

The Effect of Cerebral Oximeter Use on the Shunt Placement Concerning Carotid Endarterectomy Surgery

Abstract

Background: During carotid arterial endarterectomy (CAE) surgery, an intraluminal shunt is used to prevent hypoperfusion, which can be caused by a cross-clamping cerebral ischemia. However, routine shunt use is not recommended. Various cerebral monitoring techniques are used to determine the need for shunt placement. In this study, retrospective analysis of data on the efficacy of cerebral oximetry in the decision of shunt use during elective CAE surveys was planned. **Materials and Methods:** We collected data on 68 patients operated under general anesthesia between December 2016 and December 2017. Patients were evaluated for near infrared spectrometry (NIRS) and stump pressure values and whether shunt was placed or not. **Results:** Eight (11.7%) patients were shunting. NIRS value after cross-clamping was lower in patients with shunt. Stump pressure values were below 40 mmHg. **Conclusions:** Cerebral monitoring in elective CAE operations has great importance in determining the necessity of using intraluminal shunt to reduce the complications that may occur.

Keywords: Carotid endarterectomy, near-infrared spectrometry, stump pressure

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Introduction

Carotid artery stenosis caused by carotid artery atherosclerosis is the main cause of stroke and causes high morbidity and mortality. At present, carotid arterial endarterectomy (CAE) surgeries have been accepted as the most effective method to prevent stroke and transient ischemic attack in cases of symptomatic or asymptomatic carotid artery stenosis. However, the most important complication of CAE operations is cerebral embolism or hypoperfusion after intraoperative carotid artery clamp common carotid (CC), which is reported to be seen in 2%–3% of cases. For this reason, early detection of embolism or cerebral hypoperfusion, which may occur during the course of CC, has critical importance in preventing potential neurological damage and more serious cerebral damage.^[1] For this purpose, various cerebral monitoring methods are used in CAE surgery, for example, electroencephalogram, somatosensory evoked potentials, transcranial Doppler (TCD) in which cerebral blood flow is directly evaluated, jugular venous oxygen saturation (SpO₂) which gives information about cerebral

oxygen metabolism, and regional cerebral perfusion oximetry (NIRS).^[2]

Near infrared spectrometry (NIRS) measures regional oxygenation (oxyhemoglobin/total hemoglobin) by interpreting oxy- and deoxyhemoglobin signals. Normal NIRS values are around 60%.^[3]

Decreased brain perfusion during the intraoperative carotid artery CC leads to a decline in NIRS value. To prevent this, intraluminal shunt is placed to preserve brain perfusion.^[1]

In this study, retrospective analysis of data on the efficacy of cerebral oximetry (NIRS) in the decision of shunt use during elective CAE surveys was planned.

Materials and Methods

Following the approval of the local ethics committee (13/13.03/2018), the medical records of patients who underwent elective CAE between December 1, 2016, and December 15, 2017, were examined. Patients were evaluated for demographic data, NIRS values, blood pressure arterial values, shunt use, and the presence of postoperative neurological problems.

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In all patients taken in the room, electrocardiography, peripheral SpO₂, and noninvasive blood pressure and invasive arterial pressure monitoring were applied and 18G peripheral intravenous cannula was placed and 0.9% normal saline infusion was started. None of the patients were premedicated before surgery. NIRS probe was placed in all patients before anesthesia, and initial value was recorded and was monitored throughout the entire procedure and until the patient was taken from the operating table (INVOS 5100 Cerebral Oximeter, Somanetics Corporation). All cases were operated under general anesthesia in the standard CAE surgical position (face is looking in the opposite direction in supine position). Induction of anesthesia was achieved with thiopental (5 mg/kg, IE Ulagay), rocuronium (0.5 mg/kg, Merck Sharp and Dohme), and remifentanyl (1 µg/kg, GlaxoSmithKline). Mean arterial pressure (MAP) was measured invasively using a 20-gauge catheter placed in the radial artery. The mechanical ventilation parameters were adjusted to be within the limits of end-tidal carbon dioxide normocarbida (35–40 mmHg). Anesthesia was maintained with sevoflurane (1.5%–2%) and remifentanyl (0.05–0.1 µg/kg/min). To prevent the development of bradycardia, 1% lidocaine was applied by the surgical team on internal, external, and CC arteries. Following systemic intravenous (5000 IU) heparin administration, the carotid arterial cross-clamp was placed at the appropriate active clotting time >200. After cross-clamping, “stump pressure” was measured. The cutoff value for intraluminal shunt placement was accepted as 10% reduction (10% reduction from the previous value after cross-clamping) for NIRS and 40 mmHg for stump pressure.^[4]

The NIRS and MAP values of the patients were evaluated at awake (1), after induction (2), after intubation (3), 30 min after intubation (4), after cross-clamping (5), 5 min after cross-clamping (6), 10 min after cross-clamping (7), 20 min after cross-clamping (8), and at the postextubation period (9).

Statistical evaluation

The Statistical Package for the Social Sciences 21.0 (SPSS Inc, Chicago, Illinois, USA) was used in the analysis of the data. Mean and standard deviation were used for descriptive statistical methods when study data were evaluated. In the comparison of quantitative data, Mann–Whitney U-test was used for the comparison of the parameters between the groups, and Wilcoxon signed-rank test was used for the intragroup comparison of the parameters. The results were evaluated at a 95% confidence interval and a statistically significance level of $P < 0.05$.

Results

The records of 68 patients who underwent elective CAE were reviewed. Of the patients, 20 were female and 48 were male. The mean age was 70.4 ± 8.48 years. The duration of

cross-clamping applied to the patient was 29.14 ± 9.64 min. Intraluminal shunt was placed in 8 (11.7%) patients. The right side of 33 patients and the left side of 35 patients were operated. In patients with shunt, 4 of them were right and 4 of them were left side [Table 1].

Table 2 shows the NIRS values of patients who have shunts placed and not. NIRS value at the time when patients were awake ($P = 0.006$) and NIRS value after cross-clamping was lower ($P = 0.000$) in patients with shunt.

Table 3 shows the NIRS values and stump pressures of the 8 patients who underwent shunt placement after

Table 1: Demographics and surgical characteristics

	Shunt placed patients (n=8)	Patients without shunt (n=60)	P
Gender			
Female/male	4/4	16/44	-
Age (years)	69.37±7.59	70.55±8.64	0.716
Cross-clamping time	29.80±7.98	30.60±5.48	0.084
Operative side			
Right/left	4/4	29/31	-

Age and cross-clamping time (mean±SD). SD: Standard deviation

Table 2: Near-infrared spectrometry value

	Shunt placed patients (n=8)	Patients without shunt (n=60)	P
NIRS 1	73.25±5.11	65.01±10.34	0.006*
NIRS 2	77.37±6.10	68.10±10.70	0.200
NIRS 3	77.62±8.51	71.88±10.50	0.144
NIRS 4	66.12±9.49	66.36±9.87	0.948
NIRS 5	47±5.75	64±9.70	0.000*
NIRS 6	57.12±7.23	63.90±9.32	0.053
NIRS 7	57.75±11.43	63.93±8.69	0.073
NIRS 8	64.62±9.37	66.68±9.17	0.554
NIRS 9	67.75±5.87	70.55±9.45	0.418

* $P < 0.05$. NIRS 1: Awake, NIRS 2: After induction, NIRS 3: After intubation, NIRS 4: After 30 min, NIRS 5: After cross-clamping, NIRS 6: 5 min after cross-clamping, NIRS 7: 10 min after cross-clamping, NIRS 8: 20 min after cross-clamping, NIRS 9: At the postextubation period

Table 3: Near-infrared spectrometry (after cross-clamping) values and stump pressure with shunt placed patients

Shunt placed patients	NIRS 5	Stump pressure
Patient number 1	44	24
Patient number 2	43	25
Patient number 3	44	27
Patient number 4	51	22
Patient number 5	50	21
Patient number 6	43	25
Patient number 7	45	25
Patient number 8	47	26

NIRS 5: After cross-clamping

cross-clamping. It is seen that all values are below 40 mmHg.

The relationship between MAP and NIRS values before and after cross-clamping is given in Table 4. Both MAP and NIRS values of 2, 3, and 7 patients were found to be decreased, whereas in 1, 5, and 8 patients of MAP increased and NIRS decreased. Despite the fact that there is no change in NIRS value in patient number 4, a decrease of 8.1% in MAP value was noted. There was no statistical correlation between MAP and NIRS values.

Only one patient developed postoperative right hemiparesis. No complications were found in other patients.

Discussion

The CAE-related strokes occur due to cerebral embolism, hypoperfusion, or thrombosis. One of the measures that can be taken to avoid this is to place the intraluminal shunt to prevent the cerebral blood circulation from being interrupted. However, the routine use of shunt placement is not recommended due to the potential risks (arterial dissection, air embolism, and thrombosis).^[5] Intraoperative cerebral monitoring is required to avoid neurological complications and to prevent unnecessary shunt placement in patients undergoing general anesthesia CAE. Many different techniques are used for this purpose.^[6]

Stump pressure is the perfusion pressure that reflects the circle of Willis pressure and down the internal carotid beyond the cross-clamp. The value >40 mmHg had a sensitivity of 57% and specificity of 97% for predicting a neurological deficit.^[7] Near-infrared spectrometry is the value of regional cerebral oxygen by means of a probe placed on the head skin. The measured value reflects the mix of the arterial and venous oxygen.^[4] In patients undergoing CAE under local anesthesia, the cutoff value for stump pressure and NIRS value was determined to avoid neurological deficit. In previous studies, it has been suggested that an intraluminal shunt placement should be performed when the NIRS value after placement of the cross clamp is less than 10% or 20% and stump pressures are lower than 30 or 40 mmHg.^[4,6,8]

Table 4: Relationship between mean arterial pressure and near-infrared spectrometry values with shunt placed patients

Shunt placed patients	MAP 4-MAP 5 (%)	NIRS 4-NIRS 5 (%)
Patient number 1	+7.9	-36.23
Patient number 2	-22.9	-38.57
Patient number 3	-11.6	-17
Patient number 4	-8.1	-2
Patient number 5	+9.6	-26.47
Patient number 6	-14.2	-34.84
Patient number 7	-7.7	-39.18
Patient number 8	+11.1	-39.74

MAP 4, NIRS 4, 30 min after intubation, MAP 5, NIRS 5: After cross-clamping, -: Decrease, +: Increase. MAP: Mean arterial pressure

In this study, we evaluated the effect of intraoperative NIRS value and stump pressure measurement on shunt placement decision in patients undergoing CAE under general anesthesia; we found that shunts were used in 8 (11.7%) of 68 patients. In these 8 patients, we observed that the NIRS values of patients after cross-clamping were decreased. This decrease was statistically significant when compared to patients who did not placed shunt ($P = 0.000$). The decrease in NIRS values of these eight patients was $>10\%$ except one patient. When the stump pressures of the patients were measured in the same period, it was seen that the values of patients who placed shunt were lower than patients who did not placed shunt. Seven patients who placed shunt were found to have a decline of $>10\%$ in NIRS values and a fall of 40 mmHg in stump pressures. In one patient (patient number 4), however, the intraluminal shunt placement was decided because the stump pressure was 22 mmHg although the fall in NIRS value was minimal.

There is no clear consensus on ideal cerebral monitoring in CAE operations under general anesthesia. Therefore, it is stated that it is better to use more than one method together.^[8] We also decided to place a shunt in one of our patients for the reason that the stump pressure measurement was low when the NIRS value did not change.

Jonsson *et al.* compared stump pressures and NIRS measurements in CAE operations in terms of shunt placement, and as a result they reported that NIRS measurement was more accurate than stump pressure measurements.^[5] In a previous study comparing TCD and NIRS monitorizations, NIRS monitoring was found to be more effective in detecting the necessity of shunt use, and it was stated that it is easier to use.^[6] However, some authors suggest that the NIRS values may be affected by some factors. These factors include arterial SpO₂, systemic blood pressure, arterial carbon dioxide level, hematocrit level, and cerebral blood level.^[9] However, since the evaluation was made between two consecutive measurements, it is also stated that the effect of these factors is limited.^[11]

Following the placement of the carotid cross-clamping, it was noted that the increase in blood pressure following the fall in NIRS value was not sufficient for cerebral protection.^[8] Even Giustiniano *et al.* showed a poor correlation between blood pressure and NIRS values.^[10] In our study, we observed that NIRS and MAP values were independent of each other in patients who placed shunt. In some patients, there was a slight decrease in MAP value when the NIRS values fell further, but in some patients, MAP values were found to rise, on the contrary.

Postoperative neurological complication (right hemiparesis) was observed in only 1 of 68 patients who underwent elective CAE operation in this study. During the operation, it was observed that the patient's NIRS values were normal,

and the root pressures were above 40 mmHg during the cross-clamping period. Therefore, it was determined that there was no need to place the intraluminal shunt in the patient. It was concluded that this neurological complication may have developed due to plaque embolism.

Cerebral monitoring in elective CAE operations has great importance in determining the necessity of using intraluminal shunt to reduce the complications that may occur. Near-infrared spectrometry is a monitorization method that should be routinely used for the reason that the use is easy and easy to interpret. However, we believe that the combined use of stump pressure measurement allows more effective results.

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Conflicts of interest

There are no conflicts of interest.

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