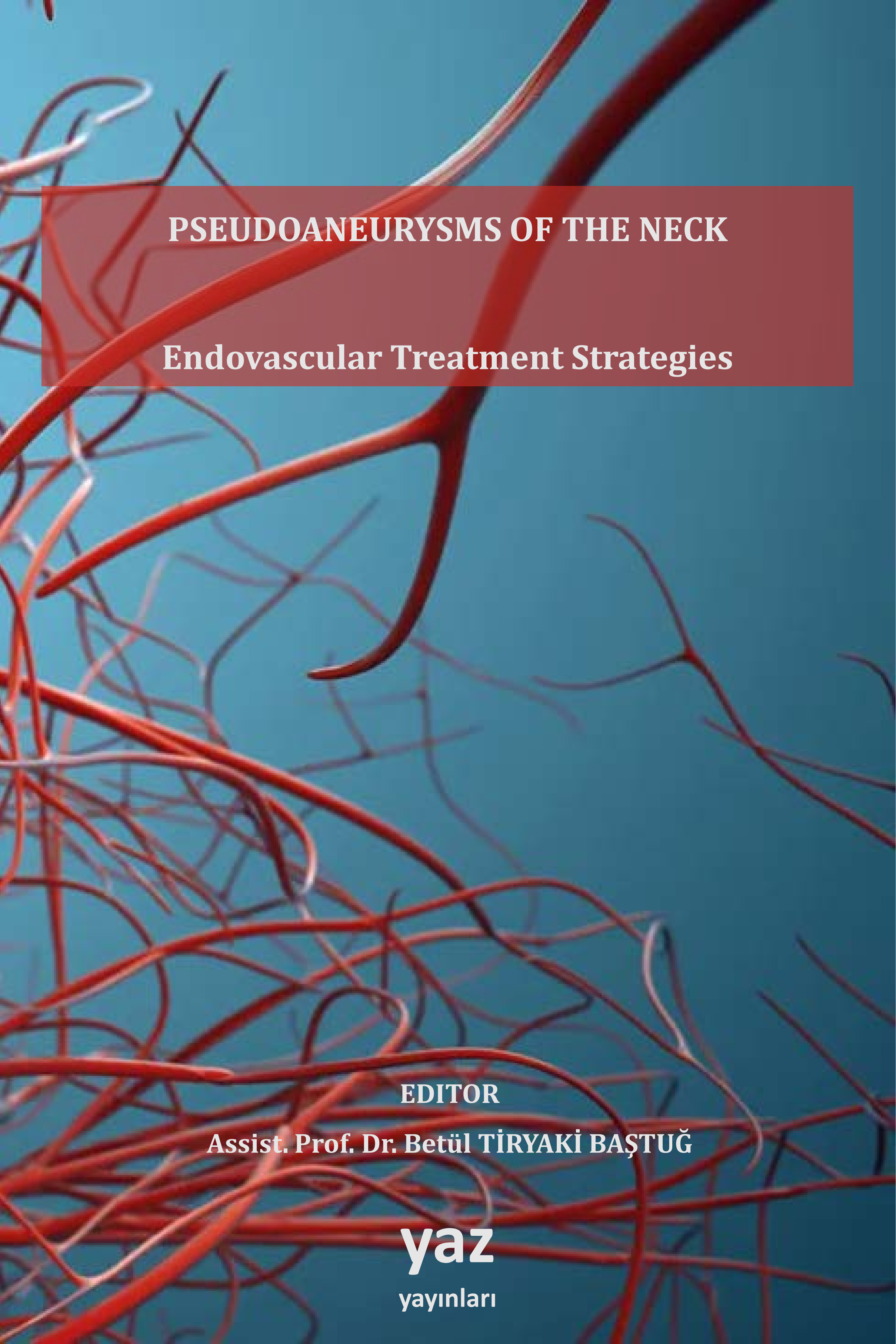

PSEUDOANEURYSMS OF THE NECK

Endovascular Treatment Strategies

EDITOR

Assist. Prof. Dr. Betül TİRYAKİ BAŞTUĞ

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Pseudoaneurysms of the Neck: Endovascular Treatment Strategies

Introduction

Betül Tiryaki Baştuğ

Pseudoaneurysms of the neck constitute an uncommon yet clinically significant subset of vascular disorders that require timely recognition and individualized management. These lesions are characterized by a focal disruption of the arterial wall with extravasation of blood into surrounding soft tissues, resulting in a pulsatile hematoma encapsulated by adventitia or perivascular fibrous tissue rather than a true arterial wall. This fundamental difference from true aneurysms imparts a uniquely unstable natural history, in which pseudoaneurysms may expand rapidly, thrombose, embolize, compress adjacent structures, or rupture catastrophically. Given the dense composition of neurovascular and aerodigestive structures within the cervical region, even relatively small pseudoaneurysms may have profound clinical implications.

The etiological spectrum of neck pseudoaneurysms is broad. Traumatic causes including penetrating injuries, blunt cervical trauma, and iatrogenic complications following catheterization, endovascular procedures, central venous access, or head and neck surgeries remain the most frequently encountered. Infectious pseudoaneurysms, though less common in modern practice, continue to pose significant management challenges, particularly in immunocompromised patients. Additionally, spontaneous pseudoaneurysms may arise in association with connective tissue disorders, inflammatory vasculitides, or underlying arterial wall abnormalities. Regardless of etiology, the clinical presentation is variable, ranging from an asymptomatic cervical mass detected incidentally to acute neurological deficits, cranial nerve palsies, severe hemorrhage, or airway compromise.

Recent advances in cross-sectional imaging have revolutionized the diagnostic workup of neck pseudoaneurysms. Duplex ultrasonography offers a rapid and noninvasive initial assessment with characteristic findings such as the "yin-yang" sign and bidirectional color Doppler flow within the sac. Computed tomography angiography (CTA), with its high spatial resolution and multiplanar reconstruction capabilities, has become the imaging modality of choice, enabling detailed evaluation of lesion morphology, neck anatomy, thrombosis, arterial wall integrity, and adjacent structural involvement. Magnetic resonance angiography (MRA) provides an alternative modality with excellent soft-tissue contrast, particularly valuable in cases where iodinated contrast or ionizing radiation is contraindicated. Together, these techniques allow for precise pre-procedural planning and risk stratification.

Historically, open surgical repair was the cornerstone of treatment. However, the intricate anatomy of the cervical region especially the proximity of the carotid bifurcation, cranial nerves IX–XII, sympathetic chain, and vital aerodigestive organs renders surgical intervention technically demanding and associated with considerable morbidity. Challenges such as difficult exposure, risk of nerve injury, potential need for vessel sacrifice, and complexities arising from prior radiation or infection have prompted a paradigm shift in recent decades.

The emergence and refinement of endovascular treatment strategies have transformed the therapeutic landscape. Minimally invasive approaches now offer tailored, vessel-preserving solutions with reduced perioperative morbidity and shorter recovery times. Covered stent-grafts have achieved excellent outcomes in excluding pseudoaneurysm sacs while maintaining vessel patency, particularly in the extracranial internal carotid and vertebral arteries. Coil embolization and liquid embolic agents provide versatile options for pseudoaneurysms arising in smaller branches or in vessels where parent artery occlusion is acceptable. More recently, flow-diverting stents and hybrid endovascular surgical approaches have expanded the therapeutic armamentarium, enabling treatment of anatomically complex or previously inoperable lesions.

Despite these advancements, clinical decision-making remains inherently nuanced. Optimal treatment requires a comprehensive evaluation of pseudoaneurysm morphology, parent vessel anatomy, collateral circulation, lesion etiology, and the patient’s overall clinical status. For instance, managing a traumatic extracranial carotid pseudoaneurysm in a young patient with preserved collaterals differs fundamentally from addressing a mycotic pseudoaneurysm in the context of active infection. Such complexity underscores the importance of a multidisciplinary approach involving interventional radiologists, head and neck surgeons, vascular surgeons, neurologists, and intensive care specialists.

This book, Pseudoaneurysms of the Neck: Endovascular Treatment Strategies, is designed to provide a thorough and up-to-date exploration of this evolving field. It integrates foundational anatomical and pathophysiological principles with detailed descriptions of imaging modalities, evidence-based treatment algorithms, procedural techniques, device selection, and post-treatment considerations. Case-based discussions, illustrative imaging examples, and insights derived from current literature further enrich the content, aiming to guide clinicians in navigating the diagnostic and therapeutic challenges of neck pseudoaneurysms.

By synthesizing contemporary evidence with practical clinical expertise, this volume aspires to serve as an essential reference for physicians involved in the management of vascular diseases of the neck. Ultimately, our goal is to support informed, patient-specific decision-making, improve procedural outcomes, and advance the level of care for individuals affected by these complex and potentially life-threatening vascular lesions.

Chapter 1

Traumatic and Iatrogenic Etiologies of Cervical Pseudoaneurysms

Betül Tiryaki Baştuğ

Pseudoaneurysms of the neck develop as a consequence of structural disruption to the arterial wall, resulting in a contained rupture that is walled off by perivascular tissues rather than the native arterial layers. Unlike true aneurysms, which exhibit dilation of all three arterial layers, pseudoaneurysms represent unstable, dynamically evolving lesions with a significantly higher risk for rupture, thrombosis, embolization, and mass effect. Understanding their etiology is foundational in clinical practice, not only for accurate diagnosis and risk prediction but also for determining the most appropriate endovascular or surgical treatment strategy. This chapter provides an expanded and detailed overview of the diverse etiological mechanisms associated with cervical pseudoaneurysms.

Traumatic Etiology

Trauma is the leading cause of pseudoaneurysm formation in the cervical region. Both penetrating and blunt mechanisms may damage arterial integrity, and the resulting pseudoaneurysm may manifest immediately or evolve over days to weeks.

1.Penetrating Trauma

Penetrating trauma causes direct arterial wall disruption, often resulting in rapid pseudoaneurysm formation.

- **Common sources include:** stab wounds, gunshot injuries, high-velocity shrapnel, glass injuries, and animal bites.
- **High-risk arteries:** external carotid artery (ECA) branches such as the facial, maxillary, occipital, and superficial temporal arteries due to their superficial course.

Because penetrating injuries frequently occur in unstable patients, pseudoaneurysms may initially go unnoticed. Delayed presentations include pulsatile neck masses, expanding hematomas, bruit, and lower cranial nerve dysfunction due to mass effect.

2. Blunt Trauma

Blunt trauma can damage cervical arteries through indirect mechanisms such as:

- Rapid acceleration–deceleration (e.g., motor vehicle crashes)
- Forced hyperextension or rotation of the neck
- Direct blow to the cervical region
- Sports-related injuries (martial arts, wrestling, rugby)

These mechanisms often cause intimal tears, dissections, or transmural ruptures. In these cases, pseudoaneurysms may develop along the arterial segments with high mobility or those anchored at bony foramina (e.g., vertebral artery segments V2–V3).

Blunt cerebrovascular injury (BCVI) remains underdiagnosed without dedicated imaging protocols, and pseudoaneurysms may only become apparent during follow-up CTA or MRA.

Iatrogenic Etiology

Iatrogenic injuries represent a major modern cause of pseudoaneurysm formation due to the increasing frequency of vascular interventions, catheterizations, and head and neck surgeries.

1. Catheter-Based and Endovascular Procedures

Endovascular manipulation can damage the arterial wall through:

- Repeated catheter exchanges
- Guidewire-induced perforation
- Balloon inflation near diseased segments
- Stent deployment in fragile or calcified arteries

Procedures such as carotid artery stenting, diagnostic angiography, thrombolysis, and thrombectomy are well-recognized risk factors if not performed with meticulous care.

2. Central Venous Catheterization

The internal jugular vein lies in close anatomical proximity to the carotid artery. Misplacement of cannulation needles can result in:

- Carotid artery puncture
- Hematoma formation
- Subsequent pseudoaneurysm resulting days later

Risk factors include obesity, coagulopathy, emergency catheterization, and lack of real-time ultrasound guidance.

3. Neck and Skull Base Surgeries

Surgical procedures frequently implicated include:

- Carotid endarterectomy (CEA)
- Thyroidectomy and parathyroid surgery
- Deep neck mass excisions
- ENT surgeries (e.g., tonsillectomy, parotidectomy)
- Transoral robotic surgery (TORS)
- Skull base tumor resections

In such cases, pseudoaneurysm formation may be delayed due to postoperative infection, suture line failure, or vessel manipulation.

Chapter 2

Non-Traumatic, Infectious, Radiation-Induced, and Unusual Etiologies of Cervical Pseudoaneurysms

Betül Tiryaki Baştuğ

Infectious (Mycotic) Etiology

Though less common, infectious pseudoaneurysms represent some of the most challenging lesions to treat due to:

- Rapid expansion
- High rupture rates
- Associated sepsis or abscess formation

1. Mechanisms

Pseudoaneurysms may develop through:

- Direct spread from deep neck infections such as parapharyngeal, retropharyngeal, and masticator space abscesses
- Hematogenous seeding from endocarditis or bacteremia
- Post-surgical infection involving the carotid or vertebral artery

2.Common Pathogens

- Staphylococcus aureus
- Streptococcus species
- Salmonella species (classic cause of mycotic aneurysms)
- Gram-negative bacilli in immunocompromised patients

3.Clinical Features

Patients frequently present with fever, neck pain, erythema, and elevated inflammatory markers. Imaging shows irregular pseudoaneurysm walls, perivascular inflammation, and possible active extravasation.

Spontaneous and Non-Traumatic Etiology

Pseudoaneurysms may form even in the absence of direct trauma due to intrinsic vessel wall abnormalities.

1. Connective Tissue Disorders

Diseases characterized by defective collagen or elastin include:

- Ehlers–Danlos syndrome (especially Type IV)
- Marfan syndrome
- Loeys–Dietz syndrome

These conditions weaken the arterial media and adventitia, predisposing to spontaneous arterial rupture or dissection.

2. Fibromuscular Dysplasia (FMD)

FMD commonly affects the renal and carotid arteries. In the cervical carotid, FMD may cause:

- Arterial stenosis
- Dissection
- Post-dissection pseudoaneurysm formation

Young women constitute the majority of affected patients.

3. Vasculitis

Conditions such as Takayasu arteritis, polyarteritis nodosa, and giant cell arteritis may damage the arterial wall through chronic inflammation or immune-mediated injury, increasing susceptibility to pseudoaneurysm formation.

Radiation-Induced Etiology

Radiation therapy induces delayed vascular complications due to:

- Fibrosis and scarring
- Endothelial damage
- Chronic inflammation
- Accelerated atherosclerosis

Patients treated for nasopharyngeal carcinoma, oropharyngeal tumors, or skull base malignancies are at particular risk.

1. Latency Period

Radiation-induced pseudoaneurysms may emerge years or even decades after therapy, making diagnosis challenging.

2. Clinical Implications

These pseudoaneurysms often present:

- Adjacent to irradiated tissues
- In the ICA at the skull base
- With signs of mucosal necrosis, hemorrhage, or sentinel bleeding

These lesions are particularly prone to rupture and require urgent management.

Post-Infectious and Inflammatory Conditions

Deep neck infections, cervical fasciitis, osteomyelitis, or severe dental abscesses can weaken arterial walls indirectly through:

- Enzymatic tissue destruction
- Persistent inflammation
- Pressure necrosis

Cases involving parapharyngeal infections are well known for eroding the internal carotid artery.

Inflammatory diseases such as Behçet's disease and Kawasaki disease may also induce vasculopathy leading to pseudoaneurysm formation.

Congenital and Unusual Causes

Rare etiologies include:

1. Congenital Arterial Dysplasia

Some individuals may have congenital defects in arterial branching, wall thickness, or elastic components, making them more vulnerable to pseudoaneurysm formation.

2. Foreign Body Injury

Sharp foreign bodies lodged in the oropharynx or esophagus can perforate adjacent arteries, most famously:

- Fish bones
- Chicken bones
- Dental instrument fragments

3. Tumoral Erosion

Aggressive head and neck tumors may erode the arterial wall through local invasion or necrosis.

4. Repetitive Microtrauma

Professional athletes and individuals engaging in repetitive neck motion may experience arterial micro-injury.

Pseudoaneurysms of the neck arise from a wide spectrum of etiologies, each with unique clinical implications and therapeutic considerations. Traumatic and iatrogenic causes remain the most common in contemporary practice, but infectious, inflammatory, and spontaneous etiologies require equal vigilance due to their complex presentations and higher risk profiles. A detailed understanding of the underlying cause is indispensable in guiding imaging decisions, predicting natural history, and selecting the most appropriate endovascular intervention.

Chapter 3

Pseudoaneurysm morphology and rupture risk

Büşra Ak

Introduction

Pseudoaneurysms are vascular pathologies that do not involve all layers of the arterial wall, but develop outside the vessel but are confined by surrounding tissues. Unlike true aneurysms, the integrity of the intima, media, and adventitia layers of the arterial wall is disrupted, and bleeding is confined within a pseudocapsule composed of surrounding tissues.

Neck pseudoaneurysms are rare but potentially life-threatening vascular pathologies, particularly those arising from the carotid artery system and vertebral arteries. The most common causes include blunt or penetrating trauma, iatrogenic interventions (central venous catheters, surgical procedures, biopsies), and, less commonly, infections. Failure to perform early diagnosis and accurate morphological assessment can lead to serious morbidity and mortality. The rupture risk of pseudoaneurysms is directly related to their morphological characteristics and is the most critical factor determining the treatment approach. Pseudoaneurysms in this region not only carry a risk of rupture due to their anatomic proximity, but can also lead to serious complications such as embolic stroke, cranial nerve compression, airway compression, and massive cervical hematoma. Therefore, accurate assessment of morphological characteristics is critical for both predicting rupture risk and determining the appropriate treatment strategy.

Morphology of Pseudoaneurysms

Pseudoaneurysms in the neck region are observed in the following vessels, which are anatomically most susceptible to trauma and intervention:

- Common carotid artery
- Internal carotid artery
- Branches of the external carotid artery
- Vertebral artery

Internal carotid pseudoaneurysms, in particular, constitute the highest clinical risk group due to the risk of intracranial embolism.

1. Definitional Morphology

A pseudoaneurysm occurs when blood escaping from the arterial lumen becomes confined to surrounding tissues, forming a pulsating hematoma. This structure is not based on a true vessel wall, but rather on fibrous tissue, clot, and surrounding soft tissue.

Classically, it consists of three main anatomical structures:

- Neck
- Sac
- Connection to the parent vessel

The width of the neck, the volume of the sac, and the flow pattern are the primary determinants of pseudoaneurysm stability.

2. Neck Characteristics

The pseudoaneurysm neck is the critical anatomical region that forms the connection between the parent vessel and the sac.

- **Narrow-necked pseudoaneurysms (<3-4 mm):** They are generally considered more stable. They have a lower risk of rupture and a higher potential for spontaneous thrombosis.
- **Wide-necked pseudoaneurysms (>5 mm):** Due to exposure to high-pressure carotid artery flow, wall tension increases, significantly increasing the risk of rupture.

Doppler ultrasonography typically shows a "to-and-fro" flow pattern. As the neck diameter increases, inflow and outflow flow increases, increasing the mechanical stress on the sac wall.

3. Sac Morphology

The sac structure is the most critical component of a pseudoaneurysm. The following characteristics should be evaluated:

- Diameter and volume
- Wall thickness
- Presence of internal thrombus

- Multilobulation

In pseudoaneurysms originating from the carotid and vertebral arteries, the sac morphology is most often:

- Saccular.
- Dimensions vary depending on the amount of bleeding, the resistance of the surrounding tissue, and thrombosis.
- Tendency to expand over time.
- Frequently contains partial thrombosis.

Pseudoaneurysms >2 cm have a higher clinical risk of rupture and are associated with compression symptoms. Multilobulated pseudoaneurysms, on the other hand, are more unstable than single-lobed structures due to heterogeneous pressure distribution.

4. Wall Structure and Histopathology

The pseudoaneurysm wall does not contain intima, media, or adventitia. Histologically, it appears as fibrin, coagulation products, granulation tissue, and inflammatory cells. Because this structure is not compressible, it cannot withstand long-term mechanical stress, especially in high-pressure vessels such as the carotid artery, and is prone to increase in diameter and rupture.

5. Relationship with Surrounding Structures

Neck pseudoaneurysms are often in close proximity to the trachea, esophagus, jugular vein, and cranial nerves. This relationship can lead to compression symptoms such as dysphagia, hoarseness, respiratory distress, and Horner syndrome as the sac expands. These conditions are generally indicative of advanced-stage morphological instability.

Accurate understanding of the morphological characteristics of neck pseudoaneurysms is vital for diagnosis and endovascular treatment planning. This information can be obtained through imaging methods:

Color Doppler Ultrasonography (CDUSG): This is the first-line diagnostic and follow-up method, with the advantage of being non-invasive and easily accessible. The diameter of the pseudoaneurysm, its neck width, and the flow pattern within the sac are evaluated. Other potentially associated lesions, such as an arteriovenous fistula (AVF) or dissection, are also evaluated.

- ***Appearance:*** The pseudoaneurysm sac appears as an echolucent, pulsatile mass.
- ***Flow Pattern***: Jet flow from the main artery to the neck and diastolic backflow from the neck to the artery (to-and-fro pattern) are characteristic and diagnostic.

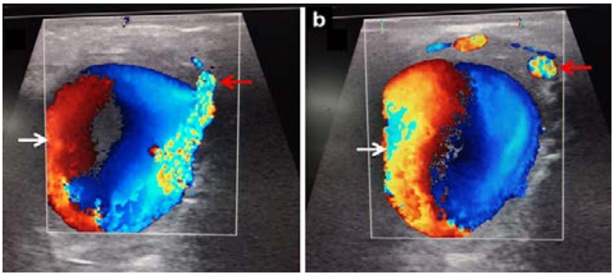


Figure 1. Color Doppler ultrasound images (a and b) showing the pseudoaneurysm fed by the internal carotid artery (red arrow) and a yin-yang pattern (white arrow).

Computed Tomography Angiography (CTA) and Magnetic Resonance Angiography (MRA): These techniques provide detailed visualization of the pseudoaneurysm's relationship with surrounding tissues (especially nerves and veins), its size, and morphology. This is the gold standard imaging method for neck pseudoaneurysms, with a focus on rupture and active extravasation. The pseudoaneurysm wall integrity, contrast enhancement, and the presence of a surrounding hematoma are evaluated.

Conventional Angiography: These are the gold standard diagnostic methods. They most clearly demonstrate the neck width, length, and sac shape of the pseudoaneurysm. They are particularly important for evaluating the neck and main artery anatomy in endovascular treatment planning.

Rupture Risk and Other Complications of Pseudoaneurysms

Neck pseudoaneurysms can lead to potentially life-threatening complications. Rupture and associated bleeding are the most feared and serious complications requiring immediate intervention.

Clinical findings of rupture vary depending on the location of the rupture, the amount and rate of bleeding, and the affected vessel. Signs of acute hemorrhage include:

- Sudden onset of severe neck pain
- Rapidly growing, hard, pulsatile neck swelling

- Signs of hemorrhagic shock (tachycardia/hypotension, altered consciousness)
- Skin ecchymosis, hematoma, and tension
- Compartment syndrome depending on anatomical location
- Neurologic findings (transient ischemic attack, hemiparesis/hemiplegia, aphasia, vision loss, severe headache)

Factors Increasing the Risk of Rupture:

- **Large Sac Size**: While the specific threshold value for neck pseudoaneurysms varies in the literature, it has been shown that rapidly growing pseudoaneurysms or pseudoaneurysms larger than 2 cm have a lower chance of spontaneous thrombosis and a significantly increased risk of rupture. In large-volume pseudoaneurysms, the tension on the sac wall increases as the diameter increases, according to Laplace's law. Therefore, the risk of rupture increases as the aneurysm diameter increases and requires urgent treatment.
- **Rapid Growth**: Pseudoaneurysms detected increasing in size during follow-up have a higher risk of rupture.
- **Neck Width and Flow Velocity**: In wide-necked pseudoaneurysms, the high-pressure jet entering the sac creates turbulence along the wall and increases intraluminal pressure. This facilitates rupture. Narrow-necked lesions are both more prone to

spontaneous thrombosis and respond better to interventional treatments.

- **Irregular Shape/Bleb Presence**: Irregular morphology or the presence of a bleb indicating a weak point increases the risk.
- **Antiplatelet/Anticoagulant Use**: In patients taking anticoagulants, the likelihood of spontaneous thrombosis decreases, intravesical bleeding continues, and the risk of rupture significantly increases. Therefore, a detailed drug history should be thoroughly investigated, especially in pseudoaneurysms that develop after carotid stenting.
- **Infection (Mycotic Etiology):** In infected cervical pseudoaneurysms, wall destruction accelerates and rapid growth occurs in a short period of time. The risk of early and sudden rupture increases significantly. This subtype of pseudoaneurysm has the highest mortality risk in the neck region.
- **Traumatic and Iatrogenic Origin**: The majority of neck pseudoaneurysms develop following blunt trauma, penetrating neck injuries, post-surgical (carotid endarterectomy), and central venous catheter complications. Pseudoaneurysms that develop after trauma usually tend to expand quickly and have a high risk of rupture.
- **Vertebral Artery Pseudoaneurysms:** While relatively rare, vertebral artery pseudoaneurysms can present with severe clinical conditions such as posterior circulation ischemia, subarachnoid hemorrhage, and cervical hematoma. Even if they are small in size, they have a high potential for rupture.

Rupture can cause bleeding into surrounding tissues, resulting in a rapidly growing, painful mass (hematoma) in the neck. Rupture in carotid artery pseudoaneurysms:

- **Airway Compression:** Large hematomas can compress the trachea (windpipe), leading to acute respiratory distress.
- **Neurological Damage**: Embolism of a clot (thrombus) or clot fragments within the pseudoaneurysm to cerebral vessels increases the risk of ischemic stroke.
- **Bleeding:** Although rare (especially in penetrating trauma), it can cause major blood loss and lead to mortality.

Other Complications:

- **Distal Embolization**: Occlusion of distal vessels by a thrombus or clot resulting from rupture within the sac (risk of stroke, especially in carotid pseudoaneurysms).
- **Compressive Neuropathy**: Compression of surrounding nerves by the pseudoaneurysm (e.g, Recurrent Laryngeal Nerve Compression, neurological deficit).
- **Skin Necrosis and Local Infection**

Neck pseudoaneurysms, even if small in size, carry a serious risk of rupture due to their development in the high-pressure carotid and vertebral artery systems. Morphological evaluation should be based on the sac diameter, neck width, wall structure, and their relationship to surrounding anatomical structures. Current imaging methods allow early diagnosis, and appropriate endovascular treatment can significantly reduce mortality.

Pseudoaneurysms with a high risk of rupture (especially symptomatic, rapidly growing, and mycotic ones) generally require urgent treatment. Treatment options include endovascular interventions or open surgical repair. These will be discussed in detail in the next section.

Chapter 4

Endovascular Treatment Options and Techniques for Cervical Pseudoaneurysms

Büşra Ak

Pseudoaneurysms, usually seen in the carotid or vertebral arteries in the neck, occur when blood leaks out of the artery due to damage to the artery wall caused by trauma, surgery, or infection, and accumulates in the surrounding tissues. Unlike a true aneurysm, the wall of a pseudoaneurysm does not involve all layers of the artery. If left untreated, they can lead to life-threatening complications such as rupture, bleeding, neurological deficits, and infection.

While surgery has traditionally been the gold standard, endovascular treatments have gained prominence over the past two decades, particularly in patients at high surgical risk, anatomically challenging lesions, or those with rapid bleeding. Due to their minimally invasive nature, short hospital stays, and acceptable neurological morbidity rates, endovascular procedures are now considered the first-line treatment option for cervical pseudoaneurysms.

The treatment option is determined by the size of the pseudoaneurysm, neck width, main vessel diameter, infection status, location (carotid, vertebral artery), the patient's general condition, and the risk of complications (especially rupture or stroke). In this section, the basic options and techniques used in the endovascular treatment of pseudoaneurysms in the neck region will be discussed in detail, based on current literature.

Conservative Treatment (Follow-up)

Initial observation may be preferred for small, asymptomatic, and stable pseudoaneurysms.

• Changes in the size and shape of the pseudoaneurysm are monitored at regular intervals with Doppler ultrasonography or CT angiography.

• It is generally suitable for lesions with small diameters (e.g., <3-5 mm), low flow, and stable lesions. Some pseudoaneurysms have the potential to thrombose spontaneously and closure.

Non-Invasive Treatments

A. Ultrasound-Guided Thrombin Injection

This is a minimally invasive procedure frequently used for carotid pseudoaneurysms.

- **Technique**: Under ultrasound guidance, thrombin (a clotting enzyme) is injected directly into the pseudoaneurysm sac. The thrombin causes the blood in the sac to clot rapidly, resulting in the closure of the pseudoaneurysm.
- Advantages: High success rate, rapid recovery, and fewer risks compared to surgery.

- **Risks:** Risk of thrombin leaking into the parent artery and causing distal embolization.

B. Ultrasound-Guided Compression

Although a traditional method, thrombin injection is more common today.

- **Technique:** Under ultrasound guidance, external pressure is applied to the pseudoaneurysm neck (the vessel feeding the aneurysm) to interrupt blood flow and promote clotting.

Endovascular Treatments

These methods, administered intravenously via catheters, are increasingly being used as an alternative to surgery. Indications for endovascular treatment include:

- Rapidly growing or symptomatic pseudoaneurysms (pain, pressure).
- Pseudoaneurysms with a high risk of rupture or bleeding.
- Pseudoaneurysms associated with carotid artery dissection.
- Patients at high surgical risk (advanced age, comorbidities).
- Lesions with anatomically difficult surgical access (high cervical or near skull base).

Endovascular treatment involves various strategies depending on the type, size, location, and, most importantly, neck anatomy of the pseudoaneurysm.

A. Coil Embolization: This technique is based on filling the pseudoaneurysm sac with platinum coils to create a thrombus and interrupt blood flow.

• **Indications**: Used in areas where surgical access is difficult or where thrombin injection is risky, such as narrow-necked pseudoaneurysms, small- to medium-sized pseudoaneurysms with a high risk of rupture, and vertebral artery pseudoaneurysms.

• **Technique**: Small metal coils (coils) are placed into the pseudoaneurysm sac or, sometimes, the feeding vessel (neck) using a catheter. These coils trigger clotting, filling the pseudoaneurysm and interrupting blood flow.

- -Standard Coiling: For lesions with wide necks or difficult locations, a coil is placed into the aneurysm sac from the proximal artery.
- -Balloon-Assisted Coiling: A temporary balloon placed at the aneurysm neck prevents the coils from migrating into the main vessel lumen.
- -Stent-Assisted Coiling: A stent is placed across the aneurysm neck, allowing the coils to be inserted through the stent cage into the aneurysm sac. This is particularly preferred for wide-necked lesions to maintain arterial patency.

• **Advantages:** Minimally invasive. Local anatomy is preserved. If the sac is completely filled, recurrence is low.

• **Disadvantages**: There is a risk of coil migration in wide-necked pseudoaneurysms. It is insufficient alone for high-flow lesions.

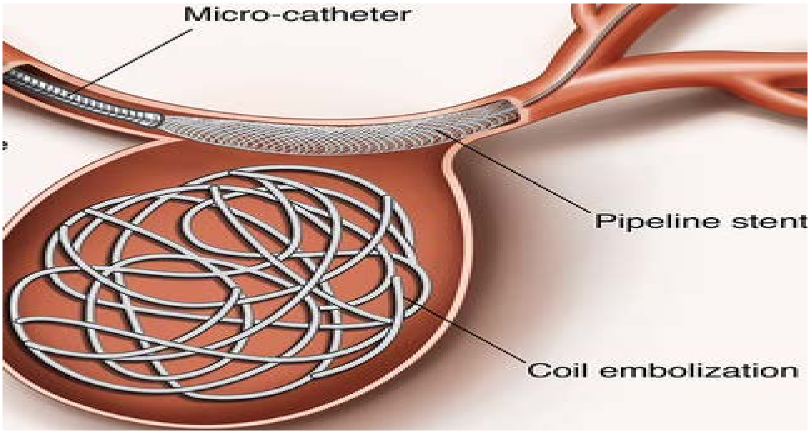


Figure 2. The figure demonstrate a saccular aneurysm.The image show the aneurysm after endovascular coil embolization, with the coil mass visible within the sac.

B. Stent Graft (Covered Stent) Application: Stent grafts are stents covered with a synthetic material. They are placed in the vessel segment containing the pseudoaneurysm, completely isolating the lesion from the main vessel lumen.

• **Technique**: A PTFE-covered stent is placed in the arterial segment containing the pseudoaneurysm, covering the inner surface of the vessel and completely covering the pseudoaneurysm's entry and exit points. This stent covers the pseudoaneurysm neck, preventing blood flow into the sac, preventing thrombosis of the lesion, and preserving normal vascular access.

• **Indications**: Vessels where preservation of arterial continuity is important (carotid, subclavian arteries), wide-necked pseudoaneurysms, traumatic arterial injuries, and high-flow lesions where coils cannot be applied.

• **Advantages**: Fast and reliable. It is the most effective method for wide-necked pseudoaneurysms. The arterial lumen is preserved.

• **Disadvantages**: Stent grafts carry the risk of sacrificing important side branches originating from the neck (e.g., branches of the external carotid artery) because they completely cover the lumen. Therefore, they are preferred for lesions without critical side branches or when side branches can be sacrificed. Long-term patency is variable.

C. Flow Diverter Stents: Flow diverters significantly reduce blood flow to the aneurysm sac by placing a high-density metal stent in the vessel wall. This slowing promotes thrombosis within the aneurysm while preserving blood flow to the side branches of the parent vessel.

• **Indications:** Generally used for wide-necked, fusiform, or pseudoaneurysms that cannot be completely filled with coils.

• **Advantages:** No access to the sac is required. Vascular anatomy is preserved.

• **Disadvantages:** These stents generally require dual antiplatelet therapy and are not the first choice for active bleeding with a risk of acute rupture.

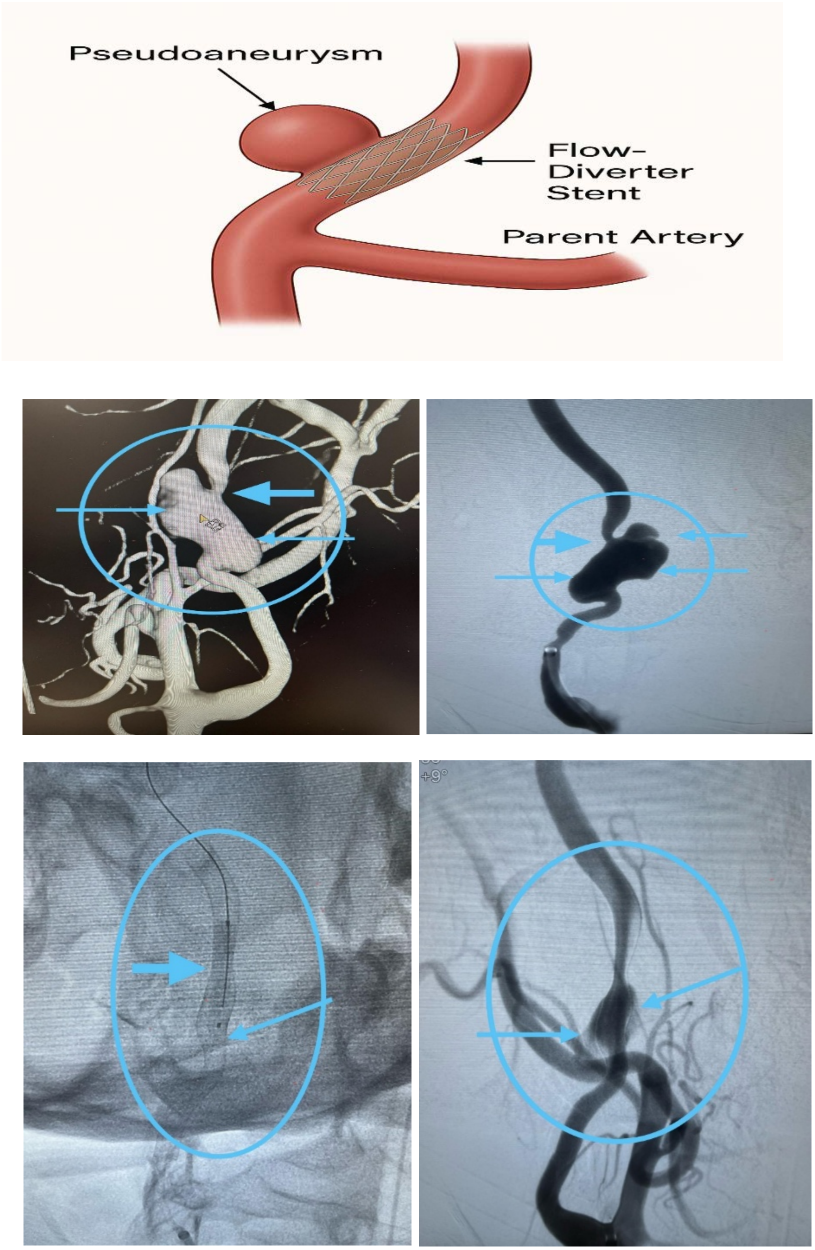


Figure 3. The wide-necked aneurysm located in the left internal carotid artery was selectively catheterized using a microcatheter. A flow-diverter stent was deployed across the aneurysm neck to redirect blood flow and promote aneurysm thrombosis.

D. Liquid Embolic Agents: Liquid embolizing agents are polymerized materials that provide permanent occlusion, particularly used in the treatment of wide-necked or irregularly shaped pseudoaneurysms and in cases requiring complete occlusion of the vascular bed.

Technique: A special liquid occlusive agent (e.g.N-butyl cyanoacrylate, Onyx) is injected into the pseudoaneurysm sac via microcatheters, resulting in rapid lesion occlusion.

-N-butyl Cyanoacrylate (NBCA)

NBCA is a tissue adhesive that, thanks to its rapid polymerization time, quickly solidifies within the vessel, forming a strong plug.

- **Technique:** NBCA is opaqued by mixing it with lipiodol, and the polymerization time is adjusted. Because it polymerizes rapidly, it is critical to precisely place the microcatheter within the pseudoaneurysm sac and inject it as a single fluid bolus.
- **Advantage**: It provides very rapid and permanent occlusion.
- **Disadvantage**: The application technique is challenging. Inadvertent leakage into the parent vessel lumen or the microcatheter can lead to catheter compression or off-target occlusion of the parent vessel.

Ethylene Vinyl Alcohol Copolymer (EVOH - Onyx/Squid)

EVOH (trade names Onyx and Squid) is a slowly polymerizing liquid dissolved in an organic solvent such as dimethyl sulfoxide (DMSO).

- **Technique:** DMSO dissolves upon contact with blood within the vessel, and the EVOH polymer slowly collapses, forming a soft, shrinking mass. This allows for a more controlled and slower injection than NBCA.
- **Advantage**: Slow polymerization allows the operator to better control how the agent fills the aneurysm sac. Catheter withdrawal is easier.
- **Disadvantage:** DMSO solvent can be toxic to the vascular endothelium and may cause mild pain during injection. It is important to ensure that the catheter and the entire system are properly filled with DMSO before injection.

Application Strategies

Liquid embolizing agents are generally used in two main strategies:

- **Pseudoaneurysm Sac Occlusion**: The agent is injected only into the pseudoaneurysm space, aiming to preserve the arterial lumen. This is particularly preferred in narrow-necked lesions.
- **Parent Artery Occlusion (PAO):** If the patient's tolerance has been demonstrated by a successful previous balloon occlusion test, the parent artery

segment (proximal and distal) containing the pseudoaneurysm is permanently occluded with liquid agents. This strategy is particularly important in cases where the artery is too damaged to be surgically repaired or is at risk of infection.

Complications and Cautions

The main complications that may be encountered with liquid embolizing agents are as follows:

- **Off-Target Embolization:** The polymer of the agent escapes into the main vascular lumen or distal circulation (embolism). This can lead to serious neurological deficits such as ischemic stroke.
- **Catheter Entrapment**: Especially when using NBCA, if the agent polymerizes prematurely at or within the catheter tip, it can cause the catheter to become entrapped within the vessel.
- **Allergic Reaction**: Although rare, allergic reactions to the materials used may occur.

The successful use of liquid embolizing agents requires a high level of technical skill, rapid decision-making, and extensive experience in interventional radiology.

Surgical Treatment

Surgery is generally considered a last resort in cases where endovascular or minimally invasive methods have failed, are complicated (e.g., rupture, rapidly enlarging), or are anatomically unsuitable.

Techniques:

- **Primary Repair**: Removal of the pseudoaneurysm and direct suturing of the opening in the artery.
- **Match Repair:** Closure of the opening created after the lesion is removed using a patch (usually the patient's own vein or synthetic material).
- **Graft Replacement:** Complete removal of the pseudoaneurysm segment and replacement with a graft (vascular transplant, synthetic, or autologous vein).
- **Ligation:** Rarely, in some cases, particularly in non-dominant vertebral arteries, ligation of the vessel containing the at-risk pseudoaneurysm may be performed when other vessels can provide adequate blood flow.

Technical Success and Complications

Endovascular techniques have a success rate exceeding 90%. Success is defined by complete occlusion of the pseudoaneurysm and preservation of the parent vessel lumen (depending on the technique chosen). Coiling and stent grafting, in particular, have high initial success rates.

Possible Complications

- **Stroke/Transient Ischemic Attack (TIA):** This is the most serious complication. It occurs when thrombi formed during the procedure migrate to the distal circulation (embolism).

- **Rupture/Bleeding**: Rupture of the pseudoaneurysm during or after the procedure.
- **Infection**: Spread of infection, especially in mycotic or infected pseudoaneurysms.
- **Stent Migration or Thrombosis**: Stent dislodgement or intrastental obstruction.
- **Neuropathy**: Rarely, damage to nerves (especially cranial nerves) during the procedure.

Endovascular methods have become the primary treatment strategy for neck pseudoaneurysms, offering results superior to or equivalent to surgery. Coil embolization, stent grafts, and flow diverters offer solutions suitable for different lesion anatomies.

The treatment option should be determined with a multidisciplinary approach based on the etiology, size, neck width of the pseudoaneurysm, the patient's clinical condition, and the presence of collateral circulation. The continued development of surgical and endovascular techniques holds the potential to further reduce neurological morbidity rates in the treatment of these challenging lesions in the future.

Chapter 5

Treatment planning

Berkay Subaşı

Endovascular treatment planning for cervical pseudoaneurysms is a multidimensional process requiring precise correlation of clinical severity, lesion morphology, vessel anatomy, hemodynamic behavior, device performance characteristics, and patient-specific considerations. Because cervical arteries supply critical brain structures and lie adjacent to vital aerodigestive and neural tissues, poor planning may result in complications such as stroke, airway compromise, cranial neuropathies, or pseudoaneurysm recurrence. A comprehensive, methodical planning approach is therefore essential for safe and effective treatment.

Clinical Assessment as the Foundation of Planning

Treatment planning begins with a detailed assessment of the patient's clinical condition, determining urgency and the therapeutic strategy.

1. Symptom-Based Stratification

Patients generally fall into one of the following categories:

- Emergent presentation
- Expanding cervical hematoma
- Sentinel bleeding (oral, nasal, tracheal)
- Airway compromise
- Acute neurologic deficit

These patients need immediate endovascular control, usually with a covered stent or rapid occlusion.

Urgent but stable cases

- Growing but non-ruptured pseudoaneurysm
- Pain, cranial nerve palsy, compressive symptoms
- Hemodynamically stable but with high rupture risk

Treated within 24–72 hours after cross-sectional imaging.

Elective cases

- Incidental pseudoaneurysms
- Small, asymptomatic lesions
- Stable iatrogenic pseudoaneurysms

Elective treatment is acceptable but should not be indefinitely deferred.

2. Etiology-Specific Planning

Traumatic pseudoaneurysms

- Often large, irregular, and high-flow.
- Vessel preservation is usually required.
- Covered stents or flow diversion are common choices.

Iatrogenic pseudoaneurysms

- Typically more focal.
- Coils or stent-assisted techniques may be adequate.

Mycotic pseudoaneurysms

- Extremely fragile with high rupture risk.
- Covered stents risk infection; may require parent vessel sacrifice.
- Must be combined with prolonged antibiotic therapy.

Dissecting pseudoaneurysms

- Flow-diverter stents are often superior; they reconstruct the entire dissected segment.

Advanced Imaging-Based Planning

Cross-sectional imaging not only confirms diagnosis but also determines the exact endovascular strategy.

1. CTA: The Primary Planning Tool

CTA provides:

- 3D vascular mapping
- Accurate pseudoaneurysm dimensions and neck definition
- Wall irregularities and dissections
- Relation to bony structures
- Calcification or mural thrombus
- Access pathway evaluation

CTA is the cornerstone of treatment planning.

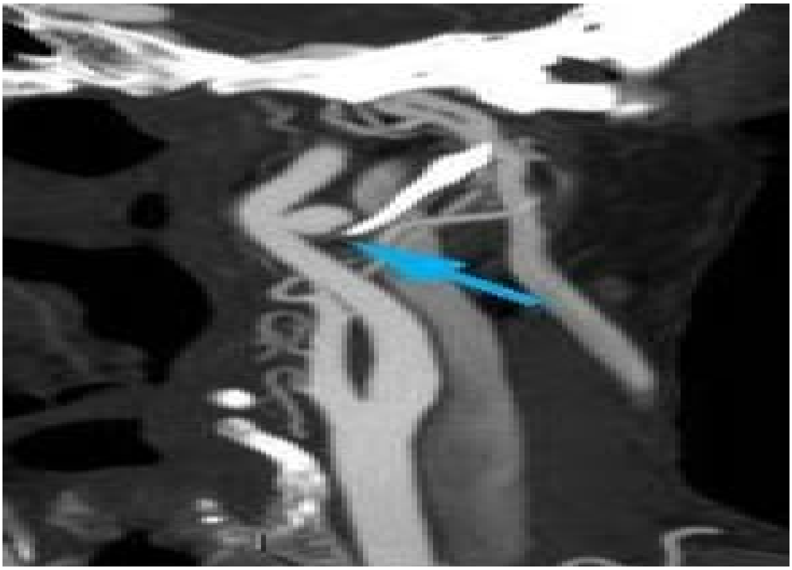


Figure 4. The CT angiography image demonstrates a well-defined saccular aneurysm arising from the internal carotid artery

2. MRA

Useful for:

- Contrast allergy or renal insufficiency
- Evaluating soft tissues, nerve compression, or adjacent venous structures
- Long-term follow-up plans

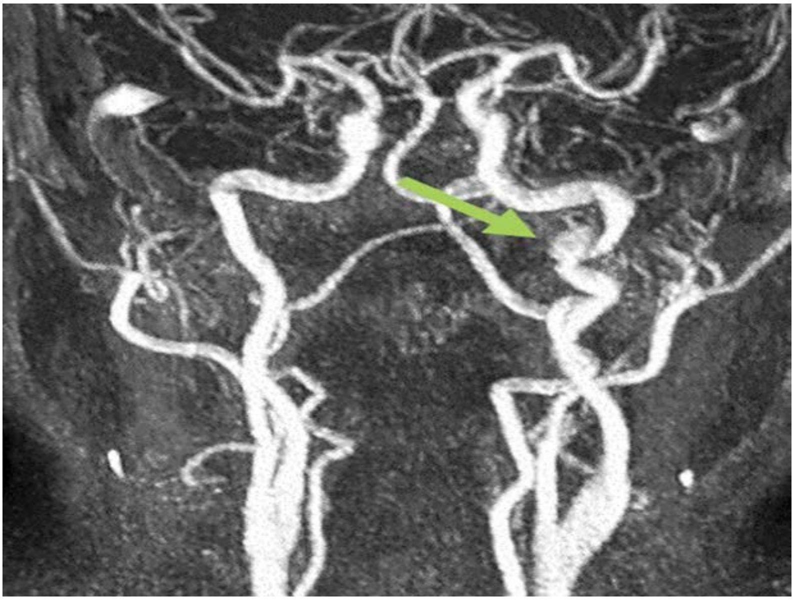


Figure 5: The MR angiography image demonstrates a saccular aneurysm arising from the supraclinoid segment of the internal carotid artery

3. Digital Subtraction Angiography (DSA)

DSA is essential for:

- Final pre-treatment hemodynamic evaluation
- Detecting inflow/outflow channels
- Confirming collateral pathways

- Tactical decisions such as whether parent vessel occlusion is acceptable

DSA findings may drastically change the treatment plan (e.g., detecting an unexpected dissection).

Figure 5. Angiogram view shows a pseudoaneurysm of the left ICA

Determining Treatment Objective: Preservation vs Sacrifice

This is the most critical decision.

1. Vessel Preservation Strategy

Preferred in:

- Internal carotid artery
- Dominant vertebral artery
- Common carotid artery

High-flow lesions where sacrifice would cause stroke

Preservation techniques include:

- Covered stent
- Flow-diverter stent
- Stent-assisted coiling

2. Parent Vessel Sacrifice

Possible when:

- The vessel is non-dominant (e.g. small vertebral artery)
- The lesion is infected (mycotic pseudoaneurysm)
- Vessel reconstruction is anatomically impossible
- The pseudoaneurysm is severely ruptured or destroyed

Balloon Test Occlusion (BTO) is used when internal carotid artery sacrifice is considered.

Access Route Planning

1. Femoral Access

- Advantages: stability, large catheter compatibility.

Most commonly used.

2. Radial Access

Advantages:

- Better navigation for type III aortic arch
- Reduced bleeding risk

- More patient comfort
- May be ideal for vertebral artery pseudoaneurysms.

3. Direct Cervical Access

Used for:

- Extremely tortuous anatomy
- Inability to advance stents via femoral/radial routes
- A last resort but lifesaving in difficult carotid lesions.

Device Selection Based on Lesion Morphology

1. Narrow-Necked Pseudoaneurysms

- Coil embolization
- Stent-assisted coiling (if preservation needed)

2. Wide-Necked Lesions

- Covered stent
- Flow-diverter
- Onyx embolization (in branches)

3. High-Flow Lesions

- Covered stent provides immediate exclusion
- Liquid embolics carry migration risk

4. Irregular, Multiseptated Cavities

- Onyx is superior due to its controlled filling behavior
- NBCA for rapid sealing in emergency situations

5. Long-Segment Dissection

- Flow diversion is preferred
- Multiple overlapping devices may be needed

Antiplatelet / Anticoagulation Planning

1. Stent-Based Treatment Requires:

- Dual antiplatelet therapy (DAPT) before and after treatment
- Intraprocedural heparinization
- Later transition to single antiplatelet therapy

2. Coil / Liquid Embolic Therapy

- Usually no prolonged antiplatelet therapy needed
- Exceptions exist when combined with stents

3. Mycotic Lesions

- Antiplatelet therapy used cautiously
- Antibiotic therapy is mandatory

Complex Scenario Planning

1. Ruptured Pseudoaneurysms

Immediate goals:

- Stop bleeding
- Protect airway
- Rapid exclusion (covered stent > coils > NBCA)

2. Multiple Pseudoaneurysms

Seen in:

- Vasculitis
- Connective tissue disorders
- Infection
- Severe trauma

Flow-diversion or staged treatments may be needed.

3. Pseudoaneurysm with Arteriovenous Fistula

Requires:

- Combined coil embolization + stent-graft
- Possible double-lumen occlusion techniques

Chapter 6

Imaging Follow-Up

Berkay Subaşı

Follow-up imaging is essential for confirming treatment success, detecting delayed complications, and ensuring the long-term durability of endovascular therapy. Because pseudoaneurysms can recur through coil compaction, stent failure, or persistent arterial injury, meticulous surveillance is mandatory.

Goals of Follow-Up Imaging

The imaging strategy must:

- Confirm total pseudoaneurysm exclusion
- Verify parent vessel patency
- Identify in-stent restenosis
- Detect endoleaks (covered stent)
- Document thrombosis progression after flow-diversion
- Identify recurrence or sac reperfusion
- Evaluate for infection or inflammatory changes

Early Follow-Up (First 24–72 Hours)

1. Doppler Ultrasound

Provides:

- Flow absence in pseudoaneurysm
- Sac thrombosis confirmation
- Stent graft patency
- Detection of early thrombosis

Advantages:

- Bedside availability
- Zero radiation

2. CTA

Indicated for:

- Covered stents (to rule out endoleak)
- Complex cavity embolization
- Wide-neck pseudoaneurysms

CTA assesses:

- Stent position
- Residual flow
- Thrombus burden
- Branch vessel patency

3. MRI/MRA

Useful when contrast cannot be given.

Evaluates soft tissues for:

- Hematoma
- Infection
- Edema

First Month (4-Week) Follow-Up

Key Objectives:

- Verify early neointimal coverage over stents
- Confirm coil stability
- Detect slow-flow recurrence
- Assess vascular remodeling after flow-diversion

CTA is preferred; MRA is acceptable.

Mid-Term Follow-Up (3–6 Months)

1. Doppler Ultrasound

To evaluate:

- Peak systolic velocity (PSV) gradients
- Early restenosis
- Flow alterations

2. CTA/MRA

To evaluate:

- Stent stenosis
- Persistent sac enhancement
- Vessel healing
- Chronic remodeling

Patients treated with flow-diversion often show full thrombosis around 6 months.

Long-Term Follow-Up (12 Months and Annually Thereafter)

Annual CTA or MRA is recommended to evaluate:

- Final endothelialization of flow-diverter
- Long-term patency of covered stent
- Coil compaction
- Late recurrence
- Secondary dissection or aneurysm formation

Pseudoaneurysms treated with coil-only techniques occasionally recur years later.

Modality-Specific Advantages and Limitations

1. Doppler Ultrasound

Advantages:

- Real-time
- Repeatable
- No radiation

Limitations:

- Deep vertebral arteries may be inaccessible
- Operator dependent

2. CTA

Advantages:

- Best resolution
- Excellent stent visualization

Limitations:

- Radiation
- Contrast nephropathy risk

3. MRA

Advantages:

- Excellent soft tissue contrast
- No radiation

Limitations:

- Metal artifact, especially in covered stents

4. DSA

Advantages:

- Gold standard for flow assessment
- Allows immediate retreatment

Limitations:

- Invasive
- Not suitable for routine follow-up

Detection and Management of Complications

1. In-Stent Restenosis

Common in:

- Young patients
- Hyperplastic response
- Covered stents

Treatment:

- Balloon angioplasty
- Additional stent insertion
- Drug-eluting balloon (select cases)

2. Endoleak

Particularly after covered stent placement.

Types:

- Type I: inadequate sealing → needs urgent repair
- Type II: retrograde filling
- Type III: fabric tear or stent fracture

3. Device Migration

Rare but serious.

Detected on CTA or DSA.

4. Infection

Especially with mycotic aneurysms.

Features:

- Soft tissue edema
- Persistent enhancement
- Gas formation

Management:

- Antibiotic therapy
- Possible stent explantation

Imaging follow-up plays a decisive role in evaluating treatment outcome, ensuring long-term success, and preventing life-threatening complications. A structured multimodality approach—Doppler ultrasound, CTA, MRA, and occasionally DSA—provides the most reliable surveillance in patients treated endovascularly for cervical pseudoaneurysms.

Table 1. Treatment Selection Table For Cervical Pseudoaneurysms

Pseudoaneurysm Feature	Recommended Treatment	Rationale / Notes
Narrow-neck, small sac	Coil embolization	Sac packing is usually sufficient; parent artery may be preserved or sacrificed.
Wide-neck saccular lesion	Covered stent **or** Flow-diverter	Vessel preservation required; stent-assisted coiling is another option.
Irregular, multilobulated, complex cavity	Onyx (EVOH) or NBCA	Liquid embolics fill irregular recesses; Onyx offers controlled injection.
High-flow traumatic pseudoaneurysm	Covered stent	Provides immediate exclusion; preferred for rapid hemorrhage control.
Dissecting pseudoaneurysm	Flow-diverter stent	Best for long-segment reconstruction; addresses the dissection plane.
Mycotic pseudoaneurysm	Parent vessel sacrifice ± coils/NBCA	Avoid stents due to infection risk; combined with prolonged antibiotics.
Distal branch artery pseudoaneurysm	NBCA **or** Onyx	Coils may be unstable in tiny vessels; liquid embolics are more effective.
Ruptured pseudoaneurysm / active bleeding	Covered stent (ICA/CCA) **or** NBCA	Rapid hemostasis is the priority.
Non-dominant vertebral artery lesion	Parent vessel occlusion	Safe sacrifice possible; coil trapping is ideal.

Table 2. Post-Treatment Imaging Follow-Up Algorithm

Time Interval	Preferred Imaging	Assessment Goals
24–72 hours	Doppler US ± CTA	Residual flow, stent position, early thrombosis, endoleak
1 month	CTA or MRA	Complete exclusion, early endothelialization, coil stability
3–6 months	Doppler US	Velocity changes (restenosis), residual sac flow
12 months	CTA or MRA	Final remodeling, stent patency, thrombosis completion
Annually	CTA/MRA or Doppler US	Late recurrence, coil compaction, delayed complications
If suspicion exists	DSA	Endoleak confirmation, device failure, planning for reintervention

TREATMENT PLANNING DECISION ALGORITHM

1. Clinical Assessment

- **Rupture / active bleeding / sentinel hemorrhage** → *Emergency treatment*
- **Symptomatic, enlarging, painful** → *Urgent treatment (within 24–72 h)*
- **Asymptomatic, stable** → *Elective treatment*

2. Imaging Evaluation (CTA + DSA)

Determine:

- Neck width
- Sac morphology (saccular, multilobulated, irregular)
- High-flow vs low-flow dynamics

- Presence of dissection
- Collateral circulation and dominance
- Relationship to bony/soft tissue structures

3. Define Primary Treatment Goal

- **Preserve parent artery?**
    - *Yes* → Covered stent / Flow-diverter / Stent-assisted coils
    - *No* → Parent vessel occlusion / Coil trapping / NBCA

4. Morphology-Based Treatment Selection

- **Narrow neck** → Coils
- **Wide neck** → Covered stent or Flow-diverter
- **Irregular or multilobulated cavity** → Onyx / NBCA
- **High-flow lesion** → Covered stent
- **Dissecting pseudoaneurysm** → Flow-diverter

5. Infection Assessment

- **Mycotic pseudoaneurysm?**
  → Avoid stents
  → Prefer parent vessel sacrifice + antibiotic therapy

6. Technical Planning

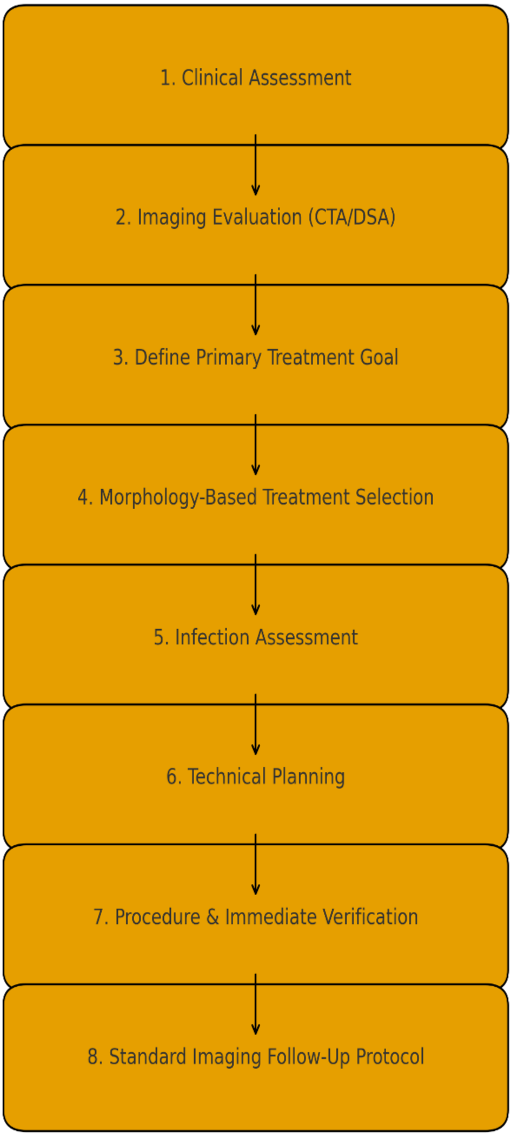
- Optimal access route (femoral/radial/direct cervical)
- Antiplatelet preparation (for stents)
- Balloon or stent assistance if needed
- Embolic protection if near ICA bifurcation

7. Procedure and Immediate Verification

- Intraprocedural DSA confirmation
- Additional device placement if needed

8. Implement Standard Imaging Follow-Up Protocol

(24–72 h → 1 month → 3–6 months → 12 months → annually)


1. Clinical Assessment
2. Imaging Evaluation (CTA/DSA)
3. Define Primary Treatment Goal
4. Morphology-Based Treatment Selection
5. Infection Assessment
6. Technical Planning
7. Procedure & Immediate Verification
8. Standard Imaging Follow-Up Protocol

Conclusion

Betül Tiryaki Baştuğ

Pseudoaneurysms of the neck represent a complex and potentially life-threatening vascular entity that demands early recognition, precise imaging assessment, and individualized therapeutic decision-making. The unique anatomy of the cervical region—where major neurovascular structures lie in close proximity—magnifies the clinical impact of even small pseudoaneurysms and underscores the need for meticulous diagnostic and therapeutic planning.

Advances in high-resolution ultrasonography, CT angiography, MR angiography, and digital subtraction angiography have dramatically improved clinicians' ability to characterize pseudoaneurysm morphology, assess rupture risk, and tailor endovascular approaches with confidence. Imaging now not only confirms the diagnosis but guides each step of treatment planning, from device selection to post-procedural surveillance.

Endovascular techniques have revolutionized the management of cervical pseudoaneurysms, offering effective, vessel-preserving solutions with significantly reduced morbidity compared with open surgery. Covered stents, flow-diverter stents, coil embolization, and liquid embolic agents provide a versatile armamentarium capable of addressing a wide range of lesion anatomies and etiologies—from traumatic and iatrogenic injuries to dissecting or mycotic pseudoaneurysms. Nevertheless, the therapeutic approach must always be individualized, taking into account lesion morphology, hemodynamic characteristics, parent vessel dominance, and the presence of infection or dissection.

Long-term success relies not only on appropriate treatment selection but also on structured imaging follow-up. Surveillance with Doppler ultrasonography, CTA, and MRA is essential to confirm complete exclusion of the pseudoaneurysm, maintain stent patency, and identify delayed complications such as restenosis, recurrence, or endoleak.

Ultimately, the management of cervical pseudoaneurysms requires a collaborative, multidisciplinary effort. Interventional radiologists, vascular surgeons, neurologists, and head and neck specialists must work together to ensure accurate diagnosis, optimal intervention, and vigilant long-term monitoring. As endovascular technologies continue to evolve, outcomes will further improve, reinforcing minimally invasive treatment as the cornerstone of contemporary care for pseudoaneurysms of the neck.

References

1. Saad NEA, Saad WEA, Davies MG, Waldman DL, Fultz PJ, Rubens DJ. Pseudoaneurysms and the role of minimally invasive techniques in their management. RadioGraphics. 2005;25(Suppl 1):S173–S189.

2. El-Sabrout R, Cooley DA. Extracranial carotid artery aneurysms: Texas Heart Institute experience. Journal of Vascular Surgery. 2000;31(4):702–712.

3. Zwolak RM, Whitehouse WM, Knake JE, Bernhard VM. Cervical carotid artery pseudoaneurysms. Journal of Vascular Surgery. 1984;1(3):415–422.

4. Welleweerd JC, den Ruijter HM, Nelissen BG, Bots ML, Kappelle LJ, Rinkel GJE, Moll FL, de Borst GJ. Management of extracranial carotid artery aneurysm. European Journal of Vascular and Endovascular Surgery. 2015;50(2):141–147.

5. Biller J, Adams HP, Boarini DJ, Godersky JC, Smoker WRK, Kongable G. Extracranial vertebral artery aneurysms and pseudoaneurysms. Stroke. 1992;23(11):1521–1528.

6. Loffroy R, Rao P, Ota S, De Lin M, Kwak BK, Krause D. Endovascular management of cervical arterial injuries. American Journal of Neuroradiology. 2010;31(3):538–545.

7. Pulli R, Dorigo W, Troisi N, Pratesi G, Innocenti AA, Pratesi C. Extracranial carotid artery aneurysms:

results of a 10-year experience. Annals of Vascular Surgery. 2013;27(6):687–693.

8. Krüger K, Zähringer M, Söhngen FD, Schulte O, Feldmann C, Stellbrink C. Femoral pseudoaneurysms: management with ultrasound-guided thrombin injection. Radiology. 2005;236(3):1104–1110.

9. Toursarkissian B, Allen BT, Petrinec D, Thompson RW, Rubin BG, Reilly JM, Flye MW, Sicard GA. Spontaneous closure of selected iatrogenic pseudoaneurysms. Journal of Vascular Surgery. 1997;25(5):803–808.

10. Dardik, A.& Lee, M. S. (2012). Carotid Artery Pseudoaneurysms: Pathophysiology and Management. Seminars in Vascular Surgery, 25(3), 173-181.

11. DuBose, J. J.& Recinos, G. (2016). Management of Traumatic Carotid Artery Injuries. Current Trauma Reports, 2(1), 1-9.

12. Ting, A. C.et al. (2019). Size and growth rate as predictors of rupture in common femoral artery pseudoaneurysms. Journal of Vascular Surgery, 69(6), 1859-1865.

13. Seth R, Obuchowski AM, Zoarski GH. Endovascular repair of traumatic cervical internal carotid artery injuries: a safe and effective treatment option. AJNR Am J Neuroradiol. 2013 Jun-Jul;34(6):1219-26. doi: 10.3174/ajnr.A3337. Epub 2012 Dec 6. PMID: 23221950; PMCID: PMC7964571.

14. Tsurukiri J, Okumura E, Yamanaka H, Jimbo H, Hoshiai A. Emergency endovascular treatment of a ruptured external carotid artery pseudoaneurysm caused by a cervical stab wound: A case report and literature review. Ulus Travma Acil Cerrahi Derg. 2017 Sep;23(5):433-437. doi: 10.5505/tjtes.2017.55560. PMID: 29052833.

15. Hori Y, Kiyosue H, Kashiwagi J, Asano T, Shuto R, Matsumoto Y, Nagatomi H, Mori H. Double stent technique for the treatment of an internal carotid artery pseudoaneurysm caused by zone III stab injury. J Vasc Interv Radiol. 2007 Oct;18(10):1300-4. doi: 10.1016/j.jvir.2007.06.032. PMID: 17911522.

16. Nguyen HS, Oni-Orisan A, Cochran J, Pollock G. Resection of a recurrent cervical internal carotid artery pseudoaneurysm after failed endovascular therapy. Surg Neurol Int. 2016 Jan 7;7(Suppl 2):S49-52. doi: 10.4103/2152-7806.173571. PMID: 26862461; PMCID: PMC4722514.

17. Hamasaki O, Ikawa F, Hidaka T, Kurokawa Y, Yonezawa U. Extracranial internal carotid artery pseudoaneurysm associated with neurofibromatosis type 1 treated with endovascular stenting and coil embolization. Vasc Endovascular Surg. 2014 Feb;48(2):176-9. doi: 10.1177/1538574413510623. Epub 2013 Nov 7. PMID: 24212405.

18. Aljalahma N, Husain F, Ashour A, Maresch M. Endovascular Treatment of Traumatic Vertebral Artery Pseudoaneurysm. Cureus. 2025 Feb

19;17(2):e79271. doi: 10.7759/cureus.79271. PMID: 39980713; PMCID: PMC11841818.

19. Dahman M, Abusulayman L, Alharbi N, Joueidi F, Abdulrahim O, Al-Omran M. Open repair of transverse cervical pseudoaneurysm. J Surg Case Rep. 2024 Apr 2;2024(4):rjae216. doi: 10.1093/jscr/rjae216. PMID: 38572277; PMCID: PMC10989297.

20. Sirakov S, Panayotova A, Sirakov A, Minkin K, Hristov H. Delayed intranasal coil extrusion after internal carotid artery pseudoaneurysm embolization. Interv Neuroradiol. 2019 Apr;25(2):139-143. doi: 10.1177/1591019918805151. Epub 2018 Oct 9. PMID: 30296867; PMCID: PMC6448381.

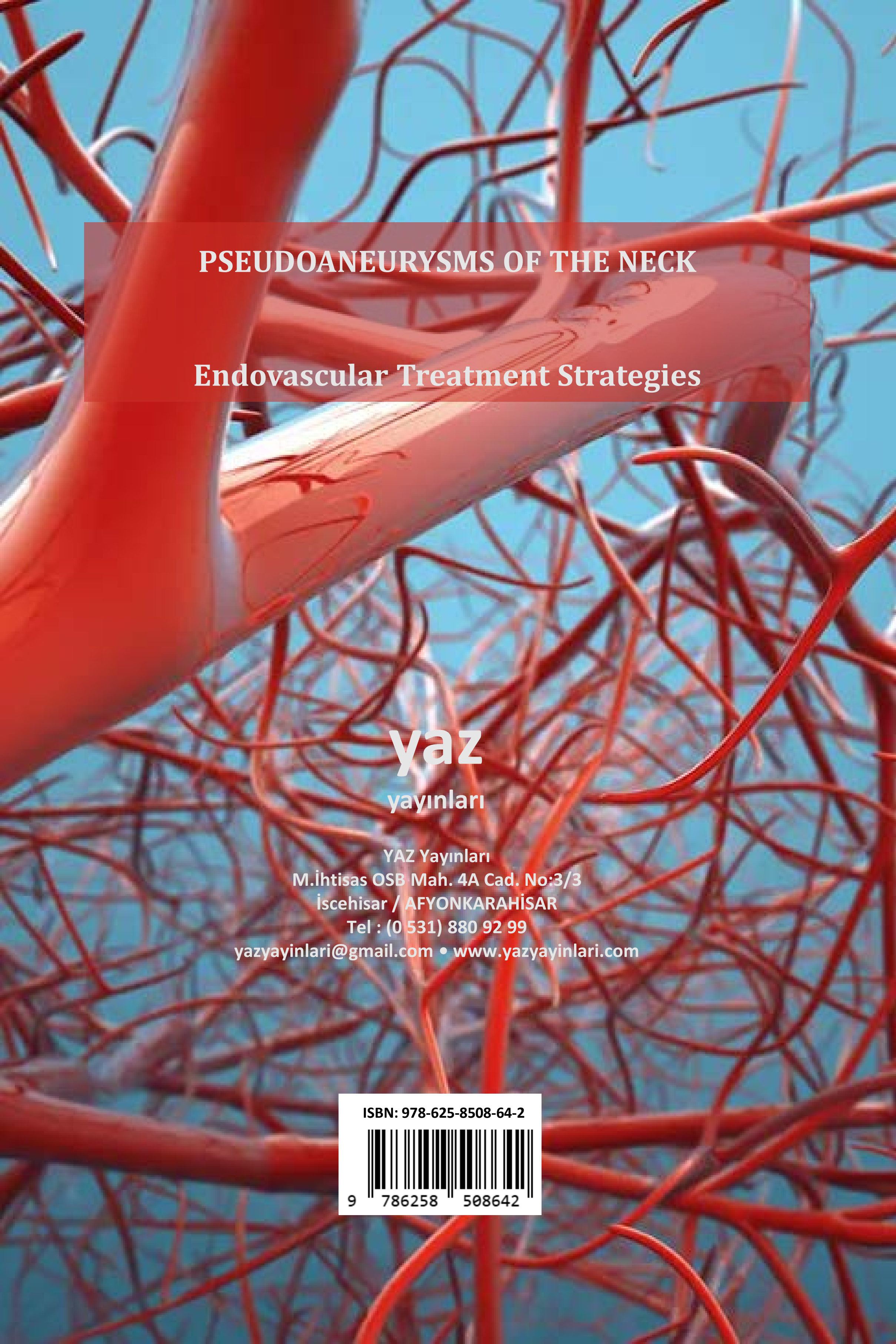
21. Yi AC, Palmer E, Luh GY, Jacobson JP, Smith DC. Endovascular treatment of carotid and vertebral pseudoaneurysms with covered stents. AJNR Am J Neuroradiol. 2008 May;29(5):983-7. doi: 10.3174/ajnr.A0946. Epub 2008 Feb 22. PMID: 18296552; PMCID: PMC8128593.

22. Aydin E, Gok M, Esenkaya A, Cinar C, Oran I. Endovascular Management of Iatrogenic Vascular Injury in the Craniocervical Region. Turk Neurosurg. 2018;28(1):72-78. doi: 10.5137/1019-5149.JTN.18189-16.1. PMID: 27593845.

23. Norris Q, Siegelman NA, Leckie S. Management and Follow-Up of a Traumatic Vertebral Artery Pseudoaneurysm: A Case Report on Pipeline Embolization and Recovery. Cureus. 2025 May

21;17(5):e84578. doi: 10.7759/cureus.84578. PMID: 40546632; PMCID: PMC12182220.

24. Karsonovich TW, Hawkins JC, Gordhan A. Traumatic Pseudoaneurysm of the Ascending Cervical Artery Treated with N-butyl Cyanoacrylate Embolization: A Case Report and Review of the Literature. Cureus. 2019 Dec 2;11(12):e6276. doi: 10.7759/cureus.6276. PMID: 31911869; PMCID: PMC6939969.



PSEUDOANEURYSMS OF THE NECK

Endovascular Treatment Strategies

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