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Original Article

Usefulness of dural surface tracing of the cortical vessels with indocyanine green videoangiography just prior to dural opening for various cerebrovascular diseases

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Abstract

Background: Indocyanine green (ICG) videoangiography can be used to delineate the locations of the cortical vessels just prior to dural opening, allowing safe and optimal dural opening. The present clinical series demonstrates the adjunct use of ICG videoangiography to optimize dural opening for the treatment of various cerebrovascular diseases.

Methods: A total of 45 patients underwent surgery for superficial temporal artery-middle cerebral artery bypass (40), arteriovenous malformation (2), and dural arteriovenous fistula (3) between January 2012 and December 2016. After the dura had been exposed, ICG (0.25 mg/kg) was administered intravenously from the peripheral vein as a bolus just prior to dural opening. The operating microscope equipped with a fluorescent filter was used to examine the illuminated field of interest, and real-time flow assessment of the underlying cortical vessels and/or dural sinus was performed. The target recipient arteries for anastomosis or vascular malformations were visualized through the dura and marked using a pyoktanin pen on the dura mater.

Results: The optimal dural opening was performed for anastomosis, and safety was ensured by locating the vascular malformations through the dura mater in all cases. The cortical vessel injury was avoided in all cases. No complication was related to this procedure.

Conclusions: Dural surface tracing of the cortical vessels with ICG videoangiography just prior to dural opening is a useful technique, which allows optimal and safe dural opening for treatment of various cerebrovascular diseases.

Key Words: Dural opening, ICG videoangiography, microneurosurgery

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INTRODUCTION

Indocyanine green (ICG) videoangiography is usually performed during intradural procedures to ensure the safety and completeness of microsurgical procedures for various cerebrovascular diseases (CVDs), by allowing the evaluation of vessel patency and delineation of vascular anatomy during the surgical procedure.[1,3,6] Dural opening must be optimally located over the preoperatively scheduled recipient cortical arteries for superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis. Safety of the dural opening must be ensured by avoiding unexpected vascular injury during surgery for arteriovenous malformation (AVM) and/or dural arteriovenous fistula (AVF).[4,5] The present study describes our initial clinical experiences with the newly developed method of dural surface tracing to delineate the locations of the cortical vessels or vascular malformations with ICG videoangiography just prior to dural opening for treatment of various CVDs. This technique enables visualization of the target cortical arteries or vascular malformations through the dura mater, allowing planning of the optimal dural opening or ensuring safe dural opening without unexpected vascular injury. Adjunct use of ICG angiography was evaluated in the present series to optimize the dural opening for various CVDs.

PATIENTS AND METHODS

The study was approved by the local institutional review committee of the hospital. Patient consent to the study was acquired using a webpage for retrospective and noninvasive study protocol. This retrospective analysis included 45 consecutive patients, 16 women and 29 men aged from 41 to 74 years (mean 57.6 years), treated for STA-MCA bypass (40), AVM (2), and dural AVF (3) between January 2012 and December 2016 at the National Defense Medical College Hospital. Medical charts, radiological findings, complications, and final results were reviewed.

Intraoperative technique

Figure 1 shows the surgical procedures of tracing of the cortical vessels on the dural surface with ICG videoangiography. The surgical procedure was performed using a Carl Zeiss surgical microscope OPMI Pentero INFRARED 800 (Carl Zeiss Co., Tokyo) or Leica OH4 (Leica Co. Germany) fluorescent microscopes. All patients received a bolus 2 ml intravenous dose of ICG solution, which consisted 25 mg ICG dissolved in 6 ml of 0.9% saline. Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously from the peripheral vein as a bolus. The operating microscope equipped with a fluorescent filter was used to examine the illuminated field of interest, and real-time flow assessment of the underlying cortical vessels and/or dural sinus was performed [Figure 1a and b]. The dural and/or cortical vessels were visualized through the dura and marked using a pyoktanin pen on the dura mater [Figure 1c]. Finally, optimal and safe dural incision could be performed [Figure 1d].

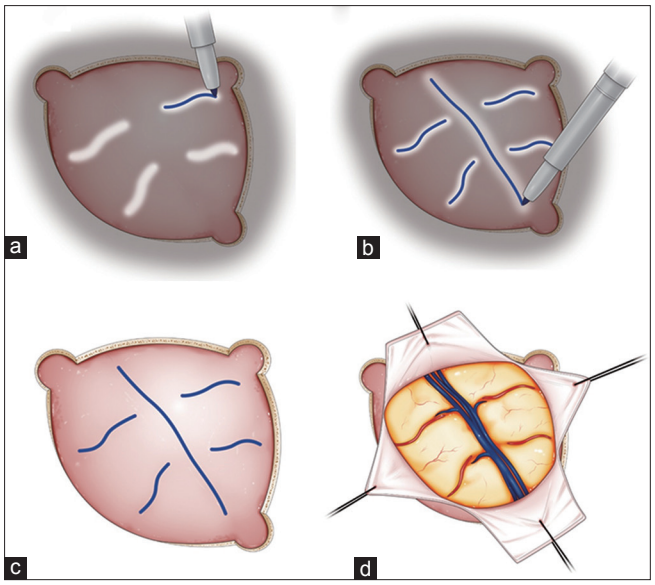

Figure 1: Schematic illustrations showing the surgical procedures of tracing of the cortical vessels on the dural surface with ICG videoangiography. The operating microscope equipped with a fluorescent filter was used to examine the illuminated field of interest, and real-time flow assessment of the underlying cortical vessels and dural sinus was performed (a and b). The dural and cortical vessels were visualized through the dura and marked using a pyoktanin pen on the dura mater (c). Finally, optimal and safe dural incision was performed (d)

RESULTS

The dura was opened and cortical vessel injury was avoided in all cases. Handling of the tools were technically successful during the surgical procedure. No further complication was related to this procedure.

Illustrative cases

Case 1: A patient with symptomatic right M1 stenosis underwent STA-M4 double bypass [Figure 2a]. Frontotemporal craniotomy was planned [Figure 2b]. Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously, and real-time flow assessment of the underlying cortical vessels was performed. The preoperatively scheduled recipient cortical arteries were visualized through the dura and marked using a pyoktanin pen on the dura mater [Figure 2c-e]. Optimal opening of the dura mater was then performed [Figure 2f].

Case 2: A patient with symptomatic moyamoya disease underwent STA-M4 double bypass [Figure 3a]. Frontotemporal craniotomy was planned [Figure 3b]. Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously, and real-time flow assessment of the underlying cortical vessels was performed. The cortical

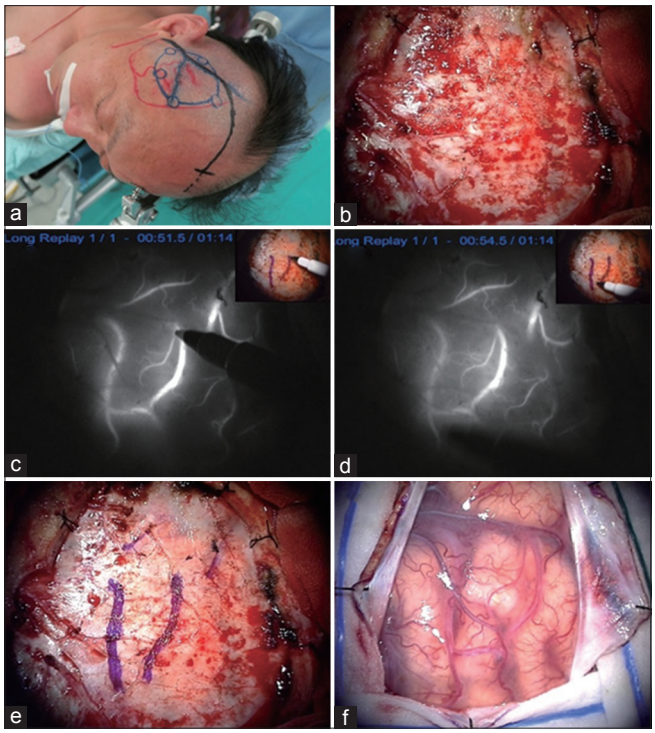

Figure 2: A patient with symptomatic right M1 stenosis underwent STA-M4 double bypass (a). Fronto-temporal craniotomy was planned (b). Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously. The preoperatively scheduled recipient cortical arteries were visualized through the dura and marked using a pyoktanin pen on the dura mater (c-e). Optimal opening of the dura mater was performed (f)

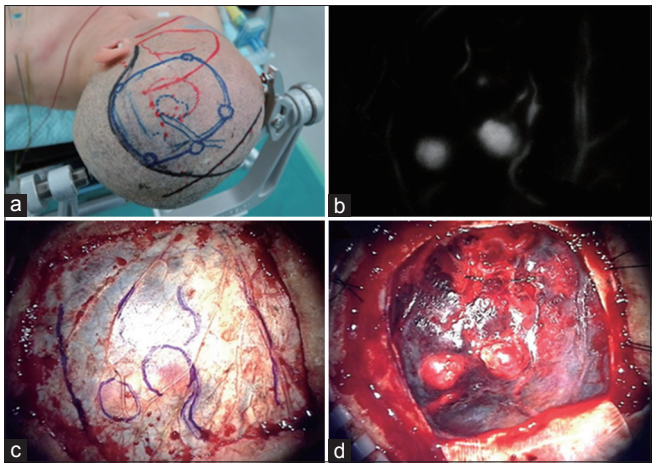

Figure 4: A patient with ruptured AVM underwent removal of the AVM in the acute stage (a). Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously, and real-time flow assessment of the underlying cortical vessels was performed. The cortically located nidus, feeders, and draining veins were visualized through the dura and marked using a pyoktanin pen on the dura mater (b and c). The dura mater was safely and accurately opened (d)

vessels were visualized through the dura and marked using a pyoktanin pen on the dura mater [Figure 3c and d]. The candidates for the recipient cortical arteries were located over the dura mater, and then optimal opening of the dura mater was performed for anastomosis [Figure 3e].

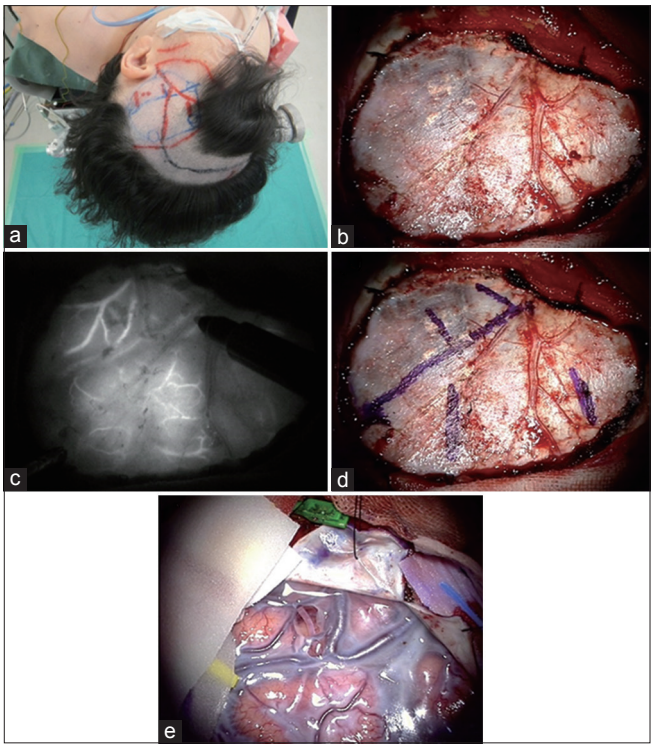

Figure 3: A patient with symptomatic moyamoya disease underwent STA-M4 double bypass (a). Fronto-temporal craniotomy was planned (b). Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously. The cortical vessels were visualized through the dura and marked using a pyoktanin pen on the dura mater (c and d). The candidates for the recipient cortical arteries were located over the dura mater, and then optimal opening of the dura mater was performed for anastomosis (e)

Case 3: A patient with ruptured AVM underwent removal of the AVM in the acute stage [Figure 4a]. Frontotemporal craniotomy was planned. Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously, and real-time flow assessment of the underlying cortical vessels was performed. The cortically located nidus, feeders, and draining veins were visualized through the dura and marked using a pyoktanin pen on the dura mater [Figure 4b and c]. The dura mater was then safely and accurately opened [Figure 4d].

Case 4: A patient with frontal base dural AVF with cortical reflux underwent direct removal [Figure 5a]. Bicoronal skin incision and bicoronal craniotomy were planned [Figure 5b]. Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously, and real-time flow assessment of the underlying cortical vessels was performed. The varix and cortical draining veins were visualized through the dura and marked using a pyoktanin pen on the dura mater [Figure 5c and d]. The dura mater was then safely and accurately opened [Figure 5e]. Varix lesion with venous lake and the fistula were confirmed to coincide with the findings of ICG videoangiography [Figure 5f]. After resection of the lesions, final ICG videoangiography showed the lesion had disappeared [Figure 5g].

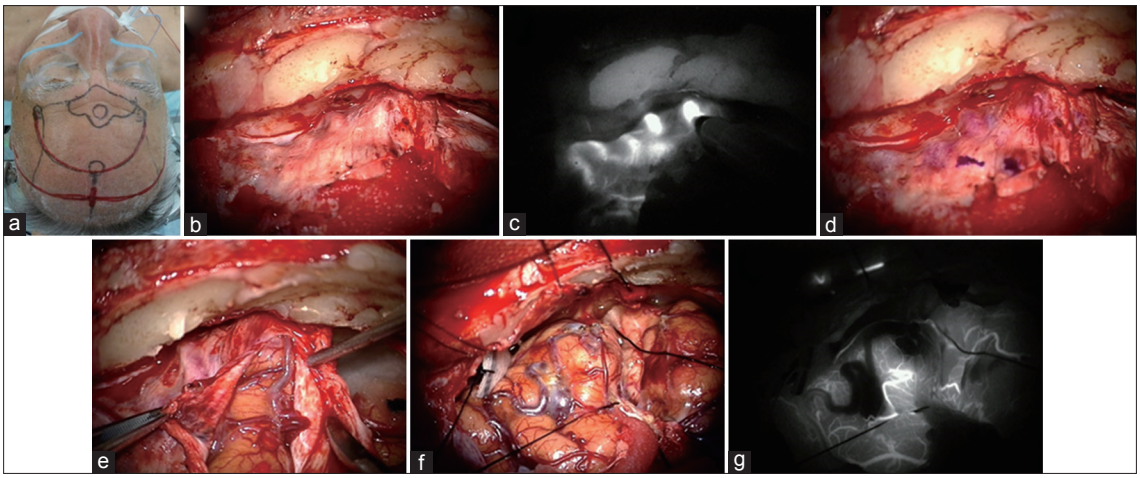

Figure 5: A patient with dural AVF with cortical reflux underwent direct removal (a). Bicoronal craniotomy was planned (b). Just prior to dural opening, ICG (0.25 mg/kg) was administered intravenously. The varix and cortical draining veins were visualized through the dura and marked using a pyoktanin pen on the dura mater (c and d). The dura mater was safely and accurately opened (e). Varix lesion and the fistula were confirmed to coincide with the findings of ICG videoangiography (f). After resection of the lesion, final ICG videoangiography showed the lesion had disappeared (g)

DISCUSSION

Only two previous studies have evaluated the use of ICG videoangiography prior to dural opening to identify the cortical vessels. ICG videoangiography was used to optimize the dural opening for avoiding cortical vessel injury prior to treatment of parasagittal lesions,[2] and ICG videoangiography was used to control dural opening very close to the margins of the dural sinus to avoid unexpected venous bleeding caused by dural sinus injury in suboccipital craniotomy for microvascular decompression.[7]

The present study describes our clinical experiences of dural surface tracing to delineate the locations of the cortical vessels with ICG videoangiography just prior to dural opening for the treatment of various CVDs. For STA-MCA anastomosis, the preoperatively scheduled candidates for the recipient cortical arteries could be visualized through the dura mater, and the extent of dural opening could be optimized to achieve completeness of anastomosis. For removal of AVM or dural AVF, the cortically located nidus, feeders, and varix with draining veins could also be visualized through the dura mater. After marking using a pyoktanin pen on the dura mater, safe and optimal opening could be performed avoiding unexpected cortical vessels injuries.

CONCLUSION

Dural surface tracing of the cortical vessels with ICG videoangiography just prior to dural opening was remarkably useful for performing safe and optimal dural opening for various CVDs.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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