Study Protocol and Statistical Analysis Plan

Brief Title: Correlation Between Carotid Stump Pressure and Interhemispheric rSO_2 Asymmetry During Awake Carotid Endarterectomy

Official Title: Evaluation of the Correlation Between Carotid Stump Pressure and Interhemispheric rSO_2 Asymmetry in Awake Carotid Endarterectomy: A Prospective Cohort Study

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NCT Number: [to be assigned upon registration]

Background and Rationale

Carotid artery stenosis accounts for 15–30% of ischemic strokes. Carotid endarterectomy (CEA) reduces recurrent stroke risk in patients with significant stenosis but carries intraoperative risk of cerebral hypoperfusion during carotid cross-clamping. Carotid stump pressure (SP) is used as a surrogate for collateral circulation, while near-infrared spectroscopy (NIRS) provides a continuous, non-invasive estimate of regional cerebral oxygen saturation (rSO_2). Limitations exist with both, and no universal threshold has been validated. Recent interest has shifted toward interhemispheric rSO_2 asymmetry as a marker of perfusion adequacy with different clinical conditions. This study investigates whether SP differs significantly between patients with asymmetry >10% and those with asymmetry ≤10%

Study Objectives

Primary Objective

To determine whether stump pressure values differ significantly between patients with interhemispheric rSO_2 asymmetry >10% vs. ≤10% during awake CEA.

Secondary Objectives

1. Interhemispheric asymmetry difference.
2. Assess correlation between SP and interhemispheric ΔrSO_2 difference.
3. Assess correlation between SP and ipsilateral ΔrSO_2.
4. Identify a carotid SP threshold predictive of significant asymmetry using ROC curve analysis.
5. Evaluate the independent predictive value of SP for asymmetry using multivariable logistic regression (adjusted for age, sex, carotid stenosis, intraoperative hemodynamics).
6. Compare intraoperative hemodynamic parameters (PaO_2 (partial pressure of arterial oxygen), SpO_2 (peripheric oxygen saturation), systolic blood pressure, heart rate) and procedural variables (need for shunt, cross-clamp duration, surgical time) between groups.
7. Document postoperative complications (neurological deficit, bleeding) within 30 days.

Study Design

Type: Single-center, prospective observational cohort study

Setting: Tertiary academic hospital (Cardiovascular Surgery Department)

Population: Adult patients undergoing elective awake CEA under regional anesthesia (superficial cervical plexus block)

Sample Size: ~60 patients (based on power analysis)

Groups:

Asymmetry group: >10% interhemispheric ΔrSO_2 difference

Symmetry group: ≤10% interhemispheric ΔrSO_2 difference

Time Perspective: Prospective, 30 days.

Masking: None (open-label observational study)

Eligibility Criteria

Inclusion Criteria:

1. Age ≥18 years
2. Elective CEA under regional (superficial cervical plexus block) anesthesia
3. Bilateral rSO_2 monitoring with NIRS
4. Successful SP measurement after cross-clamping
5. Written informed consent

Exclusion Criteria:

1. Incomplete SP or NIRS data
2. Conversion to general anesthesia
3. Intraoperative technical complications
4. Prior ipsilateral CEA or stenting
5. Major disabling stroke
6. MI within 3 months
7. Traumatic brain injury within 6 months

Intervention and Monitoring

Anesthesia: Superficial cervical plexus block.

Monitoring: ECG, SpO_2, invasive arterial pressure, bilateral frontal NIRS (INVOS 5100C).

Procedure: Standard CEA under regional anesthesia; SP measured 3 min after cross-clamping with 22G catheter.

Data Collection Points:

T1: Baseline (before cross-clamping)

T2: 3 minutes after cross-clamp

Outcome Measures

Primary Outcome:

Difference in carotid stump pressure between asymmetry (>10% ΔrSO_2) and symmetry (≤10% ΔrSO_2) groups.

Time frame: 3 minutes post-cross-clamp.

Secondary Outcomes:

1. Interhemispheric asymmetry difference.
2. Correlation between SP and interhemispheric ΔrSO_2 difference (3 min post-clamp).
3. Correlation between SP and ipsilateral ΔrSO_2 (3 min post-clamp).
4. ROC curve threshold analysis for SP predicting asymmetry.
5. Logistic regression model (SP + covariates).
6. Comparison of intraoperative hemodynamics and procedural characteristics between groups.

7. Postoperative neurological or bleeding complications within 30 days.

Statistical Analysis Plan

Descriptive statistics: Continuous data as mean ± SD or median (IQR); categorical as frequency/%.

Normality test: Shapiro–Wilk.

Primary outcome: Independent t-test (SP difference between groups). Mann–Whitney U if non-parametric.

Secondary outcomes:

Spearman's correlation (SP vs. ΔrSO_2, ipsilateral ΔrSO_2).

ROC analysis to determine SP cutoff for asymmetry (>10%).

Logistic regression (Model 1: SP; Model 2: adjusted for age, sex, stenosis; Model 3: + intraoperative variables).

Hemodynamic/procedural comparisons: t-test, Mann–Whitney, or Fisher's exact test.

30-day complications compared between groups (Fisher's exact).

Significance threshold: $p < 0.05$.

Software: IBM SPSS v26.

Power Analysis

Preliminary data:

Symmetry group SP: 56 ±15 mmHg

Asymmetry group SP: 44 ±13 mmHg

Cohen's d = 0.855

Sample size calculation (two-sample t-test, $\alpha = 0.05$, power = 0.90, two-tailed):

Required per group = ~30 patients

Total = ~60 patients

Software: G*Power 3.1

Ethics

Approval: Izmir Katip Celebi University Health Research Ethics Committee

Approval No: 0442 (17 July 2025)

Conducted per the Declaration of Helsinki.

Written informed consent required.

Data Sharing

Plan: De-identified IPD (SP values, rSO_2 data, intraoperative hemodynamics, outcomes) will be available upon reasonable request for academic purposes.

Access: Requests subject to institutional and ethical approval.