

Is Routine Left Subclavian Artery Clamping Necessary During Hemi-Arch Replacement? Impact on Cerebral Oxygenation and Early Outcomes During Unilateral Antegrade Cerebral Perfusion

Bekir Boğaçhan Akkaya

Ankara City Hospital

Hayrettin Levent Mavioğlu

Ankara City Hospital

Doğan Emre Sert

Ankara City Hospital

Ayla Ece Çelikten

Ankara City Hospital

Zeliha Aslı Demir

Ankara City Hospital

Ertekin Utku Ünal

Ufuk University

Enis Burak Gül

enisburakgul@gmail.com

Ankara City Hospital

Mehmet Ali Özatik

Ankara City Hospital

Research Article

Keywords: Left subclavian artery, Cerebral perfusion, Near-infrared spectroscopy, Hemi-arch replacement, Aortic surgery

Posted Date: April 19th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9306743/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

The optimal management of the left subclavian artery (LSA) during hemi-arch replacement with unilateral antegrade cerebral perfusion (ACP) remains controversial. Routine LSA clamping has been proposed to improve cerebral perfusion by preventing potential steal phenomena; however, its clinical benefit remains uncertain. This study aimed to evaluate the association between LSA clamping and intraoperative cerebral oxygenation as well as early clinical outcomes.

Methods

This retrospective single-center cohort study included 145 consecutive adult patients undergoing hemi-arch replacement with unilateral ACP between 2016 and 2022. Patients were divided into LSA clamping (n=56) and non-clamping (n=89) groups. The primary outcome was the percentage decrease in regional cerebral oxygen saturation (rSO₂) measured by near-infrared spectroscopy during ACP. Secondary outcomes included neurological events, postoperative complications, and early mortality.

Results

Baseline demographic and operative characteristics appeared comparable between groups. The magnitude of rSO₂ decrease during ACP was similar between LSA clamping and non-clamping groups for both right (12.0% vs 10.6%, p=0.42) and left hemispheres (6.8% vs 8.8%, p=0.56). Clinically relevant cerebral desaturation (≥20% decrease) occurred at similar rates between groups. Permanent cerebrovascular events were observed in 7.1% and 6.7% of patients, respectively (p=0.92). Early mortality occurred in 12.5% of the LSA clamping group and 11.2% of the non-clamping group (p=0.81). Mortality was markedly higher in emergent and salvage procedures compared with elective and urgent operations.

Conclusion

In this single-center retrospective cohort, routine LSA clamping was not associated with improved cerebral oxygenation or early clinical outcomes during hemi-arch replacement performed with short-duration unilateral ACP. These findings suggest that routine LSA clamping may not provide additional benefit in selected patients; however, results should be interpreted cautiously given the observational design and potential era-related confounding.

INTRODUCTION

Neurological injury remains one of the most serious complications following aortic arch surgery and continues to be a major determinant of postoperative morbidity and mortality. Despite advances in cerebral protection strategies, stroke rates after hemi-arch replacement remain between 3% and 10%, particularly in patients undergoing surgery for acute aortic syndromes (1–3).

Antegrade cerebral perfusion (ACP) combined with moderate hypothermia is currently considered a reliable strategy for cerebral protection during aortic arch procedures. Unilateral ACP is widely used in hemi-arch replacement due to its technical simplicity and its ability to provide satisfactory neurological outcomes in patients with adequate collateral circulation through the circle of Willis (4–7). Several clinical studies and meta-analyses have demonstrated comparable neurological outcomes between unilateral and bilateral cerebral perfusion strategies when circulatory arrest duration is limited (8–10).

However, the optimal management of the left subclavian artery (LSA) during unilateral ACP remains controversial. Routine LSA clamping has been proposed to prevent potential cerebral steal through the vertebral circulation and to improve left hemispheric perfusion. On the other hand, routine LSA manipulation may increase operative complexity and introduce additional risks without clear clinical benefit (11–13). Importantly, most existing studies have focused on unilateral versus bilateral ACP strategies, while the specific impact of LSA management during unilateral ACP has received limited attention.

Near-infrared spectroscopy (NIRS) is frequently used for intraoperative monitoring of regional cerebral oxygenation during aortic surgery. Although NIRS primarily reflects frontal cortical oxygenation and may not fully assess posterior circulation, it provides a practical surrogate measure of cerebral perfusion adequacy during ACP (14–16).

The primary aim of this study was to evaluate the association between LSA clamping and intraoperative cerebral oxygenation during hemi-arch replacement performed with unilateral ACP. Secondary objectives included evaluation of neurological outcomes, postoperative morbidity, and early mortality. We hypothesized that routine LSA clamping would not be associated with improved cerebral oxygenation or early clinical outcomes in hemi-arch procedures performed with short-duration unilateral ACP.

METHODS

Study design and patient population

This retrospective single-center cohort study included 145 consecutive adult patients who underwent ascending aortic replacement with hemi-arch reconstruction using unilateral antegrade cerebral perfusion (u-ACP) between January 2016 and June 2022. The study protocol was approved by the institutional ethics committee (E1-21-2172) and conducted in accordance with the Declaration of Helsinki.

Patients aged ≥ 18 years undergoing hemi-arch replacement with unilateral ACP were included. Exclusion criteria were total arch replacement, significant carotid artery stenosis ($>70\%$), prior disabling stroke, incomplete perioperative data, severe preoperative neurological injury, and irreversible malperfusion.

Patients with carotid artery disease $<70\%$ stenosis and prior non-disabling cerebrovascular events were not excluded. Severe neurological injury was defined as preoperative coma or a major neurological

deficit preventing neurological assessment. Irreversible malperfusion was defined as radiological evidence of established organ infarction or clinically non-salvageable end-organ ischemia.

Patients were divided into two groups according to LSA management strategy: LSA clamping (n=56) and non-clamping (n=89). Institutional practice involved routine LSA clamping predominantly before 2019, whereas a non-clamping strategy was generally adopted thereafter. Therefore, this comparison represents an era-based observational comparison rather than two fully concurrent strategies.

Operative technique

All procedures were performed by the same surgical team using lower moderate hypothermia (target nasopharyngeal temperature 26–28°C). Temperature management followed a risk-adapted institutional strategy. Patients with acute type A dissection or aortic rupture were typically cooled to approximately 26 °C to enhance organ protection, whereas patients undergoing less urgent procedures were generally managed at approximately 28 °C during ACP. Temperature selection was therefore based on operative urgency and anticipated circulatory arrest duration rather than LSA management strategy.

Cardiopulmonary bypass was established using right axillary, innominate, or brachial artery cannulation according to anatomical suitability and surgeon preference.

Unilateral ACP was performed during circulatory arrest at a flow rate of 10–15 mL/kg/min. Circulatory arrest duration corresponded to ACP duration in all patients.

Recorded operative variables included cardiopulmonary bypass duration, aortic cross-clamp time, ACP duration, arterial cannulation site, and lowest nasopharyngeal temperature achieved during cooling.

Cerebral monitoring

Cerebral oxygenation was continuously monitored using near-infrared spectroscopy (INVOS system, Medtronic, USA) with bilateral frontal sensors.

Regional cerebral oxygen saturation (rSO₂) values were recorded at predefined operative stages:

- baseline (before cardiopulmonary bypass)
- lowest value during ACP (ACP nadir)
- after restoration of systemic circulation

Baseline rSO₂ was defined as the value immediately before CPB initiation. The intra-ACP value was defined as the nadir rSO₂ during unilateral cerebral perfusion.

Relative NIRS change was calculated as percentage decrease from baseline to nadir:

$$(\text{rSO}_2 \text{ baseline} - \text{rSO}_2 \text{ nadir}) / \text{baseline} \times 100$$

Because measurements were obtained at predefined operative stages rather than continuously across multiple timepoints, temporal NIRS trends were analyzed descriptively rather than with formal repeated-measures statistical modeling.

Neurological evaluation

All patients underwent routine postoperative neurological examination by the cardiovascular surgical team during ICU and ward follow-up according to institutional postoperative care protocols.

Neurology consultation and brain computed tomography were performed in patients with suspected neurological deficits. Imaging was therefore symptom-driven rather than routine. All patients diagnosed with permanent cerebrovascular events had radiologically confirmed lesions consistent with neurological deficits.

Temporary cerebrovascular events were defined as neurological symptoms resolving within 24 hours without radiological infarction. Permanent cerebrovascular events were defined as neurological deficits lasting more than 24 hours with radiological confirmation.

Postoperative delirium, transient confusion, or encephalopathy were not systematically captured due to the retrospective design.

Outcomes

The primary outcome was the relative percentage decrease in rSO_2 from baseline to nadir during unilateral ACP.

Secondary outcomes included:

- permanent cerebrovascular events
- temporary cerebrovascular events
- postoperative complications (prolonged intubation, re-exploration, infection)
- early mortality

Early mortality was defined as death during the index hospitalization.

Exploratory analyses included the relationship between surgical urgency and mortality and the association between LSA management strategy and clinical outcomes.

Statistical analysis

Statistical analysis was performed using SPSS version 26 (IBM Corp).

Continuous variables were presented as mean $\pm$ standard deviation and compared using Student's t-test or Mann-Whitney U test according to distribution characteristics. Categorical variables were compared using chi-square or Fisher's exact tests as appropriate.

Because of the limited number of outcome events, multivariable regression analysis was not performed to avoid model overfitting.

Because LSA management strategy changed over time, an exploratory sensitivity analysis according to operative urgency was performed to evaluate potential differences in case mix between groups. However, this analysis was not intended to fully adjust for era-related confounding. Residual confounding related to temporal changes in surgical practice therefore cannot be excluded.

A two-sided p value <0.05 was considered statistically significant.

RESULTS

Baseline characteristics

A total of 145 patients were included in the study, including 56 patients in the LSA clamping group and 89 patients in the non-clamping group. Baseline demographic and clinical characteristics are summarized in Table 1.

Mean age was similar between groups (57.1 ± 12.8 vs 57.7 ± 13.9 years, $p=0.79$). The prevalence of hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease, prior cerebrovascular events, and carotid artery disease was comparable between groups. Operative urgency distribution was also similar between groups.

The distribution of primary aortic pathology was comparable between groups ($p=0.41$).

Operative characteristics

Operative data are summarized in Table 2. Procedure distribution was comparable between groups ($p=0.52$).

Arterial cannulation strategies were similar between groups ($p=0.57$). The most common cannulation site was the right axillary artery, followed by the innominate and brachial arteries.

Mean lowest nasopharyngeal temperatures were comparable between groups (27.5 ± 0.6 °C vs 27.3 ± 0.8 °C). Temperature selection reflected operative urgency and anticipated circulatory arrest duration rather than LSA management strategy.

Circulatory arrest during unilateral ACP duration was also comparable between groups (26.1 ± 8.2 vs 22.3 ± 7.4 minutes, $p=0.23$).

Cerebral oxygenation

In both groups, NIRS values decreased during unilateral ACP and recovered following restoration of systemic circulation. Absolute rSO₂ values at baseline, during ACP, and after reperfusion are presented in Table 3.

In the LSA clamping group, right-sided rSO₂ values were 57.2 ± 13.9 at baseline, 45.0 ± 6.4 during ACP, and 58.0 ± 11.8 after reperfusion. Corresponding left-sided values were 62.0 ± 15.2, 55.2 ± 8.3, and 61.8 ± 13.1.

In the non-clamping group, right-sided rSO₂ values were 60.0 ± 12.8 at baseline, 49.4 ± 10.1 during ACP, and 60.2 ± 10.6 after reperfusion. Left-sided values were 58.0 ± 13.7, 49.8 ± 8.9, and 58.2 ± 12.7.

Within-group analysis demonstrated a reduction in rSO₂ during ACP followed by recovery after systemic reperfusion. The magnitude of reduction appeared comparable between groups.

The percentage decrease in right-sided NIRS values was 12.0% in the LSA clamping group and 10.6% in the non-clamping group (p=0.42). The percentage decrease in left-sided values was 6.8% and 8.8%, respectively (p=0.56).

When clinically relevant cerebral desaturation was evaluated, defined as a ≥20% reduction from baseline, the incidence was comparable between groups (Table 4). Left-sided desaturation ≥20% occurred in 41.5% of patients in the LSA clamping group and 30.9% in the non-clamping group (p=0.315). Right-sided desaturation ≥20% occurred in 51.2% and 39.5% of patients, respectively (p=0.252).

Postoperative outcomes

Postoperative outcomes are summarized in Table 5. The incidence of permanent cerebrovascular events was similar between groups (7.1% vs 6.7%, p=0.92). Temporary neurological events occurred in two patients in the non-clamping group and none in the clamping group (p=0.37).

Rates of prolonged intubation, postoperative infection, and re-exploration were low and comparable between groups.

Mean hospital length of stay showed a non-significant trend toward a longer duration in the LSA clamping group (10 ± 8.2 vs 7.6 ± 6.2 days, p=0.06).

Mortality analysis

Early mortality occurred in 7 patients (12.5%) in the LSA clamping group and 10 patients (11.2%) in the non-clamping group (p=0.81).

When analyzed according to operative urgency, mortality rates were 4.3% in elective cases, 5.9% in urgent cases, 34.4% in emergent cases, and 25% in salvage procedures.

These findings indicate markedly higher mortality in emergent and salvage procedures compared with elective operations.

DISCUSSION

Principal findings

This study evaluated the association between left subclavian artery management and cerebral oxygenation during hemi-arch replacement performed with unilateral ACP. In this single-center retrospective cohort, routine LSA clamping was not associated with improved intraoperative cerebral oxygenation or early clinical outcomes.

Three main observations support these findings. First, absolute NIRS values and the magnitude of cerebral oxygenation decrease during ACP were comparable between groups. Second, the incidence of clinically relevant cerebral desaturation was similar regardless of LSA strategy. Third, neurological outcomes and early mortality appeared comparable between groups.

Interpretation of NIRS findings

Unilateral ACP is generally considered adequate for cerebral protection when circulatory arrest duration is limited and collateral circulation is sufficient. Our findings are consistent with previous reports demonstrating acceptable neurological outcomes with unilateral cerebral perfusion in selected patients.

Although LSA clamping has been proposed to prevent potential steal phenomena through the vertebral circulation, the present findings suggest that this theoretical benefit may not translate into measurable differences in frontal cerebral oxygenation during short-duration unilateral ACP.

However, these findings should be interpreted cautiously because NIRS primarily reflects frontal cortical oxygenation and may not adequately assess posterior circulation or vertebrobasilar perfusion. Therefore, the absence of NIRS differences does not completely exclude subtle differences in posterior cerebral perfusion.

Clinical interpretation

The findings of this study suggest that routine LSA clamping may not provide additional benefit in selected patients undergoing hemi-arch replacement with short circulatory arrest duration and adequate collateral circulation. Avoiding routine LSA manipulation may simplify the surgical procedure and reduce potential risks related to additional vessel handling.

However, these observations should be interpreted cautiously given the retrospective era-based design of the study and the limited sample size.

Importantly, the present findings apply specifically to hemi-arch replacement performed with short-duration unilateral ACP under moderate hypothermia. These results should not be generalized to total

arch replacement, longer circulatory arrest durations, or patients with complex malperfusion syndromes.

Mortality and operative urgency

In this cohort, early mortality appeared to be more strongly related to operative urgency than to LSA management strategy. Mortality was markedly higher in emergent and salvage procedures compared with elective operations.

Because multivariable adjustment was not performed due to limited event numbers, these observations should be interpreted as descriptive rather than evidence of independent risk relationships.

Methodological considerations

An important consideration in interpreting our findings is that the comparison was strongly linked to operative era. Routine LSA clamping was predominantly performed before 2019, whereas the non-clamping strategy was more frequently used thereafter. Therefore, the comparison reflects an era-based observational comparison rather than two fully concurrent strategies.

As a result, similarities between groups may reflect not only LSA management strategy but also temporal changes in surgical experience, perioperative management, neuromonitoring interpretation, imaging quality, and patient selection.

To partially explore this issue, a sensitivity analysis according to operative urgency was performed and demonstrated similar urgency distribution between groups. However, this approach cannot fully eliminate the possibility of residual era-related confounding.

Temperature management was based on operative urgency and anticipated circulatory arrest duration rather than LSA strategy, and comparable lowest temperatures between groups further support similar cerebral protection conditions.

Limitations

Several limitations should be acknowledged. First, this was a retrospective single-center study with a limited sample size. Second, the era-based nature of the comparison introduces potential residual confounding that cannot be fully adjusted without larger datasets.

Third, multivariable regression analysis was not performed because of the limited number of outcome events and concern for model overfitting. Fourth, NIRS monitoring reflects regional frontal cerebral oxygenation and may not fully represent global cerebral perfusion.

Finally, neurological imaging was performed based on clinical indications rather than systematic screening, which may have resulted in underdetection of subclinical events.

Conclusion

In this single-center retrospective cohort, routine LSA clamping was not associated with improved cerebral oxygenation or early clinical outcomes during hemi-arch replacement performed with short-duration unilateral ACP.

These findings suggest that routine LSA clamping may not provide additional benefit in selected patients; however, these observations should be interpreted cautiously given the observational design and potential era-related confounding. Larger prospective studies are needed to further clarify the role of LSA management in this setting.

Declarations

FUNDING

No funding.

CONFLICT OF INTEREST

All authors have no conflicts of interest to disclose.

HUMAN ETHICS AND CONSENT TO PARTICIPATE:

This study was approved by the Institutional Ethics Committee of Ankara Bilkent City Hospital (approval number: E1-21-2172). Due to the retrospective nature of the study, the requirement for informed consent was waived.

CLINICAL TRIAL NUMBER: not applicable.

References

1. Isselbacher EM, Preventza O, Hamilton Black J, Augoustides JGT, Beck AW, Bolen MA, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease. *Circulation*. 2022;146:e334–e482. DOI: 10.1161/CIR.0000000000001106
2. Czerny M, Schmidli J, Adler S, van den Berg JC, Bertoglio L, Carrel T, et al. EACTS/STS Guidelines for the diagnosis and treatment of aortic diseases. *Eur J Cardiothorac Surg*. 2024;65:ezad426. DOI: 10.1093/ejcts/ezad426
3. Itagaki S, Chikwe J, Sun E, Chu D. Impact of cerebral perfusion strategy on outcomes of aortic surgery. *Ann Thorac Surg*. 2020;109:428–435. DOI: 10.1016/j.athoracsur.2019.08.056
4. Kazui T, Washiyama N, Muhammad BAH, et al. Selective cerebral perfusion during aortic arch operations. *J Thorac Cardiovasc Surg*. 1992;104:49–54. DOI: 10.1016/S0022-5223(19)34955-3
5. Smith T, Jafrancesco G, Surace G, et al. Functional assessment of the circle of Willis before aortic arch surgery. *J Thorac Cardiovasc Surg*. 2019;158:1298–1304. DOI: 10.1016/j.jtcvs.2019.01.107

6. Preventza O, Garcia A, Cooley DA, et al. Unilateral versus bilateral cerebral perfusion. *Ann Thorac Surg.* 2015;99:80–87. DOI: 10.1016/j.athoracsur.2014.07.069

7. Piperata A, Murana G, Castrovinci S, et al. Unilateral versus bilateral cerebral perfusion during aortic surgery. *Eur J Cardiothorac Surg.* 2022;61:828–835. DOI: 10.1093/ejcts/ezab428

8. Santos K, Tran D, Ha H. Unilateral versus bilateral ACP: systematic review. *Heart Lung Circ.* 2025. DOI: 10.1016/j.hlc.2024.11.002

9. Apaydin AZ. Antegrade cerebral perfusion: current application review. *Turk Gogus Kalp Damar Cerrahisi Derg.* 2021;29:1–8. DOI: 10.5606/tgkdc.dergisi.2021.20270

10. Milewski RK, Pacini D, Moser GW, et al. Results of aortic arch surgery using cerebral perfusion. *Circulation.* 2010;122:S138–S145. DOI: 10.1161/CIRCULATIONAHA.109.902494

11. Blanco PJ, Müller LO, Watanabe SM. Computational modeling of subclavian steal. *J Biomech.* 2016;49:1593–1600. DOI: 10.1016/j.jbiomech.2016.03.045

12. Orozco-Sevilla V, Coselli JS. Management of left subclavian artery during arch replacement. *Cardiovasc Diagn Ther.* 2023;13:736–748. DOI: 10.21037/cdt-22-421

13. Cefarelli M, Murana G, Castrovinci S, et al. Factors influencing neurologic outcome in arch surgery. *Ann Thorac Surg.* 2017;104:2016–2023. DOI: 10.1016/j.athoracsur.2017.05.090

14. Murkin JM. NIRS monitoring in cardiovascular surgery. *Anesth Analg.* 2007;104:51–58. DOI: 10.1213/01.ane.0000268143.59740.8a

15. Hogue CW, Colantuoni E, et al. Clinical applications of NIRS monitoring. *Anesthesiology.* 2021;134:784–791. DOI: 10.1097/ALN.0000000000003741

16. Montisci A, Musumeci F. Cerebral perfusion and neuromonitoring review. *J Clin Med.* 2023;12:3470. DOI: 10.3390/jcm12103470

17. Vashakmadze N. Effects of unilateral cerebral perfusion. *Thorac Cardiovasc Surg.* 2025. DOI: 10.1055/s-0044-1796782

18. Banceu CM. Acute aortic syndromes review. *J Clin Med.* 2024;13:1231. DOI: 10.3390/jcm13051231

Tables

Table 1. Demographic characteristics of the two groups.

	LSA Clamping n=56	LSA non-clamping n=89	p- value
Age	57.1 ± 12.8	57.7 ± 13.9	0.520
Male Sex	42 (75%)	73 (82%)	0.200
Diabetes Mellitus	6 (11%)	13 (15%)	0.600
Hypertension	30 (54%)	57 (64%)	0.200
LVEF (%)	55 ± 5	55 ± 5	0.954
Chronic Kidney Disease	3 (5%)	4 (4%)	1.000
Coronary Artery Disease	20 (36%)	29 (33%)	0.700
Carotid Artery Disease (< 70%)	2 (4%)	6 (7%)	0.400
Cerebrovascular Event	1 (2%)	4 (4%)	0.600
Previous Surgery History	14 (25%)	14 (16%)	0.197
Type I Acute Aortic Dissection	11 (19.6%)	23 (25.8%)	0.410
AR + Ascending Aortic Aneurysm	23 (41.1%)	29 (32.6%)	
Ascending Aortic Aneurysm	11 (19.6%)	21 (23.6%)	
Sinus of Valsalva Aneurysm	3 (5.4%)	7 (7.9%)	
AR + MR + Ascending Aortic Aneurysm	3 (5.4%)	6 (6.7%)	
Ascending Aortic Aneurysm + Coronary Artery Disease	1 (1.8%)	3 (3.4%)	
Ruptured Ascending Aortic Aneurysm	2 (3.6%)	0	
Aortic Valve Endocarditis + Ascending Aortic Aneurysm	1 (1.8%)	0	
Mitral Valve Endocarditis + AR + Ascending Aortic Aneurysm	1 (1.8%)	0	

AR; Aortic Valve Regurgitation, MR; mitral valve regurgitation

Table 2. Operative parameters of the two groups.

	LSA Clamping n=56	LSA non- clamping n=89	p-value
Supracoronary Tube Graft + Hemi-arch Replacement	21 (37.5%)	35 (39.3%)	0.520
Bentall Procedure + Hemi-arch Replacement	16 (28.6%)	24 (27.0%)	
Aortic Valve Replacement + Supracoronary Tube Graft + Hemi-arch Replacement	11 (9.6%)	13 (14.6%)	
Double Valve Replacement + Supracoronary Tube Graft + Hemi-arch Replacement	4 (7.1%)	4 (4.5%)	
Supracoronary Tube Graft + Hemi-arch Replacement + Coronary Artery Bypass Graft	1 (1.8%)	4 (4.5%)	
Valve-Sparing Aortic Root Surgery	3 (5.4%)	7 (7.9%)	
Bentall Procedure + Mitral Valve Replacement + Hemi-arch Replacement	0	2 (2.2%)	
Elective Surgery	33 (58.9%)	59 (66.3%)	0.556
Urgent Surgery	10 (17.8%)	7 (7.8%)	
Emergent Surgery	11 (19.6%)	21 (23.6%)	
Salvage Surgery	2 (3.5%)	2 (2.2%)	
CPB duration (min)	183.3 ± 63.8	184.7 ± 58.9	0.88
Cross-Clamp duration (min)	116.8 ± 41.9	127.5 ± 40.7	0.54
Circulatory arrest during unilateral ACP (min)	26,1 ± 8.2	22,3 ± 7.4	0.23

Arterial cannulation site;			0.57
-Right axillary	30 (53.6%)	50 (56.2%)	
-Innominate artery	12 (21.4%)	23 (25.8%)	
-Brachial artery	14 (25.0%)	16 (18.0%)	
Lowest nasopharyngeal temperature (°C)	27.5 ± 0.6	27.3 ± 0.8	0.09

CPB, cardiopulmonary bypass; ACP, antegrade cerebral perfusion.

Table 3. Absolute regional cerebral oxygen saturation values and percentage changes during unilateral antegrade cerebral perfusion

	LSA Clamping (n=56)	LSA non-clamping (n=89)	p-value
Right rSO₂ baseline (%)	57.2 ± 13.9	60.0 ± 12.8	0.28
Right rSO₂ nadir during ACP (%)	45.0 ± 6.4	49.4 ± 10.1	0.07
Right rSO₂ post ACP (%)	58.0 ± 11.8	60.2 ± 10.6	0.31
Right rSO₂ decrease (%)	12.0 ± 10.2	10.6 ± 9.0	0.42
Left rSO₂ baseline (%)	62.0 ± 15.2	58.0 ± 13.7	0.18
Left rSO₂ nadir during ACP (%)	55.2 ± 8.3	49.8 ± 8.9	0.06
Left rSO₂ post ACP (%)	61.8 ± 13.1	58.2 ± 12.7	0.17
Left rSO₂ decrease (%)	6.8 ± 10.3	8.8 ± 9.0	0.56

Values are presented as mean ± standard deviation unless otherwise indicated. Percentage decrease represents the relative reduction from baseline to nadir rSO₂ during ACP. rSO₂, regional cerebral oxygen saturation; ACP, antegrade cerebral perfusion; LSA, left subclavian artery.

Table 4. Clinically relevant NIRS desaturation (≥20% rSO₂ decrease)

	LSA Clamping	LSA non-clamping	p-value
Left ≥20% decrease	41.5%	30.9%	0.31
Right ≥20% decrease	51.2%	39.5%	0.25

Values represent maximum percentage decrease from baseline during ACP. LSA, left subclavian artery

Table 5. Postoperative outcomes of the two groups.

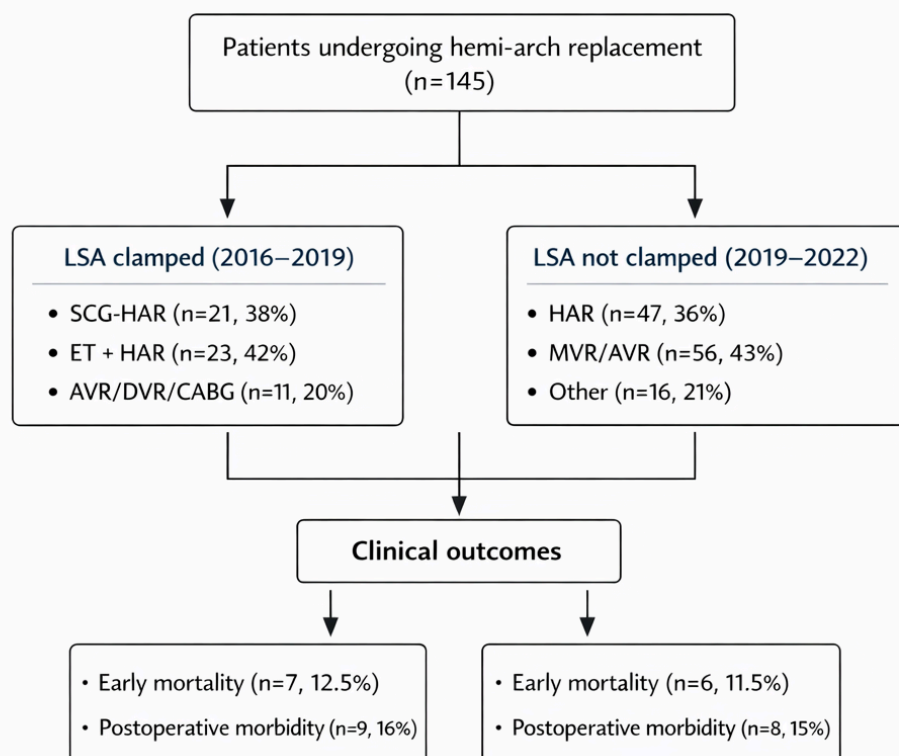
	LSA Clamping n=56	LSA non-clamping n=89	p-value
Temporary CVE	0 (0%)	2 (2%)	0.37
Permanent CVE	4 (7%)	6 (7%)	0.58
Prolonged Intubation	2 (3.6%)	4 (4%)	1.00
Post-operative Exploration	1 (1.8%)	2 (3%)	1.00
Infection	2 (3.6%)	4 (4%)	1.00
Mortality	7 (12.5%)	10 (11.2%)	0.81
-Septic Shock	4 (7.1%)	6 (6.8%)	
-Multi-organ Failure	3 (5.4%)	4 (4.4%)	
Length of stay (day) (mean)	10 ± 8.2	7.6 ± 6.2	0.06

Early mortality defined as in-hospital mortality. P values calculated using Fisher's exact test where appropriate. Septic shock, multi-organ failure, and post-cardiotomy shock represent causes of mortality rather than independent postoperative complications. CVE: cerebrovascular event.

Figures

Study Flow Diagram

Patients undergoing aortic arch surgery (January 2016 – June 2022)



Abbreviations:

ET = Elephant trunk

SCG = Supracoronary graft

HAR = Hemi-arch replacement

AVR = Aortic valve replacement

DVR = Double valve replacement

CABG = Coronary artery bypass grafting

MVR = Mitral valve replacement

CVE = Cerebrovascular event

Figure 1

Study flow diagram

Flow diagram showing patient selection, group allocation according to LSA management strategy, and early clinical outcomes. A total of 145 patients undergoing hemi-arch replacement between January 2016 and June 2022 were included. Patients were grouped according to whether the left subclavian

artery was clamped (2016–2019) or not clamped (2019–2022). Early mortality was defined as in-hospital mortality.

Abbreviations: ET = elephant trunk; SCG = supracoronary graft; HAR = hemi-arch replacement; AVR = aortic valve replacement; DVR = double valve replacement; CABG = coronary artery bypass grafting; MVR = mitral valve replacement; CVE = cerebrovascular event.

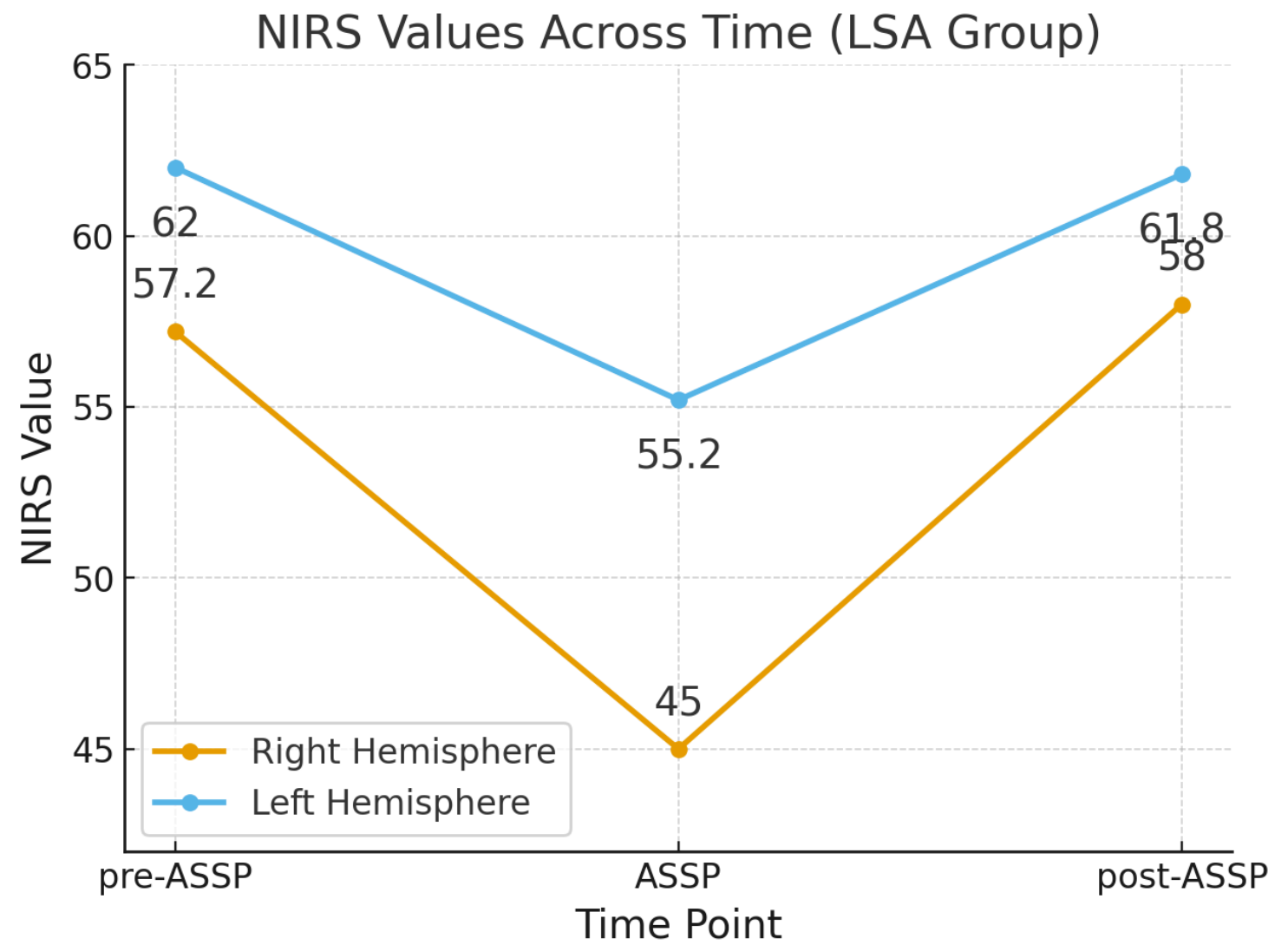


Figure 2

Temporal changes in NIRS values in the LSA clamped group

Temporal changes in right and left regional cerebral oxygen saturation (rSO₂) measured by near-infrared spectroscopy at predefined operative stages in the LSA clamped group.

Values represent mean rSO₂ values at:

baseline (before ACP),

during ACP (lowest recorded value),
and after ACP.

Error bars were not included because the figure is intended as a descriptive illustration of temporal trends; variability data are provided in Table 3.

Abbreviations: NIRS = near-infrared spectroscopy; rSO₂ = regional cerebral oxygen saturation; ACP = antegrade cerebral perfusion; LSA = left subclavian artery.

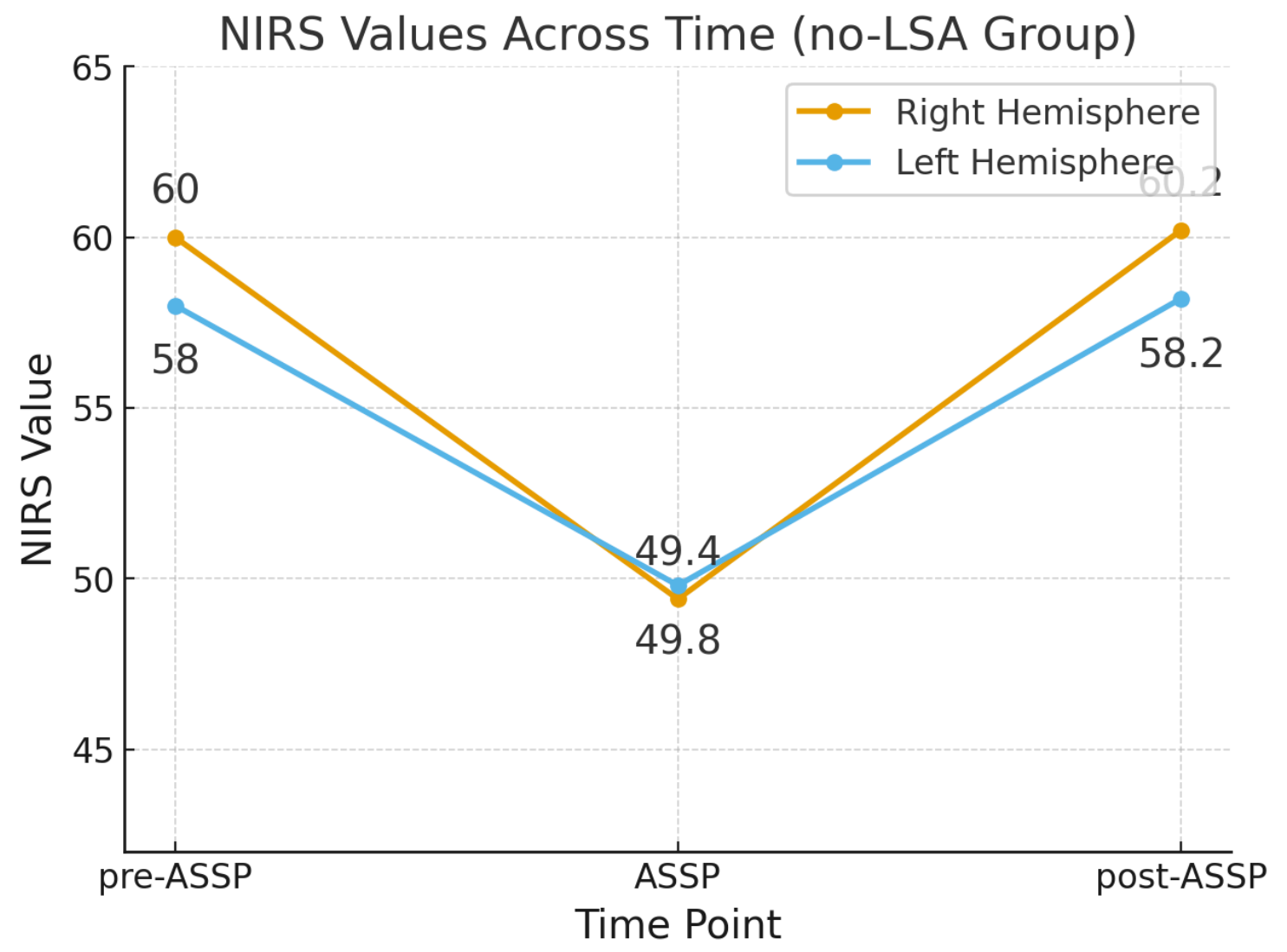


Figure 3

Temporal changes in NIRS values in the non-LSA clamped group

Temporal changes in right and left regional cerebral oxygen saturation (rSO₂) measured by near-infrared spectroscopy at predefined operative stages in the non-LSA clamped group.

Values represent mean rSO₂ values at:

baseline (before ACP),
during ACP (lowest recorded value),
and after ACP.

Error bars were not included because the figure is intended as a descriptive illustration of temporal trends; dispersion measures are reported in Table 3.

Abbreviations: NIRS = near-infrared spectroscopy; rSO_2 = regional cerebral oxygen saturation; ACP = antegrade cerebral perfusion; LSA = left subclavian artery.