Received: 2018.06.24
Accepted: 2018.07.20
Published: 2018.11.12

Clinical Study on Complications of Intracranial Ruptured Aneurysm Embolization by Stent-Assisted Coil

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ACE 1 **Yinlong Liu***
BCF 1 **Jianren Wang***
BDF 1 **Liqing Lin**
BDF 1 **Chunsheng Sang**
BD 1 **Zexi Lin**
BC 2 **Yaohua Pan**
AEG 1 **Xi'an Fu**

1 Department of Neurosurgery, The Affiliated Suzhou Hospital of Nanjing Medical University, Suzhou Municipal Hospital, Suzhou, Jiangsu, P.R. China
2 Department of Neurosurgery, Renji Hospital Affiliated to Shanghai Jiaotong University, Shanghai, P.R. China

Corresponding Author:

Source of support:

* Yinlong Liu and Jianren Wang contributed equally to this work

Xi'an Fu, e-mail: cowankang@126.com

This work was supported by Science and Technology Development Fund Project in Nanjing Medical University (2016NJMU152); Medical Basic Research Funding Project of People's Livelihood Technology and Technology-Health, Suzhou (SYS2016121); Science and Education Youth Science and Technology Project, Suzhou (KJXW2017038)

Background: The aim of this study was to retrospectively analyze the incidence of complications of intracranial complex aneurysms embolization by stent-assisted coils, and to investigate the causes of complications and corresponding treatment methods.

Material/Methods: A total of 71 patients with subarachnoid hemorrhage (SAH) underwent stent-assisted coil embolization from 2015 to 2018 were enrolled in this study. Among them, 59 cases were single aneurysm, 12 cases were multiple aneurysms (11 cases with 2 aneurysms and 1 case with 3 aneurysms), for a total of 84 aneurysms. All enrolled patients received stent angioplasty except for 1 case.

Results: There were 62 aneurysms (73.81%) treated with complete tamponade, 21 aneurysms (25.00%) treated with near-total tamponade and 1 aneurysm (1.19%) treated with partial tamponade. All aneurysms were evaluated based on GOS (Glasgow outcome scale): 55 cases had GOS of 5 scores, 12 cases had GOS of 4 scores, 3 cases had GOS of 3 scores, and 1 case had GOS of 1 score. There were 67 SAH patients with good prognosis (GOS of 4–5 scores). In our study, the incidence of complications was 12.7%. Three cases experienced acute thrombosis, 2 cases experienced aneurysm rupture during embolization, and 1 case experienced postoperative focal ischemic changes with mild neurological deficits.

Conclusions: Stent-assisted coil embolization is safe, effective, and feasible for the treatment of intracranial ruptured aneurysms. Patients had a favorable outcome of as high as 94.4%. However, clinical skills should be improved to reduce the occurrence of complications. Prompt and timely treatment for complications of intracranial ruptured aneurysm is also of great significance.

MeSH Keywords: **Aneurysm • Endovascular Procedures • Postoperative Complications • Subarachnoid Hemorrhage**

Full-text PDF: <https://www.medscimonit.com/abstract/index/idArt/911773>

2855

2

6

19

Background

Intracranial aneurysm rupture is the main reason for spontaneous subarachnoid hemorrhage (SAH) [1]. Due to the high morbidity and fatality rate, as well as the possibility of rebleeding, intracranial aneurysm seriously threatens human life. Early treatment for intracranial aneurysm is of clinical significance for SAH patients. In recent years, with the advanced development of neural intervention technology and the replacement of nerve intervention materials, intracranial aneurysm embolization technology has been widely applied because of its less trauma and positive treatment results. However, treatments for wide-necked aneurysm and Richet's aneurysm are still difficult.

Coil embolization for treatment of intracranial rupture of complicated aneurysms encounter many difficulties in surgical procedures, which is not a feasible treatment method. The stent-assisted coil embolization technology helps to stabilize the coils in the aneurysm, and contributes to the treatment of complicated intracranial aneurysms [2]. Although many studies have confirmed its effectiveness and feasibility, the rare complications during perioperative period are still worth noting [3–5].

This study retrospectively analyzed the causes of complications of stent-assisted coil embolization of intracranial ruptured aneurysms, perioperative management and patient prognosis. We also discussed the precautionary points and treatment approaches for complications.

Material and Methods

Basic characteristics of enrolled patients

A total of 71 patients with subarachnoid hemorrhage (SAH) underwent stent-assisted coil embolization from 2015 to 2018 in Department of Neurosurgery, Suzhou Municipal Hospital and Renji Hospital, Shanghai Jiaotong University School of Medicine were retrospectively analyzed. Patients treated with simple coil embolization without stent and other interventions were not included in this study. There were 33 males and 38 females aged 26–79 years, with an average age of 61 ± 7 years old. Based on the Hunt-Hess grade, 21 cases were grade I, 23 cases were grade II, 25 cases were grade III, and 2 cases were grade IV [6].

Image examinations

All patients were preoperatively diagnosed as wide-necked aneurysms and Richet's aneurysm by aortocranial angiography. Among 71 enrolled patients, 59 cases were single aneurysm, 12 cases were multiple aneurysms (11 cases with 2 aneurysms and 1 case with 3 aneurysms), for a total of 84 aneurysms. There were 35 posterior communicating aneurysms, 18 anterior

communicating aneurysms, 13 middle cerebral artery aneurysm, 6 ophthalmic artery aneurysms, 5 vertebral artery aneurysms, 3 basilar artery aneurysms, and 4 aneurysms at other sites. Besides, 63 cases were wide-necked aneurysms (tumor neck width >4 mm or neck size: aneurysm size $>1:2$), 15 cases were Richet's aneurysms and 6 cases were dissecting aneurysms. According to Fisher grade, 37 cases were grade II, 21 cases were grade III, and 13 cases were grade IV.

Perioperative management

All patients received preoperative examinations, including routine blood test, biochemical test, coagulation test, electrocardiogram, and chest radiograph. After admission for 1 to 3 days, aortocranial angiography was performed under general anesthesia to confirm the number, size, and location of aneurysms. Intravenous injection of tirofiban was administered before stent placement. The initial administration dose was $5 \mu\text{g/kg}$ and the injection should be completed within 3 minutes. Subsequently, the infusion was maintained at a rate of $5 \mu\text{g/kg/hour}$. No systemic heparin is used during the operation. After the procedure, $2.5 \mu\text{g/kg/hour}$ tirofiban was maintained for 2 hours. Nasal feeding of 100 mg aspirin and 75 mg clopidogrel was immediately performed after the procedure. Six months later, 100 mg aspirin was administered for the lifetime. Head computed tomography (CT) was routinely performed at the follow-up duration to confirm the intracranial condition. Lumbar puncture or ventricular drainage was needed if necessary.

Surgical procedure

After successful general anesthesia, the right femoral artery was punctured with Seldinger technique and the 6F arterial sheaths were placed. Angiography was performed to determine the best working angle when catheters were guided in the right place. An interventional strategy was then established. With the guidance of microcatheter, 0.014 micro guidewire was sent to the appropriate position of the distal end of the aneurysm artery. After the microcatheter was placed in an appropriate place, the micro guidewire was withdrawn. Different stent catheter systems were selected according to the diameter of the aneurysm artery, and the Enterprise stent or LVIS stent system was delivered along the microcatheter. One or more micro-coils were used for tamponading aneurysm. Under the circumstance of partial coils were placed in aneurysm artery, stents were immediately released, and aneurysms were filled in sequences. Angiography was performed every time when coils were released to observe the aneurysm filling degree and aneurysm artery condition until the aneurysm artery was unobstructed.

Results

Angiography results

The enrolled 84 aneurysms were treated with embolization with stent-assisted coil except for 1 case with multiple aneurysms. For this excluded case, the patient had C1 segment of internal carotid artery with ipsilateral A2 wide-necked aneurysm. After communicating with the family members of this patients, they asked for medication treatment for C1 segment aneurysm to observe the therapeutic efficacy. The remaining aneurysms were postoperatively evaluated based on the Raymond grade [7]. Among them, 62 aneurysms (73.81%) were treated with complete tamponade (grade I), 21 aneurysms (25.00%) were treated with near-total tamponade (grade II) and 1 aneurysm (1.19%) was treated with partial tamponade (grade III). The basic characteristics of enrolled patients are listed in Table 1.

Clinical outcomes

Seventy-one aneurysm patients were followed up for 6 months. All aneurysms were evaluated based on GOS (Glasgow outcome scale) [8]. There were 55 aneurysm patients that had GOS of 5 scores, 12 aneurysm patients had GOS of 4 scores, 3 aneurysm patients had GOS of 3 scores and 1 aneurysm patient had GOS of 1 score. There were 67 SAH patients with good prognosis (GOS of 4–5 scores). No patients died after the procedure. Six months later, there were 2 cases of aneurysm recurrence, and the recurrence rate was 2.38%.

Complications

Among 71 aneurysm patients, 9 experienced intraoperative and postoperative complications, with the incidence of complications was 12.7%. Three cases experienced acute thrombosis, 2 cases experienced aneurysm rupture during embolization and 1 case experienced postoperative focal ischemic changes with mild neurological deficits.

Intraoperative angiography found 3 cases of acute thrombosis, including 1 case of middle cerebral artery, 1 case of posterior communicating artery, and 1 case of basilar artery. After the occurrence of acute thrombosis, the angiogram showed that the blood flow of the aneurysm artery had no images because of the slow blood flow. Arterial contact thrombolysis was immediately performed via the microcatheter. Two patients were treated with slow infusion of tirofiban or urokinase, and there was no obvious absence of postoperative nerve loss (Figure 1A, 1B). One patient with basilar artery aneurysm (Figure 2A, 2B) was treated with stent-assisted aneurysm embolization (Figure 2C–2E). The basilar artery had no images after the surgery (Figure 2F). After a slow injection of

Table 1. Basic characteristics of patients.

Basic characteristics	N=71
Age (year)	54.3±14.2
Gender	
Male	33
Female	38
Hunt-Hess classification	
I	21
II	23
III	25
IV	2
DSA	71
Single aneurysm	59
Multiple aneurysms	12
Two aneurysms	11
Three aneurysms	1
Location of aneurysm	
PCA	35
ACA	18
MCA	13
Ophthalmic aneurysm	6
Vertebral aneurysm	5
Basilar apex aneurysm	3
Others	4
Aneurysm shape	
Wide-necked aneurysm	63
Richet's aneurysms	15
Dissecting aneurysm	6
Fisher classification	
II	37
III	21
IV	13

DSA – digital subtraction angiography; PCA – posterior communicating aneurysms; ACA – anterior communicating aneurysms; MCA – middle cerebral aneurysm.

10 mL tirofiban for 3 times and 100 000 U of urokinase for 4 times in thrombus, repeated angiography confirmed that the aneurysm artery was still obstructed. Hence, angiography in the

Figure 1. Treatment of the right middle cerebral artery thrombosis. (A) Right middle cerebral artery thrombosis. (Red arrow: Right middle cerebral artery thrombosis). (B) Repatency after continues pump of tirofiban. (Black arrow: Repatency of right middle cerebral artery thrombosis).

Figure 2. Handling process of complications in the interventional treatment of basilar artery apex wide-necked aneurysm. (A, B) CTA showed a wide-necked basilar artery aneurysm. (White arrow: wide-necked basilar artery aneurysm). (C) Digital subtraction angiography revealed a wide-necked carotid aneurysm of the basilar artery (neck: 7.69 mm, maximum diameter: 14.01 mm; black arrow: wide-necked carotid aneurysm of the basilar artery). (D) Placement of stent and microcatheter. (Black arrow: stent and microcatheter). (E) Stent release (black arrow) during the tamponade. (F) After multiple injections of Tirofiban and urokinase in thrombus, repeated angiography confirmed that the distal part of the basilar artery was still obstructed. (Black arrow: the distal occlusion of basilar artery). (G) Angiography in the right internal carotid artery showed that the right posterior communicating artery was compensated for bilateral posterior cerebral blood supply. (Red arrow: the right posterior communicating artery). (H) Solitaire stent 4.0/20 covered the full length of the occlusion segment, partially overlapping the Enterprise. (Red arrow: Solitaire stent). (I, J) P1 segment of the posterior cerebral artery and the SCA segment of the superior cerebellar artery were visualized. (Red arrow: the P1 segment of the posterior cerebral artery, black arrow: the SCA segment of the superior cerebellar artery). (K) No obvious ischemic changes were found in CT after the surgery.

right internal jugular was performed and the results showed that the right posterior communicating artery was compensated for bilateral posterior cerebral blood supply (Figure 2G). Due to the release of the stent, the full length of the occlusion segment was covered by the Prowler Plus release solitaire stent 4.0/20 at the working angle, partially overlapping the Enterprise (Figure 2H). After the Solitaire stent was opened, angiography showed that the forward blood flow was restored, and the P1 segment (red arrow) of the posterior cerebral artery and the SCA segment (black arrow) of the superior cerebellar artery were visualized (Figure 2I, 2J). Intravenous injection of 5 mL/hour tirofiban was continually administrated for 72 hours after the surgery. Subsequently, 100 mg aspirin and 75 mg clopidogrel were administrated. After the operation, there was no obvious neurological dysfunction except for transient diplopia.

No obvious ischemic changes were found in CT after the surgery (Figure 2K).

Intraoperative aneurysm rupture occurred in 2 cases. One case was intraoperative tamponade hemorrhage. Angiography showed aneurysm tip rupture, and the stent was rapidly released to tamponade the aneurysm (Figure 3). Postoperative neurological deficits were only mild and long-term follow-up data indicated that the patient could take care of himself. Another case was carotid-like wide-necked aneurysm in the posterior communicating artery (Figure 4). The aneurysm ruptured with an injection of a high-pressure injector system. The patient quickly developed epilepsy, convulsions, and vomiting. Respiratory tract patency, aspirator aspiration of gastric contents and placement of gastric tube gastrointestinal decompression

Figure 3. Treatment of ruptured hemorrhage during anterior communicating artery aneurysm tamponade (black arrow). (A) Angiography showed anterior communicating artery aneurysm. (B) Bleeding of the top of the tamponade during the tamponade and extravasation of the contrast agent. (C) Continuous tamponade under road-mapping. (D) After the end of treatment, the aneurysm was densely filled without extravasation of the contrast agent.

were performed to prevent vomiting aspiration. Then 10 mg diazepam was intravenously administered to control epilepsy. Stent-assisted interventional embolization was performed under general anesthesia. Postoperative cranial CT showed extensive subarachnoid hemorrhage and intraventricular hemorrhage cast. Emergency bilateral lateral ventricle drainage was performed. During the long-term follow-up, the patient recovered well with the GOS score of 5 points.

Intraoperative angiography found cerebral vasospasm in 3 cases. Angiography showed that the great vessel wall was stiff, and the diameter of the stenosis was >25%. In one case, the

tip of the guiding catheter was attached to the wall. After and the position of the leading end of the guiding catheter was adjusted, the vasospasm was alleviated 10 minutes later. The other 2 cases were aneurysm artery vasospasm. Continuous catheterization of 30 mg fasudil via the microcatheter was performed. About 30 minutes later, angiography showed alleviated vasospasm (Figure 5). Intraoperative intravenous pump of nimodipine resulted in no significant ischemic brain changes and neurological deficits.

In this study, there was 1 patient who experienced incomplete aphasia and no significant abnormalities in physical activity after

Figure 4. Berry-like wide-necked aneurysm ruptured (black arrow) during local anesthesia. (A) Angiography showed Berry-like wide-necked aneurysm. (B) Rupture during angiography. (C) Embolism.

Figure 5. Cerebral vasospasm image before and after treatment. (A) Left carotid spasm. (B) 30 min after arterial perfusion of 30 mg fasudil. Red arrow showed the left carotid.

the surgery. However, no acute thrombosis or cerebral vasospasm was seen during the surgery. The patient had C1 segment of internal carotid artery (red arrow) with ipsilateral A2 wide-necked aneurysm (black arrow, Figure 6A). After communicating with the family members of this patients, they asked for medication treatment for C1 segment aneurysm and stent-assisted embolization for A2 wide-necked aneurysm. Angiography indicated a good brain blood supply (Figure 6B). After awakening, the patient was clear-headed with severe incomplete motor aphasia. Six months later, cerebral angiography showed aneurysm recurrence (Figure 6C). The patient underwent reoperation. The carotid artery stent (Protege 7×40) was used to cover the internal carotid artery dissection and then placed into the recurrent aneurysm through the microcatheter. Six coils were placed and LVIS Jr stents were used to cover the diseased vessels (Figure 6D).

One year after surgery, Ct angiography and magnetic resonance angiography showed that the patient had no recurrence of aneurysms. The left internal carotid artery stent was good, and the dissection disappeared (Figure 6E, 6F). Surgical results of enrolled patients are listed in Table 2.

Discussion

A large number of experiments have confirmed that stent-assisted coil embolization is safe, effective, and practical for the treatment of ruptured intracranial aneurysms [9-11]. Although complications are rare, some cases can experience serious adverse consequences [11,12]. Complications should be avoided as much as possible.

Figure 6. (A–F) Image of postoperative neurologic deficit. (Red arrow: the C1 segment of internal carotid artery; Black arrow: the A2 wide-necked aneurysm).

Table 2. Surgical results of enrolled patients.

Aneurysms		N=84
DSA		
Raymond classification		
I		62
II		21
III		1
Postoperative patient (Half a year)		N=71
Glasgow outcome scale		
5		55
4		12
3		3
2		1
Surgical complications		N=9
Acute thrombosis		3
Aneurysm rupture		2
Cerebral vasospasm		3
Neurologic deficit		1

The acute thrombotic events in endovascular treatment pose great challenges to neurosurgeons because severe thrombosis can cause large blood vessel blockages leading to endovascular treatment failure and serious complications. More importantly, both the risks of thrombosis and postoperative aneurysm rebleeding should be evaluated [13]. Corresponding treatments are made in clinical work based on the characteristics of individualized patients. In this retrospective study, there were 3 cases of postoperative acute thrombosis. The risk of postoperative aneurysm rebleeding has been greatly reduced. Hence, the majority treatment was contact thrombolysis to reduce the occurrence of severe cerebral ischemia in the shortest time. Here, we utilized stent-assisted coil embolization in the surgery. We considered that the successful rate would not be very high using solitary AB stent for thrombectomy since it may cause the shift of original stent, impair the blood vessels and increase the bleeding risk. We still selected the approach of microcatheter combined with tirofiban and urokinase and achieved a better efficacy. We found that 2/3 of the patients with acute thrombosis were cured without severe complications. However, this approach is risky for those with abundant arteries since it could increase the occlusion risks when placing the double stents.

The reasons for the analysis of acute thrombotic events in the course of treatment may be as follows: 1) Preoperative preparations, such as standardized antiplatelet aggregation therapy, were not performed. 2) The blood vessel wall was stimulated when placing the stent, thus leading to platelets aggregation and thrombus. 3) The stent opened or malapposition.

We summarized some suggestions to reduce the incidence of intraoperative acute thrombotic events: 1) Intravenous injection of 11–13 mL of tirofiban (100 mL/5 mg) before stent placement and 6–9 mL/hour (calculated according to kilogram body weight) with intravenous pump after the surgery for 36–72 hours. 2) The procedures should be soft and careful to avoid injury to the arterial intima especially during the release of the stent. 3) Appropriate stents should be selected to reduce the incidence of stent opening and malapposition. 4) Heparin (3000 units heparin sodium in 500 mL saline) should be administrated through the guiding catheter during the whole procedure. Continuous intravenous infusion of heparin is performed to maintain the local heparinization.

The possible causes for aneurysm rupture occurs during interventional surgery were: 1) Specific morphology and pathological features of the aneurysm may increase the bleeding risk, such as blood blister-like aneurysms and berry-like aneurysms [14,15]. 2) High blood pressure, coughing, reflux aspiration, and any other sudden rise in intracranial pressure during the general anesthesia can induce aneurysm rupture. 3) Regulation of high-pressure injector system. In SAH patients who are highly suspected of being with aneurysms by angiography, the velocity, contrast volume, and pressure should be adjusted to a lower level in the blood vessel. For example, the administration in internal carotid artery may be adjusted to 4 mL/s, 6 mL and 250 psi, which was equivalent to the standard for vertebral arteriography. 4) The technical operation of a surgeon was very important. For example, selection of the coil size and stent model, as well as the procedure ability of the surgeon were closely related to the occurrence of hemorrhagic complications. Intraoperative bleeding can increase the difficulties in endovascular treatment that can even endanger the patient's life [16]. Therefore, emergency treatment during surgery was very important.

Here, we summarized some recommended treatments: 1) When epilepsy occurs during local anesthesia, antiepileptic drugs, sedation, intubation and CT examination should be performed immediately to determine the following treatment. 2) Strictly control the blood pressure and keep anesthesia steady. 3) Heparin is neutralized in time and the aneurysm cavity is quickly filled. 4) Postoperative control of blood pressure strictly and timely review of CT contribute to the effectiveness of interventional treatment and intracranial hemorrhage.

The degree of arterial spasm in this study was lighter, but it should also arouse our attention. Several reasons should be considered: 1) Subarachnoid hemorrhage directly stimulates the blood vessel wall. 2) The procedure is not gentle in handling the guidewire and catheter. 3) Inappropriate position of the contrast catheter or guide catheter. The position of the end of the contrast catheter or guide catheter is poor, reverse or adhering. When the tip of the catheter is reversed, the pressure of the contrast agent is too large to stimulate the artery wall. Besides, the adherent catheter directly stimulates the artery wall to lead to vasospasm. 4) Contrast agent concentration is too high to result in increased partial pressure. In our treatment, local and systemic vasodilators were used to alleviate cerebral vasospasm.

In the endovascular treatment, it is necessary to ensure that the patient is stable under general anesthesia. There are some terminal and smaller ischemic events cannot be reflected by angiography during the surgery. In the postoperative period, patients may experience neurological deficits with different degrees [17]. In the present study, 1 patient experienced severe motor aphasia after surgery. This patient had no obvious abnormalities during the surgery. The reason for the postoperative neurological deficits might be explained by the spindle-like dissecting aneurysm in the ipsilateral internal carotid artery. The lumen stenosis in the middle part was more than 50%. During the surgical operation, the guiding catheter was passed through the stenosis and placed for a long time, further narrowing the lumen of the internal carotid artery. The alteration of local blood flow might result in the entrance of small emboli in the anterior circulation vessel, thereafter resulting in a lacunar infarction in the distal functional area. This case gave us a recommendation that communication with the patient's family is of great importance. After the consent of the family members, ischemic risk factors such as carotid artery dissection should be first treated to minimize the occurrence of complications.

There are many prognostic factors affecting stent-assisted coil embolization for the treatment of complex aneurysms and its complications [18,19]. This requires a better summary of clinical experience and improvement of surgical skills in the future work accompanied by the advanced nerve intervention equipment. We believe that the treatment of complex aneurysms will be more simplistic and effective in the near future.

Conclusions

Stent-assisted coil embolization is safe, effective, and feasible for the treatment of intracranial ruptured aneurysms. However, clinical skills should be improved to reduce the occurrence of complications. Prompt and timely treatment for complications of intracranial ruptured aneurysm is also of great significance.

References:

1. Luo H, Song WX, Jiang JW et al: Effects of preadmission beta-blockers on neurogenic stunned myocardium after aneurysmal subarachnoid hemorrhage: A meta-analysis. *Clin Neurol Neurosurg*, 2017; 158: 77–81
2. Lee CJ, Lee KW, Chen WL, Chiu CC: Images diagnosis and emergent endovascular treatment of acute hemorrhagic basilar artery dissection: A case report. *Acta Neurol Taiwan*, 2016; 25: 45–50
3. Ordonez-Rubiano EG, Von-Diemling C, Cortes-Lozano W, Lobelo-Garcia NO: Stent-assisted embolization of a giant aneurysm of the middle cerebral artery using small and large coils (Penumbra Coil 400). *Cureus*, 2016; 8: e762
4. Gross BA, Moon K, Ducruet AF, Albuquerque FC: A rare but morbid neurosurgical target: Petrous aneurysms and their endovascular management in the stent/flow diverter era. *J Neurointerv Surg*, 2017; 9: 381–83
5. Kocur D, Zbrozarczyk M, Przybylko N et al: Stent-assisted embolization of wide-neck anterior communicating artery aneurysms: Review of consecutive 34 cases. *Neurol Neurochir Pol*, 2016; 50: 425–31
6. Obuchowska I, Turek G, Mariak Z, Mariak Z: Early intraocular complications of subarachnoid haemorrhage after aneurysm rupture. *Neuroophthalmology*, 2014; 38: 199–204
7. Fargen KM, Blackburn S, Carpenter JS et al: Early results of the Axiom MicroFX for Endovascular Repair of IntraCranial Aneurysm (AMERICA) study: A multicenter prospective observational registry. *J Neurointerv Surg*, 2014; 6: 495–99
8. Dinca EB, Brehar F, Giovani A, Ciurea AV: Challenges in a case of ophthalmic artery aneurysm associated with abnormal internal carotid arteries. *Asian J Neurosurg*, 2017; 12: 106–8
9. Byoun HS, Yi HJ, Choi KS et al: Comparison of endovascular treatments of ruptured dissecting aneurysms of the intracranial internal carotid artery and vertebral artery with a review of the literature. *J Korean Neurosurg Soc*, 2016; 59: 449–57
10. Muto M, Giurazza F, Ambrosiano G et al: Stent-assisted coiling in ruptured cerebral aneurysms: multi-center experience in acute phase. *Radiol Med*, 2017; 122: 43–52
11. Ishikawa T, Yamaguchi K, Anami H et al: Stent-assisted coil embolisation for bilateral vertebral artery dissecting aneurysms presenting with subarachnoid haemorrhage. *Neuroradiol J*, 2016; 29: 473–78
12. Lee K, Park H, Park I et al: Y-configuration stent-assisted coil embolization for wide-necked intracranial bifurcation aneurysms. *J Cerebrovasc Endovasc Neurosurg*, 2016; 18: 355–62
13. Adeeb N, Griessenauer CJ, Moore JM et al: Ischemic stroke after treatment of intraprocedural thrombosis during stent-assisted coiling and flow diversion. *Stroke*, 2017; 48: 1098–100
14. Zhu D, Fang Y, Yang P et al: Overlapped stenting combined with coiling for blood blister-like aneurysms: Comparison of low-profile visualized intraluminal support (LVIS) stent and non-LVIS stent. *World Neurosurg*, 2017; 104: 729–35
15. Wan J, Gu W, Zhang X et al: Endovascular coil embolization of aneurysm neck for the treatment of ruptured intracranial aneurysm with bleb formation. *Med Sci Monit*, 2014; 20: 1121–28
16. Zhang Y, Li G, Cai Y et al: Rupture during the endovascular treatment of intracranial aneurysms: outcomes and technical aspects. *Acta Neurochir (Wien)*, 2013; 155: 569–77
17. Yu B, Zheng J, Hong Y et al: Stent-assisted coil embolization of ruptured supraclinoid blood blister-like aneurysm of internal carotid artery. *Turk Neurosurg*, 2016; 26: 219–22
18. Baptista T, Braz A, Patricio M et al: [Thromboembolic complications during endovascular treatment of ruptured intracranial aneurysms – prevention and therapy]. *Acta Med Port*, 2012; 25(Suppl. 1): 25–29 [in Portuguese]
19. Pierot L, Cognard C, Anxionnat R, Ricolfi F: Ruptured intracranial aneurysms: Factors affecting the rate and outcome of endovascular treatment complications in a series of 782 patients (CLARITY study). *Radiology*, 2010; 256: 916–23