



Cerebral blood flow measurement by near infrared spectroscopy in carotid endarterectomy

Shinya Kato, MD, Kenji Yoshitani, MD, Yoshihiko Ohnishi, MD.

Department of Anesthesiology, National Cerebral and Cardiovascular Center, 5-7-1 Fujishirodai, Suita, Osaka, Japan



Abstract

To evaluate cerebral blood flow (CBF) during carotid endarterectomy (CEA) is very crucial. However, it is difficult to measure CBF in the operating room. Recently, near infrared spectroscopy (NIRS) with high accuracy has developed, which enables to measure regional cerebral blood flow by injection of indocyanine green. Kubler et al. reported that regional cerebral blood flow derived from NIRS correlated well with values assessed by radioactive microspheres in pigs. (1) We have demonstrated preliminary data that BFI as regional cerebral blood flow of the diseased side significantly decreased during clamping the common carotid artery in American Society of Anesthesiologists Annual Meeting 2013. We analyzed the change of the cerebral blood flow by clamp the carotid artery in carotid endarterectomy with an increased number of cases.

Methods

After approval of institutional ethical board, patients undergoing elective carotid endarterectomy were enrolled in this study. After induction of general anesthesia, NIRS sensor was placed bilaterally 1cm above eyebrow on the scalp. The dye indocyanine green (0.5 mg/kg) was injected pre carotid cross clamping, during carotid cross clamping and after carotid unclamping. After obtaining hemodynamics stability, we injected indocyanine green via cubital vein. The kinetics of an intravenous bolus of indocyanine green was monitored by NIRS (NIRO 200NX, Hamamatsu Photonics, Hamamatsu, Japan). Blood flow index (BFI) was calculated using slope of the concentration of indocyanine green. The impact of the carotid cross clamping on BFI was evaluated.

Results

We studied 45 patients (43 male, 2 female; aged 71±7). Figure depicted BFI of diseased side significantly decreased during carotid cross clamping compared to the level of pre carotid cross clamping. (from 0.14± 0.14 μmol/l/s to 0.087± 0.045 μmol/l/s) ($p < 0.01$) After unclamping the carotid artery, BFI increased significantly. (from 0.087± 0.045 μmol/l/s to 0.12± 0.064 μmol/l/s) ($p < 0.01$) BFI of healthy did not show significant change during the surgery. (pre clamping: 0.12± 0.069 μmol/l/s; during clamping: 0.11± 0.064 μmol/l/s; after unclamping: 0.15± 0.15 μmol/l/s, $p = 0.30$) We maintained significantly high blood pressure during carotid cross clamping. (systolic pressure pre clamping: 126± 21mmHg; during cross clamping 164± 16 mmHg; after unclamping 112± 16mmHg, diastolic pressure: pre clamping 56± 11; during clamping 70± 11mmHg; after unclamping 51± 12mmHg)

Conclusion

BFI as regional cerebral blood flow of the diseased side significantly decreased during clamping the common carotid artery, even if high blood pressure was maintained. However, BFI of the healthy side did not show the significant change. By using the BFI derived from NIRS, it is possible to measure the regional cerebral blood flow during the operation.

Introduction

- Evaluation of CBF during CEA is very crucial. However, it is difficult to measure CBF in the operating room.
- Recently, NIRS with a sample rate of 20 Hz has been introduced which measure the rCBF by injection of ICG.
- The change of CBF by carotid cross clamping is not known.
- We measured the change of the rCBF by carotid cross clamping in CEA using NIRS with ICG tracer.

Methods

Subjects: Patients undergoing elective CEA

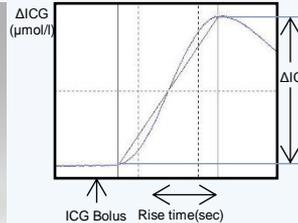
Methods: After induction of general anesthesia, NIRS sensor was placed bilaterally 1cm above eyebrow on the scalp. The dye ICG (0.5 mg/kg) was injected in the following time.

- Pre carotid cross clamping
- During carotid cross clamping
- After carotid unclamping

Materials: The kinetics of an intravenous bolus of ICG was monitored by NIRO 200NX (Hamamatsu Photonics, Hamamatsu, Japan)(Figure 1). Measurement: Blood flow index (BFI) was calculated using the software of NIRO ICG (Hamamatsu Photonics, Hamamatsu, Japan),(Figure 2)



(Figure 1) NIRO 200NX (Hamamatsu Photonics, Hamamatsu, Japan)



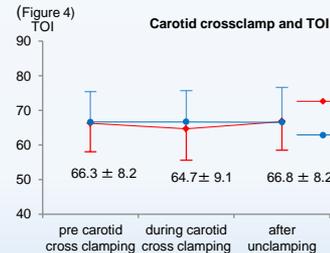
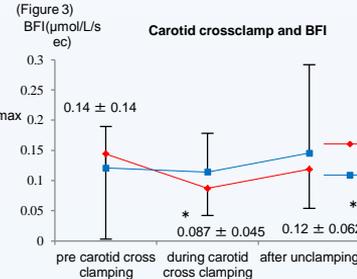
(Figure 2) Typical change of blood ICG concentration and measurement of BFI

(Table 1) Patients Characteristics

Age(yr)	71 ± 7	Rise time is defined as time 10% and 90% of the ICG maximum BFI = ΔICG maximum/Rise time (2)
Sex(M/F)	43 / 2	
Body weight (kg)	67.6 ± 18	
Height (cm)	164 ± 7	
Diseased side (L/R)	22/23	
Symptom of ipsilateral carotid territory symptom	22	
Powers stage (0/1/2)	14/20/11	
Presence of anterior communication artery	42	
Presence of posterior communication artery	36	
Cerebral infarction	32	

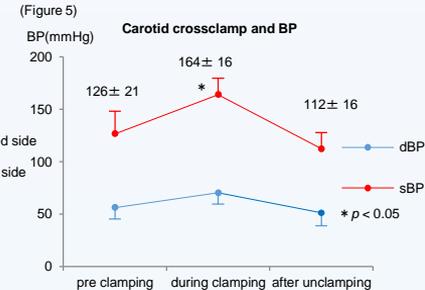
Results

- We studied 45 patients in this study.
- Patient's characteristics are shown in table 1.
- Although we maintained significantly high blood pressure during carotid cross clamping (Figure 5), BFI of diseased side significantly decreased during carotid cross clamping compared to the level of pre carotid cross clamping and after unclamping. (Figure 3)
- BFI of healthy side did not show significant change during carotid cross clamping. TOI did not change significantly during carotid cross clamping. (Figure 4)



Discussion

- BFI decreased significantly during carotid cross clamping, even if higher BP was maintained during carotid cross clamping and TOI remained unchanged.
- BFI may be more sensitive than TOI.
- It is reported that BFI correlated the cortical blood flow. (1) Hence, the result of this study is valid.



Conclusion

- BFI as regional cerebral blood flow of the diseased side significantly decreased during clamping the common carotid artery, even if high blood pressure was maintained.
- TOI did not decreased during clamping the common carotid artery.

Reference

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- Terborg C, Brauer S, Harscher S, et al. Bedside assessment of cerebral perfusion reductions in patients with acute ischaemic stroke by near-infrared spectroscopy and indocyanine green. *Journal of neurology, neurosurgery, and psychiatry*. 2004;75:38-42.

