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Original Article

Comparison of clinical efficacy and safety between microsurgical clipping and stent-assisted coil embolization for wide-necked aneurysms

Zhiwei Huang, Chuanyi Fu, Xifeng Li, Xuying He, Chuanzhi Duan

Department of Neurosurgery, Neurosurgery Institute, Key Laboratory on Brain Function Repair and Regeneration of Guangdong, Zhujiang Hospital, Southern Medical University, Guangzhou 510282, Guangdong, China

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Abstract: Objective: To investigate the clinical efficacy and safety of microsurgical clipping and intravascular intervention (stent-assisted coil embolization) for the treatment of wide-necked aneurysms. Method: 140 patients with intracranial wide-necked aneurysms treated in our hospital from January 2012 to December 2015 were recruited in this study and divided into experiment group (70 cases) and control group (70 cases) by reference to the random number table. The patients in experimental group received intravascular intervention (stent-assisted coil embolization) and the patients in control group received microsurgical clipping for treatment. The treatment effectiveness was evaluated by comparing the postoperative quality of life and degree of embolization between the two groups. Meanwhile, the complications in each patient of both groups were statistically analyzed for safety comparison. Results: The postoperative instant complete embolism rate was 78.6% and 75.7% respectively in experiment group and control group, without statistically significant difference between two groups (P>0.05). The postoperative good prognosis rate was 94.3% and 97.1% respectively in experiment group and control group, without statistically significant difference between two groups (P>0.05). In addition, the incidence of complications was 7.1% and 8.4% respectively in experiment group and control group , without statistically significant difference between two groups (P>0.05). Conclusion: There was no significant difference in clinical efficacy between microsurgical clipping and intravascular intervention for carotid aneurysm. Both treatment methods could significantly improve the clinical symptoms and reduce the surgical complications for patients. In clinical application, the optimal therapeutic regimen shall be selected according to the aneurysm site and physical conditions of the patients to improve the survival rate.

Keywords: Microsurgical clipping, intravascular intervention (stent-assisted coil embolization), carotid aneurysm

Introduction

Intracranial aneurysm, with higher incidence in cerebrovascular disease, is the main cause of spontaneous subarachnoid hemorrhage. Only one third of the patients would survive after the surgery. Once the intracranial aneurysm ruptured, patients will have high risks of disability and mortality. The wide-necked intracranial aneurysm is one of the complex intracranial aneurysms [1]. Microsurgical clipping is an important method for the treatment of intracranial aneurysm [2]. This surgery excludes aneurysm outside of the normal circulation system; however, it has large incision and requires more experiment for surgeons. Intravascular interventional treatment has become increasingly preferred for the treatment of intracranial aneurysms [3]. In recent years, clinical studies indicated that stent-assisted coiling had obvious effect in treating narrow-necked aneurysms [4], but the wide-necked aneurysms was a little difficult for intravascular intervention. With the continuous development of interventional techniques, the indications of intravascular intervention are further expanded in the treatment of wide-necked aneurysm, so that the disease which was difficult to treat by interventional therapy in the past would be possibly completely cured. The self-expandable stent technology with high compliance is highly safe and easy to control, so it can be combined with coil embolization through circuitous intracranial vessels to become the main treatment method for intra-

Table 1. Comparison of general information between two groups

	Microsurgical clipping group	Intravascular intervention group
Number of cases (cases)	70	70
Age (years old)	(50.1 ± 13.4)	(51.6 ± 12.1)
Sex (cases)		
Male	22	23
Female	48	47
Hunt-Hess Classification (cases)		
Grade I	10	8
Grade II	29	30
Grade III	24	24
Grade IV	7	8

cranial wide-necked aneurysm. However, this intervention also has some limitations due to difficulty in operation and complications such as cerebral hemorrhage and cerebral embolism [5]. Stent-assisted coiling is a new treatment method for wide-necked intracranial aneurysms, with advantages especially in the early treatment of unruptured aneurysms and the treatment of post-circulation aneurysms. However, intravascular intervention cannot completely replace the microscopic clipping operation, because some studies showed that microsurgical clipping had a better effect than intravascular intervention [6]. At present there is no unified standard about treatment of intracranial aneurysm. To compare the efficacy of these two treatment methods, 140 patients with wide-necked aneurysms of our hospital received microsurgical clipping and intravascular intervention (stent-assisted coil embolization) respectively, and statistical analysis was conducted to compare the clinical efficacy and safety between two groups.

Materials and methods

General information

140 patients with intracranial aneurysm treated in our hospital from January 2012 to December 2015 were selected as the research objects, including 95 females and 45 males, aged between 41 to 72 years old, with an average of (50.7 ± 11.4) years old; 146 wide-necked aneurysms were detected in these 140 patients; 22 aneurysms were located in cavernous sinus segment, 25 aneurysms in the upper segment of internal carotid artery, 43 aneurysms in the anterior communicating artery, 10 aneurysms in the anterior cerebral artery, 34 aneurysms in the posterior communicating artery, and 12 aneurysms in middle cerebral artery. 82 aneurysms were in the diameter of 6~15 mm, and 58 aneurysms in 4~6 mm. Hunt-Hess clinical classification: 18 cases of grade I, 59 cases of grade II, 48 cases of grade III, and 15 cases of grade IV. The patients were randomly divided into experiment group (70 cases) and control group (70 cases). The patients in the experimental group were treated with intravascular intervention (stent-assisted coil embolization) and the patients in control group were treated with microsurgical clipping surgery. There were no statistically significant differences between the experimental group and the control group (P>0.05) in the aspects of gender, age and the type of wide-necked aneurysm, so these two groups were comparable. See **Table 1** for details. Prior to surgery, all patients had signed the informed consent.

Operation mode

Vascular intervention (stent-assisted coil embolization) surgery: 3 days before operation, all the patients in the experiment group began to take anti-platelet drugs. Tracheal intubation was performed under general anesthesia preoperatively; to determine the location, size, shape, and orientation of the aneurysms, femoral artery puncture was used for angiography of cerebral blood vessels, the lesion width on neck and tumor size of the aneurysms were measured; and the relationship between the parental arteries and aneurysms was observed. Then, the self-expandable stent was selected and gradually released using semi-release technology. The guiding catheter was placed technically, and the release position of the stent was determined according to the end of delivery catheter. The catheter was stopped when its end came to the place near the neck site of the aneurysms, and the stent was released. Microcatheter then was super selectively delivered into the aneurysm sac through the stent mesh, then, soft or super-soft spring coils with minimal diameter for the aneurysms

Table 2. Comparison of degree of thrombus between two groups

Group	n	Complete embolization	Subtotal embolization	Partial embolization
Experimental group	70	55 (78.6%)	11 (15.7%)	4 (5.1%)
Control group	70	53 (75.7%)	15 (21.4)	2 (2.9)
P value	-	>0.05	>0.05	>0.05
χ^2	-	1.67	1.32	1.41

Table 3. Comparison of prognosis conditions between two groups

Group	n	Good prognosis rate	Dysfunction	Number of dead cases
Experimental group	70	66 (94.3%)	3 (4.3%)	1 (1.4%)
Control group	70	68 (97.1%)	1 (1.4%)	1 (1.4%)
P value	-	>0.05	>0.05	>0.05
χ^2	-	0.14	0.13	0.15

Table 4. Comparison of postoperative complications between experimental group and control group

Complication types	Experimental group (n=70)	Control group (n=70)	*P* value	χ^2
Acute thrombosis	1	1	>0.05	0.12
Vasospasm	1	1	>0.05	0.12
Spring coil displacement	0	0	-	-
Rupture of aneurysms	0	1	>0.05	0.18
Rehaemorrhagia	1	1	>0.05	0.12
Recurrence of aneurysms	0	0	-	-
Residual aneurysmal neck	1	1	>0.05	0.12
Cerebral ischemic stoke	1	1	>0.05	0.12
Total	5 (7.1%)	6 (8.4%)	>0.05	0.17

were used to gradually fill the cavity in sequence until the aneurysm cavity was densely filled. In order to ensure that the stent was located inside the aneurysm cavity, angiography shall be conducted, and then the spring coil was fully released. In case of larger delivery resistance for aneurysm coil or retention of intravascular contrast agent, embolism can be terminated. During the surgery, 300 mg Aspirin and 300 mg Plavix were administered through stomach tube. At the end of surgery, the catheter sheath was removed, and the femoral artery was closed by using vascular closure device. On postoperative day 3, each patient was treated with low molecular heparin, clopidogrel and aspirin for anti-platelet therapy for about 3 months; in addition, the patients shall take aspirin for a lifetime. In order to relieve the headache, the patients were recommended to take pain relieving and sedative drugs. At the same time, nimodipine anti-vasospasm drug should be administrated as effective and timely measures to prevent and control the postoperative complications.

Microsurgical clipping: all patients in the control group received trachea intubation under general anesthesia, then under a microscope, the arachnoid was cut along lateral fissure vein, and the lateral fissure cistern, carotid cistern or suprasellar cistern were separated to fully expose the neck of aneurysm. A piece of fine silica gel was placed within the cistern and repeatedly rinsed with papaverine solution. Routine anti-cerebral vasospasm and intracranial pressure reduction treatment were given postoperatively, and the blood pressure of the patients was closely monitored.

Observation indices

The degree of thrombosis, prognosis effect 3 months after surgery, and the incidence of postoperative complications were compared between the two groups.

Evaluation of efficacy

Digital Subtraction Angiography (DSA) follow-up was conducted for both experiment group and control group immediately and 3 months after surgery respectively, and the effectiveness of the two treatment methods was evaluated by observing and comparing their degree of aneurysm occlusion. The evaluation criteria for immediate angiography were divided into three types [7]: complete embolization, subtotal embolization and partial embolization, respectively characterized by aneurysm nonvisualization, visualization of partial contrast agents into the tumor and (or) tumor neck, and visualization of a greater part of the tumor. In this study, Modified Rankin Scale was used to evaluate the recovery of patients [8] with a range of 0-5 points. 0-2 points indicate good postoperative recovery and 3-5 points indicate dysfunction.

Table 5. Comparison of general surgery conditions between experimental group and control group

Group	Average hospital stay (d)	Average operation time (min)	Average intraoperative blood loss (ml)
Experimental group (n=71)	16.1±2.2*	63.4±5.1*	110.2±13.5*
Control group (n=70)	21.5±4.1	87.3±6.2	244.1±20.1
P value	0.045	0.047	0.032
t value	7.83	7.72	6.89

*$P<0.05$ in comparison between two groups.

At the same time, the general surgery conditions of the two groups were compared.

Statistic analysis

SPSS19.0 statistical analysis software was mainly used for statistical analysis in this study. Measurement data were expressed by mean ± standard deviation, and t test was used for comparison. Enumeration data were expressed by rate, and χ^2 test was used for comparison. $P<0.05$ indicated that there was statistically significant difference.

Results

Comparison of degree of thrombus and prognosis conditions between two groups

In this study, the surgeries were successful in all patients of two groups. There was no statistically significant difference in complete embolization rate between the experiment group (78.6%) and the control group (75.7%) ($P>0.05$). See **Table 2** for details. In postoperative follow-up, there was no significant difference in good prognosis rate between the experiment group (94.3%) and the control group (97.1%) according to the results of Modified Rankin Scale ($P>0.05$). See **Table 3** for details.

Comparison of postoperative complications between experiment group and control group

5 patients had complications in the experiment group, including 1 case of acute thrombosis, 1 case of vasospasm, 1 case of cerebral ischemic stroke, 1 case of rehaemorrhagia and 1 case of residual aneurysmal neck. 6 patients had complications in the control group after microsurgical clipping, including 1 case of acute thrombosis, 1 case of vasospasm, 1 case of ruptured aneurysm, 1 case of cerebral ischemic stroke, 1 case of rehaemorrhagia and 1 case of residual aneurysmal neck. There was no significant difference in overall complication rate between the experiment group (7.1%) and the control group (8.4%) ($P>0.05$). See **Table 4** for details.

Comparison of general surgery conditions between two groups

The hospital stay was 13-53 days with a mean value of (21.5 ± 4.1) days in control group, and 8-34 days with a mean value of (16.1 ± 2.2) days in the experiment group. The average hospital stay in patients treated with intravascular intervention was less than that in patients with microsurgical clipping, with statistically significant difference ($P=0.045$). The operation time and intraoperative blood loss in the experimental group were also significantly less than those in the control group, with statistically significant differences. See **Table 5** for details.

Discussion

The intracranial aneurysms can be divided into wide-necked aneurysms and narrow-necked aneurysms according to the diameter of the aneurysm. Intracranial wide-necked aneurysms refer to those with an aneurysm neck ≥4 mm, while relatively wide-necked aneurysms refer to those with aneurysmal neck and aneurysmal radial width≥1/2-3/4. The vast majority of intracranial aneurysms are primary, known as "congenital aneurysm", "berry aneurysm or saccular aneurysm". Microsurgical clipping is a traditional method for the treatment of intracranial aneurysms. Since Guglielmi et al. firstly applied the intravascular embolization treatment with Guglclmi detachable coil (GDC) for the patients with ruptured intracranial aneurysms, it has been gradually accepted by clinicians because of its safe, minimally invasive and effective characteristics [9]. Large-sample randomized controlled trials showed that as compared with surgical clipping, the risk of embolization treatment was lower, and the effect was better in 1 to 7 years [10]. With continuous development and innovation of interventional diagnosis and treatment technology, the clinical use of intracranial special stent combined with spring coil embolization has effectively improved the cure rate and safety for intracranial wide-necked aneurysms. This technology has the advantages of better closing the aneurysmal neck, maximally achieving dense embolization, inducing thrombus formation within aneurysm cavity, and making aneurysm cavity become dead space, so that the intracranial wide-necked aneurysms can be eventually cured as far as possible and the complications can be maximally reduced [11] after the aneurysm embolization. CARAT study showed that the degree of aneurysm embolization was negatively correlated with re-haemorrhagia, so dense embolization shall be maximally achieved in aneurysm treatment [12]. For wide-necked intracranial aneurysms, spring coil alone will intrude into the parent artery, failing to achieve dense embolization. Stent-assisted embolization for intracranial aneurysm can prevent the coil from intruding into the parent artery, and improve the degree of aneurysm embolization. The hemodynamics of the artery and the aneurysmal neck were altered after stent implantation, and the recurrence rate of aneurysms, especially the small aneurysms, was reduced [13, 14]. It was reported that the success rate of stent-assisted coil embolization for wide-necked aneurysms was 92%-100%; satisfaction rate for embolization was 32% to 76% (grade 0 and grade 1); and the recurrence rate was 7% to 18.9% [15]. The immediate satisfaction rate for embolization was 78.6% in experiment group and 75.7% in control group after surgery in this study, which were similar to those reported in the literature. The reasons for thrombosis in aneurysm embolization were as follows: infusion stagnation between guiding catheter and microcatheter; thrombosis in aneurysm during the process of packing or original thrombus shedding off into the parent artery; excessive embolization or spring coil partly shedding off into the parent artery; without systemic anticoagulant; or long time intravascular operation; antiplatelet drug resistance [16]. The incidence of thromboembolism for stent-assisted aneurysm embolization was 3.7% to 7.4%; the incidence of intraoperative thromboembolism was 0 to 7.4%, and the incidence of postoperative thromboembolism was 0 to 4.5% [17]. Therefore, radiographic follow-up shall be carried out for the stent-assisted coil embolization in treatment of wide-necked aneurysms. In case of aneurysm recurrence, embolization treatment shall be conducted again [18]. However, wide-necked aneurysm is still one of the difficulties in intravascular intervention because the spring coil can easily intrude into the parent artery or escape from the tumor cavity and run to distal vessels. Application of the traditional two-dimensional spring coils could completely occlude 85% of the narrow-necked aneurysms, but only 15% of the wide-necked aneurysms. This requires the surgeons to not only maximally change the hemodynamic effects within the tumor body, but also prevent adverse stenosis consequences due to intimal hyperplasia. These technical and operational issues need more in-depth analysis. Therefore, in the choice of intravascular intervention for relatively intracranial wide-necked aneurysms, we must weigh the pros and cons, and comprehensively evaluate the disease conditions of the patients.

The results of this study showed that the overall difference in clinical efficacy and safety was not so great between microsurgical clipping and intravascular intervention (stent-assisted coil embolization) for wide-necked aneurysms. There was no statistically significant difference in complete embolization rate for blood vessels between control group with microsurgical clipping (75.7%) and experiment group with intravascular intervention (stent-assisted coil embolization) (78.6%) ($P>0.05$). Follow-up results showed that the difference was not statistically significant in good prognosis rate between experiment group with intravascular intervention (stent-assisted coil embolization) (94.3%) and control group with microsurgical clipping (97.1%) for carotid aneurysms ($P>0.05$). The common complications in carotid aneurysm surgery include acute thrombosis, vasospasm, coil displacement, aneurysm rupture and ischemic stroke [17]. Acute thrombosis may be mild or severe; usually the mild conditions are mainly manifested by mild hemiplegia or incomplete aphasia, while the severe conditions would mainly cause massive cerebral infarction, and lead to death [18]. Common intraoperative complications include vasospasm, which will lead to massive cerebral infarction and death in severe cases [19]. Vasospasm is often caused by mechanical stimuli. The stent may be not soft enough for some patients, and in these cases, it is easy to induce vasospasm. Intraoperative or postoperative intravenous drip of nimodipine is the main method for vasospasm [20]. In this study, 1 case of acute thrombosis, 1 case of vasospasm, 1 case of aneurysm rupture, 1 case of ischemic stroke, 1 case of rehaemorrhagia and 1 case of residual aneurysmal neck were present in the control group with microsurgical clipping surgery; a total of 5 cases of complications including 1 case of acute thrombosis, 1 case of vasospasm, 1 case of ischemic stroke, 1 case of rehaemorrhagia and 1 case of residual aneurysmal neck were present in the experiment group with intravascular intervention (stent-assisted coil embolization) for carotid aneurysms. The incidence of complications was 8.4% and 7.1% respectively in control group and experiment group, but there was no statistically significant difference (P>0.05).

In summary, both microsurgical clipping and intravascular embolization were effective in the treatment of intracranial wide-necked aneurysms. However, the operation time, intraoperative blood loss and hospital stay in the patients with intravascular intervention were significantly lower than those in patients with microsurgical clipping surgery. In intravascular intervention surgery, the surgeons must face and solve the issues on higher incidence of vasospasm and cerebral ischemic events. This study still had some limitations in imperfect number of cases and follow-up time as well as lack of statistical analysis of large-scale multi-center cases, so further studies are required to verify the long-term effects of two treatment methods.

Declaration of conflict of interest

None.

Address correspondence to: Dr. Chuanzhi Duan, Department of Neurosurgery, Neurosurgery Institute, Key Laboratory on Brain Function Repair and Regeneration of Guangdong, Zhujiang Hospital, Southern Medical University, 253# Industry Rd, Guangzhou 510282, Guangdong Province, P.R. China. Tel: +86-2062782758; E-mail: duan_chuanzhi@163.com

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