

Association between triglyceride-glucose index and risk of acute kidney injury in patients with aneurysmal subarachnoid hemorrhage

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Table S1 Baseline characteristics of aSAH patients according to AKI

Characteristics	Overall (N=3271)	Non-AKI (n=3115)	AKI (n=156)	P-value
Age, mean (SD)	55.11 (11.93)	54.93 (11.85)	58.76 (12.84)	<0.001
Female, n (%)	2129 (65.1)	2064 (66.3)	65 (41.7)	<0.001
Smoking status, n (%)				0.001
Current smoker	140 (4.3)	129 (4.1)	11 (7.1)	
Previous smoker	656 (20.1)	609 (19.6)	47 (30.1)	
Never	2475 (75.7)	2377 (76.3)	98 (62.8)	
Drinking, n (%)	643 (19.7)	596 (19.1)	47 (30.1)	0.001
Medical history, n (%)				
Hypertension	808 (24.7)	754 (24.2)	54 (34.6)	0.004
Diabetes	183 (5.6)	163 (5.2)	20 (12.8)	<0.001
Coronary heart disease	82 (2.5)	79 (2.5)	3 (1.9)	0.829
Chronic obstructive pulmonary disease	233 (7.1)	211 (6.8)	22 (14.1)	0.001
WFNS, n (%)				<0.001
I	1895 (57.9)	1840 (59.1)	55 (35.3)	
II	542 (16.6)	522 (16.8)	20 (12.8)	
III	88 (2.7)	83 (2.7)	5 (3.2)	
IV	333 (10.2)	312 (10.0)	21 (13.5)	
V	413 (12.6)	358 (11.5)	55 (35.3)	
Aneurysm characteristics				
Anterior location, n (%)	2669 (81.6)	2542 (81.6)	127 (81.4)	1
Size of aneurysm, cm, mean (SD)	0.76 (0.69)	0.76 (0.70)	0.74 (0.60)	0.596
Management of aneurysm, n (%)				0.006
No treatment	2195 (67.1)	2101 (67.4)	94 (60.3)	
Clip	413 (12.6)	397 (12.7)	16 (10.3)	
Coil	663 (20.3)	617 (19.8)	46 (29.5)	
External ventricular drain, n (%)	70 (2.1)	58 (1.9)	12 (7.7)	<0.001
DIND	616 (18.8)	576 (18.5)	40 (25.6)	0.034
Median no. of cerebral angiograms (IQR)	3.00 (2.00,3.00)	3.00 (2.00,3.00)	3.00 (1.00,3.00)	0.106
Antibiotics use, n (%)	1206 (36.9)	1100 (35.3)	106 (67.9)	<0.001
Laboratory results, mean (SD)				
FBG, mg/dL	125.69 (43.60)	124.47 (42.59)	150.03 (55.02)	<0.001
TG, mg/dL	122.09 (94.89)	120.56 (91.68)	152.65 (141.78)	<0.001
TC, mmol/L	4.40 (1.00)	4.40 (0.99)	4.40 (1.29)	0.520

HDL-C, mmol/L	1.38 (0.44)	1.39 (0.44)	1.32 (0.51)	0.050
LDL-C, mmol/L	2.52 (0.81)	2.52 (0.80)	2.49 (1.02)	0.656
Serum creatinine, mg/dL	0.70 (0.25)	0.67 (0.18)	1.29 (0.57)	<0.001
eGFR, mL/min/1.73 m ²	99.43 (18.80)	101.16 (16.49)	64.58 (26.82)	<0.001
TyG	8.74 (0.61)	8.72 (0.60)	9.07 (0.71)	<0.001

SD, standard deviation; TyG, Triglyceride glucose index; DIND, delayed ischemic neurological deficit; Median no. of cerebral angiograms, total number of computed tomography angiography (CTA) and digital subtraction angiography (DSA) procedures combined; FBG, fasting blood glucose; TG, triglyceride; TC, total cholesterol; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; eGFR, estimated glomerular filtration rate.

Table S2 Predictors of AKI on univariate and multivariate logistic regression

Characteristics	Univariate OR (95% CI)	p Value	Multivariate OR (95% CI)	p Value
Age	1.03 (1.01–1.04)	<0.001	1.03 (1.01–1.05)	<0.001
Male	2.75 (1.98–3.81)	<0.001	3.29 (2.12–5.12)	<0.001
Smoking status				
Current smoker	ref	ref	ref	ref
Previous smoker	0.91 (0.46–1.79)	0.77	0.72 (0.35–1.51)	0.39
Never	0.48 (0.25–0.92)	0.03	0.77 (0.37–1.59)	0.48
Drinking	1.82 (1.28–2.6)	<0.001	0.98 (0.59–1.64)	0.95
Medical history				
Hypertension	1.66 (1.18–2.33)	0.004	1.38 (1.05–2.00)	0.03
Diabetes	2.66 (1.62–4.37)	<0.001	1.63 (1.23–2.84)	<0.001
Coronary heart disease	0.75 (0.24–2.41)	0.63		
Chronic obstructive pulmonary disease	2.26 (1.41–3.62)	<0.001	1.17 (0.69–2)	0.56
WFNS				
I	ref	ref	ref	ref
II	1.28 (0.74–2.12)	0.35	1.11 (0.65–1.9)	0.71
III	2.02 (0.69–4.71)	0.14	1.83 (0.68–4.88)	0.23
IV	2.25 (1.34–3.78)	0.002	1.76 (1.03–3.03)	0.04
V	5.14 (3.48–7.60)	<0.001	2.47 (1.59–3.84)	<0.001
Aneurysm characteristics				
Posterior location	1.01 (0.67–1.53)	0.95	0.91 (0.58–1.43)	0.69
Size of aneurysm	0.95 (0.72–1.26)	0.74	0.89 (0.66–1.2)	0.45
Management of aneurysm				
Clip	ref	ref	ref	ref
Coil	0.90 (0.51–1.5)	0.70	1.19 (0.64–2.24)	0.59
No treatment	1.67 (1.15–2.38)	0.006	1.76 (0.91–3.39)	0.09
External ventricular drain	4.39 (2.31–8.36)	<0.001	1.86 (0.91–3.81)	0.09
DIND	1.52(1.05–2.2)	0.027	1.44 (0.97–2.14)	0.07
No. of cerebral angiograms	0.88 (0.75–1.02)	0.09		
Antibiotics use	3.88 (2.75–5.48)	<0.001	2.81 (1.93–4.08)	<0.001
TyG (Continuous)	2.17 (1.74–2.71)	<0.001	1.90 (1.48–2.45)	<0.001

SD, standard deviation; TyG, Triglyceride glucose index; DIND, delayed ischemic neurological deficit; No. of cerebral angiograms, total number of computed tomography angiography (CTA) and digital subtraction angiography (DSA) procedures combined.

Table S3 Predictors of 90-day mortality on univariate and multivariate Cox regression

Characteristics	Univariate HR (95% CI)	p Value	Multivariate HR (95% CI)	p Value
Age	1.02 (1.01-1.03)	<0.001	1.01 (1.00-1.02)	0.033
Male	1.29 (1.05-1.58)	0.015	1.14 (0.86-1.49)	0.363
Smoking status				
Current smoker	ref	ref	ref	ref
Previous smoker	1.31 (0.74-2.30)	0.351	1.38 (0.77-2.49)	0.284
Never	1.15 (0.67-1.96)	0.62	1.40 (0.77-2.52)	0.267
Drinking	1.14 (0.89-1.46)	0.295	1.00 (0.70-1.42)	1
Medical history				
Hypertension	1.16 (0.92-1.45)	0.2	0.92 (0.73-1.17)	0.507
Diabetes	1.48 (1.02-2.15)	0.039	1.17 (0.79-1.73)	0.428
Coronary heart disease	1.18 (0.65-2.15)	0.593	1.03 (0.56-1.89)	0.932
Chronic obstructive pulmonary disease	1.43 (1.02-2.01)	0.038	0.93 (0.64-1.33)	0.677
WFNS				
I	ref	ref	ref	ref
II	2.32 (1.70- 3.17)	<0.001	2.21 (1.61-3.03)	<0.001
III	0.85 (0.31- 2.30)	0.741	0.85 (0.31-2.32)	0.753
IV	2.48 (1.73- 3.56)	<0.001	2.38 (1.66-3.43)	<0.001
V	9.81 (7.66-12.57)	<0.001	6.36 (4.82-8.40)	<0.001
Aneurysm characteristics				
Posterior location	1.25 (0.98-1.60)	0.071	0.99 (0.77-1.28)	0.937
Size of aneurysm	1.31 (1.17-1.45)	<0.001	1.22 (1.10-1.36)	<0.001
Management of aneurysm				
Clip	ref	ref	ref	ref
Coil	0.98 (0.67-1.44)	0.929	1.23 (0.81-1.87)	0.334
No treatment	4.10 (3.32-5.06)	<0.001	3.60 (2.43-5.36)	<0.001
External ventricular drain	4.21 (2.89-6.16)	<0.001	1.99 (1.33-2.98)	0.001
DIND	1.21 (0.94-1.54)	0.132	1.23 (0.96-1.58)	0.102
No. of cerebral angiograms	0.66 (0.60-0.72)	<0.001	1.07 (0.90-1.27)	0.451
Antibiotics use	1.75 (1.43-2.14)	<0.001	1.09 (0.87-1.35)	0.467
TyG (Continuous)	1.50 (1.29-1.74)	0.010	1.20 (1.03-1.39)	0.020

SD, standard deviation; TyG, Triglyceride glucose index; DIND, delayed ischemic neurological deficit; No. of cerebral angiograms, total number of computed tomography angiography (CTA) and digital subtraction angiography (DSA) procedures combined.

Table S4 Baseline characteristics of patients with quartile TyG index, excluding those who died within 7 days of admission

Characteristics	Total (n = 3158)	Quartile 1 (n = 790)	Quartile 2 (n = 789)	Quartile 3 (n = 789)	Quartile 4 (n = 790)	p
Age, mean (SD)	55.07 (11.88)	53.61 (13.17)	55.22 (11.69)	55.51 (11.18)	55.93 (11.25)	0.001
Female, n (%)	2070 (65.5)	510 (64.6)	504 (63.9)	524 (66.4)	532 (67.3)	0.439
Smoking status, n (%)						0.635
Current smoker	138 (4.4)	32 (4.1)	32 (4.1)	41 (5.2)	33 (4.2)	
Previous smoker	627 (19.9)	159 (20.1)	157 (19.9)	142 (18.0)	169 (21.4)	
Never	2393 (75.8)	599 (75.8)	600 (76.0)	606 (76.8)	588 (74.4)	
Drinking, n (%)	619 (19.6)	155 (19.6)	156 (19.8)	145 (18.4)	163 (20.6)	0.73
Medical history, n (%)						
Hypertension	777 (24.6)	134 (17.0)	180 (22.8)	233 (29.5)	230 (29.1)	<0.001
Diabetes	175 (5.5)	18 (2.3)	27 (3.4)	33 (4.2)	97 (12.3)	<0.001
Coronary heart disease	78 (2.5)	24 (3.0)	16 (2.0)	21 (2.7)	17 (2.2)	0.542
Chronic obstructive pulmonary disease	222 (7.0)	59 (7.5)	56 (7.1)	54 (6.8)	53 (6.7)	0.939
WFNS, n (%)						<0.001
I	1877 (59.4)	499 (63.2)	499 (63.2)	466 (59.1)	413 (52.3)	
II	526 (16.7)	137 (17.3)	132 (16.7)	134 (17.0)	123 (15.6)	
III	87 (2.8)	17 (2.2)	19 (2.4)	24 (3.0)	27 (3.4)	
IV	322 (10.2)	77 (9.7)	76 (9.6)	80 (10.1)	89 (11.3)	
V	346 (11.0)	60 (7.6)	63 (8.0)	85 (10.8)	138 (17.5)	
Aneurysm characteristics						
Anterior location, n (%)	2583 (81.8)	644 (81.5)	651 (82.5)	627 (79.5)	661 (83.7)	0.168
Size of aneurysm, cm, mean (SD)	0.76 (0.68)	0.76 (0.76)	0.77 (0.67)	0.74 (0.62)	0.77 (0.67)	0.906
Management of aneurysm, n (%)						0.566
No treatment	582 (18.4)	158 (20.0)	146 (18.5)	143 (18.1)	135 (17.1)	

Clip	2170 (68.7)	537 (68.0)	540 (68.4)	533 (67.6)	560 (70.9)	
Coil	406 (12.9)	95 (12.0)	103 (13.1)	113 (14.3)	95 (12.0)	
External ventricular drain, n (%)	64 (2.0)	13 (1.6)	9 (1.1)	22 (2.8)	20 (2.5)	0.071
DIND, n (%)	589 (18.7)	137 (17.3)	151 (19.1)	154 (19.5)	147 (18.6)	0.704
No. of cerebral angiograms, mean (SD)	2.34 (0.99)	2.27 (1.03)	2.34 (0.98)	2.33 (0.98)	2.41 (0.95)	0.050
Antibiotics use, n (%)	1174 (37.2)	285 (36.1)	257 (32.6)	294 (37.3)	338 (42.8)	<0.001
Laboratory results, mean (SD)						
FBG, mg/dL	124.06 (41.79)	105.05 (23.11)	113.89 (26.00)	122.30 (31.15)	154.98 (58.18)	<0.001
TG, mg/dL	122.09 (94.63)	62.67 (16.92)	90.45 (20.28)	120.16 (28.27)	215.03 (145.43)	<0.001
TC, mmol/L	4.40 (1.00)	4.01 (0.88)	4.34 (0.95)	4.49 (0.95)	4.77 (1.06)	<0.001
HDL-C, mmol/L	1.38 (0.44)	1.52 (0.44)	1.44 (0.44)	1.34 (0.41)	1.22 (0.40)	<0.001
LDL-C, mmol/L	2.52 (0.81)	2.21 (0.70)	2.49 (0.79)	2.64 (0.78)	2.76 (0.87)	<0.001
Serum creatinine, mg/dL	0.69 (0.24)	0.65 (0.19)	0.67 (0.21)	0.71 (0.25)	0.75 (0.29)	<0.001
eGFR, mL/min/1.73 m ²	99.90 (18.46)	104.34 (17.69)	101.78 (17.55)	98.25 (17.80)	95.21 (19.45)	<0.001

SD, standard deviation; TyG, Triglyceride glucose index; DIND, delayed ischemic neurological deficit; No. of cerebral angiograms, total number of computed tomography angiography (CTA) and digital subtraction angiography (DSA) procedures combined; FBG, fasting blood glucose; TG, triglyceride; TC, total cholesterol; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; eGFR, estimated glomerular filtration rate.

Table S5 Association between TyG index and AKI, excluding those who died within 7 days of admission

TyG index	Number of AKI (%)	Model 1		Model 2		Model 3	
		OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Continuous	141(4.5%)	2.07 (1.63-2.62)	<0.001	1.99 (1.54–2.56)	<0.001	1.83 (1.39–2.40)	<0.001
Q1 (≤ 8.33 ; N = 790)	20 (2.5%)	1	Ref	1	Ref	1	Ref
Q2 ($8.33 < \text{TyG} \leq 8.67$; N = 789)	19 (2.4%)	0.95 (0.5-1.79)	0.871	0.90 (0.47–1.72)	0.750	0.96 (0.50-1.83)	0.890
Q3 ($8.67 < \text{TyG} \leq 9.06$; N = 789)	40 (5.1%)	2.06 (1.19-3.55)	0.010	2.00 (1.14–3.49)	0.020	1.86 (1.05-3.28)	0.033
Q4 (> 9.06 ; N = 790)	62 (7.8%)	3.28 (1.96-5.48)	<0.001	2.99 (1.76–5.1)	<0.001	2.62 (1.51-4.55)	<0.001
P for trend			<0.001		<0.001		<0.001

Model 1: unadjusted; Model 2: adjusted for age, sex, aneurysm location, aneurysm size, WFNS grade; Model 3: adjusted for age, sex, smoking, hypertension, diabetes, aneurysm location, aneurysm size, WFNS grade, management of aneurysm, antibiotics use, and delayed ischemic neurological deficit. AKI, acute kidney injury; TyG index, triglyceride-glucose index; OR, odds ratio; CI, confidence interval.

Table S6 Predictors of AKI on univariate and multivariate logistic regression, excluding those who died within 7 days of admission

Characteristics	Univariate OR (95% CI)	p Value	Multivariate OR (95% CI)	p Value
Age	1.03 (1.01-1.05)	<0.001	1.03 (1.02–1.05)	<0.001
Male	2.95 (2.09-4.17)	<0.001	3.67 (2.52–5.35)	<0.001
Smoking status				
Current smoker	ref	ref	ref	ref
Previous smoker	0.83 (0.42-1.65)	0.59	0.76 (0.36–1.61)	0.47
Never	0.44 (0.23-0.85)	0.01	0.84 (0.40–1.74)	0.63
Drinking	1.82 (1.28–2.6)	<0.001	0.96 (0.56–1.65)	0.89
Medical history				
Hypertension	1.73 (1.21-2.47)	0.0025	1.46 (1.01–2.13)	0.03
Diabetes	2.86 (1.72-4.75)	<0.001	1.54 (1.20–2.84)	<0.001
Coronary heart disease	0.85 (0.27-2.74)	0.79		
Chronic obstructive pulmonary disease	2.30 (1.41-3.78)	<0.001	1.17 (0.67–2.05)	0.58
WFNS				
I	ref	ref	ref	ref
II	1.27 (0.73-2.19)	0.39	1.07 (0.61–1.88)	0.81
III	2.18 (0.85-5.62)	0.11	1.92 (0.71–5.16)	0.2
IV	2.5 (1.48-4.21)	<0.001	2.01 (1.17–3.47)	0.01
V	5.49 (3.62-8.33)	<0.001	2.91 (1.85–4.58)	<0.001
Aneurysm characteristics				
Posterior location	1.02 (0.77-1.34)	0.90	0.94 (0.71–1.26)	0.69
Size of aneurysm	1.02 (0.66-1.57)	0.94	0.97 (0.61–1.55)	0.89
Management of aneurysm				
Clip	ref	ref	ref	ref
Coil	0.93 (0.54-1.59)	0.78	1.24 (0.66–2.35)	0.51
No treatment	1.36 (0.9-2.04)	0.14	1.50 (0.75–3.01)	0.25
External ventricular drain	4.73 (2.41-9.27)	<0.001	1.97 (0.93–4.18)	0.08
DIND	1.65 (1.13-2.42)	0.0103	1.55 (1.02–2.33)	0.04
No. of cerebral angiograms	0.94 (0.8-1.11)	0.4921		
Antibiotics use	4.57 (3.15-6.65)	<0.001	3.01 (2.01–4.52)	<0.001
TyG (Continuous)	2.07 (1.63-2.62)	<0.001	1.83 (1.39–2.40)	<0.001

SD, standard deviation; TyG, Triglyceride glucose index; DIND, delayed ischemic neurological deficit; No. of cerebral angiograms, total number of computed tomography angiography (CTA) and digital subtraction angiography (DSA) procedures combined.

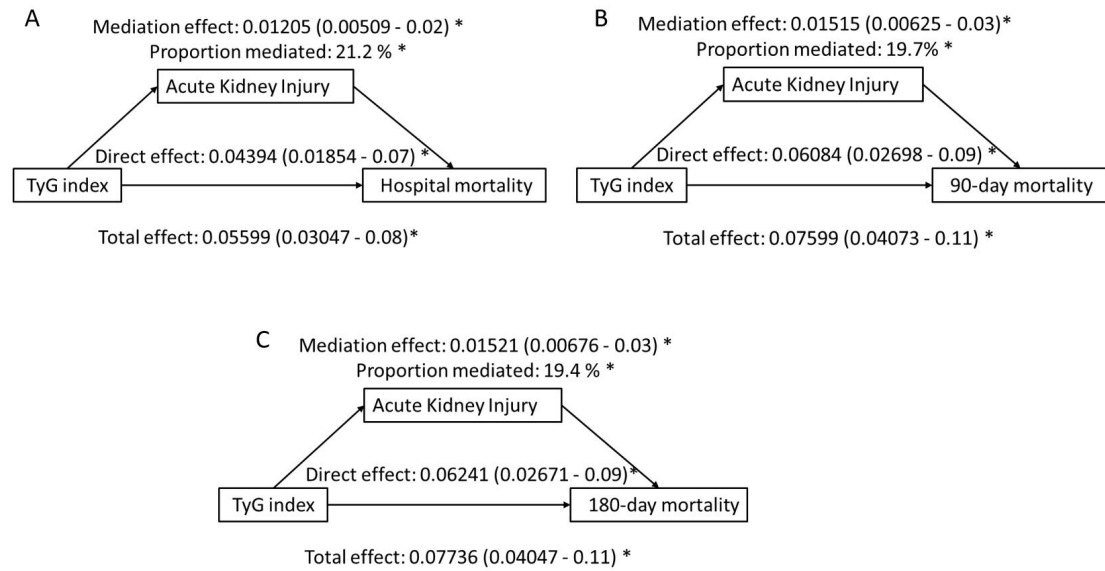


Figure S1 Mediation analysis. Age, sex, hypertension, diabetes, smoking, aneurysm location, aneurysm size and antibiotics use were included as covariate variables. * $p < 0.001$.

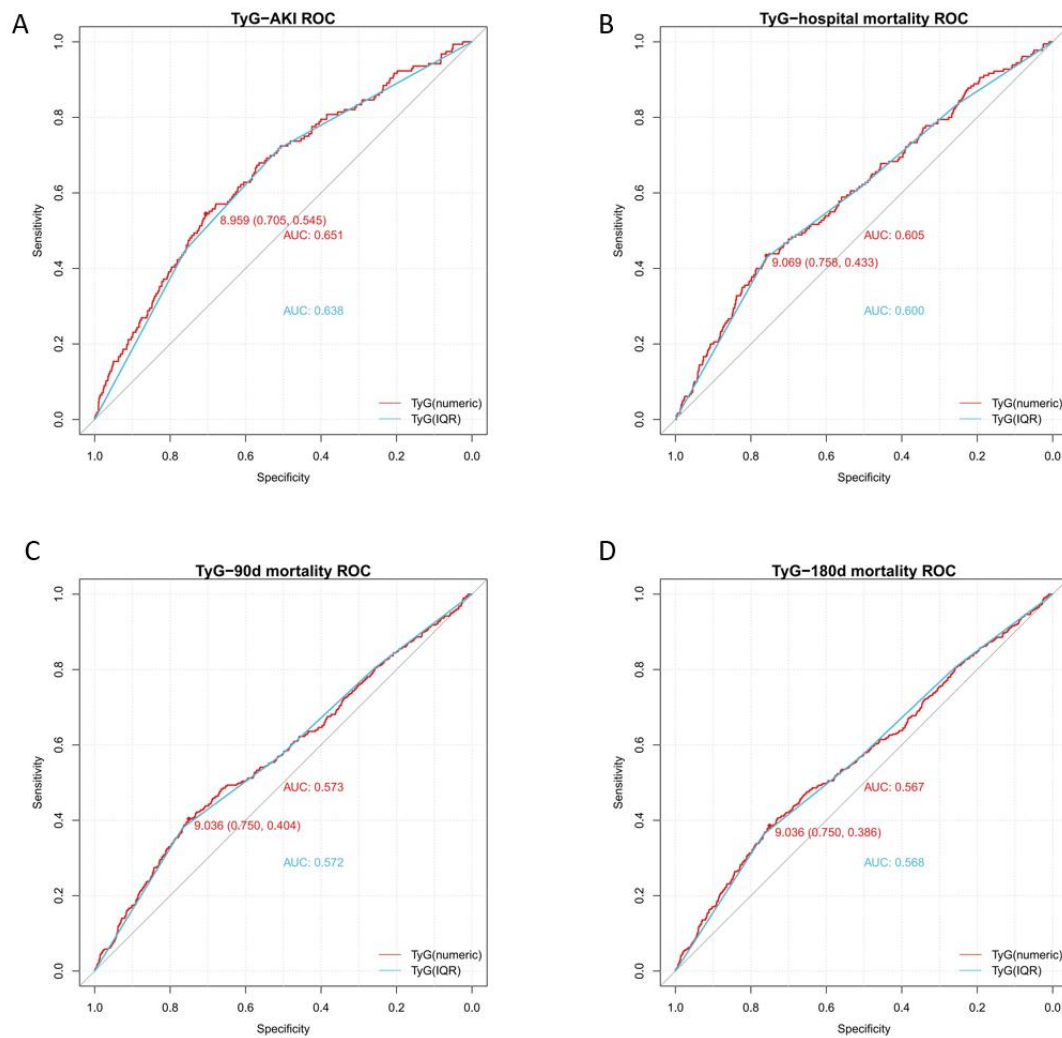


Figure S2 ROC curve analysis of TyG index for AKI, hospital mortality, 90-day mortality, and 180-day mortality.

← ↻ 🔒 <https://asahaki.shinyapps.io/asahaki/>

AKI Prediction of aSAH

TyG index:

Age:

Sex:

Hypertension:

Diabetes:

Aneurysm Location:

Aneurysm Size:

WFNS:

Antibiotics use:

Predicted Risk of AKI: 15.25 %

Figure S3 Sample application interface with input variables on the left side with patient facing risk on the right side of the image.

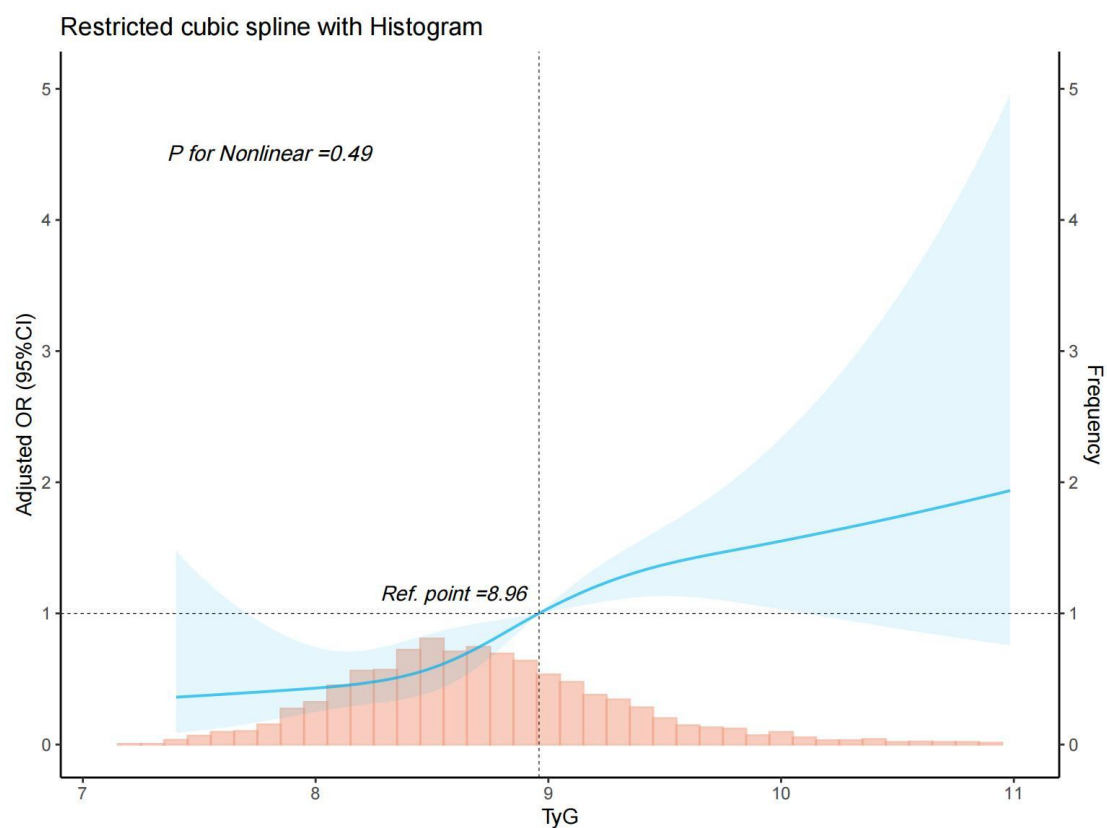


Figure S4 Restricted cubic spline curve of TyG index with AKI in patients with aneurysmal subarachnoid hemorrhage, excluding those who died within 7 days of admission. Adjusted for age, sex, smoking, hypertension, diabetes, aneurysm location, aneurysm size, WFNS grade, aneurysm management, antibiotic use, and delayed ischemic neurological deficit.