Clinical Evidence Guide

MONITORING CEREBRAL PERFUSION IN CAROTID ENDARTERECTOMY

With the INVOS™ cerebral/somatic oximeter

The common methods of monitoring bilateral cerebral perfusion adequacy and identifying the need for shunting during carotid endarterectomy (CEA) under general anesthesia are electroencephalogram (EEG), stump pressure (SP), or transcranial Doppler (TCD) monitoring.

This clinical evidence guide explores how INVOS™ monitoring technology can be a practical and continuous method to monitor perfusion and identify patients who may benefit from shunting, either alone or in combination with other monitoring modalities.

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INVOS™ monitoring technology can be used to identify patients at risk for cerebral ischemia during CEA.

Near infrared spectroscopy monitoring during carotid endarterectomy: which threshold value is critical?

Mille T, Tachimiri ME, Klersy C, et al.

Study design	Single-center, retrospective study (Italy)
Arms	Single arm: INVOS™ monitoring technology
Objective	Identify the relative change from baseline rSO_2 values 2 minutes after clamping that is predictive of impending cerebral ischemia
N	594
Population	CEA patients under general anesthesia
Threshold for intervention	No interventions were described and no shunts were placed
Results	▪ 20/594 patients (3.4%) presented with neurological complications ▪ 16/594 patients (2.7%) showed an early decrease in rSO_2 >20% from baseline – 6/16 patients (37.5%) showing an early decrease in rSO_2 >20% from baseline also presented with neurological complications – 14/578 of the remaining patients (2%) showing a decrease in rSO_2 <20% from baseline presented with neurological complications (p = 0.0001) ▪ An rSO_2 decrease of 11.7% from baseline at 2 minutes after clamping was identified as the optimal threshold to identify patients with a neurological complication: – Positive predictive value (PPV) = 10% – Negative predictive value (NPV) = 99% – Sensitivity = 75% – Specificity = 77% ▪ A threshold of 20% was associated with lower sensitivity (30%), higher specificity (98%), with a PPV and NPV of 37% and 98%, respectively, for identifying patients with neurological complications
Conclusions	Near-infrared spectroscopy (NIRS) monitoring technology is a useful method to detect cerebral ischemia during CEA.

INVOS™ technology may be an effective monitoring method compared to EEG to inform shunt selection during CEA.

Near-infrared spectroscopy to indicate selective shunt use during carotid endarterectomy

Pennekamp CWA, Immink RV, den Ruijter HM, et al.

Study design	Single-center, prospective observational study (The Netherlands)
Arms	Single arm: concomitant monitoring with INVOS™ technology, EEG, and TCD
Objective	Compare the ability of INVOS™ monitoring technology and TCD to EEG in detecting cerebral ischemia and determining the need for shunting
N	151
Population	CEA patients under general anesthesia with a sufficient TCD window
Definition of desaturation	rSO_2 ≥16% from baseline value
Threshold for intervention	Shunt was placed when EEG detected the occurrence of new delta or theta activity
Results	▪ 17/151 (11%) of patients were shunted based on EEG changes – In 16/17 cases, rSO_2 also dropped to ≥16% from baseline – In 5/134 of the remaining patients not shunted, rSO_2 dropped to ≥16% from baseline value without EEG changes – 129 patients showed no change in EEG or rSO_2 drop of ≥16% from baseline value ▪ Compared to EEG, rSO_2 demonstrated the following regarding indications for shunting: – PPV = 76% – NPV = 99% – Sensitivity = 94% – Specificity = 96% ▪ Similar results were seen with TCD, although the PPV and specificity were lower at 53% and 90%, respectively ▪ A trend toward higher incidence of stroke in shunted patients was seen (11.8% vs. 1.5%; p = 0.06)
Conclusions	NIRS monitoring technology may be effective for shunt selection. The optimal threshold for shunt selection requires further study.

Compared to transcranial Doppler, NIRS monitoring proved safe and reliable during CEA and reduced unnecessary shunt use.

Near-infrared spectroscopy versus transcranial Doppler-based monitoring in carotid endarterectomy

Cho JW, Jang JS.

<table>
<tr><td>Study design</td><td>Retrospective review of medical records of patients who underwent carotid endarterectomy (CEA) at a single center (Korea)</td></tr>
<tr><td>Arms</td><td>TCD group: transcranial Doppler (TCD) used for cerebral monitoring during CEA
NIRS group: near-infrared spectroscopy (NIRS) used for cerebral monitoring during CEA (INVOS™ 5100C system)</td></tr>
<tr><td>Objective</td><td>To compare the safety and reliability of NIRS to that of TCD for cerebral monitoring during CEA</td></tr>
<tr><td>N</td><td>74 (45 TCD, 29 NIRS)</td></tr>
<tr><td>Population</td><td>Patients who underwent CEA using selective shunt-based TCD or NIRS</td></tr>
<tr><td>Threshold for intervention</td><td>TCD group: selective shunt inserted when middle cerebral artery blood flow decreased to <30% of baseline, or in patients with poor temporal view
NIRS group: shunt inserted when regional cerebral oxygen saturation decreased to <80% of baseline</td></tr>
<tr><td>Results</td><td>
<table>
<tr><th>Outcome</th><th>TCD group</th><th>NIRS group</th><th>p value</th></tr>
<tr><td>30-day mortality, n (%)</td><td>1 (2.2)</td><td>0</td><td>1</td></tr>
<tr><td>30-day stroke, n (%)</td><td>4 (8.9)</td><td>0</td><td>0.15</td></tr>
<tr><td>Hypoglossal nerve injury, n (%)</td><td>1 (2.2)</td><td>0</td><td>1</td></tr>
<tr><td>Other neurologic symptoms, n (%)</td><td>10 (22.2)</td><td>0</td><td>0.005</td></tr>
<tr><td>Shunt used, %</td><td>44.4</td><td>10.3</td><td>0.002</td></tr>
</table>
Shunt use had no significant effect on 30-day mortality or 30-day stroke but researchers reported an effect of shunt use on other neurologic symptoms (p = 0.079)
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<tr><td>Conclusions</td><td>▪ Regarding postoperative stroke and neurologic symptoms, NIRS appears to be safe and reliable for monitoring cerebral perfusion during CEA.
▪ NIRS monitoring reduces unnecessary shunt usage compared to TCD monitoring.</td></tr>
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Preoperative cerebral oxygen saturation values and changes in oxygen saturation during carotid clamping predict the risk of postoperative neurologic complications after CEA.

Brain oxygen supply parameters in the risk assessment of cerebral complications during carotid endarterectomy

Kamenskaya OV, Yu I, Lomivorotov VV.

Study design	Prospective, nonrandomized cohort study
Arms	One arm: NIRS monitoring (INVOS™ 5100 system)
Objective	To determine if the risk of neurologic complications from carotid endarterectomy (CEA) can be predicted by the preoperative cerebral oxygen saturation (rSO_2) and the decrease in rSO_2 during carotid clamping
N	466
Population	Adult patients who underwent CEA with bilateral monitoring of rSO_2
Threshold for intervention	No intervention
Results	▪ Patients with neurological complications had: – Lower preoperative rSO_2 on the surgical side (55% vs. 62%, p = 0.018) – Greater ΔrSO_2 during clamping on the surgical side (11% vs. 22%, p = 0.029) ▪ Multivariate regression analysis showed the following: – Preoperative rSO_2 and ΔrSO_2 are independent predictors of stroke – ΔrSO_2 is an independent predictor of cognitive disorders ▪ Preoperative rSO_2 and ΔrSO_2 cutoffs were significantly correlated with outcomes: – Preoperative rSO_2 <50% increased the risk of stroke by 6-fold (OR 6.0; 95% CI 1.30 – 27.68) – ΔrSO_2 >20% during clamping increased: ▪ Risk of stroke by 10-fold (OR 10.8; 95% CI 2.05 – 56.77) ▪ Risk of cognitive disorders by 8-fold (OR 8.7; 95% CI 2.55 – 29.59)
Conclusions	▪ During temporary carotid artery clamping, ΔrSO_2 >20% below baseline significantly increases the risks of ischemic stroke (10-fold) and cognitive disorders (8-fold) after CEA. ▪ Preoperative rSO_2 <50% significantly increased the risk of ischemic stroke (6-fold) after CEA.

INVOS™ monitoring technology paired with an interventional algorithm can inform the need for shunt placement during CEA.

Evaluation of an intraoperative algorithm based on near-infrared refracted spectroscopy monitoring, in the intraoperative decision for shunt placement, in patients undergoing carotid endarterectomy

Zogogiannis ID, Iatrou CA, Lazarides MK, et al.

Study design	Multicenter, prospective, randomized controlled trial (Greece)
Arms	GROUP A: INVOS™ monitoring technology and use of an interventional protocol to restore rSO_2 GROUP B: INVOS™ monitoring technology without the use of an interventional protocol GROUP C: Control, no INVOS™ monitoring technology used
Objective	Examine the effect of using NIRS monitoring with an interventional protocol on the decision to place a shunt
N	253
Population	CEA patients under general anesthesia
Threshold for intervention	rSO_2 <80% of baseline value prompted use of interventional protocol, including consideration to place a shunt
Results	▪ The incidences of shunt placement were significantly different between groups ($p < 0.001$): – Group A = 27.7% – Group B = 59.5% – Group C = 100% ▪ Compared to group A, patients in groups B and C had a 3.7 and 70.6 times greater likelihood of receiving a shunt, respectively ▪ Compared to group B, group C had a 19.4 times greater likelihood of receiving a shunt ▪ There were no significant differences in the incidences of postoperative neurologic deficits among the three groups
Conclusions	NIRS monitoring technology paired with the use of a specific treatment algorithm may aid in the selective shunting of patients undergoing CEA.

A selection of clinical studies using INVOS™ technology intraoperatively in carotid endarterectomy surgery

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