Occlusion of the Internal Carotid Artery by Means of Microcoils for Preventing Epistaxis Caused by Guttural Pouch Mycosis in Horses

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ABSTRACT. Occlusion of the internal carotid artery by insertion of intravascular platinum microcoils for guttural pouch mycosis was experimentally evaluated in 9 healthy adult Thoroughbred horses. The internal carotid artery was ligated to its origin, and an arteriotomy was made distal to the ligature, which was then occluded by insertion of the microcoil approximately 13 cm distal to its origin. Cessation of blood flow was determined visually and by angiography at the arteriotomy site. Six horses were evaluated for complication clinically and by endoscopy after surgery. One horse was necropsied after 30 days of surgery for histological evaluation of artery thrombus formation. In the other 3 horses, the blood flow of the right internal carotid artery was monitored, before and after microcoil occlusion of the left internal carotid artery. One or 2 microcoils stopped blood flow within a few minutes. No other abnormal findings were observed clinically. Thrombus was observed in the occluded segment of 1 horse 30 days after insertion; but no abnormalities were detected. The blood flow in the right internal carotid artery increased by approximately 28–58% after occlusion of the left internal carotid artery. This microcoil vascular occlusion technique causes an effective thrombosis, and based on experimental studies and clinical application in 2 horses with epistaxis due to guttural pouch mycosis, this technique would appear to be safe and efficacious.—KEY WORDS: equine, guttural pouch mycosis, internal carotid artery, platinum microcoil, vascular occlusion.

Epistaxis with guttural pouch mycosis in horses is one of the most common findings and can be fatal unless treated [5, 11]. Bleeding commonly occurs from the internal carotid artery and less commonly from the external carotid and maxillary arteries [2, 4, 5, 9, 11, 21]. One surgical treatment is to ligate the internal carotid artery at its origin [4, 11], however, fatal epistaxis may occur before adequate thrombus in the affected region [10, 17, 20]. Insertion of a balloon catheter can achieve effective occlusion of the arterial segment and prevent epistaxis [2, 7, 8]. Although, problems associated with this technique include implantation of an indwelling catheter, increased potential for infection, failure of the balloon, and necessity of removing the catheter after healing [2, 8, 9].

The purpose of the study was to evaluate the use of platinum microcoils for occluding the internal carotid artery and to determine the effect of occlusion on blood flow in the contralateral internal carotid artery in the horse.

MATERIALS AND METHODS

Horses: Nine healthy adult Thoroughbred horses, average 2.7 years old and average weight 461 kg, were studied. The use of animals for this study complied with the guidelines for the humane use of animals as outlined by The Japan Racing Association Animals For Research and The Animals Protection Guideline from the Prime Minister’s office.

Group I: Six horses were anesthetized and positioned in right lateral recumbency. After sedation with xylazine (1.0 mg/kg intravenously [IV]), anesthesia was induced with 10% guaifenesin solution (500 ml IV) mixed with thiopental sodium (2 g) and maintained with isoflurane-oxygen inhalation. Lactated Ringer’s solution was administered at a rate of approximately 10 ml/kg/hr IV during anesthesia. The surgical approach is described by Freeman and Donawick [7, 8]. Skin incision of about 8 cm length was made in the middle of the atlas wing and blunt dissection, avoiding the parotid gland, was performed to expose the left internal carotid artery. This was then ligated close to its origin from the common carotid artery, and an arteriotomy was made distal to the ligature. A 3 Fr polyethylene catheter (Micro ferret-18 superselective infusion catheter, MF-3.0–18–135–12-HC; A Cook Group Company, Denmark) filled with sterile heparinized saline solution, was inserted through the arteriotomy for a distance of approximately 13 cm. A microcoil (Tornado embolization microcoil, MWCE-18S-6/2-Tornado; A Cook Group Company, Denmark) was inserted through the catheter and advanced into the artery using a guide wire (Cirrus-14 wire guide with coating, TPMG-14-135-Cirrus; A Cook Group Company, Denmark). The microcoil is made from platinum and equipped with Dacron fibers. Its length is 70 mm and 0.46 mm in diameter when extended inside the catheter. In the vessel, it forms a tornado-like shape with a diameter of 6 mm proximally and 2 mm distally, and approximately 6 mm in length (Fig. 1). Cessation of blood flow was determined visually and by angiography. For angiography, a micro ferret catheter was inserted 5 cm into the artery and injected with 2 ml iohexisol, a non-ionic hypotonic contrast media (Omnipaque 240; Daiichi Pharmaceutical Co., Ltd., Tokyo). Lateral angiograms (70 KV, 6 mAs) were taken using a portable X-ray generator.
After the catheter was withdrawn, the artery was ligated and the subcutaneous tissue and skin were sutured. After surgery, endoscopy was performed to observe the upper airway and internal carotid artery inside the left guttural pouch. Phenylbutazone (2 g/day) was administered orally for 5 days. Horses were also observed for signs of dysphagia and nervous dysfunction, such as Horner’s syndrome.

**Group II**: Three horses, were anesthetized as described above, and positioned in left lateral recumbency for surgical exposure of the right internal carotid artery. To monitor blood flow, a probe (FR-040T; Nihon Kohden, Tokyo) was attached to a site 2 cm distal to the origin of the internal carotid artery. The horses were then repositioned into right lateral recumbency for surgical exposure of the left internal carotid artery. A catheter was then inserted into the right medial plantar artery for continuous monitoring of mean arterial pressure by a transducer connected to a multichannel monitor (HP M1165A; Hewlett Packard Company, Tokyo). Mean arterial pressure was adjusted to 50, 70 and 90 mmHg by administration of dobutamine (0–1.5 µg/kg/min) and the blood flow of the right internal carotid artery was monitored using an electromagnetic hemotachometer (MFV-3100; Nihon Kohden, Tokyo). After the left internal carotid artery was ligated and occluded similar to horses in Group I, blood flow was again monitored by administering dobutamine.

**Post-mortem examination**: One horse from Group I was sacrificed by euthanasia 30 days after surgery and necropsied to evaluate the internal carotid arteries and adjacent tissue. All the horses in Group II were sacrificed by euthanasia immediately after the completion of surgery to confirm the location of the coil in the internal carotid artery. These horses were sacrificed with an overdose of thiopental sodium and suxamethonium chloride IV.

**RESULTS**

**Group I**: In 2 horses out of 6, 1 indwelling microcoil was used and for the rest, 2 indwelling microcoils were needed to occlude the internal carotid artery sufficiently. Regurgitant blood from the arteriotomy disappeared completely within a few minutes of inserting the coil. In angiography, the contrast media did not penetrate beyond the coil (Fig. 2). In observations by endoscopy, the internal carotid artery appeared to contract 5–7 days after surgery (Fig. 3). None of the horses had any abnormal clinical findings.

**Group II**: Blood flow in the right internal carotid artery was increased by 58.0% at a mean arterial pressure of 50 mmHg, by 43.2% at 70 mmHg, and by 27.6% at 90 mmHg (Table 1) after occlusion of the left internal carotid artery.

**Post-mortem examination**: In Group I, white thrombus obstructed completely the internal carotid artery at the site of the microcoil adjacent to the basilar bone and at the ligature. These thrombi were created by leukocytes concentrated in reaction to foreign microbes (Fig. 4). In the portion of the artery on the guttural pouch membrane in between these thrombi, erythrocytes were concentrated as a red thrombus. No abnormal findings, such as degeneration or necrosis, were observed on the cranial nerves adjacent to the microcoil.
The indwelling coils were observed to occlude the internal carotid artery directly below the basilar bone.

Clinical case: In case 1, two microcoils were inserted in the right internal carotid artery, and in case 2, one microcoil was inserted in the left internal carotid artery. Endoscopy was performed 10 days after surgery. In both horses it was confirmed that bleeding had occurred from the internal carotid artery and regression of the fungal lesion had begun. Post surgery, the surgical sites were lavaged with povidone-iodine solution once a week for one month; no complications occurred.

DISCUSSION

Although *Aspergillus fumigatus* or *Emericella nidulans* are considered to be responsible for guttural pouch mycosis [6, 15, 16, 20], the pathogenesis is not yet understood. A balloon catheter technique has been devised to allow immediate intravascular occlusion of the artery and to prevent retrograde flow from the cerebral arterial circle [2, 7, 8]. Because of the reported complications with the implantation of balloon catheters [2, 7, 8], we determined the efficacy of inserted microcoils as an alternative to balloon catheterization for arterial occlusion.

Vascular occlusion occurs because the positively charged metal coils react with the negative charged blood components to encourage agglutination and adherence with the coils. This method of vascular occlusion is based on an electro-detachable coil (GDC coil) that was devised by Guglielmi et al. [12, 13], and has been used in human cerebrovascular diseases including cerebral aneurysm, carotid cavernous fistula, and intracranial arteriovenous malformation [13, 14, 18, 19]. Also, this technique is known to be useful for treatment of hemorrhagic gastric and duodenal ulcers, and abdominal and visceral aneurysm [22].

The coils were equipped with Dacron fibers to be capable of promoting blood coagulation. There are 9 types of microcoil with different lengths and diameters. In this study, coil selection was made taking into account the diameter (approximately 4 mm) of the internal carotid artery. Coils can be inserted smoothly at the selected site through catheters and then take a tornado-like shape once released inside the blood vessel. These characteristics should allow them to be installed even in an internal carotid artery where there is regurgitant blood and to occlude the vessel within a few minutes after insertion. This assumption was confirmed by postoperative endoscopy and observation of a contracted
carotid arterial segment as well as observation of the coil location at necropsy immediately after implantation.

Although the technique is similar to the balloon catheter occlusion technique, we observed tachycardia most likely caused by the arterial ligation involving vagal nerves. This event suggests the necessity of taking precautions to avoid damaging contiguous nerves while isolating the internal carotid artery. In one horse, both the internal carotid artery and the occipital artery arose as a single trunk and this required careful arterial isolation. The polyethylene micro ferret catheters used for placing the coils are flexible thus reducing the risk of perforating the artery during insertion. Complete occlusion of the arteries by the microcoils was confirmed by the absence of regurgitant blood from the arteriotomy. If one coil was found insufficient to stop blood flow, an additional coil was inserted to achieve embolization. Insufficient transformation to the tornado-like shape could be a major factor of the occlusion failure and the additional insertion of a coil made the occlusion complete by connecting with the initial coil. The insertion of the initial coil should be performed distally when possible since it can not be removed after insertion. Although angiography was used to confirm blood flow cessation in this study, we do not believe this would be necessary in clinical application because cessation of regurgitant blood flow alone would serve as an appropriate indicator of adequate occlusion.

None of the horses developed clinical postoperative complications. On pathological examination of 1 horse 30 days after surgery, no abnormalities were detected in cranial nerves adjacent to the thrombosed vessel segment or in the guttural pouch mucous membrane. Compared to the balloon catheter technique, reliable thrombus formation without affecting tissues adjacent to the thrombosed vessel segment is the advantage of this technique.

Blood flow in the right internal carotid artery was monitored in Group II horses before and after embolization of left internal carotid artery. Compared with preocclusion blood flow, the postocclusion blood flow tended to increase at various mean arterial pressures respectively. This increase was believed to be generated by a compensatory action to maintain blood flow to the brain. However, the increase of blood flow was not as much as to fully restore total internal carotid flow. This implies that a portion of the obstructed blood flow is mainly being compensated through the vertebral artery. This finding suggests that occlusion of internal carotid artery does not affect the brain, and also confirms the observation of Freeman et al. that the ligation of the internal carotid artery does not change the arterial pressure at distal sites [10].

Subsequent to the experimental study we used the microcoil technique in 2 clinical cases with epistaxis due to guttural pouch mycosis. We occluded the internal carotid

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**Table 1. The blood flows in the opposite internal carotid artery before and after occlusion (Group II)**

![Fig. 4. Photomicrograph of internal carotid artery from one Group I horse. Cross section through the internal carotid artery immediately adjacent to the coil near the basilar bone. Thirty days after coil insertion a white thrombus completely obstructs the vessel lumen. (hematoxylin and eosin stain; × 50)](image)
artery on the affected side in both horses because this is the vessel most commonly involved. Contraction of the internal carotid artery and regression of the fungal lesion were observed by endoscopy postsurgery, suggesting the occlusion to be complete. For clinical application, this occlusion technique may also be considered for occlusion of the external carotid artery. It is known that the external carotid artery has a high probability of regurgitant blood flow compared to the internal carotid artery, because it has many branches [2, 9]. The primary artery which may contribute to regurgitant flow is the major palatine artery, which is formed by an arterial loop which connects with its opposite counterpart in the supramaxillary region [9]. Because the balloon catheter technique has been used for lesions involving the external carotid artery [2, 9], the microcoil technique we describe may also be applicable.

The results of our experimental study and experience with 2 clinical cases indicate that the internal carotid artery can be effectively occluded without complications by intraluminal insertion of 1 or 2 microcoils. This suggests that the occlusion technique is of high clinical utility as a surgical treatment for preventing epistaxis caused by guttural pouch mycosis.

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REFERENCES