

Incidence and neurological outcomes of aneurysm rupture during interventional neuroradiology procedures in a hybrid operating suite

Kentaro Yamakawa · Shuya Kiyama ·
Yuichi Murayama · Shoichi Uezono

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Abstract A hybrid operating suite, where craniotomy, brain CT scanning, fluoroscopy, and angiography can be performed on the same operating table, is becoming popular among neurosurgeons. However, whether use of a hybrid operating suite can improve neurological outcome has not been studied. We reviewed the incidence and outcomes of ruptures of cerebral vascular lesions during interventional neuroradiology procedures performed in our hybrid operating suite. Of 602 patients who underwent coil embolization under general anesthesia, five cases of intraprocedural rupture of the aneurysms were identified. Despite emergency neurosurgical intervention within 2 h of rupture of the aneurysms, two of these five patients died and one patient had permanent neurological deficit post-surgery. Whether use of a hybrid operating suite improves neurological outcome remains uncertain.

Keywords Interventional neuroradiology · Aneurysm rupture · Hybrid operating suite

Introduction

Interventional neuroradiology (INR) is a rapidly expanding speciality [1]. INR procedures are increasingly used to treat cerebral aneurysms and arteriovenous malformations

(AVM). These procedures are often performed in a remote radiology suite, where a full range of surgical equipment is not readily available. Technical support for anesthesiologists is also distant. Hemorrhagic complications because of aneurysmal and AVM rupture are usually treated by packing more coils. If endovascular packing fails to achieve hemostasis, emergency craniotomy and clipping of a bleeding aneurysm may be required. Patients may also develop acute hydrocephalus secondary to subarachnoid hemorrhage, necessitating ventricular drainage. Transfer of unstable patients from a radiology suite to a neurosurgical operating room (OR) is time-consuming and may worsen neurological outcome. A so-called *hybrid operating suite*, where both radiologic and surgical procedures can be performed on the same operating table, may be useful in emergencies during INR. However, whether or not the use of a hybrid operating suite for INR procedures improves patients' outcome has not yet been examined. We reviewed the incidence and outcomes of ruptures of cerebral vascular lesions during INR procedures performed in our hybrid operating suite. Between November 2003 and February 2010, 602 patients with a cerebral aneurysm or AVM underwent coil embolization under general endotracheal anesthesia. None of these patients had neurological deficit before surgery. Five cases of intraprocedural rupture of the aneurysms were identified in 602 patients. We report briefly the clinical course of these five patients who required emergency neurosurgery.

K. Yamakawa · S. Kiyama (✉) · S. Uezono
Department of Anesthesiology,
The Jikei University School of Medicine,
Nishi-Shimbashi 3-25-8, Minato-ku, Tokyo 105-8461, Japan
e-mail: BYG07622@nifty.com

Y. Murayama
Division of Endovascular Neurosurgery,
Department of Neurosurgery,
The Jikei University School of Medicine, Tokyo, Japan

Case reports

Case 1

A 71-year-old woman with an unruptured 5-mm aneurysm of a right middle cerebral artery was scheduled for coil

embolization. A microcatheter, which had been advanced into the aneurysm, perforated the aneurysmal wall. Anti-coagulation with heparin was immediately reversed with protamine. Surgeons rapidly converted to craniotomy and clipped the aneurysm. The time required from perforation of the aneurysm to start of emergency craniotomy was 35 min. The patient had left hemiplegia, left facial palsy, and dysarthria postsurgery. These symptoms eventually disappeared in the following weeks. Technical details of the procedure for this patient have been reported elsewhere [2].

Case 2

A 47-year-old man had an intracranial hemorrhage in his left occipital lobe because of rupture of an AVM. He had an endovascular coiling of AVM without problems and was neurologically intact postsurgery. One month later, he underwent the second coil embolization of his remaining AVM. A microcatheter perforated a known small aneurysm located between a basilar artery and a superior cerebellar artery. Perforation was confirmed by extravasation of a contrast agent and subsequent brain computed tomography (CT). After immediate reversal of anticoagulation, a drainage catheter was placed into his ventricle 35 min after aneurysmal perforation. Although craniotomy and cerebral decompression were also performed to treat sustained intracranial hypertension, the patient died 1 month later without neurological improvement.

Case 3

A 64-year-old woman was referred to our neurosurgical service for INR procedure of a small unruptured aneurysm of an anterior communicating artery. During the final stage of embolization, a coil perforated the aneurysm. A few more coils were placed into the aneurysm. Emergency ventriculostomy was performed to reduce intracranial pressure 90 min after the perforation. She did not recover

despite full intensive care and died 1 month after the INR procedure.

Case 4

A 56-year-old woman with a right internal carotid artery aneurysm had been medically followed for the preceding 4 years. Because of an increase in the size of the aneurysm, endovascular coiling was scheduled. Several coils were successfully placed into the aneurysm, but the last coil perforated the aneurysm. Heparin was antagonized with protamine and a few more coils were placed. Because she did not wake up from anesthesia, a ventricular drain was inserted 112 min after rupture of her aneurysm. Fortunately, she made a full neurological recovery.

Case 5

A 63-year-old woman with a right internal carotid aneurysm underwent a coil embolization. During the procedure, a loop of coil ruptured the aneurysm. Subarachnoid hemorrhage was diagnosed by CT scan and emergency ventriculostomy was performed 75 min later. She showed left hemiplegia and homonymous hemianopsia, which improved slightly 1 month after the procedure.

Details of aneurysmal rupture and neurological prognosis are summarized in Table 1.

Discussion

Aneurysmal and AVM rupture are two of the most feared complications of endovascular treatment. Perforation is caused by a guidewire, a microcatheter, or the detachable coil itself. Doerfler and colleagues [3] reported five intra-procedural ruptures in 164 patients who underwent treatment with Guglielmi detachable coils, with mortality of 20%. In our retrospective analysis, five patients without preoperative neurological deficits suffered from rupture of

Table 1 Intra-procedural ruptures of aneurysms

Case	Age/sex	Aneurysm location	Perforating device	Time to emergency surgery (min)	Neurosurgical procedure	Glasgow Outcome Scale	
						At POD 7	At POD 28
#1	71/F	Right MCA	Microcatheter	35	Craniotomy	3	4
#2	47/M	BA-SCA	Microcatheter	35	Ventriculostomy/craniotomy	2	1
#3	64/F	AcomA	Coil	90	Ventriculostomy	2	1
#4	56/F	Right ICA	Coil	112	Ventriculostomy	3	5
#5	63/F	Right ICA	Coil	75	Ventriculostomy	3	3

AcomA anterior communicating artery; BA basilar artery; ICA internal carotid artery; MCA middle cerebral artery; SCA superior cerebellar artery
Glasgow Outcome Scale: 1, dead; 2, vegetative state; 3, severe disability; 4, moderate disability; 5, good recovery

their cerebral vascular lesions during INR procedures. Incidence of intraprocedural rupture was 0.83%, with mortality of 40%. This relatively low incidence of rupture is comparable with a figure of 1% reported by Brisman and his colleagues for 600 consecutive patients treated by coiling [4]. However, in their results only six patients with a preoperatively ruptured lesion had rupture of aneurysms again during the procedure, with zero mortality. Levy and colleagues report intraprocedural rupture in 2% of their 274 patients, with mortality of 33% [5]. Despite emergency neurosurgical intervention within 2 h from occurrence of INR complication, two of our patients died and one patient had permanent neurological deficit postsurgery. This may suggest there are relatively few things anesthesiologists can do to improve patients' prognosis. Having said that, we believe anesthesiologists should try to stabilize the hemodynamics and reverse heparin-induced anticoagulation as quickly as possible in this emergency. Transient cardiac arrest by bolus injection of adenosine may help control massive bleeding from ruptured aneurysms during surgical clipping [6]. Although the efficacy of inducing cardiac arrest during INR procedures is unclear, close communication between a neurosurgeon and an anesthesiologist is essential in these circumstances.

It is impossible to know whether the clinical outcomes would have been worse if these procedures had been performed in a remote radiology suite. To determine whether the use of a hybrid operating suite improves patients' outcome, data are required for patients who had INR procedures in a remote radiology suite. However, we started to use a hybrid operating suite from quite an early stage when the INR treatments for cerebral vascular lesions were started in our hospital. Therefore, only very few patients have been treated in a remote angiography suite, and this has made meaningful comparison difficult. Some may argue that ventricular drainage could have been performed as a temporizing measure even in a radiology suite. However, more definitive procedures may be required, as in Cases 1 and 2 in our series. Transporting intubated patients with intravascular catheters and monitoring devices is not only stressful for an anesthesiologist but is also

associated with risks of hemodynamic fluctuation and further bleeding from the aneurysm or AVM. Performing INR procedures in a hybrid operating suite can theoretically mitigate these risks, but our results show that the neurological outcomes may not necessarily be as good as they should be. A hybrid operating suite, where craniotomy, CT scanning, fluoroscopy, and angiography can be performed on the same operating table, is becoming popular among neurosurgeons [7], and anesthetic risks may be reduced, particularly in cases of emergency craniotomy after INR procedures. However, whether use of a hybrid operating suite would significantly improve neurological outcome remains uncertain.

Conflict of interest Kentaro Yamakawa, Shuya Kiyama, Yuichi Murayama, and Shoichi Uezono have no conflict of interest.

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