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Prospective Analysis of Complications of Catheter Cerebral Angiography in the Digital Subtraction Angiography and Magnetic Resonance Era

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Abstract

Permanent and temporary neurological complications of catheter cerebral angiography were prospectively evaluated in 500 consecutive diagnostic cerebral angiographic procedures, 268 performed on 213 males and 232 on 175 females. Complications were divided into permanent (>1 week), reversible (≦1 week, >24 hours), and temporary (≦24 hours). There were four permanent (0.8%), one reversible (0.2%), and nine temporary neurological complications (1.8%). There was no death. With the correct selection of patients, catheter cerebral angiography is considered to be safe with acceptable rates of complications.

Key words: cerebral angiography, digital subtraction angiography, neurological complication

Introduction

Complications associated with catheter cerebral angiography have been much investigated in the past 30 years.[2-5,7,8,10,13-17,21,23] During this period, diagnostic methods in neuroradiology have greatly changed through the introduction of computed tomography (CT) and magnetic resonance (MR) imaging. Furthermore, CT angiography and MR angiography have reduced the need for conventional angiography. Digital subtraction angiography (DSA) technology and bi-plane equipment have shortened the time required for angiography and decreased the total amount of the contrast material. Most reports of complications associated with cerebral angiography come from specialized neuroradiological facilities in the United States and Europe, where fairly large numbers of cerebral angiographies are carried out within short periods. In Japan, cerebral angiography is still performed in general hospitals by neurosurgeons with a lower annual volume than in specialized institutions. The present prospective study evaluated the incidence of temporary and permanent neurological complications in the DSA and MR era in a series of 500 consecutive diagnostic cerebral angiographies.

Materials and Methods

This prospective study of complications of catheter cerebral angiography included patients who underwent the procedure during the period from December 1993 to June 1996. Patients who underwent endovascular surgery were excluded (126 cases), except for one patient, who suffered an embolic complication during diagnostic cerebral angiography that was treated by local fibrinolysis (Case 5). Cerebral angiography performed for stereotactic localization of radiosurgery in 66 patients with cerebral arteriovenous malformations was also excluded since radiosurgery-specific epilepsy was observed on several occasions. The patients were aged from 14 days to 88 years (mean 51 years) (Table 1). The study included 500 procedures, 268 were performed on 213 males and 232 were performed on 175 females. The clinical diagnoses are shown in Table 2.

The basic techniques of cerebral angiography were as follows: a) transfemoral approach; b) local anesthesia; c) use of a 4.0-5.0 French introducing sheath; d) use of non-ionic contrast material (iohexol 300 mgI/ml); e) use of a 4.0-5.0 French headhunter catheter (H1) with a 0.035 inch guidewire; f) mechan-

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Table 1 Clinical characteristics of patients

Age (yrs)	Male	Female	Total
-1	2	5	7
-10	7	10	17
-20	7	13	20
-30	24	16	40
-40	9	14	23
-50	48	36	84
-60	79 (T6, P1)	61	140 (T6, P1)
-70	75 (T1, R1, P2)	44 (T1)	119 (T2, R1, P2)
-80	17	30 (T1, P1)	47 (T1, P1)
-90	0	3	3
Total	268 (T7, R1, P3)	232 (T2, P1)	500 (T9, R1, P4)

Number of neurological complications is shown in parentheses. P: permanent, R: reversible, T: temporary.

Table 2 Clinical diagnoses and angiography-related neurological complications

Diagnosis	Procedures	Complications
Cerebral ischemia	142	10 (T7, R1, P2)
Aneurysm/subarachnoid hemorrhage	141	3 (T1, P2)
Brain tumor	83	0
Vascular malformation	50	0
Intracerebral hemorrhage	31	0
Moyamoya disease	19	0
Head and neck lesions	15	1 (T1)
Trauma	5	0
Facial spasm	5	0
Others	9	0
Total	500	14 (T9, R1, P4)

P: permanent, R: reversible, T: temporary.

ical injection of contrast material at a rate of 4–5 ml/sec, total dose of 6 ml for the common carotid artery (4–5/6/sec), 3/4/sec for the internal carotid artery and the vertebral artery, and 8–10/12/sec for the aorta; g) DSA with bi-plane simultaneous data acquisition (DFP-60A; Toshiba, Tokyo); h) stereoscopic study by two separate contrast injections when necessary; i) no systemic heparinization; j) bed rest in the supine position until the morning following the procedure; k) examination on an in-patient basis; l) intentionally delayed angiography for at least 3 hours, but most often 6 hours after ictus for patients with acute ruptured cerebral aneurysms; and m) flushing of the catheter with heparinized saline (6000 U/l) at the appropriate time interval.

Several exceptions to the above techniques were as follows: a) transbrachial approach using a 4.0 French modified Simmons catheter with a 4.0 French vascular sheath when the transfemoral route was inappropriate (10 cases), and b) general anesthesia for pediatric patients. The amounts of contrast material for each injection and for the total examination were reduced for pediatric patients according to age and body weight. In patients under the age of 3 years, a 3.0 French catheter with a hockey-stick tip-configuration was used without a vascular sheath. When catheterization was difficult, several additional catheters with different tip configurations, such as head hunter H3 or H5, were used.

Patients underwent neurological examination during and immediately following angiography, and at the least on the evening of the same day and the next morning, but generally patients were followed up for several days on an in-patient basis. *All* subjective and objective changes or indications of deterioration, either new or additional, were recorded as complications, even those not apparently directly related to angiography. Complications were defined as temporary if completely resolved within 24 hours, those that persisted longer than 24 hours but resolved within 7 days were classified as reversible. Complications lasting longer than 7 days were considered permanent. The three neurosurgeons performing angiography in our institution more than 17 years (M.K.), 10 years (K.Y.), and 9 years (M.N.) experience in angiography.

Results

There were 14 neurological complications (2.8%) and seven non-neurological complications (1.4%). Neurological complications included four permanent (0.8%), one reversible (0.2%), and nine temporary complications (1.8%) (Table 3). Non-neurological complications were all temporary, and included three cases of nausea/vomiting, and one each of skin eruption, hypotension, dizziness, and arrhythmia.

Table 3 Types of neurological deficits and complication

Neurological deficit	Complication
Sensory/motor deficits	4 (T3, P1)
MCA branch occlusion	2 (R1, P1)
Cortical blindness	2 (T2)
Transient global amnesia	2 (T2)
Aneurysmal rebleeding	1 (P1)
Dizziness (pons infarction)	1 (P1)
Blurred vision	1 (T1)
Involuntary movement	1 (T1)
Total	14 (T9, R1, P4)

MCA: middle cerebral artery, P: permanent, R: reversible, T: temporary.

There was no death. Aneurysmal rebleeding (Case 1) and pontine lacunar infarction (Case 2), both of which occurred after angiography, were included as permanent complications, but were possibly unrelated to angiography.

Case Presentation

Case 1: A 67-year-old male in a drowsy state was brought to our hospital. CT revealed left subdural hematoma and subarachnoid hemorrhage, so emergency diagnostic angiography was performed without the intentional delay of several hours which is commonly applied to reduce the chance of rerupture. Angiography showed a left middle cerebral artery aneurysm (Hunt and Kosnik grade IV). The aneurysm rebled 30 minutes after completion of the angiography in the intensive care unit when oral suction caused severe coughing (3 hours after ictus). The patient's condition further deteriorated. The aneurysm rebled again during the clipping operation. He was severely disabled and was transferred 5 months later to a local hospital. We considered this aneurysmal rebleeding to be a permanent complication.

Case 2: A 54-year-old male with mild weakness of the left upper extremity underwent uneventful catheter cerebral angiography, which showed only minimal atherosclerotic changes. MR imaging showed multiple small ischemic lesions. The morning following the angiography, the patient noticed dizziness when he walked. Follow-up MR imaging showed a new lacunar infarction in the right pons. The dizziness disappeared after several months. This event was considered to be a permanent complication.

Case 3: A 79-year-old female with a ruptured large, partially thrombosed left middle cerebral artery aneurysm was treated by surgical coating on day 4. One week later, the patient underwent follow-up angiography. During angiography, the upper branch of the left middle cerebral artery that originated from the aneurysm was partially occluded by an embolus. No fibrinolysis was attempted for fear of rebleeding. This patient developed total aphasia and mild right hemiparesis. Whether the embolus originated from an intra-aneurysmal or a catheterization-related thrombus was impossible to determine. The patient was transferred to a local hospital 3 months later in a severely disabled state. This event was considered to be permanent complication.

Case 4: A 66-year-old male presented with occlusion of the right cervical internal carotid artery and severe stenosis of the left intracranial internal carotid artery (C_2 portion). He underwent uneventful follow-up angiography after right superficial temporal artery-middle cerebral artery anastomosis. He got up and walked during the night after the angiography, despite orders to remain in bed, and complained of an unstable gait. He had mild right hemiparesis and motor aphasia. Within about a month, these deficits recovered to the previous state. Follow-up MR imaging showed a new infarction in the white matter near the left anterior horn. This event was considered to be a permanent complication.

Case 5: A 60-year-old male complaining of numbness of the right hand underwent catheter angiography. He had an occlusion of the right cervical internal carotid artery and stenoses of the left intracranial internal carotid artery (tandem lesions). The left common carotid artery had an anomalous origin from the innominate artery. During catheter manipulation to the left common carotid artery, embolic occlusion of the upper branch of the left middle cerebral artery occurred. The patient suddenly became restless, and developed right hemiparesis and aphasia. Urokinase (480,000 U) was infused to the left common carotid artery, which resulted in marked improvement of the symptoms within 30 minutes. However, the patient again became aphasic and right hemiparetic. Local fibrinolysis was then performed using a microcatheter. Recanalization of the middle cerebral artery was achieved by 240,000 U of urokinase. His aphasia and hemiparesis rapidly resolved almost completely. Mild motor aphasia completely disappeared in a week, and follow-up MR imaging showed no new infarction related to angiography. This event was considered to be a reversible complication.

Discussion

The role of catheter cerebral angiography has changed in the 20 years since the introduction of CT. Angiography is now never performed for neurotrauma except in the event of vascular injuries. Angiography for neoplastic lesions is limited and has been replaced by MR imaging and MR angiography in most cases. However, stroke patients with more complicated medical status increasingly undergo catheter cerebral angiography.

I. Reported complication rates

Complication rates of cerebral angiography have not greatly reduced in the past 30 years despite improved diagnostic x-ray equipment, contrast materials, and catheter technologies (Table 4).[2,3,7,8,10,15-17,21,23] This may imply that there are inherent risks in cerebral angiography which cannot be avoided, and that patients with higher risks undergo

Table 4 Reported rates of neurological complications of cerebral angiography

Author (Year)	No. of procedures	Permanent complication	Transient complication	Death
Takahashi and Kawanami (1972)[21]	500	0.6	1.2	0.0
Olivecrona (1977)[17]	5531	0.2	4.2	0.03
Kerber *et al.* (1978)[10]	603	0.0	1.0	0.0
Mani *et al.* (1978)[15]	5000	0.04	0.86	0.02
Earnest *et al.* (1984)[3]	1517	0.3	2.3	0.0
McIvor *et al.* (1987)[16]	229	5.7	5.4	0.0
Dion *et al.* (1987)[2]	1002	0.1*	1.2*	0.0
		0.3**	1.5**	0.0
Grzyska *et al.* (1990)[7]	1095	0.09	0.45	0.0
Waugh and Sacharias (1992)[23]	939	0.3	0.6	0.0
Heiserman *et al.* (1994)[8]	1000	0.5	0.5	0.0
Present study	500	0.8	2.0	0.0

*Occurrence in the first 24 hours. **Occurrence between 24 and 72 hours after angiography.

cerebral angiography. Differences in the definition of complications and the difference between prospective and retrospective studies may greatly affect the complication rates. Thus, we cannot draw conclusions from a simple comparison of the complication rates in these studies. Our study showed an incidence of 0.8% for permanent and 2.0% for reversible/temporary neurological complications, which are similar to those of previous reports. The slightly higher incidence of complications in our series may be attributable to our strict criteria for complications.

II. Risk factors

The risk factors for increased neurological complications are advanced age, increased serum creatinine level, and the use of more than one catheter.[3] Institutions where fewer diagnostic cerebral angiographies are performed may have significantly higher complication rates than the published data.[6] Catheter technique (level of angiographic experience) may also influence the rate of angiographic complications,[15,16] but others deny this.[8,17,21] A procedure longer than 80 minutes is a significant risk factor, which is closely related to the proficiency of the operator.[14] Improved contrast materials and imaging technology have caused marked reductions in allergic complications and the total amount of contrast material used. Complication rates have increased, especially in angiography performed for stroke or transient ischemic attack,[8,21] but contradictory results have been reported.[4] Recent hemorrhage (subarachnoid hemorrhage and intracerebral hemorrhage) is considered to be a high risk factor for cerebral angiography.[6,11] In cases of aneurysmal subarachnoid hemorrhage, a 6-hour intentional delay for angiography is recommended for prevention of rebleeding if the clinical situation allows.[11] In our series, most neurological complications occurred in older patients with ischemic vascular diseases.

III. Specific complications in our series

Transient global amnesia may be caused by angiography, most commonly vertebral angiography but aortography or coronary angiography are also causes.[18,19] Possible mechanisms of amnesia are embolism (clot from the catheter or guidewire, or atheromatous debris), spasm, and neurotoxic effects of the contrast material. However, embolism is considered to be the major mechanism of this complication.[18,19,22,24]

Visual disturbance, including cortical blindness, is a known complication, which is transient with a benign course.[9,13,20] One patient developed both transient global amnesia and cortical blindness after cardioangiography, suggesting a common mechanism for these two symptoms.[1] Although the true mechanism of visual disturbance is not known, disruption of the blood-brain barrier caused by hyperosmolar contrast material may be responsible because of the reversibility of vision without resultant infarction.[13,20] However, disruption of the blood-brain barrier can also occur as a result of embolic occlusion and reperfusion in the vertebrobasilar system, similar to transient global amnesia.

Transient involuntary movement can also be caused by angiography.[1,12] This complication is usually temporary and benign, but the causative mechanism is unknown. Either hypoperfusion or embolism may cause ischemia in the region of the subthalamic nucleus of Luys or its related struc-

tures, resulting in involuntary movement of the opposite side.

IV. Methods to minimize complications

Late neurological complications after angiography might not be differentiated from manifestations of the primary disease. We performed all cerebral angiographies on an in-patient basis, which increased the cost of angiography, but allowed thorough pre- and postangiography observation, and detection of any neurological change or deterioration as early as possible.

Reduction of the complication rates of catheter cerebral angiography to zero would seem to be impossible, especially because many of the patients who undergo angiography are of advanced age. One way to reduce complication rates would be to use less invasive imaging techniques, such as CT or MR angiography, as much as possible, to avoid unnecessary catheter angiography.

Endovascular techniques allow for the recanalization of acutely occluded cerebral vessels with fibrinolytic agents, such as urokinase and tissue plasminogen activator. Since most of the complications in our series were caused by embolus resulting from catheter manipulation, it is advisable to prepare for interventional selective local fibrinolysis should embolic complication occur as in Case 5.

Our series of 500 consecutive cases of catheter cerebral angiography included four permanent (0.8%) and 10 reversible/temporary complications (2.0%), which is similar to the incidence in previous reports. With the advent of modern vascular imaging technology, the need for catheter cerebral angiography has been reduced. However, this procedure is still considered to be safe with acceptable complication rates assuming the correct selection of patients.

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Commentary

This report provides important information and a good review about the complications of cerebral angiography even in the DSA and MR era. The need for catheter cerebral angiography has been reduced with the advance of modern vascular imaging technology. However, this catheter procedure seems to be still necessary and has become more important because of its accurate diagnostic and therapeutic capabilities. The complication rate in this report is similar to those of previous reports. As the authors mentioned, one of the feasible ways to reduce complication rates would be to use less invasive imaging techniques as much as possible, avoid unnecessary angiography and restrict use to well-experienced specialists. We have to make all efforts to reduce the complication rates as much as possible. In the near future, high resolution 3-D CT or MR angiography will take the place of cerebral angiography completely for the diagnosis of intracranial lesions because of their less invasive character.

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Cerebral angiography is mostly performed by specialized neuroradiologists, but by neurosurgeons in Japan. There may be advantages that neurosurgeons do the procedure, especially for patient's care during and after angiography. This paper provides some objective data regarding the complications of angiography, which is done with the advanced technique, contrast materials and equipment. Recently the role of conventional angiography has been reduced in neurosurgical field with the recent advancement of diagnostic tools such as MR imaging, MR and CT angiography. However, catheter angiography is necessarily used for cerebrovascular disease. Apparently, it should be used with caution for older patients with ischemic disease. This report of a 0.8% incidence of permanent and 2.0% incidence of reversible/temporary neurologic complications of angiography, which is similar to the rates of complications by other studies, shows that it is as safe as expected.

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Angiography remains essential for the pathognomonic diagnosis of vascular lesions of the central nervous system even after the introduction of present advanced imaging techniques. It seems important to remember that even with extreme improvement in the fields of catheter and contrast medium there is certain ratio of complications as stated in this paper. There have been some reports dealing with complications like this one and it is worth to note that the reported complication rates are almost the same. This does not necessarily mean that the technique is immature, but that the population includes patients in their 70s and 80s.

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The authors used rather strict criteria for the diagnosis of neurological complications caused by angiography. Their report may provide information about the standard complication rate of cerebral angiography in the DSA era. It seems somewhat strange that complication rate is not decreased from previous reports in spite of recent advancement of catheters, contrast materials and imaging system.

Several factors might influence this fact, such as criteria of complication, angiographer's skill, patient selection, etc. Now magnetic resonance angiography and three-dimensional CT angiography are available and these can contribute as alternative examinations, so one should select patients who really need angiography.

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This is an excellent review of complications and occurred after 500 diagnostic cerebral arteriograms reported by Komiyama and colleagues. It is an accurate account since all the patients were in the hospital for at least a day after the study. I do not be-

lieve that the Cases 1 and 2 are really angiographic complications, which reduces their permanent complications even further. It should be noted that the complications occurred in patients being studied for ischemic disease or for subarachnoid hemorrhage. Inherently, this is a higher risk group. I agree with the authors' conclusion in that, although the number of catheter angiograms performed are considerably lower and the catheters and contrast media are more refined, the rate of complications reported in large series over the years has remained the same. This is probably the "baseline" complication rate inherent with this procedure which seems to occur in patients with cerebrovascular ischemic disease.

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