Prediction Model for In-Stent Restenosis After Carotid Artery Angioplasty and Stenting

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Disclosure

- I have nothing to disclose.

Outline

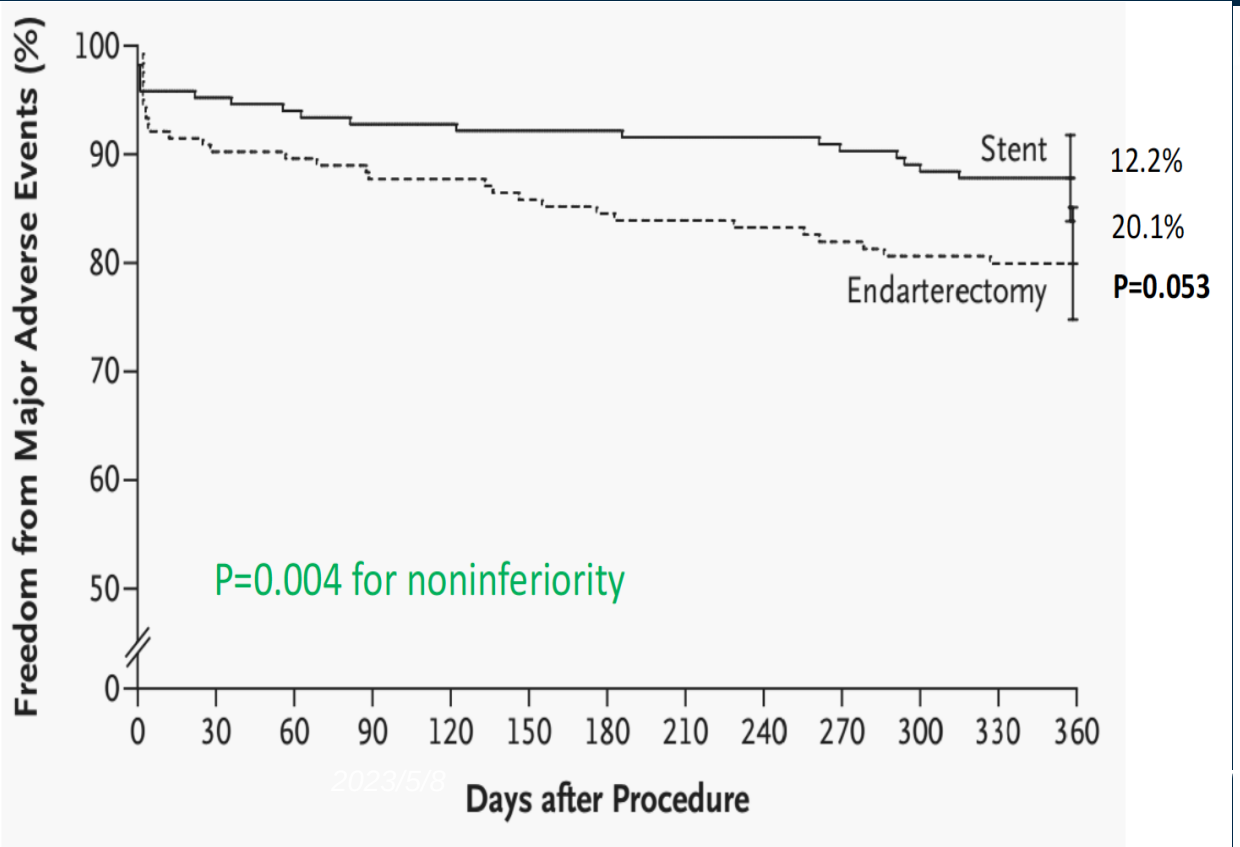
- Introduction
- Method
- Results
- Conclusion

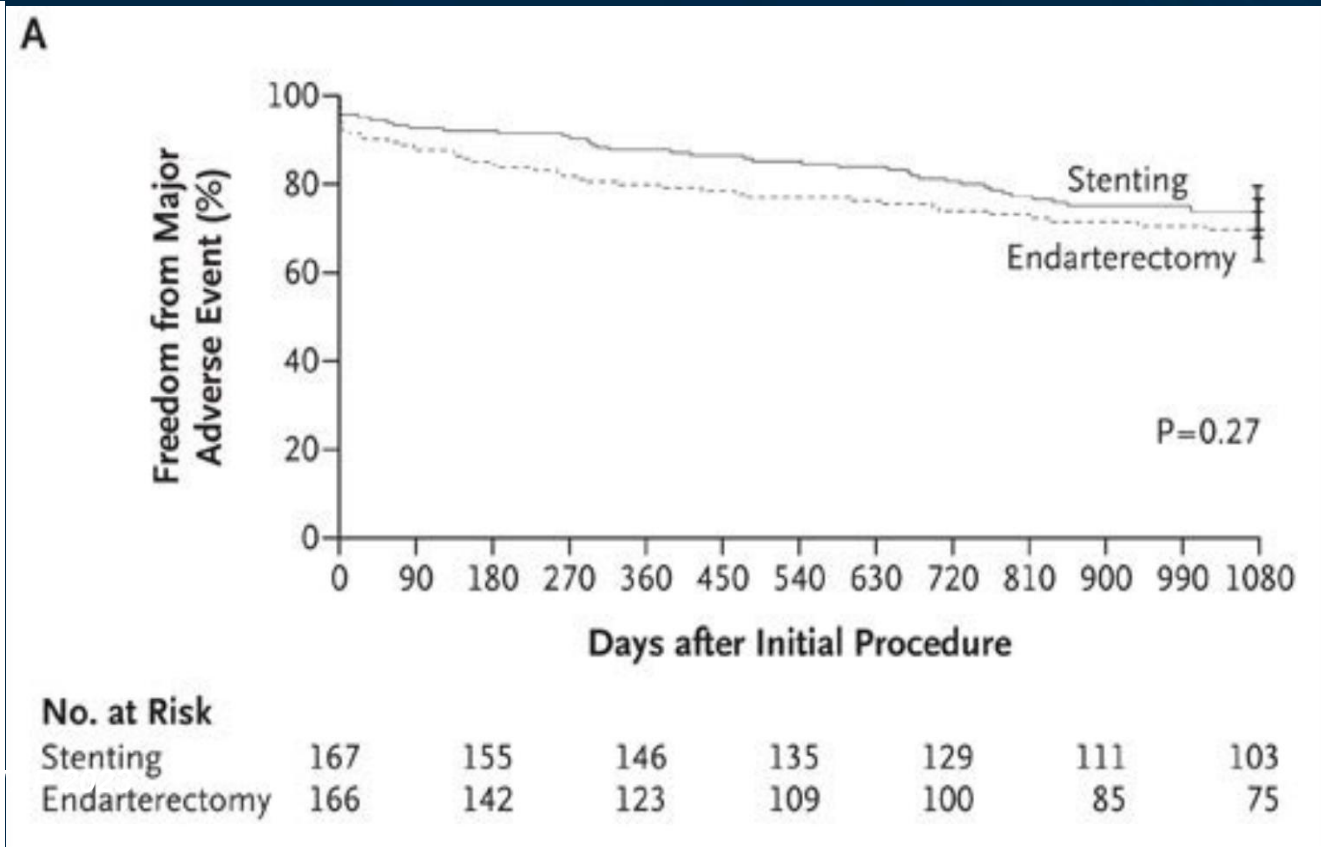
Carotid artery stenting VS Endarterectomy

SAPPHIRE trial

- RCT for High-Risk Patients (N=344)
- Symptomatic with ICA>50% stenosis; Asymptomatic with ICA>80% stenosis
- Emboli-protection device (+)

N Engl J Med 2004; 351:1493-1501
N Engl J Med 2008; 358:1572-1579

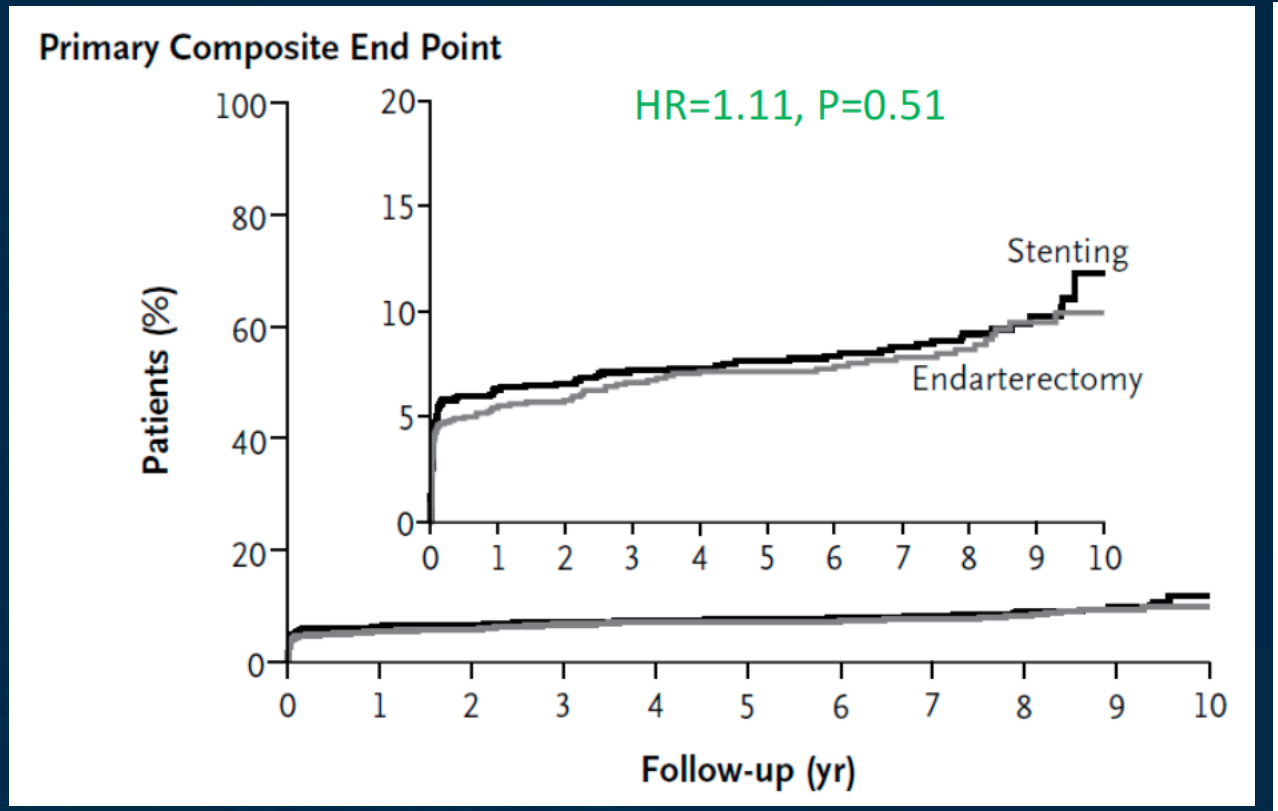


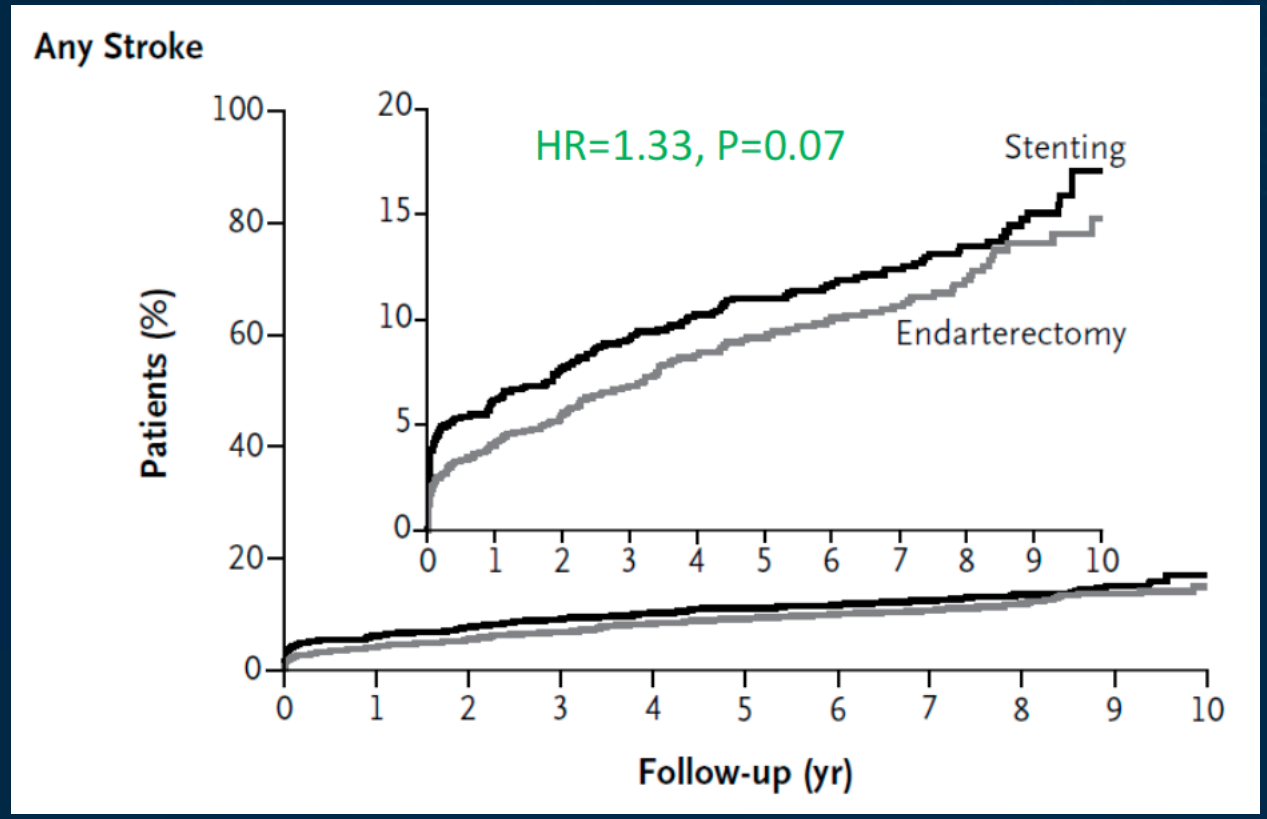


Carotid artery stenting VS Endarterectomy

CREST trial

- 10 years result of CREST
- N=2502





N Engl J Med 2016; 374:1021-1031

Carotid artery stenting VS Endarterectomy

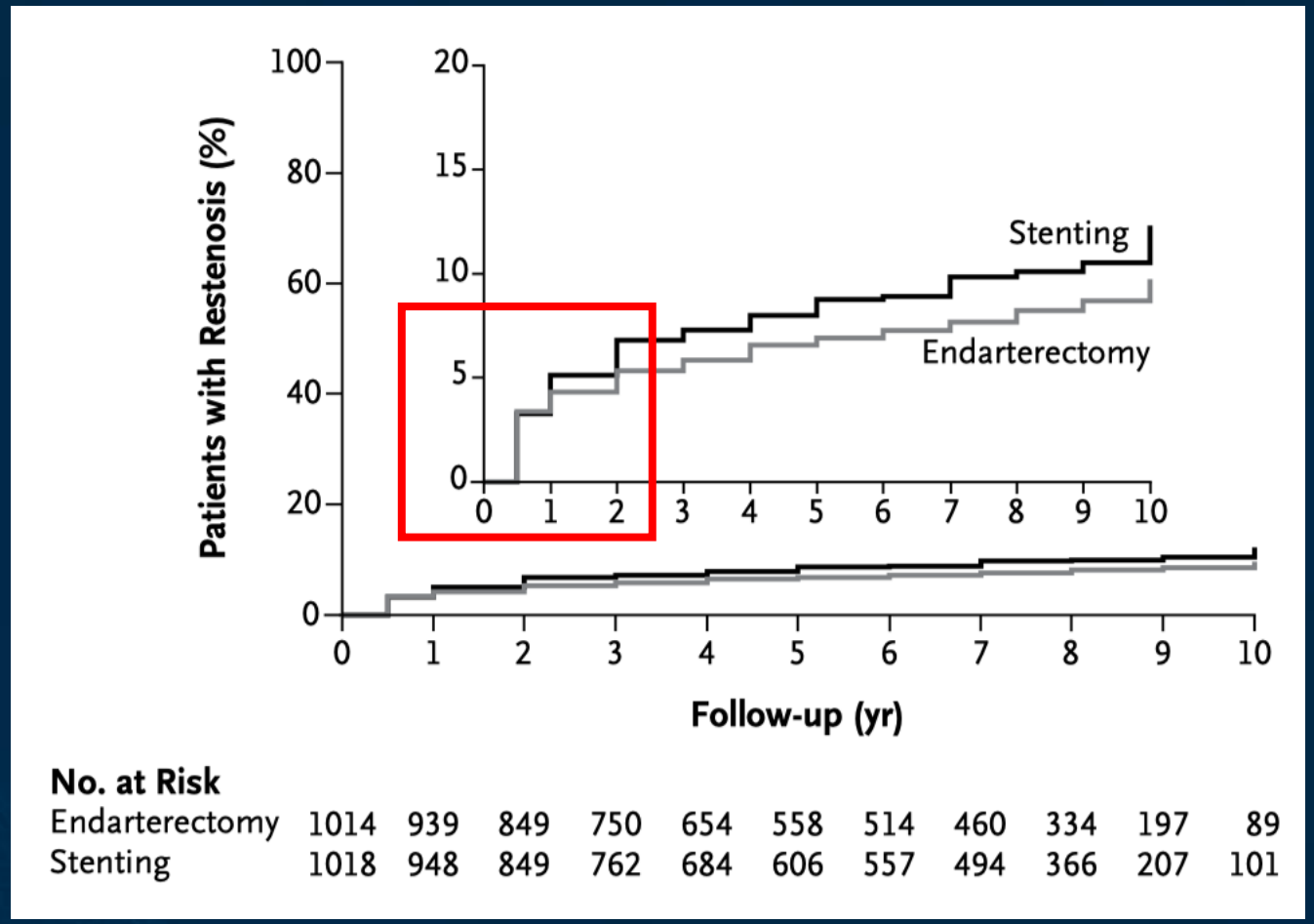
- Long term effect: equal

- Carotid artery stenting
  - Less invasiveness
  - Less discomfort
  - Less hospital stay

- In Taiwan:
  - CAS → patient's preference
  - CAS is mainstream treatment for patients with carotid stenosis in Taiwan

J Am Coll Cardiol 2011;58:1557-65

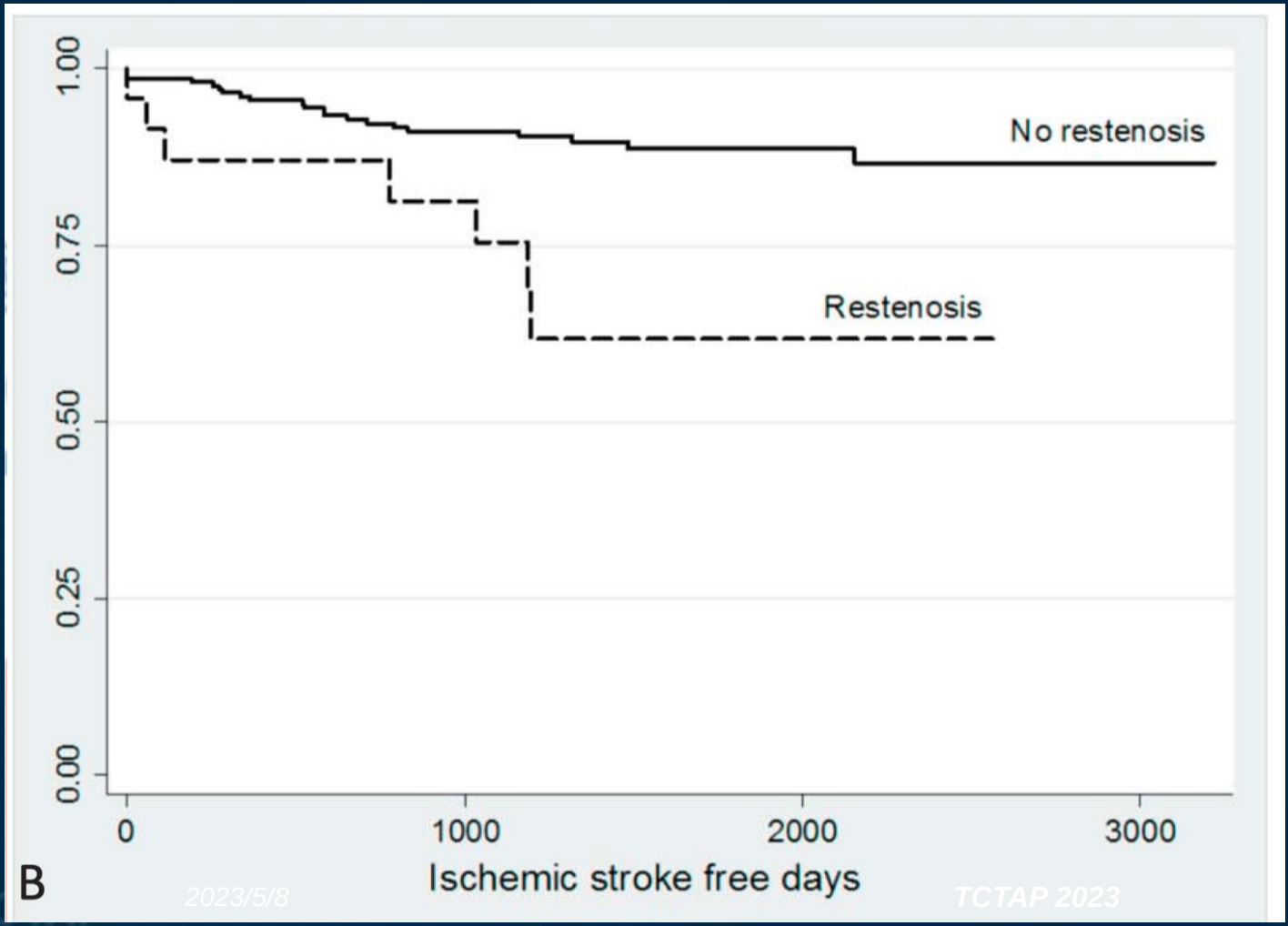
CREST study:
10 years after carotid angioplasty with stenting



- Cumulative in-stent restenosis (ISR) incidence
  - 12.2 %

N Engl J Med 2016; 374:1021-1031

Cumulative ischemic stroke free survival



- The increased risk of recurrent cerebrovascular events related to ISR

Acta Cardiol Sin 2016;32:205-214

Potential factors for CAS ISR

- Age > 75
- Female
- Smoking
- DM
- Dyslipidemia
- Hypertension
- PAD
- CAD
- Contralateral carotid occlusion

- Post-endarterectomy stenosis
- Hx of CAS ISR
- Post R/T stenosis
- Closed or opened cell stent
- Residual stenosis
- Calcified plaque
- Lesion length > 20mm
- Post stenting hemodynamics

- Multiple stent implanted
- Stent diameter
- Predilatation
- Post CAS DUS: PSV > 120
- Pre-procedure impaired vasoreactivity
- CRP at 48 hrs
- WBC at 24 hrs
- vWF, ET-1 post CAS 6m
- HDL ↓ , TC

Vascular 2017, Vol. 25(6) 576–586

Clinical question

What are the potential influencing factors for CAS in-stent restenosis ?

Study Aim

- The study sought to identify potential factors and construct a prediction model for CAS ISR.

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Methods

- Retrospective Cohort study
- Populations: receive CAS, no matter what etiology
  - Angiography: in-stent restenosis > 50%, or DUS: PSV > 175 cm/s
  - f/u time: 4 years

- CAS population: 1500+ (1997 ~ 2019)
  - Based on CREST study, cumulative ISR incidence 7% in 4 years
  - Estimate CAS ISR sample size = 1500+ x 7% = ~100 cases
  - Case volume of CAS in NTUH annually = 50-60

- Model construction: National Taiwan University Hospital
- External validation: Chang Gung Memorial Hospital in Taiwan

Study flow Diagram

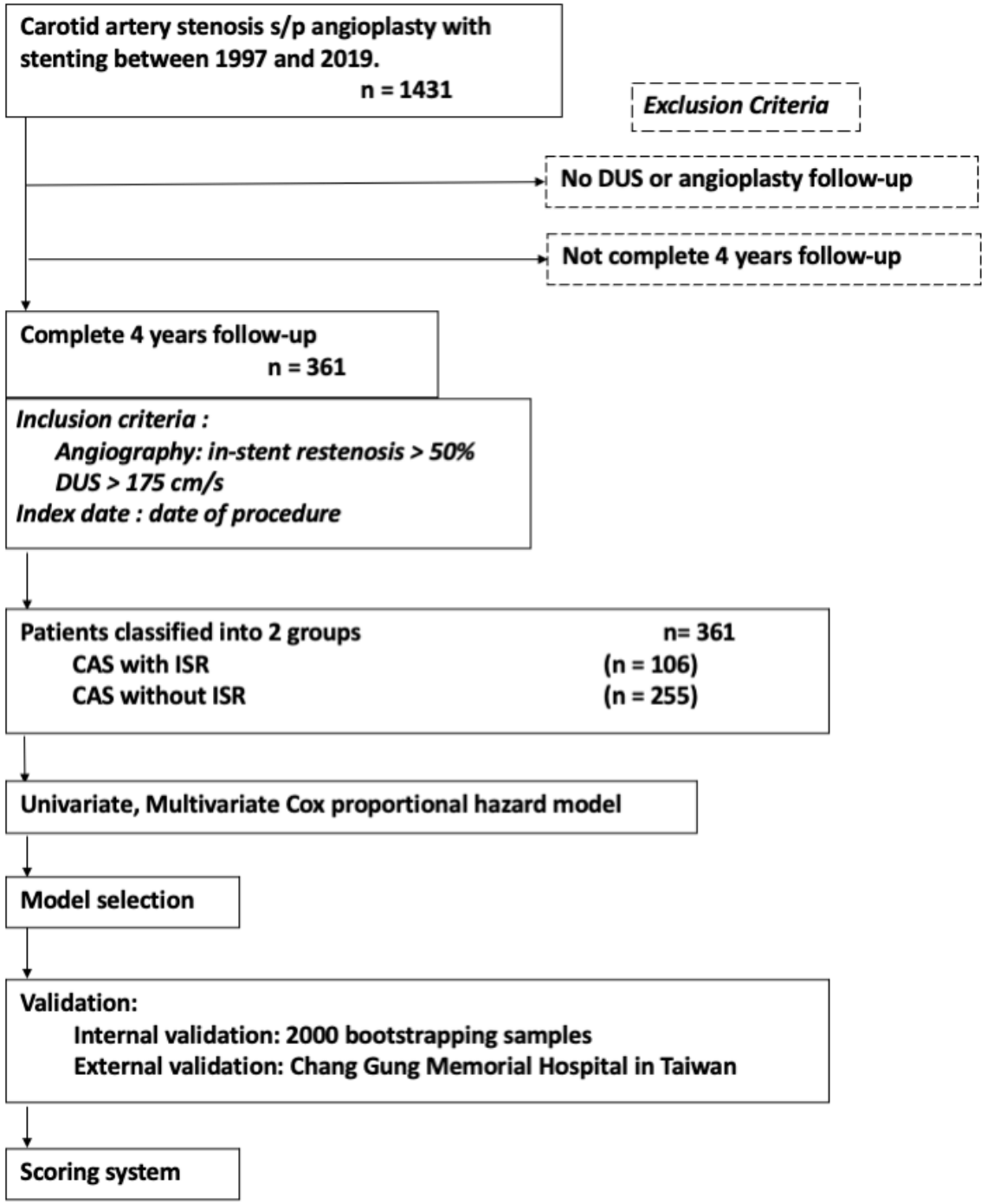

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Table 1. Baseline characteristics of the patients undergoing CAS with and without ISR

Variable	Valid *n*	ISR (*n* = 106)	Non-ISR (*n* = 255)	*P*
Age, years	361	67.2 ± 11.0	69.7 ± 9.2	0.025
Male gender, n (%)	361	78 (73.6)	198 (77.6)	0.407
Body mass index, kg/m^2	316	24.4 ± 3.5	24.8 ± 3.5	0.329
Hypertension, n (%)	361	89 (84.0)	216 (84.7)	0.859
Diabetes, n (%)	361	46 (43.4)	99 (38.8)	0.420
Hyperlipidemia, n (%)	361	73 (68.9)	153 (60.0)	0.113
Smoking (active or any history), n (%)	361	54 (50.9)	125 (49.0)	0.739
Alcohol n (%)	308	16 (27.6)	43 (17.2)	0.070
Cardiovascular disease n (%)	360	77 (72.6)	178 (70.1)	0.626
Atrial fibrillation, n (%)	356	7 (6.9)	25 (9.8)	0.374
Chronic kidney disease stage 3-5, n (%)	352	54 (53.5)	130 (51.8)	0.776
End stage renal disease, n (%)	356	0 (0.0)	3 (1.2)	0.270
Head and neck radiation exposure history, n (%)	360	18 (17.1)	17 (6.7)	0.002
Stroke history, n (%)	354	35 (34.3)	54 (21.4)	0.011

Table 2. Angiographic and procedural characteristics of the patients undergoing CAS with and without ISR (1)

Variable	Valid *n*	ISR (*n* = 106)	Non-ISR (*n* = 255)	*P*
CAS target, n (%)	361			0.001
Left ICA		63 (59.4)	104 (40.8)	
Right ICA		43 (40.6)	151 (59.2)	
Ipsilateral CCAS, n (%)	361	20 (18.9)	18 (7.1)	0.001
Bilateral ICAS, n (%)	359	58 (55.2)	76 (29.9)	<0.001
VA stenosis, n (%)	361	51 (48.1)	97 (38.0)	0.076
SCA stenosis, n (%)	361	17 (16.0)	22 (8.6)	0.039
CCA diameter, mm	361	7.7 ± 0.8	7.9 ± 0.7	0.129
ICA diameter, mm	361	5.2 ± 0.7	5.7 ± 0.6	<0.001
ICA diameter, n (%)				0.005
<5 mm	361	19 (17.9)	20 (7.8)	
≥5 mm	361	87 (82.1)	235 (92.2)	

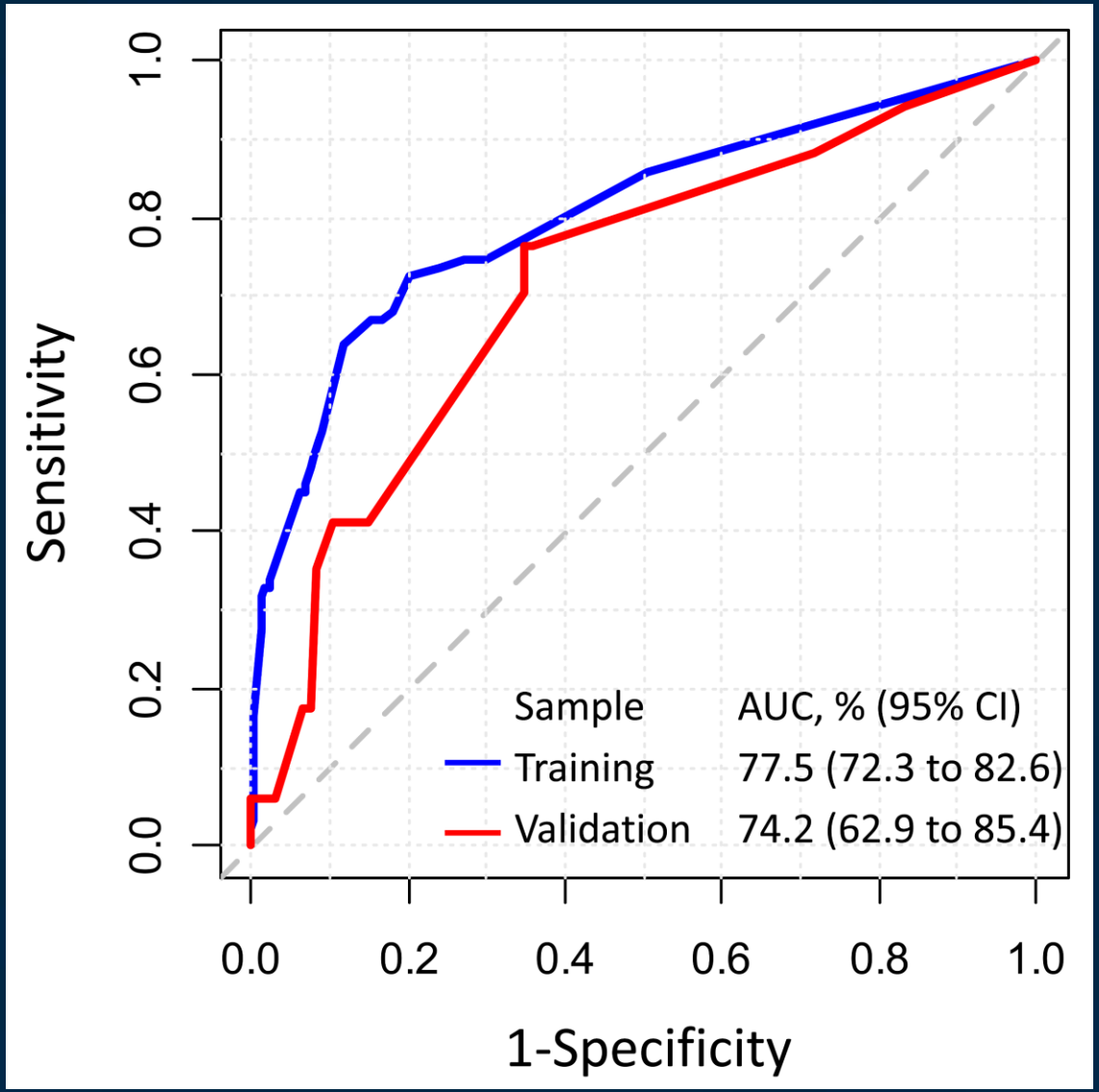
Table 2. Angiographic and procedural characteristics of the patients undergoing CAS with and without ISR (2)

Variable	Valid *n*	ISR (*n* = 106)	Non-ISR (*n* = 255)	*P*
Lesion length, mm	328	28.0 ± 17.3	18.5 ± 8.7	<0.001
Lesion diameter stenosis, %	361	94.2 ± 8.2	88.9 ± 8.5	<0.001
Total occlusion of ICA, n (%)	361	46 (43.4)	20 (7.8)	<0.001
Predilatation, n (%)	361	60 (56.6)	70 (27.5)	<0.001
Carotid stent type, n (%)	361			0.091
Open cell		5 (4.7)	26 (10.2)	
Close cell		101 (95.3)	229 (89.8)	
Maximum stent diameter, mm	361	8.7 ± 1.4	9.4 ± 1.1	<0.001
Stent to ICA ratio	361	1.7 ± 0.3	1.6 ± 0.2	0.121
Multiple stents, n (%)	361	48 (45.3)	25 (9.8)	<0.001
Post dilatation, n (%)	361	103 (97.2)	238 (93.3)	0.147
Residual stenosis, %	361	4.1 ± 6.3	5.5 ± 7.3	0.103
Bifurcation coverage, n (%)	361	93 (87.7)	231 (90.6)	0.416

Table 3. Multivariable Cox proportional hazard model for the associated factors of the risk of ISR

Variable	*B*	% or mean	Adjusted HR (95% CI)	*P*
Head and neck radiation exposure history	0.915	10.5	2.50 (1.42–4.38)	0.001
Bilateral ICAS	0.679	38.3	1.97 (1.28–3.03)	0.002
SCA stenosis	0.743	9.6	2.10 (1.15–3.85)	0.016
ICA diameter < 5 mm	0.684	8.0	1.98 (1.08–3.64)	0.027
Total occlusion of ICA	1.139	19.2	3.12 (1.71–5.71)	<0.001
Multiple stents	1.122	21.1	3.07 (1.71–5.52)	<0.001

ROC curves of the prediction model



Simple score function of ISR

Variable	Point	Total points	Probability of ISR (%)
Head and neck radiation exposure history		0	0.16
No	0	12	0.30
Yes	16	13	0.32
Bilateral ICAS		16	0.36
No	0	20	0.43
Yes	12	24	0.51
SCA stenosis		25	0.53
No	0	28	0.59
Yes	13	29	0.61
ICA diameter		32	0.67
<5 mm	12	36	0.76
≥5 mm	0	40	0.83
Total occlusion of ICA		44	0.89
No	0	45	0.90
Yes	20	48	0.94
Multiple stents		52	0.97
No	0		
Yes	20		

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Conclusion

- Independent predictors for carotid artery stenting in-stent restenosis
  - Head and neck radiation exposure history
  - Bilateral internal carotid artery stenosis
  - Subclavian artery (or right innominate artery) stenosis
  - Internal carotid artery diameter < 5 mm
  - Total occlusion of internal carotid artery
  - Use of multiple stents (more than one stent)

- The proposed prediction model for CAS ISR provided generalizability to Asian population.

Limitation

- Retrospective cohort study
  - Selection bias
- Single center study
  - Limited number of cases
  - Conduct an external validation for generalizability of our scoring system in another tertiary center in Taiwan
- Missing values in laboratory data
  - Didn’t put into the prediction model
- Training set and validation set → All Asian population
  - Extrapolate to other ethnic group ??