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# Rapid temporary coiling of the parent artery for the management of intraprocedural aneurysm rupture

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## Abstract:

Intraprocedural rupture (IPR) of an intracranial aneurysm is the most feared complication of primary and stent-assisted coiling because it carries a high risk of morbidity and mortality. The endovascular strategy applied to control IPR depends on the cause of the rupture and stage of the procedure. Rupture during primary or stent-assisted coiling is traditionally managed with the use of continued packing, balloon microcatheter placement, or in rare cases, with parent artery sacrifice. In this technical note, we describe the use of temporary coiling of the parent artery to control IPR in three cases. Temporary parent artery coiling creates a subocclusive state, resulting in aneurysmal blood flow reduction without interruption of blood flow to the distal territory. Flow reduction combined with the thrombogenicity of the previously deployed coils results in hemostasis. In the cases presented here, IPR occurred during the late stage of coiling. In each case, parent artery coiling was performed along with heparin reversal. After confirmation of hemostasis, the coils were retrieved to restore normal blood flow. We demonstrate that the technique of temporary parent artery coiling may be a safe and effective option for the management of IPR during primary or stent-assisted coiling.

## Keywords:

Aneurysm, ruptured/therapy, cerebral angiography, \*embolization, therapeutic, embolization, therapeutic/\*adverse effects/\*instrumentation, \*embolization, therapeutic/humans, intracranial aneurysm/pathology, intracranial aneurysm therapy, intraoperative complications/neurosurgical procedures/\*adverse effects, risk factors, subarachnoid hemorrhage therapy, subarachnoid hemorrhage/treatment outcome

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## Introduction

Intraprocedural rupture (IPR) of an aneurysm is one of the most feared complications associated with coiling of an intracranial aneurysm (IA). Although IA rupture is less common during endovascular procedures than open surgical management, it carries a higher risk of morbidity and mortality.<sup>[1-4]</sup> IPR of an IA demands immediate steps to stop the bleeding and complete the procedure. These steps include reversal of anticoagulation, control of blood

pressure, and the use of endovascular techniques to reduce the IA blood flow. Endovascular techniques to manage IPR during IA coiling include continued coiling through the same or a second microcatheter, temporary balloon occlusion of the parent artery for hemostasis, or parent artery sacrifice.<sup>[3,4]</sup> These strategies result in reduced blood flow to the IA and promote natural hemostatic pathways. Similar effects can be achieved through subocclusive temporary coiling of the parent artery. Subocclusive temporary coiling can be performed rapidly without the need to prepare and deploy a new balloon catheter and without complete

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flow arrest to the distal territory. To the best of our knowledge, the use of this technique has not been described in the literature. Here, we demonstrate three cases of the use of subocclusive temporary coiling of the parent artery to achieve hemostasis after IPR during aneurysm coiling. In this technique, coiling of the parent artery is performed without detachment through the already placed microcatheter to reduce distal blood flow without total flow arrest in order to produce a subocclusive flow state. After hemostasis is obtained, the parent artery coil is recaptured and normal blood flow is restored. In this manuscript we discuss the technique of temporary parent vessel coiling and compare it with techniques used for the management of IPR.

## Case Report

Case 1 was performed under moderate sedation, and cases 2 and 3 were performed under general anesthesia. Femoral artery access was used for all cases, and heparin was administered in all cases. Because cases 2 and 3 presented with aneurysm rupture, intravenous heparin was administered after the first coil had been deployed. Primary coiling for the ruptured aneurysms was performed within 24 h of presentation. In each of those 2 cases, an external ventricular drain was placed for hydrocephalus and intracranial pressure monitoring.

The patients gave informed consent for the procedures. One patient also gave informed consent for video recording. Institutional review board approval was deemed unnecessary.

### Case 1

A 64-year-old man presented with a wide-necked right middle cerebral artery (MCA) aneurysm that was discovered during evaluation for minor head trauma. He was neurologically intact. His right MCA bifurcation aneurysm measured 6 mm. Stent-assisted coiling was planned. The patient was started on dual antiplatelet therapy 5 days before the planned procedure. Two microcatheters were used (SL-10, Stryker, Fremont, CA, USA). The first microcatheter was used to deliver and deploy an Atlas stent (Stryker) across the aneurysm neck, while the second microcatheter was positioned inside the aneurysm sac. First, two coils (6 mm × 20 cm Target, Stryker, and 4 mm × 8 cm MicroPlex, MicroVention-Terumo, Tustin, CA, USA) were deployed smoothly; however, a third coil (4 mm × 8 cm MicroPlex) was deployed after overcoming some resistance. Postcoiling contrast injection showed extravasation from the aneurysm dome. We brought the SL-10 microcatheter back into the M1 segment and deployed a 5 mm × 15 cm MicroPlex coil into that segment, proximal to the aneurysm. The effect of the heparin was reversed with intravenous protamine (30 mg). A subocclusive

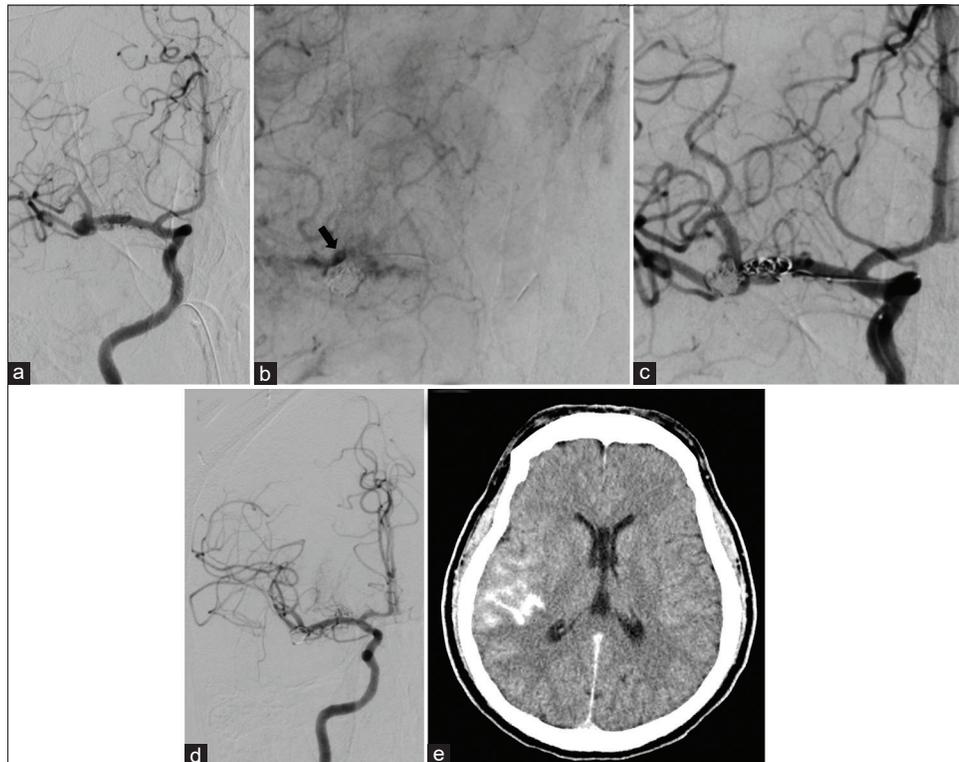
state was achieved, allowing hemostasis. The coil was retrieved after cessation of contrast extravasation was confirmed with an internal carotid artery (ICA) injection. Final angiographic runs demonstrated good wall apposition of the stent with a coil-packing density of nearly 30%. Postprocedural computed tomography (CT) showed subarachnoid hemorrhage (SAH), but the patient returned to his preoperative neurological status and was discharged on the first postoperative day. The technique is demonstrated in Video 1 [https://drive.google.com/file/d/1cZIBWL4Sz4\\_mb3jjj0T4K1\\_iIUE57suO/view?usp=sharing](https://drive.google.com/file/d/1cZIBWL4Sz4_mb3jjj0T4K1_iIUE57suO/view?usp=sharing) and Figure 1a-e and illustrated in the schematic diagram, Figure 2.

### Case 2

A 58-year-old woman presented with Hunt-Hess Grade V and Fisher Grade IV SAH. A CT angiogram showed a 4-mm ruptured right-sided posterior inferior cerebellar artery (PICA) aneurysm. We transferred the patient to the angiography suite for primary coiling. Right vertebral artery injection confirmed a 4-mm PICA aneurysm with a daughter sac arising from the aneurysm neck. A 4 mm × 15 cm HyperSoft three-dimensional (3D) coil (MicroVention-Terumo) was deployed in the aneurysm using a 0.0165" Prowler LP-ES microcatheter (Codman Neuro, Raynham, MA, USA). Postdeployment contrast injection showed herniation of the coil loop from the daughter sac along with some contrast extravasation. At this point, the microcatheter was pulled back into the lumen of the V4 segment of the vertebral artery. Coiling of the V4 segment was performed to produce a subocclusive state. Intravenous protamine (30 mg) was administered immediately to reverse the effect of the heparin administered at the beginning of the procedure. After cessation of extravasation was confirmed with a repeat contrast injection, the temporary coil deployed in the V4 segment was retrieved. At this point, the microcatheter was navigated into the aneurysm sac and coiling was completed by placing two 2 mm × 4 cm HyperSoft 3D coils. Postprocedural head CT showed no significant increase in the amount of SAH. The patient's postprocedural course was complicated by vasospasm and a persistent comatose state. Due to the lack of postprocedural recovery, care was withdrawn at the request of the patient's family 14 days after the initial procedure. The technique is shown in Figure 3a-f.

### Case 3

A 60-year-old woman presented with Hunt-Hess Grade III and Fisher Grade III SAH. A CT angiogram demonstrated a 4-mm A1-A2 aneurysm. She was taken for primary coiling. A right carotid injection confirmed a 4 mm × 5 mm multilobulated anterior communicating artery aneurysm. A Prowler 14 microcatheter (Codman Neuro) was advanced into the right A1 segment and into the aneurysm, and



**Figure 1:** (a) Right internal carotid artery anteroposterior projection demonstrates a middle cerebral artery bifurcation aneurysm. (b) Contrast extravasation was identified after the deployment of a third coil (arrow). (c) Subocclusive state created by temporary coiling of the middle cerebral artery. (d) No contrast extravasation is visible on the final internal carotid artery angiographic run. (e) Postprocedure computed tomography scan shows subarachnoid hemorrhage in the right insular region

one 5 mm × 10 cm Galaxy coil (Codman Neuro) was deployed into the aneurysm. Subsequently, two more coils (4 mm × 6 cm and 3.5 mm × 9 cm Galaxy) were deployed into the aneurysm. Contrast extravasation was noticed after the deployment of the last (third) coil. A 6 mm × 10 cm Galaxy coil was delivered into the right A1 and ICA terminus but not detached to produce a subocclusive state. The coil was recaptured without detachment. A repeat contrast injection showed no extravasation or vessel injury, with excellent flow into the right A1 and M1. Postprocedure head CT showed a slight increase in SAH with minor intraventricular hemorrhage. The patient made an excellent recovery and was neurologically intact at 1-month follow-up. The technique is shown in Figure 4a-f.

## Discussion

IPR is one of the most dreaded complications of IA coiling. The incidence of intraprocedural aneurysm rupture ranges from 2.7% to 5%.<sup>[2]</sup> Risk factors include small aneurysm size (<3 mm), presence of a daughter sac, acute rupture, and anterior circulation location.<sup>[5,6]</sup> In addition to these morphological and clinical aneurysm features, several technical factors have been shown to increase the risk of IPR. These include coil oversizing and overpacking and the use of a balloon to assist coiling.<sup>[4,7,8]</sup>

Aneurysm rupture may be caused by breach of the aneurysm wall by the microcatheter, coils, or the microwire. Technical management of the rupture depends on several factors such as the mechanism of rupture (microcatheter vs. coil vs. microwire), stage of coiling (early vs. late), and primary coiling versus stent- or balloon-assisted coiling. We believe that the rupture in case 1 may have ensued because of overpacking the aneurysm sac with coils. Risk factors for IPR in cases 2 and 3 were the previous ruptures. An additional risk factor in case 2 was the presence of a daughter sac. In case 3, overpacking and the multilobulated morphology may have predisposed the aneurysm to rupture.

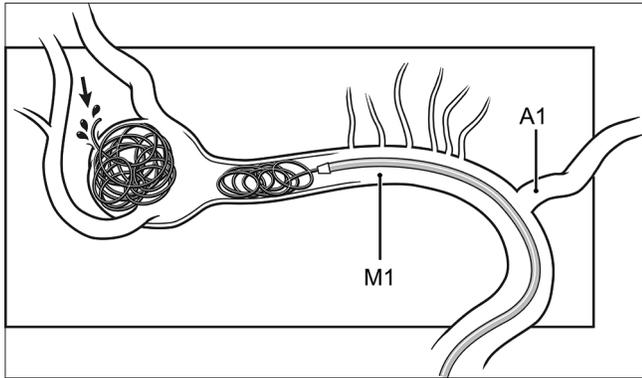
The choice of coil size depends on the size of the parent artery, for example, for a 4-mm vessel; we would pick a 4-mm coil to achieve occlusion of the artery. The duration of coil deployment and degree of parent artery occlusion depends on the subsequent resolution of extravasation from the aneurysm. We normally partly deploy the coil to slow the anterograde flow into the artery. We then repeat runs to confirm if the extravasation has stopped. We continue the deployment of the coil until extravasation stops. Usually, complete occlusion of the parent artery is not necessary. Once the extravasation stops, we retrieve the coil immediately.

The technique of temporary coiling of the parent artery is particularly useful for cases in which the rupture occurs during middle to late stages of coiling. Thrombogenicity of coils within the sac along with flow reduction resulting from coiling of the parent artery is the principal mechanism behind temporary coil occlusion. The technique may be used effectively for both primary

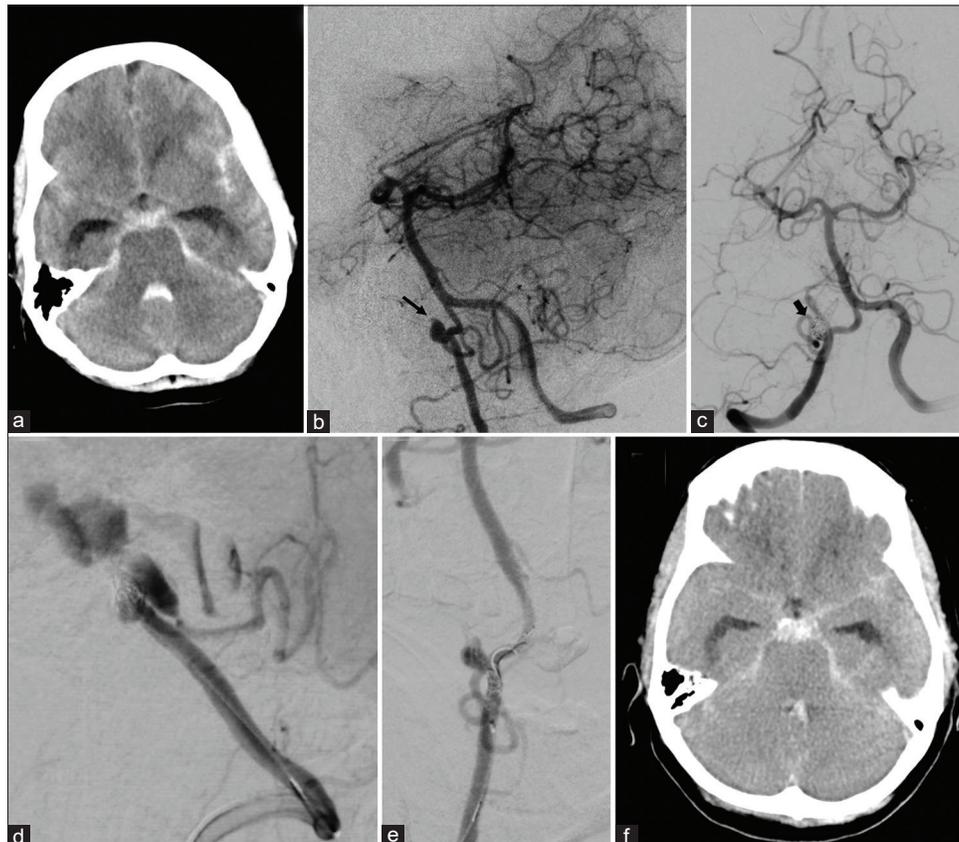
and stent-assisted coiling. The technique may not be effective when the rupture occurs before the initiation of coiling, for example, as a result of perforation of the aneurysm wall by the microwire or microcatheter.

The use of temporary parent artery coiling may be compared with balloon occlusion of the parent artery. Temporary coiling has potential advantages over temporary balloon occlusion. Considerable time can be saved by introducing a coil through a microcatheter that is already in the arterial lumen instead of preparing and introducing a new device such as a balloon microcatheter. Temporary coiling is subocclusive, allowing at least some degree of continuous blood flow into the distal territory resulting in a lower risk of stroke. Table 1 demonstrates a comparison of various techniques of intraprocedural rupture (IOR) management.

To the best of our knowledge, this is the first description of the technique. However, the effectiveness of the technique needs to be demonstrated in a multicenter setting with a larger sample size. Furthermore, although none of the patients included here had a new neurological deficit after the procedure, a postoperative



**Figure 2:** Schematic diagram illustrating the use of temporary coiling technique in the setting of intraprocedural rupture of a middle cerebral artery aneurysm. A1, the first segment of the anterior cerebral artery; M1, the first segment of the middle cerebral artery



**Figure 3:** (a) Head computed tomography scan shows diffuse subarachnoid hemorrhage and intraventricular hemorrhage. (b) Right vertebral artery injection shows right posterior inferior cerebellar artery aneurysm with a tiny daughter sac (arrow). (c) Coils are seen herniating from the aneurysm sac. (d) Contrast extravasation is noticed (arrow). (e) The vertebral artery is coiled temporarily to create a subocclusive flow state, resulting in cessation of contrast extravasation. (f) Postprocedure computed tomography scan again shows subarachnoid hemorrhage. There was no remarkable change in subarachnoid hemorrhage severity, possibly due to external ventricular drainage



**Figure 4:** (a) Head computed tomography scan demonstrates subarachnoid hemorrhage in the sylvian and interhemispheric fissures. (b) Right internal carotid artery injection shows an aneurysm of the A1–A2 segment of the anterior cerebral artery. (c) Later, arterial phase during coiling shows contrast extravasation (arrow). (d) Oblique and (e) lateral internal carotid artery projections show temporary coiling of the internal carotid artery terminus and anterior cerebral artery take-off to create a subocclusive flow state. (f) Computed tomography scan head shows an increase in subarachnoid hemorrhage severity in addition to coiling artifact

**Table 1: Comparison of balloon and coil occlusion strategies for the management of intraprocedural aneurysm rupture**

Variable	Temporary balloon occlusion	Temporary coil occlusion	Parent artery sacrifice
Degree of flow limitation	Occlusive	Subocclusive	Occlusive
Mechanism	Flow arrest and tamponade	Flow reduction	Flow arrest
Indication	Rupture during middle and late stage of coiling	Rupture during middle and late stage of coiling	Any stage and etiology
Time	+++	++	++
Coil remodeling	Yes	No	No
Risk of stroke	+++	+	++++
Cost	+++	++	++

+ signs indicate relative impact of hemostatic technique on each parameter

magnetic resonance imaging of the brain would have been useful in demonstrating the absence of any ischemic insult from parent artery coiling.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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