

Impact of Antegrade Cerebral Perfusion Time on Outcomes of Aortic Arch Surgery

Yu Hohri, MD, PhD¹, Megan Chung, BS¹, Giacomo Murana, MD, PhD², Yanling Zhao, MS, MPH³, Sabrina Castagnini, MD², Edoardo Bianco MD², Paul Kurlansky, MD³, Davide Pacini, MD², Hiroo Takayama, MD, PhD¹

1. Cardiothoracic Surgery, New York Presbyterian Hospital/Columbia University Irving Medical Center, New York, USA
2. Cardiac Surgery Department, S Orsola Hospital, University of Bologna, Bologna, Italy.
3. Center for Innovation and Outcomes Research, New York-Presbyterian Hospital, Columbia University Irving Medical Center, New York, USA

Objective

- **Background**

Bilateral selective antegrade cerebral perfusion (ACP) has been shown to be useful in aortic arch surgery (1,2).

ACP time is frequently used to assess the procedural impact on outcomes of arch surgery with contradictory findings in the literature (3).

- **Aim:**

To study the association between ACP time, particularly when prolonged, and outcomes of arch surgery.

1. Angleitner P. *J Thorac Cardiovasc Surg.* 2020;159(6):2159-2167.e2
2. Angeloni E. *Ann Thorac Surg.* 2015;99(6):2024-2031.
3. Keeling WB. *Ann Thorac Surg.* 2023;115(2):387-394.

Objective

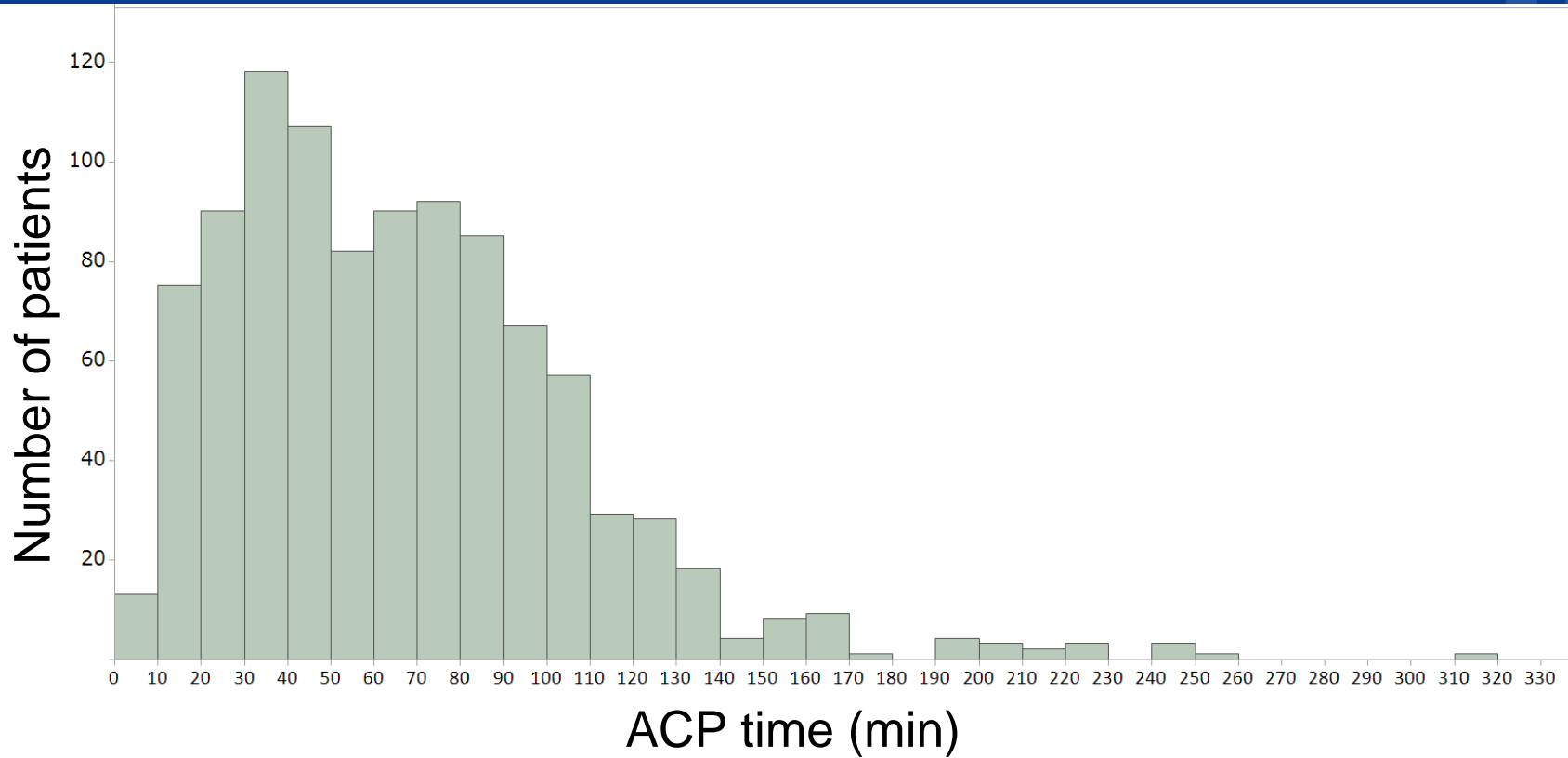
All aortic arch surgery from January 2006 to May 2020 at two aortic centers
n=1728

Exclusion criteria

- Retrograde cerebral perfusion (n=24)
- Only hypothermia with circulatory arrest (n=47)
- Unilateral selective antegrade cerebral perfusion (n=538)
- Intraoperative lowest temperature $<21^{\circ}\text{C}$ or $>28^{\circ}\text{C}$ (n=129)

Study patients; n=990

Distributions of ACP time



ACP time	Patients
ACP <30 min	n=191
31<ACP<60min	n=303
61<ACP<90min	n=263
ACP >90min	n=233

Methods

- **Endpoints:**

Major postoperative outcomes included in-hospital mortality, stroke, acute renal failure, and respiratory failure

- **Analysis:**

- Cubic spline was used to visualize the relationship between ACP time as a continuous variable and primary endpoints
- SACP time was used as a categorical variable (<30 , 31-60, 61-90, and >91 minutes) in multivariable logistic regression to determine its association with the primary endpoints

Results: Operative details by SACP time

Variables	Total (n=990)	ACP <30 min (n=191)	31<ACP<60min (n=303)	61<ACP<90min (n=263)	ACP >90min (n=233)	p-value
Indication						
Aneurysm	530 (53.5)	118 (61.8%)+	98 (32.3%)*,**	167 (63.6)	147 (63.1)	< 0.001
Acute type A dissection	376 (38.0)	63 (33.0%)+	185 (61.1%)*,**	75 (28.5)	53 (22.8)	< 0.001
Aortic arch surgery						
Hemi arch replacement	410 (41.4)	180 (94.2%)+,++,+++	205 (67.7%)*,**	22 (8.3)\$	3 (1.3)	< 0.001
Total arch replacement	580 (58.6)	11 (5.8%)+,++,+++	98 (32.3%)*,**	241 (91.3)\$	230 (98.7)	0.001
Cardiopulmonary bypass						
ACP time	61.0 [35.0,89.0]	20.0 [14.0,26.0]+,++,+++	44.0 [36.0,51.0]*,**	75.0 [68.0,82.0]\$	109.0 [99.0,129.0]	< 0.001
CPB time	200.0 [166.0, 244.0]	164.0 [131.0, 208.5]+,++,+++	193.0 [158.0, 230.0]*,**	205.0 [179.0, 252.0]\$	223.0 [192.0, 272.0]	< 0.001
Aortic cross clamp time	124.0 [96.5,166.0]	115.0 [75.0,154.0]+,++,+++	119.0 [95.0,160.0]*,**	131.0 [101.0,177.0]	133.0 [105,183.0]	< 0.001
Lower body ischemia time	43.0 [33.0, 54.0]	25.0 [19.0, 30.0] +,++,+++	43.0 [36.0, 50.0]*,**	46.0 [37.0, 63.8]\$	52.0 [41.0, 75.0]	< 0.001

+; ACP<30 min versus 31<ACP<60 significant with p< 0.05, ++; ACP<30 min versus 61<ACP<90 significant with p< 0.05, +++; ACP<30 min versus ACP>91 significant with p< 0.05, *; 31<ACP<60 min versus 61<ACP<90 significant with p< 0.05, **; 31<ACP<60 min versus ACP>91 significant with p< 0.05, \$; 61<ACP<90 min versus ACP>91 significant with p< 0.05, post hoc 2-way comparison with Bonferroni Correction.

Results: In-hospital outcomes by SACP time

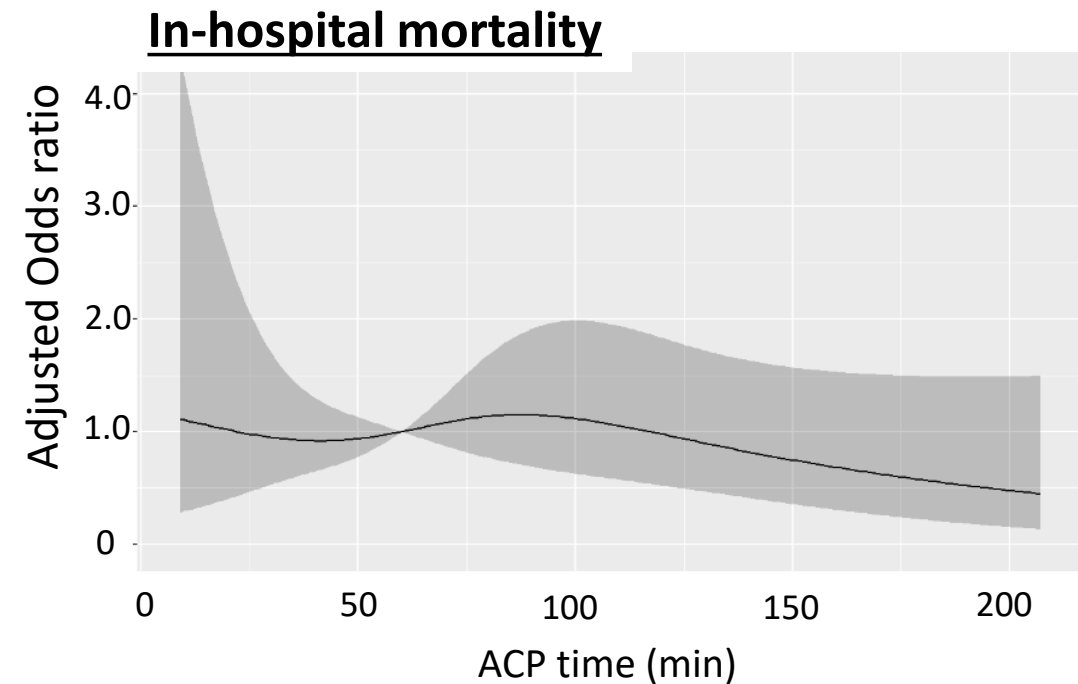
Variables	Total (n=990)	ACP <30 min (n=191)	31<ACP<60min (n=303)	61<ACP<90min (n=263)	ACP >90min (n=233)	p-value
In hospital mortality	113 (11.4)	12 (6.3)	39 (12.9)	31 (11.7)	31 (13.3)	0.06
Stroke	70 (7.1)	12 (6.3)	21 (6.9)	24 (9.1)	13 (5.6)	0.46
Acute renal failure	171 (17.3)	21 (11.0)	55 (18.2)	46 (17.4)	49 (21.0)	0.04⁺⁺⁺
respiratory failure	262 (26.5)	30 (15.7)	93 (30.7)	69 (26.1)	70 (30.0)	0.001^{+,+++}
Reoperation for bleeding	81 (8.2)	12 (6.3)	21 (6.9)	27 (10.2)	21 (9.0)	0.35
Hospital stay	13.0 [8.0,23.0]	9.0 [7.0,16.0]	13.0 [8.0,24.0]	14 [9.0,26.0]	16.0 [10.0,25.0]	<0.001^{++,++++}

+; ACP<30 min versus 31<ACP<60 significant with p< 0.05,

++; ACP<30 min versus 61<ACP<90 significant with p< 0.05,

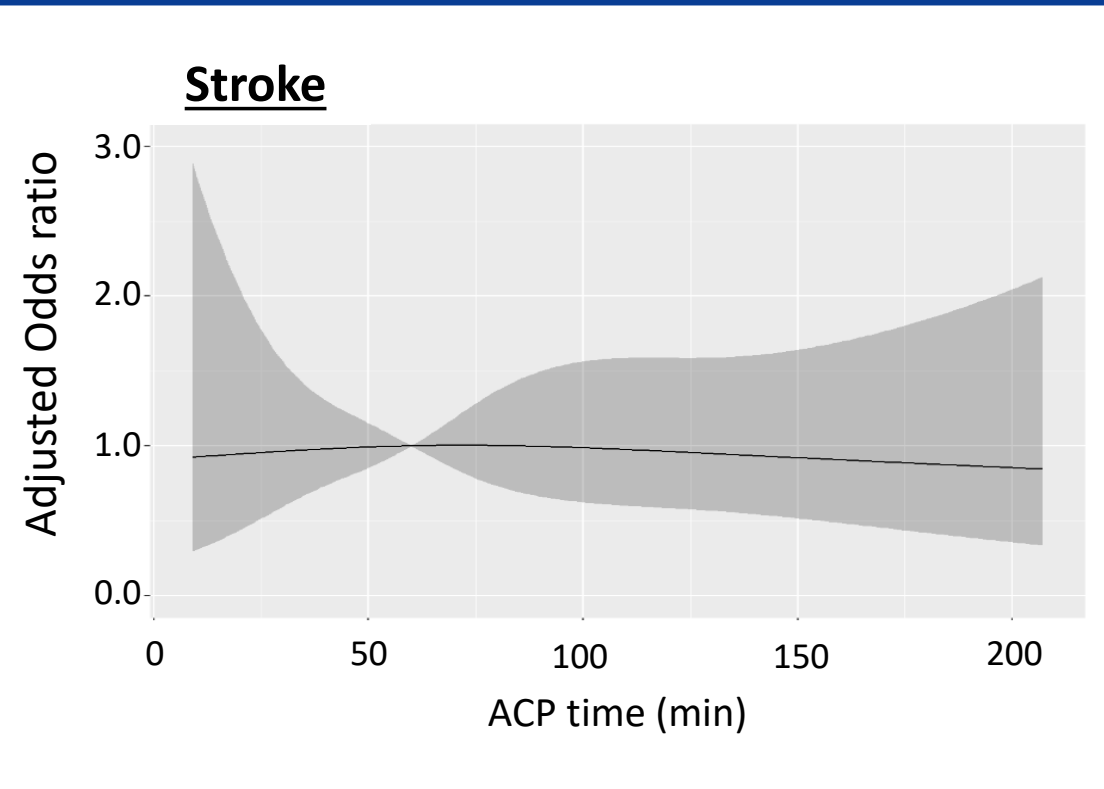
+++; ACP<30 min versus ACP>91 min significant with p< 0.05, post hoc 2-way comparison with Bonferroni Correction.

Results: Cubic spline and Multivariate Logistic analysis for mortality



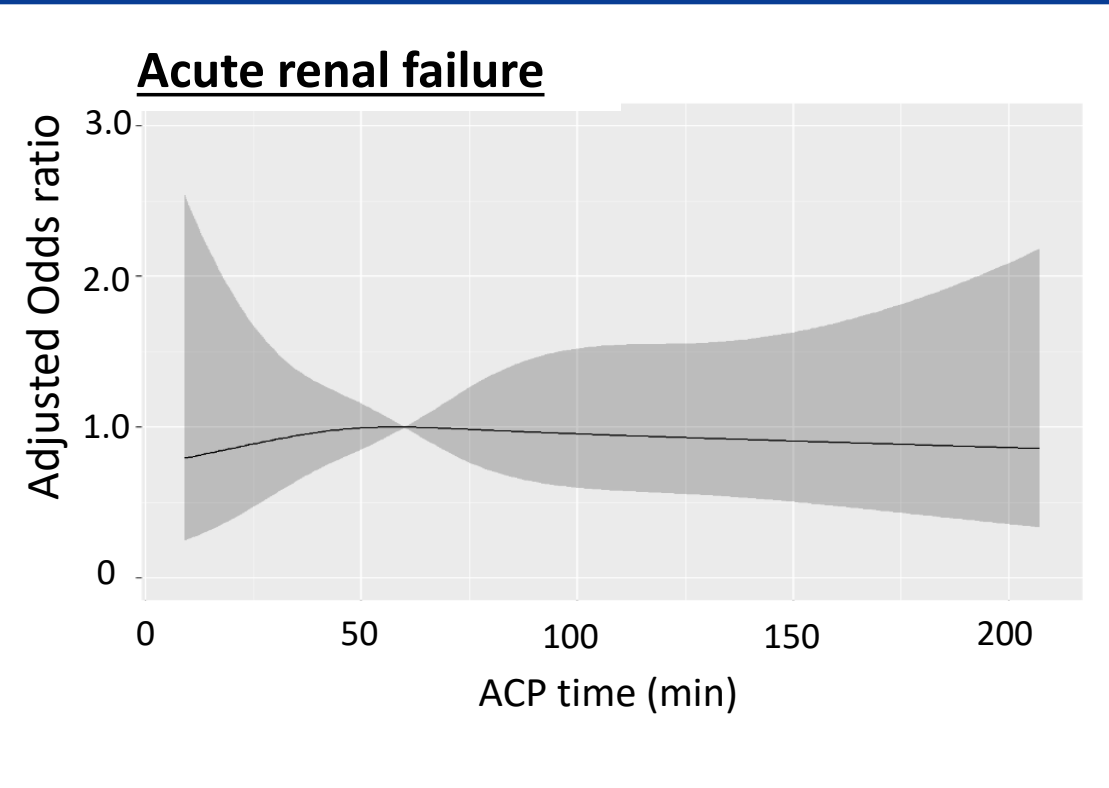
In-hospital mortality	Odds ratio	95% CI	P-value
Age	1.03	1.01-1.05	0.001
Female	1.92	1.23-3.02	0.005
Preoperative chronic kidney disease (CKD)	2.32	1.09-4.94	0.029
Cerebrovascular disease	2.66	1.44-4.93	0.002
Previous cardiac surgery	0.91	0.54-1.54	0.726
Left ventricular ejection fraction (LVEF)	0.96	0.94-0.98	0.002
Acute type A aortic dissection	1.57	0.95-2.60	0.081
Total arch replacement (TAR)	1.65	0.83-3.28	0.151
ACP time			
< 30 min (Reference)	1		
30-60min	1.45	0.67-3.18	0.348
60-90min	1.17	0.43-3.17	0.764
90min-	1.24	0.41-3.73	0.707
Cardiopulmonary bypass (CPB) time	1.01	1.00-1.01	< 0.001
Lower body ischemia (LBI) time	1.01	0.99-1.02	0.389

Results: Cubic spline and Multivariate Logistic analysis for Stroke



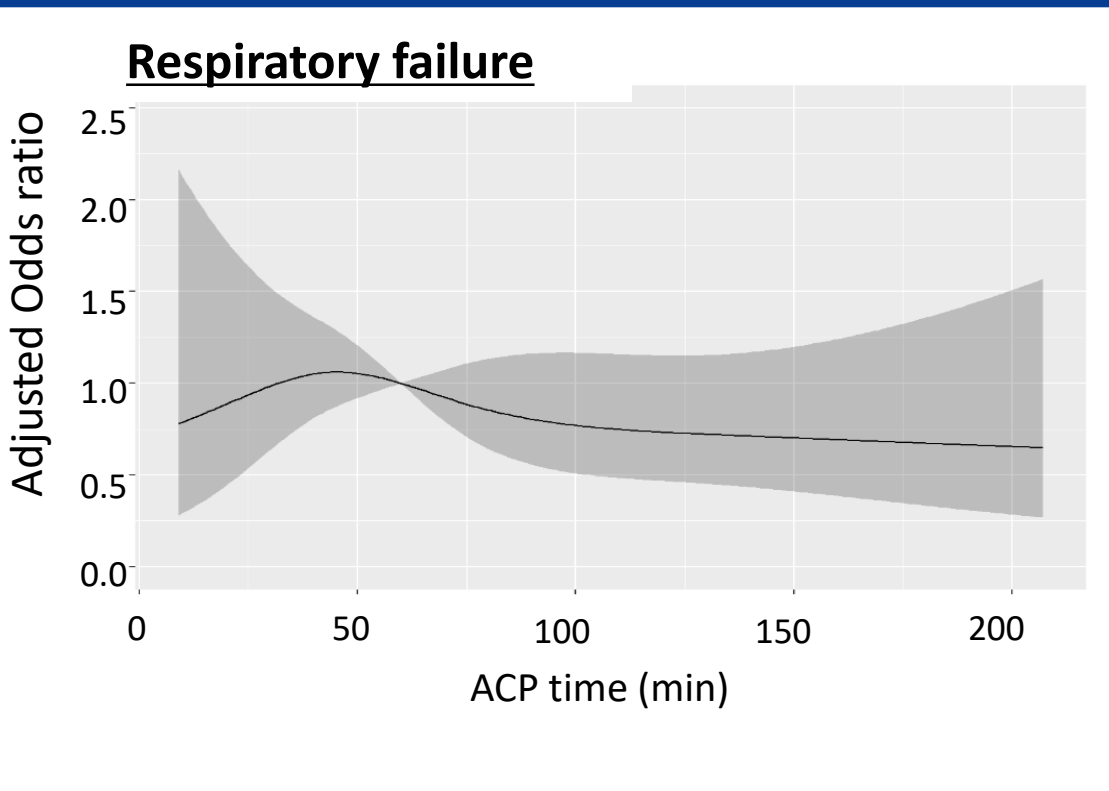
Stroke	Odds ratio	95% CI	P-value
Age	1.03	1.01-1.06	0.003
Cerebrovascular disease	1.08	0.45-2.61	0.866
LVEF	1.01	0.97-1.04	0.731
Acute type A aortic dissection	1.93	1.11-3.36	0.020
TAR	2.58	1.16-5.73	0.020
ACP time			
< 30 min (Reference)	1		
30-60min	0.56	0.24-1.30	0.177
60-90min	0.53	0.18-1.56	0.252
90min-	0.30	0.09-1.03	0.056
CPB time	1.00	0.997-1.01	0.584
LBI time	1.01	0.99-1.02	0.466

Results: Cubic spline and Multivariate Logistic analysis for renal failure



Acute renal failure	Odds ratio	95% CI	P-value
Age	1.02	1.00-1.04	0.022
female	0.92	0.61-1.37	0.673
diabetes	1.09	0.55-2.15	0.807
Hypertension	1.19	0.79-1.81	0.406
CKD	2.99	1.58-5.64	0.001
Cerebrovascular disease	2.20	1.27-3.82	0.005
Connective tissue	1.13	0.39-3.24	0.820
Previous cardiac surgery	1.01	0.65-1.56	0.962
LVEF	0.98	0.96-0.999	0.040
Acute type A aortic dissection	1.90	1.23-2.93	0.004
TAR	1.54	0.86-2.75	0.143
ACP time < 30 min (Reference)	1		
30-60min	1.26	0.67-2.39	0.475
60-90min	0.99	0.43-2.28	0.985
>90min	1.14	0.46-2.83	0.770
CPB time	1.00	1.00-1.01	0.018
LBI time	1.01	0.998-1.02	0.100

Results: Cubic spline and Multivariate Logistic analysis for respiratory failure



respiratory failure	Odds ratio	95% CI	P-value
Age	1.03	1.02-1.05	< 0.001
female	1.22	0.86-1.74	0.260
diabetes	1.71	0.94-3.13	0.080
Hypertension	0.93	0.65-1.33	0.688
CKD	3.14	1.66-5.93	< 0.001
Cerebrovascular disease	1.65	0.96-2.85	0.072
Connective tissue	1.36	0.56-3.34	0.497
Previous cardiac surgery	1.23	0.84-1.81	0.292
LVEF	0.96	0.95-0.98	< 0.001
Acute type A aortic dissection	2.45	1.66-3.62	< 0.001
TAR	1.70	1.01-2.84	0.044
ACP time < 30 min (Reference)	1		
30-60min	1.48	0.784-2.61	0.172
60-90min	0.99	0.477-2.07	0.977
>90min	1.08	0.48-2.42	0.850
CPB time	1.01	1.005-1.01	< 0.001
LBI time	1.01	0.996-1.01	0.258

Limitations

- This is a retrospective study at two large-volume aortic centers.
- Only patients who underwent arch surgery with a lowest temperature of 21.1°C -28.0°C were included.

Conclusion

- In aortic arch surgery utilizing bilateral ACP, ACP time, even with prolonged use beyond 90 minutes, was not associated with major in-hospital complications
- ACP time may not be a suitable variable to address the surgical impact of arch surgery