

Item #7: 2024 Risk-Adjusted Mortality Outcome for Isolated CABG Surgery

Limin Wang, MD, PhD, Research Scientist Senior, HCAI (or designee)

1



1

Proposed Risk Models for the 2024 CABG Public Report

2



2

Summary Statistics of CABG and CABG + Valve Surgeries

Comparison of Study Population for 2016- 2024									
	2024	2023	2022	2021*	2020*	2019	2018 [#]	2017	2016
All CABG Cases	15760	15,902	15,200	14,796	13,606	16,271	16,060	16,238	16,109
Isolated CABG Cases	12949	13,043	12,566	11,452	10,949	13,252	12,790	13,049	12,867
Operative Mortalities	288 (2.22%)	265 (2.03%)	310 (2.47%)	274 (2.39%)	289 (2.64%)	291 (2.20%)	313 (2.45%)	290 (2.22%)	305 (2.37%)
CABGs followed for Readmission	10,400	10,592	10,234	9,514	9,202	11,144	11,023	11,384	10,908
30-Day Readmissions	1,040 (10.95%)	1,166 (11.01%)	1,158 (11.32%)	1,067 (11.22%)	1,060 (11.52%)	1,334 (11.97%)	1,359 (12.33%) [§]	1,159 (10.18%)	1,257 (11.51%) [§]

Beginning with 2018 data, a new CABG and PDD linkage method developed by UC Davis was used.
 § Beginning with 2018 data, Isolated CABG 30-day readmission is all cause, unplanned 30-day readmission.
 * COVID cases were excluded from public reports.



3

Summary Statistics of CABG and CABG + Valve Surgeries

Comparison of Study Population among 2016-2024									
	2023-2024	2022-2023	2021-2022	2020-2021	2019-2020	2018-2019	2017-2018	2016-2017	2015-2016
All CABG Cases	31,662	31,102	29,996	28,402	29,877	32,343	32,298	32,347	32,133
Isolated CABGs	25,992	25,607	24,017	22,401	24,203	26,042	25,839	25,913	25,443
Post-operative Strokes	347 (1.34%)	354 (1.38%)	367 (1.52%)	351 (1.57%)	388 (1.60%)	439 (1.69%)	408 (1.58%)	380 (1.47%)	369 (1.50%)
CABG + Valve Cases	3,573	3,422	3,143	3,063	3,523	4,161	4,331	4,531	4,805
CABG + Valve Mortalities	174 (4.87%)	183 (5.35%)	178 (5.66%)	179 (5.84%)	196 (5.56%)	215 (5.17%)	224 (5.17%)	210 (4.63%)	237 (4.93%)

Beginning with 2018 data, a new CABG and PDD linkage method developed by UC Davis was used.
 § Beginning with 2018 data, Isolated CABG 30-day readmission is all cause, unplanned 30-day readmission.
 * COVID cases were excluded from public reports.



4

Methods to Develop Risk Models

Model building:

- Bivariate analysis to identify significant **preprocedural** patient variables for the risk model
- Stepwise logistic regression to select significant variables (p-value <0.1) to develop parsimonious model, including age, gender and race into the model
- Model review to ensure variables with clinical relevance to the risk are forced into the model
- Logistic regression model – calculation on logistic regression coefficients and their odd ratios with 95% confidence intervals and probability values (p-value)
- Model fitting and evaluation based on probability values and model's discrimination capability (c-statistic)
- Comparison with previous models to make adjustment if necessary

5

5

Methods to Develop Risk Models

Model discrimination

c-statistic

Model calibration

- Hosmer-Lemeshow (HL) test
- Data were partitioned into 10 groups by patient risk and observed outcomes were compared with predicted outcomes for each of the groups.

Model internal validation

Bootstrapping

- 11,000 patients were drawn with replacement, repeated the procedure 100 times (100 bootstrapping samples).
- Mean odd ratios with 95% confidence intervals and mean c-statistic were calculated.

6

6

Logistic Regression Risk Model for Isolated CABG Operative Mortality, 2024

7



7

Isolated CABG Operative Mortality, 2024

Handout 1

- Number of Isolated CABG: 12,949
- Number of Deaths: 288
- Operative Mortality Rate: 2.22%

Risk Factors: 25 (Significant risk factors with bold)
age, gender, race, **BMI, status of procedure**, hypertension, CVD, pneumonia, **chronic lung disease, myocardial infarction**, heart failure, **EF, cardiogenic shock, arrhythmia**, mitral insufficiency, left main disease, number of diseased coronary vessels, diabetes, **liver disease, creatinine, PVD**, immunocompromise, prior cardiac surgery, **previous PCI, dual payer status**

Discrimination

c-statistic: 0.836

Validation

Bootstrapping:

Mean c-statistic : 0.841



8

Isolated CABG Operative Mortality, 2024

Calibration

➤ Hosmer-Lemeshow test:

P-value = 0.217

➤ No systematic over- or under-estimation at the extremes

Model Calibration for Isolated CABG Operative Mortality, 2024

Risk group	Isolated CABG cases	Observed deaths	Predicted deaths	Difference	95% CI of predicted death	
1	1296	2	2.3	0.3	0.4	7.8
2	1297	2	4.3	2.3	1.2	10.6
3	1296	7	6.0	-1.0	2.2	13.1
4	1296	3	8.1	5.1	3.5	15.9
5	1295	8	10.7	2.7	5.3	19.3
6	1295	14	14.3	0.3	7.9	23.9
7	1295	16	19.6	3.6	11.9	30.4
8	1295	37	28.5	-8.5	19.0	41.0
9	1295	57	47.5	-9.5	35.0	63.1
10	1289	142	146.6	4.6	123.9	172.4



9

Discussion


10



10

Public Comment


11



11

CAP Decision

12



12

Item #8: 2023-2024 Risk-Adjusted Mortality Outcome for CABG + Valve Surgery

Limin Wang, MD, PhD, Research Scientist Senior, HCAI (or designee)

13



13

Logistic Regression Risk Model for CABG + Valve Operative Mortality, 2023-2024

14



14

CABG + Valve Cases by Type, 2023-2024

2023-2024	AVR + CABG	MV Repair + CABG	MVR + CABG	AVR + MV + CABG	Total CABG + Valve
N	2,296	419	653	205	3,573
Operative Deaths	80	12	63	19	174
Operative Mortality, %	3.48%	2.86%	9.65%	9.27%	4.87%

15

15

CABG + Valve Operative Mortality, 2023-2024

Handout 2

- Number of CABG + Valve: 3,573
- Number of Deaths: 174
- Operative Mortality Rate: 4.87%

Risk Factors: 21 (Significant risk factors with bold)

surgery type, age, gender, race, BMI, status of procedure, hypertension, CVD, pneumonia, chronic lung disease, myocardial infarction, heart failure, **EF**, mitral insufficiency, diabetes, **bilirubin, dialysis, PVD**, immunocompromise, **prior valve**, previous PCI

Discrimination

c-statistic: 0.796

Validation

Bootstrapping:

Mean c-statistic: 0.806

16

CABG + Valve Operative Mortality, 2023-2024

Calibration

➤ Hosmer-Lemeshow test:

P-value = 0.367

➤ No systematic over- or under-estimation at the extremes

Model Calibration for CABG + Valve Operative Mortality, 2023-2024						
Risk group	CABG+ Valves cases	Observed deaths	Predict ed deaths	Differ ence	95% CI of predicted death	
1	357	1	2.7	1.7	0.5	8.3
2	357	3	4.1	1.1	1.2	10.4
3	357	3	5.3	2.3	1.8	12.2
4	357	4	6.8	2.8	2.7	14.1
5	357	11	8.6	-2.4	3.8	16.5
6	357	11	10.9	-0.1	5.4	19.6
7	357	15	14.3	-0.7	7.9	23.9
8	357	25	19.6	-5.4	11.9	30.4
9	357	36	29.0	-7.0	19.4	41.7
10	360	65	72.7	7.7	56.9	91.4



17

Discussion


18



18

Public Comment


19



19

CAP Decision

20



20

Item #9: 2023-2024 Risk-Adjusted Post-Operative Inpatient Stroke Outcome for Isolated CABG Surgery

Limin Wang, MD, PhD, Research Scientist Senior, HCAI (or designee)

21



21

Logistic Regression Risk Model for Isolated CABG Post-Operative Stroke, 2023 – 2024

22



22

Isolated CABG Post-Operative Stroke, 2023-2024

Handout 3

- Number of Isolated CABG : 25,992
- Number of Post-Operative Stroke: 347
- Post-Operative Stroke Rate: 1.34%

Risk Factors: 20 (Significant risk factors with bold)

age, gender, **race**, BMI, **status of procedure**, hypertension, **CVD**, pneumonia, **MI**, heart failure, **EF**, cardiogenic shock, arrhythmia, mitral insufficiency, number of diseased vessels, **diabetes**, **MELD score**, dialysis, PVD, previous PCI

Discrimination

c-statistic: 0.708

Validation

Bootstrapping:
Mean c-statistic: 0.703



23

Isolated CABG Post-Operative Stroke, 2023-2024

Calibration

- Hosmer-Lemeshow test:

P-value = 0.485

- No systematic over- or under-estimation at the extremes

Model Calibration for Isolated CABG Post-Operative Stroke, 2023-2024


Risk group	Isolated CABG Cases	Observed Stroke	Predicted Stroke	Difference	95% CI of Predicted Stroke	
1	2621	10	10.0	0.0	4.8	18.4
2	2582	13	13.5	0.5	7.3	22.9
3	2605	16	16.5	0.5	9.5	26.6
4	2596	15	19.5	4.5	11.9	30.3
5	2584	22	23.0	1.0	14.6	34.5
6	2595	29	27.5	-1.5	18.2	39.8
7	2600	28	33.3	5.3	23.0	46.7
8	2599	44	41.6	-2.4	30.0	56.4
9	2599	72	56.1	-15.9	42.4	72.8
10	2611	98	106.0	8.0	86.8	128.2



24

Discussion


25



25

Public Comment

26



26

CAP Decision

27



27

Item #10: 2023-2024 Risk-Adjusted Hospital Readmission Outcome for Isolated CABG Surgery

Limin Wang, MD, PhD, Research Scientist Senior, HCAI (or designee)

28



28

Logistic Regression Risk Model for Isolated CABG 30-Day Readmission, 2023-2024

29



29

Isolated CABG 30-day Readmission, 2023-2024

Handout 4

- Number of Isolated CABG : 20,992
- Number of 30-day Readmissions: 2,305
- 30-day Readmission Rate: 10.98%

Risk Factors: 26 (Significant risk factors with bold)
age, gender, race, BMI, status of procedure,
hypertension, **CVD, chronic lung disease, MI, heart**
failure, EF cardiogenic shock, atrial fibrillation,
mitral insufficiency, **infectious endocarditis,** left main
disease, number of diseased vessels, **diabetes, MELD**
score, creatinine, PVD, immunocompromise,
cancer, prior valve, prior carotid surgery, **dual payer**
status

Discrimination

c-statistic: 0.662

Validation

Bootstrapping:

Mean c-statistic: 0.670



30

Isolated CABG 30-Day Readmission, 2023-2024

Calibration

➤ Hosmer-Lemeshow test:
P-value = 0.152

➤ No systematic over- or under-estimation at the extremes

Model Calibration for Isolated CABG Operative Readmission, 2023-2024						
Risk group	Isolated CABG cases	Observed 30-day readmission	Predicted 30-day readmission	Difference	95% CI of predicted 30-day readmission	
1	2099	98	99.1	1.1	80.5	120.6
2	2099	108	123.4	15.4	102.6	147.1
3	2099	127	141.4	14.4	119.1	166.7
4	2100	173	160.0	-13.0	136.2	186.8
5	2100	211	180.8	-30.2	155.4	209.1
6	2099	196	204.4	8.4	177.4	234.5
7	2099	244	233.7	-10.3	204.7	265.7
8	2099	265	274.2	9.2	242.7	308.6
9	2099	334	344.3	10.3	308.9	382.6
10	2099	549	543.8	-5.2	499.1	591.5



31

Acknowledgements


- Healthcare Analytics Branch
 - Shannon Conroy, Ph.D.
 - Denise Stanton
 - Samuel Tekle
 - Christopher Krawczyk, Ph.D.
- HCAI Contractor
 - Beate Danielsen, Ph.D.



32

Discussion


33



33

Public Comment


34



34

CAP Decision

35



The HCAI logo is located in the bottom right corner of the slide. It consists of the letters 'HCAI' in a bold, sans-serif font, with a red vertical bar to the left of the letters. Below the letters, the text 'Department of Health Care Access and Information' is written in a smaller, lighter font.