

## Cerebral oximetry monitoring method for the evaluation of the need of shunt placement during carotid endarterectomy

*Karotis endarterektomi sırasında şant yerleştirme gerekliliğinin serebral oksimetre izlem yöntemi ile değerlendirilmesi*

Murat Aksun,<sup>1</sup> Senem Girgin,<sup>1</sup> Volkan Kuru,<sup>1</sup> Atilla Şencan,<sup>1</sup> Levent Yılık,<sup>2</sup> Gülçin Aran,<sup>1</sup> Ali Gürbüz,<sup>2</sup> Nagihan Karahan<sup>1</sup>

<sup>1</sup>Department of Anaesthesiology and Reanimation, İzmir Katip Çelebi University, İzmir Atatürk Training and Research Hospital, İzmir, Turkey

<sup>2</sup>Department of Cardiovascular Surgery, İzmir Katip Çelebi University, İzmir Atatürk Training and Research Hospital, İzmir, Turkey

The primary objective of anesthetic and surgical approach in carotid surgery is to protect the heart and brain from an ischemic damage. As a result, a shunt application which carries the blood from the common carotid artery to the internal carotid artery may be required during surgery. Shunt is usually used in patients with contralateral carotid artery stenosis or circle of Willis disease. Several monitoring methods are available to identify the need for intraoperative shunting. In this article, we aimed to present our clinical experience related to the use of cerebral oximetry monitoring method in the decision of shunt usage in carotid surgery.

**Key words:** Carotid endarterectomy; cerebral oxymetry; shunt.

A carotid endarterectomy (CEA) is an effective and well tolerated method for treating symptomatic patients with carotid stenosis of greater than 70%.<sup>[1-3]</sup> However, this surgical procedure has a perioperative stroke risk of 2-7.5%.<sup>[1,2]</sup> To minimize this, various monitoring methods, such as stump bleeding from the internal carotid artery (ICA), carotid artery stump pressure (CASP), jugular venous oxygen saturation (SO<sub>2</sub>), transcranial Doppler (TCD), electroencephalography (EEG), the bispectral index (BIS), and cerebral oximetry [near-infrared spectroscopy (NIRS)] have been used to determine the presence of inadequate

Karotis ameliyatlarında anestezi ve cerrahi yaklaşımın birincil hedefi, kalp ve beyni iskemik hasardan korumaktır. Bu nedenle, ameliyat sırasında kanı ana karotis arterden internal karotis artere taşıyan bir şant uygulaması gerekebilir. Şant sıklıkla karşı taraf karotis arterde darlık bulunan ya da Willis halkası yetersizliği bulunan hastalarda kullanılmaktadır. Ameliyat sırası şant kullanımını gerekliliğine karar vermede çeşitli izlem yöntemleri bulunmaktadır. Bu makalede, karotis cerrahisinde şant kullanımını kararının verilmesinde serebral oksimetre izlem yönteminin kullanımına ilişkin klinik deneyimlerimiz sunuldu.

**Anahtar sözcükler:** Karotis endarterektomi; serebral oksimetre; şant.

cerebral perfusion and whether there is a need for shunting during carotid clamping.<sup>[1]</sup>

The blood of the common carotid artery (CCA) is directed to the ICA via a shunt that is commonly used in patients with contralateral carotid artery stenosis or circle of Willis disease. Monitoring with NIRS is an easy, noninvasive method for measuring continuous regional cerebral oxygen saturation (rSO<sub>2</sub>),<sup>[4]</sup> and the cost of the essential sensor needed to perform this procedure costs approximately 350 TL per patient (\$210 USD).



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Correspondence: Murat Aksun, M.D. İzmir Katip Çelebi Üniversitesi Atatürk Eğitim ve Araştırma Hastanesi Anesteziyoloji ve Reanimasyon Kliniği, 35360 Karabağlar, İzmir, Turkey.

Tel: +90 232 - 244 44 44 / 2380 e-mail: murataksun@yahoo.com

With a cerebral oximetry device, beams from a light source are placed on two forehead electrodes, and these go through a banana-shaped path and return to the photo detectors on the electrodes. The ones close to the light source detect reflections from the skin, subcutaneous fat tissue, and bone tissue while those far from the light source detect the reflections from a deep watershed area at the junction of the anterior cerebral artery and the middle cerebral artery in the brain tissue. Blood flow rates in this region of the brain are 30% arterial and 70% venous; therefore, the values revealed by the cerebral oximetry devices show a mixture of arterial and venous blood at a ratio of 3:7.<sup>[5]</sup> Additionally, NIRS monitoring allows for the direct measurement of SO<sub>2</sub>, which is affected by the presentation and consumption in the cerebral cortex. Having this information could possibly give an early warning regarding perfusion defects. Furthermore, rSO<sub>2</sub> monitoring has a low false-negative rate (2.6%) but a high false-positive rate (66.7%).<sup>[6]</sup>

**TECHNIQUES**

In this article, we aimed to present our clinical experience related to the use of cerebral oximetry monitoring method in the decision of shunt usage in carotid surgery. In six of the 25 NIRS-monitored patients (4 males, 2 females; mean age 70.3 years; range 67 to 75 years), a significant decrease in cerebral SO<sub>2</sub> was observed when the cross-clamp was put into place. In our clinic, following electrocardiography (ECG) and peripheral oxygen saturation (SpO<sub>2</sub>) monitoring vascular access was achieved with two 18 gauge cannula and arterial monitoring was performed on patients who would later undergo a CAE. Those with electrodes placed on the right and left part of the forehead for NIRS monitoring (INVOS® 5100C Cerebral/Somatic Oximeter, Somanetics Corporation, Troy, MI, USA) had surgery under general anesthesia after recording their base values, and they were intubated

with 1.2 mg/kg<sup>-1</sup> rocuronium following anesthesia induction with 2 µg/kg<sup>-1</sup> fentanyl and 3-5 mg/kg<sup>-1</sup> sodium thiopental.

In six of the 25 NIRS-monitored patients, a significant decrease in cerebral SO<sub>2</sub> was observed when the cross-clamp was put into place, but the surgical team was warned that this would occur. Furthermore, increased cerebral oximetry values were observed after the use of a shunt in these six cases, and the data from these patients was recorded as follows: the mean right carotid stenosis was 75% (range 60-90%), the mean left carotid stenosis was 70% (range 60-80%), the mean operation time was 104.16 minutes (range 90-120), and the mean cross-clamp time was 27.16 minutes (range 25-32). Their preoperative and intraoperative NIRS values are presented in Table 1. We also observed that the cerebral oximetry values of the patients with unilateral or bilateral carotid stenosis were close to the normal values. However, the baseline values were a bit lower.

The cerebral arterial system is correlated with the circle of Willis which receives blood from the four main arteries. When the internal and external carotid arteries are both cross-clamped on the operated side, we believe that the bilateral decrease of saturation is connected to the decrease in pressure throughout the whole system, especially in the early episodes.

In patients who do not require a shunt, the mean rSO<sub>2</sub> difference was 10% of the baseline value, but this was not considered taken into account because 20% decreases from the baseline value are important in cerebral oximetry monitorization.

**DISCUSSION**

While the most sensitive monitoring for cerebral perfusion and function usually takes place during a neurological examination of patients who are awake, many CEA operations are performed under general anesthesia. Occasionally the use of a shunt may

**Table 1. Pre- and intraoperative near infrared spectroscopy values of the patients**

Cases	BS (R)	BS (L)	BC (R)	BC (L)	AC (R)	AC (L)	AS (R)	AS (L)
	n	n	%	%	%	%	%	%
1	48	53	4.1	5.6	52	50.9	4.1	0
2	62	65	19.3	11.2	48.3	49.2	12.9	9.23
3	56	58	1.7	8.9	55.3	32.7	7.1	6.8
4	51	47	17.6	1.9	31.3	23.4	15.6	14.8
5	61	57	22.9	27.8	49.1	42.3	3.2	3.5
6	58	65	13.7	8.6	62	44.6	6.8	4.6

BS: Baseline score; BC: Before clamp; AC: After clamp; AS: After shunt; R: Right; L: Left; %: Percentage of difference from the baseline value.

be required to ensure adequate cerebral perfusion in these patients, and many methods have been developed to achieve this, such as the measurement of CASP, EEG, and TCD along with cerebral oximetry monitoring. Although no clear connection has ever been shown between any of these methods and the rate of neurological complications, many surgeons use them for determining whether or not a shunt is required.

Carotid artery stump pressure is cheap and can be used to measure the ICA pressure after the clamping of the external artery and CCA. This measurement roughly assesses the adequacy of cerebral collateral circulation, but the lack of a standard procedure along with the accompanying multiple variables are the disadvantages of CASP. In addition, it does not allow for continuous monitoring.<sup>[4]</sup>

In a prospective study composed of 40 patients, Fassiadis et al.<sup>[7]</sup> investigated the correlation between NIRS monitoring and TCD in patients who underwent CEA under local or general anesthesia. They performed a correlation analysis regarding the percentage of decline in the mean flow velocity (FVm) between TCD and rSO<sub>2</sub> via NIRS monitoring and reported that the rSO<sub>2</sub> was well correlated with TCD. However, they determined that their inability to obtain reliable FVm readings on TCD in 35% of the patients was a serious disadvantage and that NIRS monitoring was a high-level device that provides a reliable and satisfactory evaluation of cerebral perfusion and oxygenation. In another prospective study by Pugliese et al.<sup>[1]</sup> that included 40 patients, the authors sought to determine the timing of the detection of an adverse event as well as the presence of false positivity and negativity. Therefore, they evaluated the neurological events and changes in parameters after carotid clamping utilizing TCD and rSO<sub>2</sub> measurements and concluded that rSO<sub>2</sub> was more reliable than TCD. In a different study conducted on 24 patients, Takeda et al.<sup>[8]</sup> detected cerebral ischemia with NIRS monitoring during a balloon occlusion test in conjunction with CEA and reported that a 10% decline from the baseline value was dangerous, but a 5% decline was safe.

The cerebral oximetry device is used in our hospital primarily in cases of acute dissection because of the limited number of electrodes. The useful information and postoperative data that we obtained from this device led us to also use it in carotid surgery. While shunt usage in this type of surgery is usually a decision of the surgeon after the stump pressure is measured in suspected cases, because a correlation was observed

between the cerebral oximetry values and the stump pressure in our first 10 patients, the data we obtained from the NIRS monitoring provided the surgical team with the necessary confidence to consider the routine measurement of the stump pressure to be unnecessary. Thereafter, our surgical team followed our warnings after clamping the artery, and NIRS monitoring has now gained the trust of the surgical team. In addition, similar to our findings, Kragsterman et al.<sup>[9]</sup> reported that there was also a significant correlation between stump pressure and rSO<sub>2</sub> values.

### Conclusion

We believe that NIRS monitoring is a valuable tool which provides beneficial information that can be used to determine whether a shunt is needed in carotid surgery. Furthermore, it can help prevent possible potential risks because of its noninvasive nature and ease of application. In addition, it provides current data and can be employed as a trend monitor. Our findings determined that NIRS monitoring is an indispensable method that can be used for patients undergoing CEA surgery, and in the future, we believe that it will be offered routinely in centers everywhere.

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