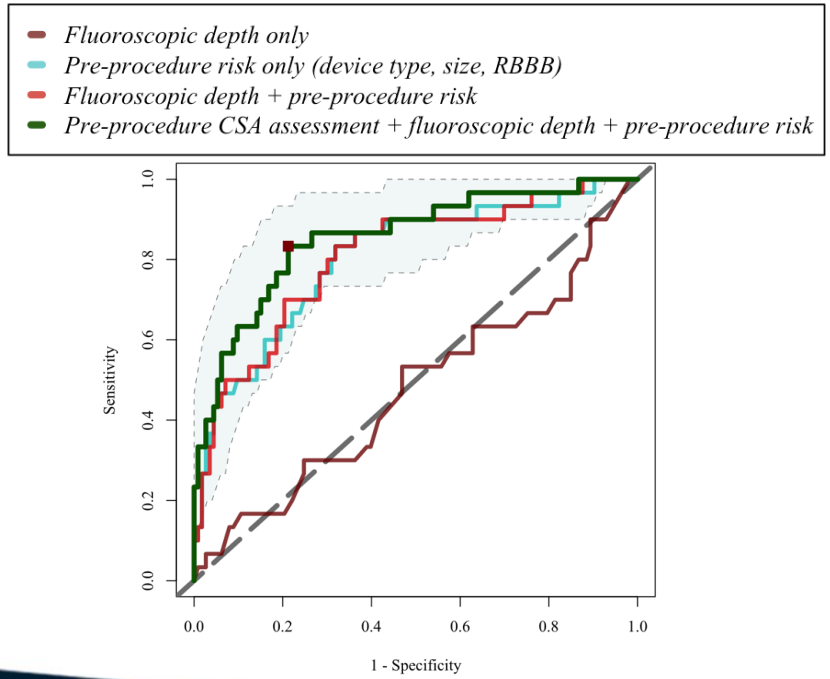
Firth's model chosen to account for potential small-sample bias in RBBB distribution

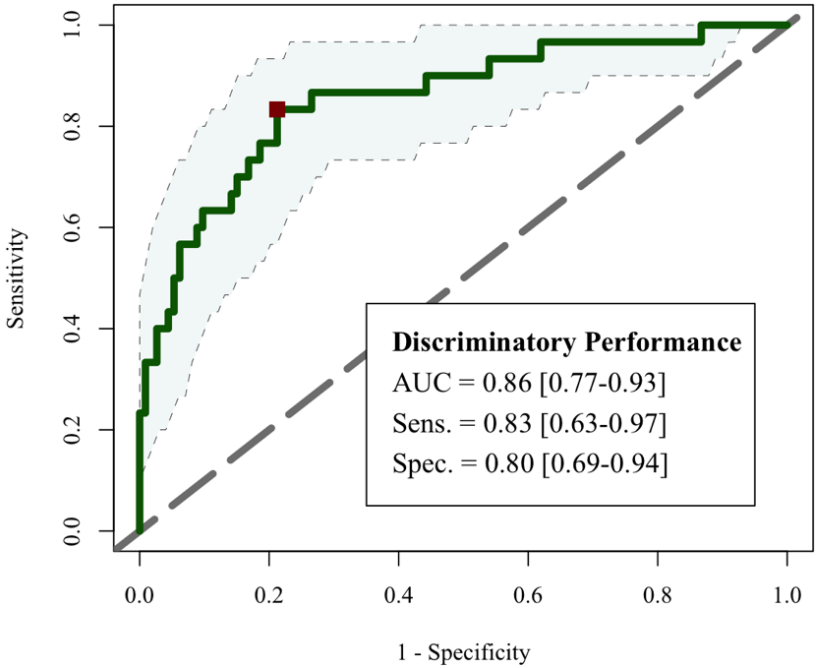
Discrimination performance was equivalent to standard logistic regression alternative (p=0.996)

** Reference category: device implanted at the level of Point B, ∠X-mid B-C=0º, RBBB absent.*

† Computed as procedural fluoroscopic device depth – point B height from pre-procedure CTA

Comparison with alternative models & performance of final model





Limitations

- Post-hoc analyses on modest sample size and number of PPI events (n=30)
  - Penalised regression used mitigate small-sample bias
- External validation required
- Some late PPI events may be unrelated to the TAVI

Conclusions

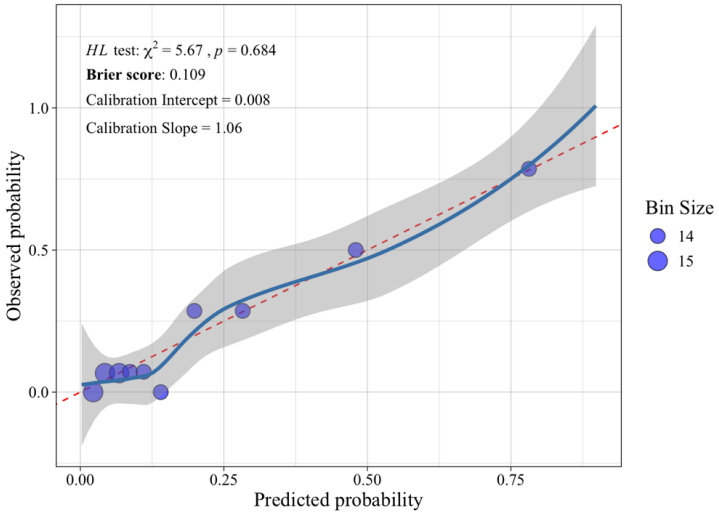
- Integrating patient specific and cardiac phase stratified CT angiography alongside traditional variables, significantly ***enhances*** prediction of PPI
- Our risk model exhibited ***strong discriminatory capacity*** (AUC 0.86), although needs prospective and external validation
- Future work can help refine automated tools to overlay proposed individualized CT-A derived landmarks to guide ***real-time implant depth***

Supplementary Slide (1)
No differences in clinical and demographic characteristics of included and excluded participants

	Included (n=143)		Excluded (n=51)		
Variable	Median / n	IQR / %	Median / n	IQR / %	p-value
Age (years)	83.0	[9.3]	83.0	[6.0]	0.654
Gender (Female)	47	37%	11	22%	0.840
CTA assessed in systole	99	69%	16	31%	0.495
RBBB	22	15%	6	12%	0.814
I° AVB	37	32%	12	24%	0.845
Bileaflet valve	5	3%	0	0%	0.333
*Average native aortic valve annulus diameter (mm)	24.5	[3.4]	25.2	[4.0]	0.514
Device diameter (mm)	29.0	[3.0]	29.0	[8.0]	0.413
†Device oversizing (mm)	3.8	[4.4]	4.4	[4.7]	0.320
‖Device oversizing (%)	15.6	[18.1]	18.8	[18.9]	0.391
Self-Expanding Mechanism	85	59%	32	63%	0.398
Fluoroscopic device depth (mm)	3.7	[2.5]	3.3	[2.8]	0.387
Outcome: PPI Requirement	30	21%	*11	22%	0.839
Within 48h of TAVI	19	13%	7	14%	0.811
Within 1y follow-up	11	8%	4	8%	1.000

Supplementary Slide (2)
Model performed well following optimism correction

Calibration Plot



	Basic model		Stratified 5-fold cross validation with 10 repeats		Optimism-corrected estimates (bootstrap, 10,000 replicates)	
Calibration Metric	Value	95% CI	Value	95% CI	Value	95% CI
AUC	0.86	[0.77–0.93]	0.84	[0.64–0.97]	0.84	[0.76–0.92]
Brier Score	0.11	–	0.12	[0.07–0.20]	0.12	[0.10–0.16]
Calibration Intercept	0.008	–	-0.045	[-0.875–1.347]	-0.141	[-0.570–0.335]
Calibration Slope	1.060	–	0.944	[0.270–1.777]	0.910	[0.543–1.315]