An aneurysm is an abnormal dilation of a blood vessel caused by a weakness in the wall of the artery, which puts it at risk for rupture. In most populations, the prevalence of intracranial aneurysms ranges from 1% to 6%. Most cerebral aneurysms are categorized as saccular, fusiform, or dissecting types. Saccular aneurysms, which are seen most frequently at cerebral artery bifurcations, are the most common cause of spontaneous subarachnoid hemorrhage (SAH), although only 0.7% to 1.9% of all cerebral aneurysms rupture. Fusiform aneurysms and dissecting aneurysms are less common. Blood blister-like aneurysms (BBLAs) represent a unique class of aneurysms. Although the term “blood blister-like aneurysm” is used to describe various aneurysms including sessile, broad-based saccular aneurysms at nonbranching sites, and dissecting aneurysms involving either a short or a long segment of the supraclinoid internal carotid artery (ICA), there is debate regarding the histopathologic relationship of the BBLA to saccular or dissecting aneurysms. Most authors think that BBLAs arise from a tear in the vessel wall, contained after rupture by only fragmented adventitia and clot. There are noticeable differences from other ruptured cerebral aneurysms in the risk of rerupture, in treatment strategy, and in the high rate of mortality.

BBLAs are defined as small, hemispheric lesions protruding from nonbranching sites on the ICA. Extremely thin, fragile walls, poorly defined necks, and a high tendency to rupture characterize these aneurysms. Although several reports have been published regarding the diagnosis and treatment of BBLAs, optimal management strategy remains unclear. Moreover, the natural history of BBLAs remains incompletely understood. The aim of this report is to review the available literature regarding this challenging and dangerous clinical entity.

Learning Objectives: After participating in this CME activity, the neurosurgeon should be better able to:
1. Define and characterize blood blister-like aneurysms (BBLAs), specifically the features that distinguish BBLAs from other types of aneurysms.
2. Describe the challenges in the diagnosis and treatment of BBLAs.
3. Describe the open and endovascular treatment options for patients with BBLAs.
Sundt and Murphey first used the term “blister” to describe an aneurysm in 1969. In 1986, Sugita’s group clearly described 8 cases of fragile aneurysms of the dorsal wall of the ICA with an unusually high tendency for intraoperative rupture. Although the group described the aneurysms as saccular or semifusiform, they noted that the treatment strategy should take into account the unique nature of these aneurysms, rather than treating them like other saccular aneurysms. Ogawa et al. used the term “blister-like” (chimame) in 1988, and Abe et al. coined the term “blood blister-like aneurysm of the ICA.” Authors have subsequently described this type of aneurysm in a nonuniform manner. Terms used to describe BBLAs have included blister aneurysm, blister-like aneurysm, chimame-like aneurysm, frog-eye-like aneurysm, semifusiform aneurysm, nonsaccular aneurysm of the suprachlinalid ICA, sclerotic cerebral aneurysm, ICA medial/distal-medial wall aneurysm, ICA superior/dorsal wall aneurysm, ICA trunk aneurysm, and ICA nonbranching side aneurysm.

In addition to the difficulty with nomenclature, characterizing these aneurysms as truly BBLAs, rather than saccular aneurysms, can often be challenging. Because of their small size, surgical resection of the dome for pathologic analysis is usually not feasible, so the diagnosis of BBLA often cannot be confirmed. Without this confirmation, it can be difficult to distinguish between a small saccular aneurysm of carotid walls. The medium is not present, and the adventitia is lacerated at the border between the normal and sclerotic cells. In contrast, a focal wall defect covered with a blood clot or fibrinous tissue is the characteristic feature of the BBLA. The vessel wall of a BBLA does not involve all layers of the wall, so it is called a “false aneurysm” or “pseudoaneurysm.”

Furthermore, BBLAs do not share the same features as dissecting aneurysms. Dissecting aneurysms typically display an intimal flap and a false lumen. Abe et al. demonstrated that neither an intimal flap nor a false lumen was present in histopathologic analysis of BBLAs. Rather than an intact adventitia around the double-barrel lumen, as seen in dissecting aneurysms, BBLAs have a fragmented adventitia, suggesting a full-thickness disruption of the arterial wall. A report from Ishikawa et al. in 1997 demonstrated that at the rupture point of a BBLA, the internal elastic lamina is lacerated at the border between the normal and sclerotic carotid walls. The medium is not present, and the adventitia is fragmented. This full-thickness defect on the arterial wall is a defining characteristic of BBLAs, leading to a high incidence of rebleeding and premature rupture during dissection compared with saccular or dissecting aneurysms.

### Table 1. Characteristics of Blood Blister-Like Aneurysms

<table>
<thead>
<tr>
<th>Characteristic</th>
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<tbody>
<tr>
<td>Small size</td>
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<tr>
<td>Fragile wall</td>
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<tr>
<td>Lack of a aneurysmal neck</td>
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<tr>
<td>Lack of a true arterial wall with fragmentation of all arterial wall layers</td>
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<tr>
<td>Tendency to avulse with minimal retraction</td>
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<tr>
<td>High frequency of intraoperative rupture</td>
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<tr>
<td>High rate of rebleeding and recurrence</td>
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<tr>
<td>Arising from nonbranching points of the suprachlinalid internal carotid artery</td>
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</table>

**Histopathologic Characteristics**

BBLAs do not share the same histopathologic features as saccular aneurysms. A saccular-type aneurysm, or the so-called true aneurysm, is composed of a 3-layer arterial wall with thickened intima and/or adventitia containing rich collagen cells. In contrast, a focal wall defect covered with a blood clot or fibrinous tissue is the characteristic feature of the BBLA. The vessel wall of a BBLA does not involve all layers of the wall, so it is called a “false aneurysm” or “pseudoaneurysm.”

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The continuing education activity in Contemporary Neurosurgery is intended for neurosurgeons, neurologists, neuroradiologists, and neuropathologists. Contemporary Neurosurgery (ISSN 0163-2108) is published bi-weekly by Lippincott Williams & Wilkins, Inc., 16522 Hunters Green Parkway, Hagerstown, MD 21740-2116. Customer Service: Phone (800) 638-3030, Fax (301) 223-2400, or E-mail customerservice@lww.com. Visit our website at www.lww.com. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved. Priority Postage paid at Hagerstown, MD, and at additional mailing offices. POSTMASTER: Send address changes to Contemporary Neurosurgery, Subscription Dept., Lippincott Williams & Wilkins, 16522 Hunters Green Parkway, Hagerstown, MD 21740-2116. Publisher: Randi Davis Subscription rates: Individual: US $716 with CME, $612 without CME; international $961 with CME, $792 without CME. Institutional: US $903, international $926. In-training: US resident $139 with CME, international $162. Single copies: $35. GST Registration Number: 895524239. Send bulk pricing requests to Publisher. COPYRIGHTING: Contents of Contemporary Neurosurgery are protected by copyright. Reproduction, photocopying, and storage or transmission by magnetic or electronic means are strictly prohibited. Violation of copyright will result in legal action, including civil and/or criminal penalties. Permission to reproduce copies must be secured in writing; at the newsletter website (www.contemporaryneurosurgery.com), select the article, and click “Request Permission” under “Article Tools” or e-mail permissionercare@copyright.com. Reprints: For commercial reprints and all quantities of 500 or more, e-mail reprintsolutions@wolterskluwer.com. For quantities of 500 or under, e-mail reprints@lww.com, call 1-866-903-6951, or fax 1-410-528-4434. PAID SUBSCRIBERS: Current issue and archives (from 1999) are available FREE online at www.contemporaryneurosurgery.com.
BBLAs are thought to be most likely attributable to atherosclerosis and hemodynamic stress, which may not explain the mechanisms that distinguish these aneurysms from saccular aneurysms. Therefore, the pathogenesis of BBLAs remains unclear.

Epidemiology
BBLAs account for only about 1% of all intracranial aneurysms, 0.5% to 2% of all ruptured intracranial aneurysms, and 0.9% to 6.6% of aneurysms of the ICA. Because BBLAs are rare, their epidemiology has not been fully elucidated. Specific epidemiologic risk factors associated with BBLA development include hypertension, cigarette smoking, and female sex. A systematic review of 322 patients from 63 studies demonstrated that the mean age for BBLA occurrence was 50.6 years, and 72% of cases were in women.

Location
Although there have been reports describing BBLAs located at other sites within the intracranial circulation, the initial and common definition of a BBLA limits the location to the anteromedial aspect of the supraclinoid ICA. On the basis of anatomic location, the origin of BBLAs of the ICA has been reported at 6 different sides. Ogawa et al. reported that the most common location for BBLAs is the anteromedial wall (65% of 40 cases), followed by the anterior wall (12.5%), the anterolateral wall (12.5%), the medial wall (5%), the lateral wall (2.5%), and the posteromedial wall (2.5%). To date, only a few BBLAs have been reported at locations within the basilar artery, anterior communicating artery, and middle cerebral artery (MCA). Furthermore, a BBLA at the posterior communicating artery (PComA) was reported in a single case, which resulted in death 1 week after surgery secondary to vasospasm-related infarction and edema.

Clinical Presentation and Diagnosis
Although saccular aneurysms tend to present with some warning signs, virtually all patients with the BBLA report no symptoms until the aneurysm ruptures. Most patients with a BBLA have a severe clinical condition at admission and present with headache, seizure, vomiting, loss of consciousness, or coma as the initial symptom. Moreover, comorbidities associated with SAH such as hydrocephalus, cardiovascular or pulmonary complications, and vasospasm can be tremendous problems in these cases.

BBLAs can be diagnosed with noninvasive or conventional digital subtraction angiography (DSA). Conventionally, the gold standard for diagnosis of BBLAs is DSA; however, Shigeta et al. reported that 30% of initial angiograms in patients with BBLAs were negative. Angiographic diagnosis of BBLAs may be challenging, because these lesions are often small and in an unusual location. Furthermore, overlap of vessel curvature, artifacts, and focal atheromatous irregular appearance may complicate the diagnosis. These aneurysms are frequently superimposed on the ICA, appearing as a shadow or double density on both anteroposterior and lateral views. A 30-degree oblique angiogram may demonstrate these aneurysms most effectively.

A high degree of suspicion for this lesion is recommended in patients with SAH of unknown origin, particularly when the bleeding pattern is more typical for an ICA source. Early repeat angiography is useful, as rapid growth of BBLAs is not uncommon (Figure 1).

Treatment
BBLAs have a propensity for growth and rupture over time without treatment. The unique and threatening pathophysiology of these aneurysms makes nonoperative management a nonviable option. Treatment in the acute setting reduces the substantial risk of rerupture. However, some treatment modalities, such as stent-based endovascular techniques, which require anticoagulant and antiplatelet medications, can increase the risk of hemorrhagic complication, which is particularly relevant in patients requiring ventricular catheterization for hydrocephalus.

Figure 1. Case illustration 1. A, Left carotid DSA reveals no obvious aneurysm on the day of SAH. B, Repeat DSA performed 9 days after initial angiogram showing a BBLA (arrow) at the nonbranching side of the ICA.
The main goal of treatment is to eliminate the aneurysm from the circulation to prevent rerupture. This requires a comprehensive understanding of the anatomy and dynamics of the aneurysm. Optimal treatment of BBLAs remains challenging for neurosurgeons and neurointerventionalists. Despite a growing body of literature on BBLAs, the best treatment has yet to be clearly established. Fundamentally, treatment options can be categorized as surgical and endovascular. Regardless of whether the treatment modality is surgical or endovascular, management of a BBLA should be guided by detailed knowledge of the vascular anatomy and familiarity with the treatment options for this particular type of aneurysm.

Surgical treatment strategies for BBLAs include trapping (with clipping, balloon occlusion, or coiling) with or without bypass; primary bypass; direct clipping; wrapping; clip placement with wrapping; and direct arterial suturing/stapling. Endovascular treatment of BBLAs includes flow-diverting stents or primary coil embolization with or without stents.

Each of these open surgical and endovascular options has been proposed as a reliable method to treat BBLAs, but each has its limitations. Because of the high risk of aneurysm rupture during therapeutic attempts, various urgent strategies must be kept in reserve to prevent a fatal outcome.

Preoperative Preparation and Anesthesia

Careful preoperative evaluation can minimize the complications of treatment. This begins with the recognition that the aneurysm being treated may represent a BBLA. The neurosurgeon or neurointerventionalist must understand the specific risks and challenges presented by BBLAs.

Reducing the risks of treatment depends on identifying the potential anesthetic and procedural challenges. All surgical procedures related to BBLAs require close communication between the surgeon and the anesthesiologist. The risk of intraoperative aneurysm rupture has been reported to be between 5% and 20% for non-BBLAs; this risk may increase to approximately 43% for BBLAs. For this reason, when a BBLA is approached, the anesthesiologist must be prepared to replace intravascular volume at short notice, induce temporary asystole with adenosine, and manage cerebral swelling to facilitate dissection. Moreover, proximal control of the ICA in the neck should be obtained.

Microvascular Doppler ultrasonography and indocyanine green videoangiography are very useful to assess blood flow in parent and branch vessels. Electrophysiologic monitoring includes electroencephalography and somatosensory-evoked potentials, which are versatile tools that can aid in the treatment of these lesions, particularly when parent artery sacrifice is being considered. Preoperative balloon test occlusion (BTO) also can be considered to decide on the necessity of arterial bypass if parent artery sacrifice is undertaken.

Microsurgical Treatment

Clipping

Although direct surgical clipping may be considered high-risk for BBLAs because of an unusually high risk of avulsion of the aneurysm or stenosis/obliteration of the parent vessel, it is the most commonly reported technique in the current literature for repairing BBLAs. Parallel clip placement, vascular closure staple clipping, and encircling clip placement are some other reported techniques for permanent treatment of BBLAs.

In the literature, controversial reports have been published with regard to direct clipping. Ogawa and colleagues reported a 37.5% incidence of aneurysmal rupture and fatal bleeding with BBLAs during and after surgery. An intraoperative rupture rate of 43% during acute-phase surgery was reported by Satoh et al. in 2006. In our experience, direct clipping is possible if the BBLA involves a very small part of the artery and the adjacent arterial wall is healthy enough to hold clips. Often, however, the BBLA involves a large segment of the artery and the origin of branches, especially the PComA if the supraclinoid ICA is the location.

Wrapping

For situations in which direct clipping of the BBLA is not possible, wrapping is another option for treatment. Some authors maintain that wrapping alone does not prevent rebleeding and is associated with a high incidence of postoperative bleeding rates; however, clipping on wrapping material (sling or diaper technique) is a reasonable technique. It is important to remember that wrapping can be a rescue plan, although in our experience, it is not suggested as primary treatment for BBLAs.

Trapping

Although the optimal method of treatment must be individualized to the patient, the high failure rate after primary clipping or coiling alone makes definitive treatment with surgical or endovascular trapping, with or without extracranial-to-intracranial (EC–IC) bypass, an attractive first-line option and a reasonable rescue plan. Trapping the aneurysm can be accomplished either by placing permanent clips before and after the aneurysmal segment of the ICA or by coiling closed the aneurysmal segment of the ICA. Proximity to the ophthalmic artery, PComA, and anterior choroidal artery must be noted carefully.

When considering trapping of the involved segment of the ICA, BTO is the ideal test to evaluate whether trapping would be tolerated. However, because patients with true BBLAs present with SAH, and most of these are high-grade SAH (Hunt and Hess grades 3–5), BTO may not be possible, either because of the need for patient cooperation or because the patient’s condition may not allow a long and thorough evaluation. Even when BTO is not possible, a thorough angiographic evaluation should be performed, which frequently is sufficient to obtain the necessary information. Special emphasis should be placed on evaluating collateral circulation; venous phase (with and without cross-compression); and potential bypass conduits such as the superficial temporal artery, the external carotid artery, and the level of carotid bifurcation in the neck (Figures 2–5).

Bypass

High-flow bypass with aneurysm trapping is a safe and reliable method of treatment. Although there are reports of parent artery sacrifice or aneurysm trapping without bypass, a bypass performed by an experienced neurosurgeon increases
the safety of ICA occlusion and also allows for more liberal application of temporary clips during the dissection of the aneurysm. “Ischemic complications in relation to ICA obliteration were successfully circumvented by RA [radial artery] graft bypass,” wrote Kazumata et al. in their recent report of 20 patients with BBLAs. With reconstitution of cerebral blood flow and complete obliteration of the aneurysmal segment, high-flow bypass with aneurysm trapping is our preferred first-line treatment in patients with BBLAs.

The choice of bypass technique depends on the collateral circulation that exists and the available donor arteries for bypass. High-flow bypass can be performed using either an arterial or venous bypass graft anastomosed proximally to the external carotid artery in the neck and anastomosed distally to MCA M2 branches. Lower-flow bypass options include anastomosis of the superficial temporal artery to MCAM3 or M4 branches, when there is a clinical circumstance that precludes high-flow bypass.

It is advisable to complete the bypass before performing arachnoid dissection of the proximal sylvian or carotid cisterns; manipulation of these fragile aneurysms carries with it a high risk of intraoperative rupture. If the bypass is in place and patent, there is an added degree of safety in the event of intraoperative rupture.

**Endovascular Treatment**

Endovascular treatment is difficult in the patient with a ruptured BBLA because of the sessile nature of the aneurysm. Coil embolization usually requires stent placement to hold the coil mass in the small aneurysm dome. In patients with ruptured BBLAs, the required antiplatelet/anticoagulants for safe stent placement must be used with great care, especially

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**Figure 2.** Case illustration 2. *A*, CT scan showing grade 4 SAH in a 52-year-old woman who presented with headache. *B* and *C*, DSA showing BBLA.

**Figure 3.** *A* and *B*, DSA of the same patient shown in Figure 2, immediately after surgery, shows the patent radial artery graft from the superficial temporal artery to the MCA.
in the setting of concurrent hydrocephalus requiring ventricular drainage.

In addition to stent-assisted coiling, endovascular options include parent artery occlusion, endovascular aneurysm trapping, combined endovascular trapping with open EC–IC bypass, standalone stent placement, stent-within-a-stent (SWS) technique, and, more recently, flow-diverting stent placement. There are no reports regarding the long-term efficacy of these treatments in BBLAs, but numerous reports of the feasibility of these techniques are reviewed here.

Primary Coil Embolization

McNeely et al. described primary coil embolization of a favorable BBLA in 2000. A combined open and endovascular treatment was reported in 2003 by Pelz et al.; initial balloon occlusion of the ICA was performed in 2 patients, but both patients reportedly required subsequent surgical trapping because of persistent aneurysm filling. Planned staged approaches with initial coil embolization followed by either EC–IC bypass or flow-diverting stent placement have been demonstrated to be feasible.

Parent Artery Occlusion and Endovascular Trapping

Parent artery occlusion remains a reasonable technique. This can be performed either as a standalone procedure or in combination with a surgical EC–IC bypass, depending on the relationship of the aneurysm to adjacent branches, on the collateral circulation, and on tolerance of balloon test occlusion.
Hoy et al. presented 15 cases in which endovascular trapping or parent artery occlusion was performed successfully. Parent artery occlusion is also used as a bailout treatment in patients who fail stent-based treatment because of hemorrhagic complications from anticoagulant/antiplatelet medications.

**Stenting and Flow Division**

Stent-assisted coiling is most commonly reported. Successful treatments without coil placement include stand-alone stent placement; SWS technique, in which a second stent or third is laid down within the lumen of the first stent to reduce porosity; and flow-diverting stent placement. Flow-diverting stent placement has been demonstrated by Chalouhi et al. and Cruz et al. to be successful at 6- to 12-month follow-up. This is certainly an attractive option, but unexplained distal intraparenchymal hemorrhages after flow-diverting stent placement demonstrate our incomplete understanding of this new technology. For this technique, antplatelets are required, and efficacy in the treatment of BBLAs still needs to be proven.

**Antiplatelet and Anticoagulant Use**

Antiplatelet and anticoagulant use must be considered in patients with ruptured BBLAs and in those with concurrent acute hydrocephalus requiring ventricular catheterization. Meckel et al. provided a report of antiplatelet and anticoagulant use in a series of 13 patients, in which 11 of the patients underwent stent-assisted coiling and 2 underwent SWS treatment. One third of their patients received postprocedural antiplatelet monotherapy, and half of the patients had no continuation of heparin postprocedurally. Although this series is small, no thromboembolic event or delayed in-stent thrombosis was observed. Two patients had postprocedural hemorrhagic complications. In one patient, there was a fatal rupture. In the other, there was a small rupture prompting cessation of antiplatelet agents and immediate parent artery occlusion.

**Conclusion**

Treatment options for patients with BBLA should be individualized. Despite advances in surgical and endovascular options, BBLAs carry a significant risk both in natural history and in treatment. Management of BBLAs should be guided by the patient's vascular anatomy, the unique characteristics of this aneurysm, and knowledge of the specific risks and benefits of the various surgical and endovascular techniques.

**Readings**


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1. BBLAs are different from saccular aneurysms.
   - True or False?

2. Most BBLAs present as unruptured incidental findings.
   - True or False?

3. BBLAs have been reported only on the supraclinoid ICA.
   - True or False?

4. Magnetic resonance angiography is the gold standard for the detection of BBLAs.
   - True or False?

5. The risk of intraoperative rupture of a BBLA is similar to that of a saccular aneurysm.
   - True or False?

6. The best surgical strategy for patients with BBLAs is direct surgical clipping.
   - True or False?

7. A high percentage of patients with BBLAs can be treated conservatively, with nonoperative management.
   - True or False?

8. Before surgical or endovascular treatment, it is important to know the relationship of the aneurysmal segment to the PComA.
   - True or False?

9. Loading with dual antiplatelet agents and continuing dual antiplatelet agents after stent-assisted coiling or SWS treatment of a BBLA is essential.
   - True or False?

10. High-flow arterial bypass is necessary whenever the supraclinoid ICA is occluded.
    - True or False?