

Remote Cerebellar Hemorrhage (Zebra Sign) in Vascular Neurosurgery: Pathophysiological Insights

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Abstract

Hemorrhage in regions remote from the site of initial intracranial operations is rare, but may be fatal. Postoperative cerebellar hemorrhage as a complication of supratentorial surgery, with a radiological appearance known as zebra sign, is an increasingly recognized clinical entity and is associated mainly with vascular neurosurgery or temporal lobe resection. The pathophysiology remains unclear. Three cases of remote cerebellar hematoma occurred after neck clipping of anterior communicating artery aneurysms. All patients had similar clinical findings and underwent pterional craniotomy with the head in accentuated extension. One patient died and the two were discharged without symptoms. Cerebellar hemorrhage probably has a multifactorial origin involving positioning associated with abundant cerebrospinal fluid drainage causing cerebellar sag with resultant vein stretching and bleeding, and use of aspirin or other antiplatelet agents.

Key words: cerebellum, remote hemorrhage, intracranial aneurysm, anterior communicating artery, pathophysiology

Introduction

Intracerebral hemorrhage remote from the site of surgery is an infrequent complication after supratentorial neurosurgical procedures. Cerebellar hemorrhage following supratentorial craniotomy is the most commonly described pattern of remote hemorrhage,^{2,5,8,9,11,12,14,18,22,23,25,26,28,29} and may cause significant neurological morbidity and mortality. Head position, perioperative hypertension, lumbar drainage of cerebrospinal fluid (CSF), and postoperative epidural drainage have all been proposed as causes of remote cerebellar hemorrhage (RCH).^{7,24} RCH tends to occur in patients with unruptured aneurysms, compared to patients with ruptured aneurysms.^{5,18} However, RCH has also occurred after surgical treatment of ruptured aneurysms.^{26,29} Blood over the folia of the cerebellum may lead to a radiological appearance known as zebra sign.³ The exact mechanisms causing zebra sign remain controversial, although several factors have been implicated, mainly after cerebrovascular surgery.

Here we report three consecutive cases of anterior communicating artery (AComA) aneurysms that

evolved with RCH and discuss the common underlying pathophysiological features.

Illustrative Cases

Case 1: A 74-year-old female presented at the emergency room complaining of sudden intense headache. Neurological examination revealed meningismus. She had a history of transient ischemic attacks (TIAs) and use of aspirin. Computed tomography (CT) disclosed Fisher grade III subarachnoid hemorrhage (SAH) and moderate hydrocephalus. Angiography revealed an AcomA aneurysm (Fig. 1) and important segmental stenosis (Fig. 2), secondary to arteriosclerosis.

At surgery, her head was positioned with slight rotation and accentuated extension. A right pterional craniotomy was performed and the aneurysm was clipped uneventfully. The lamina terminalis was fenestrated to facilitate circulation of CSF and avoid hydrocephalus. Postoperatively, patient was lethargic and confused. CT demonstrated RCH and zebra sign (Fig. 3). Her neurological condition deteriorated and she died 3 days later.

Case 2: A 62-year-old female attended the emergency room complaining of sudden headache. Neurological examination did not find any abnormalities,

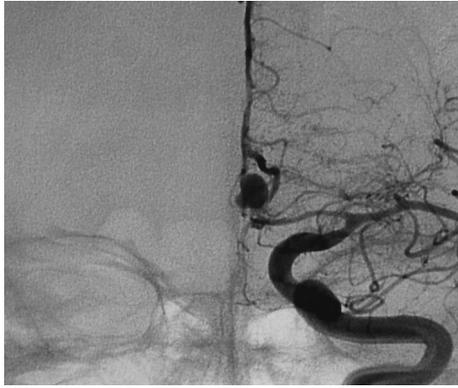


Fig. 1 Case 1. Left carotid angiogram depicting a large and complex anterior communicating artery aneurysm, and segmental stenosis secondary to spasm or sclerosis in the internal carotid artery and anterior cerebral artery.



Fig. 2 Case 1. Left vertebral angiogram revealing severe stenosis in the posterior circulation.

except for neck stiffness. CT disclosed Fisher grade II SAH. She had been taking aspirin to treat previous TIAs. Angiography demonstrated an AcomA aneurysm and accentuated arteriosclerosis of the carotid and intracranial vessels.

At surgery, her head was positioned with slight rotation and accentuated extension. A pterional approach was carried out and the aneurysm was clipped without incident. The lamina terminalis was opened and communication opened with the basal cisterns. Twelve hours after surgery, the patient was alert but confused. CT demonstrated cerebellar hemorrhage with zebra sign (Fig. 4). No hydrocephalus was observed. She gradually recovered and was discharged without neurological deficits.

Case 3: A 65-year-old female was admitted com-

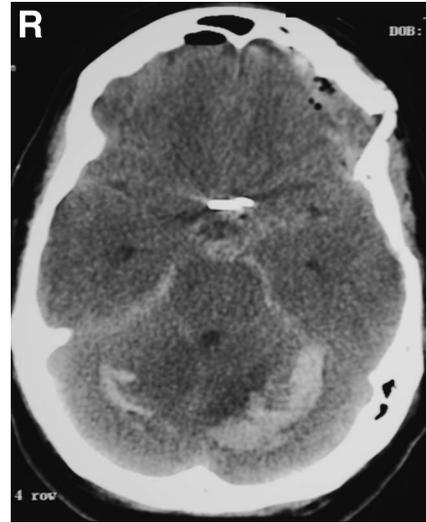


Fig. 3 Case 1. Postoperative computed tomography scan showing blood over the cerebellar folia forming the zebra sign, and a hypodense region within the cerebellum indicating an area of infarction.

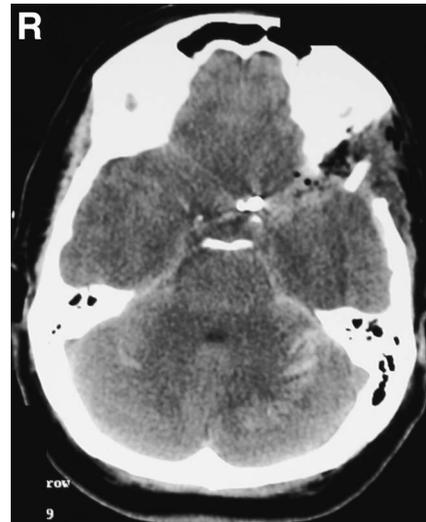


Fig. 4 Case 2. Postoperative computed tomography scan showing a streaky pattern of bleeding over the cerebellar hemispheres.

plaining of intense headache. Neurological examination revealed no abnormalities. She had been taking aspirin to prevent TIAs. CT displayed Fischer grade III SAH with moderate ventricular enlargement. Angiography identified an AcomA aneurysm.

At surgery, her head was positioned with slight rotation and accentuated extension. A pterional approach was utilized to treat the aneurysm. The lami-

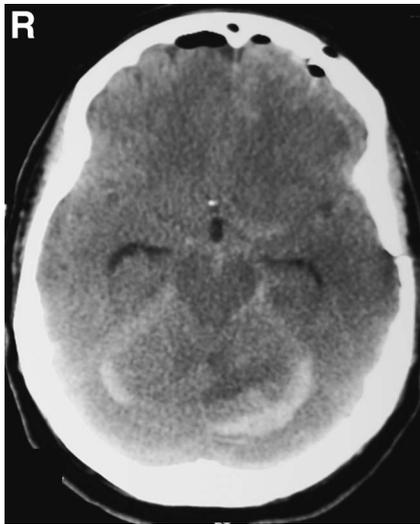


Fig. 5 Case 3. Postoperative computed tomography scan revealing remote cerebellar hemorrhage following the zebra sign, and a small area of infarction.

na terminalis was fenestrated to avoid hydrocephalus. After surgery, she was somnolent and agitated. CT revealed the classic zebra sign of cerebellar hemorrhage (Fig. 5). Hydrocephalus did not progress and the patient recovered completely.

Discussion

RCH is probably under-recognized and under-reported.⁹⁾ RCH is generally associated with supratentorial craniotomies in vascular neurosurgery or temporal lobectomy for epilepsy, occurring after approximately 0.6% of all supratentorial craniotomies, 2.8% of craniotomies to treat unruptured aneurysms, and 1.4% of craniotomies for temporal lobectomy,⁹⁾ and after 2.5% of temporal lobectomies for epilepsy.⁶⁾ RCH is often asymptomatic, so some patients with remote hemorrhage do not undergo postoperative imaging and the hemorrhage is not identified. Superior cerebellar folia, the most common pattern demonstrated by CT, may be ascribed to postoperative blood in the subarachnoid space layering on top of the folia,⁹⁾ forming a streaky bleeding pattern appearing as the zebra sign. However, magnetic resonance imaging shows that true intraparenchymal hemorrhage may occur as well, with or without the zebra image pattern.

Recent aspirin use within 7 days before surgery apparently increased the risk of RCH. Aspirin and antiplatelet agents have been implicated as risk factors for postoperative hemorrhage.^{1,9,10,17,19,22,27)} Although aspirin use seems to be an important and

Table 1 Possible predisposing factors for remote cerebellar hemorrhage in cerebrovascular surgery and the pathophysiological basis

Predisposing factors	Mechanism involved
Unruptured aneurysm	CSF free circulation and drainage
Lamina terminalis fenestration	CSF free circulation and drainage
Use of epidural or subcutaneous drain under negative pressure in presence of dural tears	CSF loss
Patient position with extensive head extension	Increased venous pressure and stretching of cerebellar veins
Preoperative use of antiplatelet agents	Reduced hemostasis
Severe arteriosclerosis	Vessel stiffness

CSF: cerebrospinal fluid.

avoidable preoperative risk factor, preoperative use of aspirin was not identified in most of the cases previously reported. Therefore, aspirin use cannot be implicated as the only causal factor in most cases of RCH.⁹⁾ Other factors must also be involved in the occurrence of RCH and zebra sign (Table 1).

RCH occurred in 3.5% of cases of repair of unruptured anterior circulation aneurysms.⁵⁾ RCH also occurred in 42 cases after supratentorial procedures,⁹⁾ nearly 38% occurring after surgical repair of unruptured aneurysms, half of which were AComA aneurysms, as described here. No RCH occurred after surgery for ruptured aneurysm was reported.⁹⁾ RCH seems to be associated with frontotemporal craniotomies with the patient in the supine position.⁹⁾

The loss of substantial CSF volume during surgery must also be important in the pathophysiological development of RCH, as demonstrated by the association of RCH with procedures that involve drainage of CSF from the cisterns or ventricular system.⁹⁾ RCH has also been reported after spinal procedures involving dural tears and subsequent conspicuous CSF drainage.^{4,9,13,15)} The involvement of CSF drainage is further supported by the finding that RCH occurs more often during the clipping of unruptured aneurysms compared to ruptured aneurysms, probably because of the lack of free circulation of CSF in patients with blood within the subarachnoid spaces.⁹⁾ Postoperative drainage of CSF may also be involved in the occurrence of cerebellar hemorrhage, especially if negative pressure is applied.¹³⁾ In almost all patients undergoing craniotomy in our institution, including the present patients, drainage with slight uncontrolled negative pressure of the bag is inserted in the subgaleal space, but no negative pressure is applied with evidence of

dural tears. The system of drainage is removed within 24 hours. We believe that such negative pressure facilitates CSF drainage in the presence of dural tears, which could be linked to the pathophysiology of RCH.

Only CSF loss, although important, may not cause RCH. Many cerebrovascular surgical centers have routinely performed extensive opening of the cisterns and fenestrated the lamina terminalis without observing subsequent increase in RCH occurrence. Positional jugular vein compression caused by the transverse process of the atlas may be implicated in venous hypertension and RCH.²¹⁾ This is particularly important in association with any head extension. We have routinely adopted extensive extension of the head for approaching AComA aneurysms. AComA aneurysm surgery is also often associated with lamina terminalis fenestration and significant CSF drainage. Positioning may additionally predispose to cerebellar sag, leading to stretching of the cerebellar veins.

There is a growing consensus suggesting that RCH is a manifestation of cerebellar venous hemorrhage and infarction.^{2,5,9,12,18,22)} The characteristic location in the superior cerebellar and vermian cortices corresponds to the territory drained by the superior cerebellar veins, and the occurrence of bilateral lesions may also be explained by this venous drainage pattern.⁹⁾ The venous drainage of the tentorial surface of the cerebellum is cephalad, via short bridging veins into the tentorium, torcular herophili, and transverse sinuses, and via the bridging superior vermian vein and the vein of the cerebellomesencephalic fissure into the basal veins of Rosenthal.^{9,20)} These vessels may be vulnerable to stretching with cerebellum sag away from the tentorium, as may occur after substantial CSF drainage.^{9,29)} We suppose that this phenomenon may be aggravated by concomitant extension of the head. Stretching may cause transient vein occlusion, with increased venous pressure, which is also aggravated by compression of the jugular veins secondary to surgical positioning. Two of our patients presented with accentuated arteriosclerosis, so vessel stiffness caused by sclerosis may contribute to RCH.

Such a scenario of increased venous pressure, created by positioning and CSF drainage, may further predispose the parenchyma in these regions to venous hemorrhage.⁹⁾ Conversely, bleeding may be exacerbated by aspirin use. Therefore, increased venous pressure caused by CSF loss and surgical positioning, associated with preoperative use of antiplatelet agents, such as aspirin, creates the appropriate environment for venous hemorrhage,^{9,16,18)} suggesting that any single factor is unlikely to cause

RCH.

RCH is a well recognized complication after supratentorial neurosurgical procedures and possibly cannot be explained by just one single factor. We believe that positioning associated with abundant CSF drainage may predispose to cerebellar sag contributing to vein stretching and bleeding. Use of aspirin or other antiplatelet agents may aggravate the clinical consequences. Arteriosclerosis may also be involved in the pathophysiology. Patients receiving antiplatelet therapy should be aware of this potentially fatal surgical complication, particularly if requiring surgical treatment for AComA aneurysm.

References

- 1) Bashein G, Nessly ML, Rice AL, Counts RB, Misbach GA: Preoperative aspirin therapy and reoperation for bleeding after coronary artery bypass surgery. *Arch Intern Med* 151: 89–93, 1991
- 2) Brisman MH, Bederson JB, Sen CN, Germano IM, Moore F, Post KD: Intracerebral hemorrhage occurring remote from the craniotomy site. *Neurosurgery* 39: 1114–1122, 1996
- 3) Brockmann MA, Nowak G, Reusche E, Russlies M, Petersen D: Zebra sign: cerebellar bleeding pattern characteristic of cerebrospinal fluid loss. Case report. *J Neurosurg* 102: 1159–1162, 2005
- 4) Chaddock WM: Cerebellar hemorrhage complicating cervical laminectomy. *Neurosurgery* 9: 185–189, 1981
- 5) Cloft HJ, Matsumoto JA, Lanzino G, Cail WS: Posterior fossa hemorrhage after supratentorial surgery. *AJNR Am J Neuroradiol* 18: 1573–1580, 1997
- 6) de Paola L, Troiano AR, Germiniani FM, Coral P, Della Coletta MV, Silvado CE, Moro M, de Araújo JC, Mäder MJ, Werneck LC: Cerebellar hemorrhage as a complication of temporal lobectomy for refractory medial temporal epilepsy: report of three cases. *Arq Neuropsiquiatr* 62(2B): 519–522, 2004
- 7) Friedman JA, Piepgras DG, Duke DA, McClelland RL, Bechtle PS, Maher CO, Morita A, Perkins WJ, Parisi JE, Brown RD Jr: Remote cerebellar hemorrhage after supratentorial surgery. *Neurosurgery* 49: 1327–1340, 2001
- 8) Fukamachi A, Koizumi H, Nukui H: Postoperative intracerebral hemorrhages: A survey of computed tomographic findings after 1074 intracranial operations. *Surg Neurol* 23: 575–580, 1985
- 9) Heros RC, Nelson PB: Intracerebral hemorrhage after microsurgical cerebral revascularization. *Neurosurgery* 6: 371–375, 1980
- 10) Holden MP, Cobbe SM: Dangers of aspirin before cardiac surgery. *BMJ* 305: 365–366, 1992
- 11) König A: Postoperative hemorrhage. *J Neurosurg* 86: 916–917, 1997 (letter)
- 12) König A, Laas R, Herrmann HD: Cerebellar hemorrhage as a complication after supratentorial

- craniotomy. *Acta Neurochir (Wien)* 88: 104–108, 1987
- 13) Mikawa Y, Watanabe R, Hino Y, Ishii R, Hirano K: Cerebellar hemorrhage complicating cervical durotomy and revision C1-C2 fusion. *Spine* 19: 1169–1171, 1994
 - 14) Miyamoto Y, Nakasu S, Nakasu Y, Handa J: [Postoperative intracerebral hematoma remote from the site of craniotomy]. *Neurol Med Chir (Tokyo)* 25: 219–222, 1985 [Jpn, with Eng abstract]
 - 15) Morandi X, Riffaud L, Carsin-Nicol B, Guegan Y: Intracerebral hemorrhage complicating cervical “hourglass” schwannoma removal: Case report. *J Neurosurg* 94(1 Suppl): 150–153, 2001
 - 16) Noetzel H, Jerusalem F: *Die Hirnvenen und Sinusthrombosen*. New York, Springer-Verlag, 1965 (Ger)
 - 17) Palmer JD, Sparrow OC, Iannotti F: Postoperative hematoma: A 5-year survey and identification of avoidable risk factors. *Neurosurgery* 35: 1061–1065, 1994
 - 18) Papanastassiou V, Kerr R, Adams C: Contralateral cerebellar hemorrhagic infarction after pterional craniotomy: Report of five cases and review of the literature. *Neurosurgery* 39: 841–852, 1996
 - 19) Price RF: Postoperative hemorrhage. *J Neurosurg* 86: 917, 1997 (letter)
 - 20) Rhoton AL Jr: The posterior fossa veins. *Neurosurgery* 47(3 Suppl): S69–S92, 2000
 - 21) Seoane E, Rhoton AL Jr: Compression of the internal jugular vein by the transverse process of the atlas as the cause of cerebellar hemorrhage after supratentorial craniotomy. *Surg Neurol* 51: 500–505, 1999
 - 22) Toczek MR, Morrell MJ, Silverberg GA, Lowe GM: Cerebellar hemorrhage complicating temporal lobectomy. *J Neurosurg* 85: 718–722, 1996
 - 23) van Calenbergh F, Goffin J, Plets C: Cerebellar hemorrhage complicating supratentorial craniotomy: Report of two cases. *Surg Neurol* 40: 336–338, 1993
 - 24) Van de Kelft E, Bosmans J, Parizel PM, Vyve MV, Selosse P: Intracerebral hemorrhage after lumbar myelography with iohexol: Report of a case and review of the literature. *Neurosurgery* 28: 570–573, 1991
 - 25) van Loon J, van Calenbergh F, Goffin J, Plets C: Controversies in the management of spontaneous cerebellar haemorrhage: A consecutive series of 49 cases and review of the literature. *Acta Neurochir (Wien)* 122: 187–193, 1993
 - 26) Waga S, Shimosaka S, Sakakura M: Intracerebral hemorrhage remote from the site of the initial neurosurgical procedure. *Neurosurgery* 13: 662–665, 1983
 - 27) Watson CJE, Deane AM, Doyle PT, Bullock KN: Identifiable factors in post-prostatectomy haemorrhage: The role of aspirin. *Br J Urol* 66: 85–87, 1990
 - 28) Yasargil MG, Yonekawa Y: Results of microsurgical extra-intracranial arterial bypass in the treatment of cerebral ischemia. *Neurosurgery* 1: 22–24, 1977
 - 29) Yoshida S, Yonekawa Y, Yamashita K, Ihara I, Morooka Y: Cerebellar hemorrhage after supratentorial craniotomy: Report of three cases. *Neurol Med Chir (Tokyo)* 30: 738–743, 1990

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Commentary

The authors presented 3 cases with postoperative remote cerebellar hemorrhage after clipping of A-com aneurysms, and discussed possible mechanisms of this rare but important complication. They discussed several predisposing factors such as CSF drainage or loss, patient position with extended head which increases the venous pressure, and use of antiplatelet agents. Remote cerebellar hemorrhage has become widely recognized among neurosurgeons in recent years. This article has again reminded us of this potentially devastating complication.

Though discussed in the article, I think that the major main factor would be CSF overdrainage during or after operation. Some neurosurgeons might have experienced a few cases in which ventricular overdrainage led to cerebellar hemorrhage showing zebra sign. In this article, “drainage with slight uncontrolled negative pressure of the bag” was routinely used, though they also stated that “no negative pressure is applied with evidence of dural tears.” Even if the dura was sutured primarily, CSF leak might be unavoidable if negative pressure is applied. In this regard, I recommend that routine postoperative use of negative pressure epidural (subgaleal) drainage system be reconsidered. Although there might be several other predisposing factors, surgical steps and postoperative care should be cautiously reevaluated to prevent this complication.

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Post-operative cerebellar hemorrhage following supratentorial craniotomy is a well recognized condition. Such a complication is eventually seen by our institutions but the pathologies approached by pterional or any other supratentorial route as vascular and other cisternal surgeries has to be done under microsurgical techniques often with increased CSF drainage, wide skull base exposures, extensive

microsurgical cisternal dissections and head extension in selected cases, suggesting that almost nothing can be done to avoid most of those previously described predisposing factors suggested by the authors and literature review. However, although most cases presented as asymptomatic, some morbidity and even mortality can be found. For this reason, the awareness of such a complication not related to concomitant cerebellar pathology is essential and this is the most important issue of this well done report of three illustrative cases and literature review.

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Remote cerebellar hemorrhage after a craniotomy has been reported infrequently, as Dr. Figueiredo et al. have done and reminded us again here.

In 1975 and 1976, we experienced this serious complication after EC-IC bypass surgery (ref 28 of this article). This was reported separately by Dr. Eguchi in detail.¹⁾ Both patients were awake just after surgery and followed by rapid neurological deterioration around 2 hours later. The hemorrhage could be confirmed only at the time of autopsy, as the CT scan diagnosis was just at the very beginning of its development and could not be used as diagnostic aid. We concluded the hemorrhage might be related to: preoperative aspirin administration, intraoperative Rheomacrodex administration, intraoperative labile hypertension, and postoperative hypertension in which systolic pressure elevated up to 210 mmHg. The reason for the bleeding in the cerebellum was ascribed to increased hemodynamic stress at the vertebrobasilar artery territory as compared with that of the internal carotid artery, as both patients had internal carotid artery occlusion on one side and stenosis on the other side. Retrospectively, the role of subgaleal drainage with negative pressure should also have been considered. I used this drainage after the tradition of the clinic in all the cases of craniotomy including EC-IC bypass surgery until the end of 1976, when I returned back from Zürich to Kyoto. So both cases did have subgaleal negative pressure drainage. After checking the operative reports at that time now, I confirmed this.

Dr. Yoshida (ref 29 of this article) has reported 3 cases of cerebellar hemorrhage from our institute (National Cardiovascular Center, Japan) in 1990 and has drawn attention to the danger of postoperative negative pressure drainage which might cause the tear of the superior vermian vein in the supine position.

It was for me very impressive that Prof. Donaghy did not use any drainage, when he demonstrated his technique of EC-IC bypass on December 6, 1973 at Zürich University Hospital, in which I had the honor to be assistant.²⁾ The meaning of this “no drainage,” I could not realize until I came back to Zürich in 1993 on the occasion of Prof. Yasargil’s retirement. I observed then that Prof. Yasargil finished every craniotomy without any drainage as standard technique. I took over the method as standard also at the time of acute aneurysm surgery³⁾ and also at the time of bypass surgery. In acute aneurysm surgery, when necessary only ventricular drainage was done exceptionally, in which the CBF pressure was regulated between 15–20 cmH₂O, so that excessive CSF loss was avoided.

In my series of more than 250 EC-IC bypasses, more than 1000 aneurysm surgeries, and more than 1000 craniotomies for other lesions until the end of May 2009, I can remember no cerebellar hemorrhage — zebra sign was observed during the period of ca. 13.5 years. This could be confirmed by having routinely checked with CT on day after surgery in every case.

References

- 1) Eguchi T, Yonekawa Y: [Intracerebellar hematoma following microsurgical STA-cortical MCA bypass surgery]. No Shinkei Geka 5: 1085–1088, 1977 (Jpn, with Eng abstract)
- 2) Yonekawa Y: [Operative neurosurgery: personal view and historical backgrounds (1). EC-IC bypass]. No Shinkei Geka 34: 859–867, 2006 (Jpn, with Eng abstract)
- 3) Yonekawa Y: [Operative neurosurgery: personal view and historical backgrounds (3). Anterior circulation — pterional approach]. No Shinkei Geka 35: 703–718, 2007 (Jpn, with Eng abstract)

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