Nurse Anesthetists' Roles in Caring for Patients Undergoing Endovascular Therapy for the Treatment of Unruptured Cerebral Aneurysms

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Abstract

This article reviews the roles of nurse anesthetist (NA) in the perioperative management of patients undergoing endovascular therapy (EVT) for unruptured cerebral aneurysms (UCAs). The EVT has emerged as a minimally invasive and effective treatment for UCAs, necessitating comprehensive perioperative care to optimize patient outcomes. In the pre-procedural phase, responsibilities include neurological and hemodynamic assessments, risk identification, and patient education to reduce anxiety and improve readiness. Intra-procedural care emphasizes maintaining hemodynamic stability, monitoring vital signs, and managing complications such as vasospasm, thromboembolism, and contrast reactions in collaboration with the interprofessional team. In the post-procedural phase, the NA provides vigilant monitoring for neurological deterioration, preventing vascular complications, and supporting recovery through patient education and discharge planning. By integrating evidence-based care plans to address risks such as hypertension, hemorrhage, impaired respiratory function, and hematoma, NAs play a critical role in enhancing safety and reducing complications. Their specialized expertise significantly advances perioperative nursing practice in complex neurointerventional procedures. This review also proposes structured nursing care plans that integrate risk-prevention strategies to support safe perioperative management in EVT procedures.

Keywords: Endovascular therapy; Cerebral aneurysm; Nurse anesthetist; Perioperative care; Patient safety

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Cerebral aneurysms are localized dilatations of intracranial arteries, typically resulting from structural defects in the vessel wall. These lesions most commonly occur at arterial bifurcations, where elevated hemodynamic stress contributes to vascular pathology. Histopathological analysis often reveals a compromised vessel architecture, characterized by thinning or absence of the tunica media and fragmentation of the internal elastic lamina, while the tunica adventitia remains, albeit with potential fibrin infiltration[1]. Among various morphological forms, saccular or "berry" aneurysms account for approximately 90% of all cases[2]. Other types include fusiform aneurysms, which are longitudinal enlargements of the vessel, as well as traumatic, infectious, dissecting, and microaneurysms, often associated with chronic hypertension[2].

From an epidemiological perspective, cerebral aneurysms are most frequently located in the anterior circulation of the circle of Willis, representing nearly 85% of all cases[3]. The primary clinical concern is the risk of rupture, which can lead to subarachnoid hemorrhage (SAH). SAH is a neurological emergency

What is already known about this topic?

EVT has become the preferred minimally invasive treatment for UCAs due to its lower morbidity, shorter recovery time, and improved procedural safety compared to traditional microsurgical clipping. In this context, nurses play a vital role throughout the perioperative process. Their responsibilities include preoperative neurological assessments, risk identification, and patient education, as well as intraoperative hemodynamic management and postoperative neurological monitoring. The role of NA is crucial in maintaining physiological stability, detecting early complications such as vasospasm, thromboembolism, or bleeding, and preventing access-site hematomas. Previous literature emphasizes that systematic and vigilant nursing interventions are essential for ensuring patient safety and achieving positive neurological outcomes in EVT procedures.

What does this study add?

This review synthesizes evidence regarding the role of NAs in EVT for UCAs. It highlights key perioperative nursing responsibilities and proposes practical nursing care plans, including neurological monitoring, hemodynamic management, and surveillance of vascular access sites. The review also presents a structured framework for perioperative nursing care to enhance patient safety and facilitate the early detection of procedure-related complications.

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associated with high morbidity and mortality. The management of unruptured cerebral aneurysms (UCAs) has increasingly shifted toward minimally invasive treatments, such as stenting and endovascular coiling, thereby necessitating comprehensive perioperative care.

The management of unruptured aneurysms differs substantially from that of SAH, particularly in terms of hemodynamic targets, procedural planning, and perioperative risk management[3].

Endovascular therapy (EVT) necessitates complex anesthetic management, strict hemodynamic control, and rapid response to neurological complications. Nurse anesthetist (NA) therefore plays a critical role in maintaining physiological stability, assisting in complication management, and supporting the neurointerventional team throughout the perioperative process.

Risk factors for cerebral aneurysm formation

The risk factors for the formation and rupture of cerebral aneurysms are multifactorial, encompassing well-documented non-modifiable and modifiable elements[4,5] (Table 1)[6-9]. Genetic susceptibility is also a significant component, evidenced by familial clustering and associations with genetic disorders such as autosomal dominant polycystic kidney disease[4,5]. Conversely, modifiable risk factors like hypertension and cigarette smoking are major contributors to aneurysm growth and rupture[4]. This comprehensive risk stratification is essential for guiding clinical management, informing primary prevention strategies, and facilitating critical decisions regarding the necessity and timing of intervention.

Clinical manifestations

The clinical presentation of a cerebral aneurysm is varied and largely dependent on its size, location, and rupture status. Unruptured aneurysms are often asymptomatic and are typically discovered incidentally during neuroimaging for unrelated neurological concerns. However, approximately 10% to 15% of unruptured aneurysms become symptomatic[1]. These symptoms may include localized headaches, cranial nerve palsies, or neurological deficits resulting from mass effect or compression of adjacent structures. For instance, an aneurysm near the optic or oculomotor nerve may cause visual disturbances, ptosis, or diplopia, reflecting direct neural impingement.

Data from the International Study of Unruptured Intracranial Aneurysms (ISUIA) trial further illuminate the spectrum of clinical presentations. In this study, unruptured aneurysms were diagnosed during the evaluation of various clinical symptoms (Table 2)[10].

Table 1. Risk factors for cerebral aneurysm formation[6-9]

Risk factors
Extreme age
Female sex
Uncontrolled hypertension
Current cigarette smoking
Alcohol abuse
Family history
Genetic disorders, e.g., polycystic kidney disease, pseudoxanthoma elasticum

Table 2. Clinical presentations of unruptured cerebral aneurysms[10]

Clinical presentations	%
Hemorrhage from another aneurysm	30.4
Headache	23.7
Ischemic cerebrovascular disease	10.6
Transient ischemic attack	10.5
Cranial nerve palsy	8.0
Seizure	2.9
Symptoms of mass effect	2.7
Subdural or intracerebral hemorrhage	1.2
Brain tumor	0.8
Degenerative CNS disease	0.4
Nonspecific neurologic symptoms	7.1

CNS=central nervous system

Diagnosis

The diagnostic approach to cerebral aneurysms integrates clinical history, physical examination, and radiological imaging. A history of hypertension is common, as it is a well-established risk factor for aneurysm formation and rupture. On examination, a patient may be hypertensive yet fully conscious, although those with significant hemorrhage may present with drowsiness, confusion, or coma, reflecting increased intracranial pressure (ICP) or diffuse brain injury.

Specific neurological signs can indicate the location and mass effect of an aneurysm. For example, a large aneurysm in the posterior communicating, posterior cerebral, or superior cerebellar artery may compress the oculomotor nerve, resulting in ipsilateral ptosis, pupillary dilation, and diplopia. Furthermore, hemiparesis or hemiplegia may occur if nearby motor tracts are affected. In cases of SAH, patients often report neck pain and stiffness, caused by meningeal irritation from blood in the subarachnoid space[11].

Definitive diagnosis of cerebral aneurysms relies primarily on advanced neuroimaging modalities that provide detailed visualization of the intracranial vasculature. Among these, magnetic resonance angiography (MRA) and computed tomography angiography (CTA) are widely used as non-invasive screening tools. For definitive anatomical characterization, particularly for pre-surgical planning, digital subtraction angiography (DSA) remains the gold standard[12]. DSA involves the catheter-based injection of a contrast agent and serial imaging, which provides superior spatial resolution and enables assessment of flow dynamics and wall morphology. Although invasive, DSA is indispensable in complex cases where precise localization and morphological assessment are critical for treatment decisions.

Treatment options for aneurysms

The management of cerebral aneurysms has evolved significantly over recent decades, with diverse treatment strategies tailored to the aneurysm's size, location, morphology, and rupture status, as well as patient-specific risk factors. Therapeutic approaches can be broadly categorized as microsurgical clipping and EVT, each with distinct indications and outcomes.

Microsurgical clipping is a traditional technique in which a titanium clip is placed across the neck of the aneurysm to exclude it from the cerebral circulation. Clipping offers the advantage of long-term durability and a lower risk of recurrence. However, it is associated with higher procedural morbidity, including risks of infection, hemorrhage, and neurological deficits, particularly in elderly patients or those with comorbidities[13].

EVT techniques, including coil embolization, stent-assisted coiling, and flow-diverting stents, have become the preferred treatment for many aneurysms due to their minimally invasive nature and favorable safety profile. Coils are deployed into the aneurysm sac to induce thrombosis, while stents are used to support coil placement or reconstruct the parent vessel in wide-necked or complex aneurysms. These methods have demonstrated high rates of aneurysm occlusion, lower rates of procedural complications, and shorter hospital stays compared to open surgery[14,15].

Despite substantial advancements in endovascular techniques, inherent limitations remain. Reported rates include procedural failure of 0% to 10%[3], complications in 5% to 10% of cases[16], unfavorable outcomes in 4% to 5%, and mortality in 1% to 2% of patients[17,18]. Regarding treatment durability, successful aneurysm obliteration is achieved in 86.1% of cases, while recurrence occurs in 24.4%, retreatment is required in 9.1%, and the annual risk of bleeding is approximately 0.2%[18]. The ISUIA reported 1-year morbidity and mortality rates of 6.4% and 3.1%, respectively[10].

Endovascular therapy for cerebral aneurysms

EVT has become a cornerstone in the management of cerebral aneurysms, providing a less invasive alternative to traditional microsurgical clipping. This technique was first introduced in 1990 with the development of electrolytically detachable platinum coils by Dr. Guido Guglielmi and colleagues, and subsequently received FDA approval in 1995[19,20]. Evidence from the International Subarachnoid Aneurysm Trial (ISAT) demonstrated that endovascular coiling was associated with more favorable outcomes than microsurgical clipping for ruptured aneurysms, contributing to the growing adoption of endovascular approaches[19]. Consequently, EVT has become widely used in the management of UCAs. The 2015 guidelines from the American Heart Association and American Stroke Association further provide recommendations for the management of UCAs[21]. Since then, advancements in endovascular technology have significantly improved the safety, efficacy, and accessibility of aneurysm treatment[22,23].

Coil embolization involves inserting detachable platinum coils into the aneurysm sac through a microcatheter. The coils trigger thrombosis within the sac, effectively disconnecting the aneurysm from the cerebral circulation. This technique is especially effective for small- to medium-sized aneurysms with narrow necks, offering long-lasting occlusion with minimal impact on the parent vessel[22].

Stent-assisted coiling is employed for wide-necked aneurysms where coil stability is a concern. A stent is deployed across the aneurysm neck to serve as a scaffold, preventing coil migration and enhancing the efficacy of long-term occlusion. This technique has demonstrated improved outcomes in morphologically complex aneurysms, although it carries a higher risk of thromboembolic complications, especially in the context of ruptured aneurysms[24].

Flow-diverting stents are designed to redirect blood flow away from the aneurysm while maintaining patency of the parent vessel. These devices promote gradual thrombosis and endothelial remodeling, making them ideal for large, giant, or fusiform aneurysms that are not suitable for coiling or clipping. Flow diversion has demonstrated promising results in aneurysm occlusion and vessel reconstruction;

however, careful patient selection is crucial due to the necessity for dual antiplatelet therapy and potential delayed complications[25].

Landmark studies—including ISAT[19], ISUIA[10], and UCA Study of Japan (UCAS)[26]—have reported superior 1-year outcomes with endovascular coiling compared with surgical clipping. However, these studies have limitations, including selection bias, incomplete follow-up, and relatively homogeneous populations.

Complications associated with endovascular therapy

1) Intraprocedural aneurysm rupture: Perforation of the aneurysm dome by a microwire, microcatheter, or coil loop is the most feared intra-procedural event[27]. Although rare, with reported rates between 1% and 4%, it is associated with very high morbidity and mortality[21,28].

2) Vessel injury: The parent artery from which the aneurysm arises may be injured during the procedure, leading to dissection or perforation. This can result in vessel occlusion, hemorrhage, or pseudoaneurysm formation[29].

3) Thromboembolic events: The most common complication of EVT is thromboembolism, which can lead to ischemic stroke[27]. Thrombi may form on catheters, microwires, or the implanted devices (coils, stents) and embolize distally.

4) Complications of antiplatelet therapy: While necessary to prevent ischemic events, dual antiplatelet therapy poses a significant risk of bleeding complications, which can range from minor systemic bleeding to severe gastrointestinal hemorrhage or life-threatening intracranial bleeding[28,29]. Balancing ischemic and bleeding risks is a key challenge in patient management.

5) Adverse reactions to contrast media: Contrast agents are crucial for visualizing vascular structures during EVT, especially in DSA-guided procedures[30]. However, their use can lead to a range of adverse reactions, from minor to severe, which may affect procedural safety and patient outcomes.

The management of UCAs involves complex ethical challenges, as decisions regarding intervention must balance the procedural risks of endovascular treatment against the natural history of rupture.

The role of NA in the care of patients with UCAs

The NA plays a crucial role in caring for patients undergoing EVT for cerebral aneurysms, especially in managing the complex physiological and neurological needs of this group.

Pre-procedural phase[31-33]

The pre-anesthetic assessment involves evaluating the patient's cerebrovascular condition, including the number, location, and size of all detected aneurysms. A thorough clinical evaluation entails recording baseline vital signs and performing a neurological exam to identify any pre-existing deficits. This neurological assessment should document the Glasgow coma scale (GCS) score, pupil size and reactivity, and the presence of focal neurological impairments.

Standard pre-procedural laboratory tests are necessary, including a complete blood count, serum electrolytes, coagulation profile, and baseline creatinine levels. Cross-matching or a type and screen is crucial to allow quick administration of blood products if intra-procedural hemorrhage occurs. Additionally, a chest radiograph and electrocardiogram (ECG) should be obtained.

Dual antiplatelet therapy assessment involves the NA playing a key role in evaluating patient adherence and coordinating with the interventional team about whether to continue or temporarily withhold these agents, to balance bleeding and thromboembolic risks properly. Patients are usually prescribed dual antiplatelet therapy—most often aspirin and clopidogrel—before the procedure[3].

Furthermore, a clear history of allergies to iodine, shellfish, or previously administered iodinated contrast media must be elicited. Given the risk of contrast-induced nephropathy[30], a history of renal impairment should be carefully assessed before contrast administration. Adequate hydration prior to the procedure is also recommended to reduce the risk of renal complications. Patients must remain nothing per oral (NPO) for 8 hours for solids and 2 hours for clear liquids before the procedure[32]. In emergency situations where the patient has not fasted, rapid sequence induction (RSI) combined with techniques to mitigate increased ICP must be employed[31].

Education, emotional support, and an explanation of the procedure are provided to help reduce anxiety. A key part of pre-procedural preparation is counseling the patient and family about potential complications of anesthesia. This discussion must include the risks of intra-procedural aneurysm rupture or re-bleeding and the possibility of delayed extubation requiring post-procedural mechanical ventilation[34].

Intra-procedural phase

During the induction of general anesthesia, the NA is responsible for closely monitoring vital signs, including ECG, blood pressure (BP), oxygen saturation (SpO_2), and end-tidal CO_2 ($ETCO_2$)[31,32,34]. The readiness of intravenous fluid administration and suction equipment must also be ensured. Concurrently, baseline peripheral circulation must be assessed by examining and documenting the patient's bilateral dorsalis pedis and posterior tibial pulses[35].

Maintaining BP within ±20% of the patient's baseline is crucial. Intravenous induction with short-acting agents like propofol or etomidate is preferred, as long as these are carefully titrated to avoid sudden BP changes[36]. To reduce the hemodynamic response during tracheal intubation, several pharmacologic strategies can be used. These include administering opioids such as fentanyl (2-3 μg/kg), β-adrenergic blockers (e.g., esmolol 1.5 mg/kg)[36-38], labetalol (10-20 mg), an additional dose of propofol (0.5-1 mg/kg), or increasing the anesthetic depth with a volatile agent like sevoflurane before intubation[36].

During the procedure, the primary goal is to maintain hemodynamic stability. The NA is responsible for preventing two critical complications: hypertension, which increases the risk of aneurysm rupture or re-bleeding[39], and hypotension, which can cause inadequate perfusion of ischemic brain tissue. A smooth emergence from anesthesia is essential to minimize the risk of coughing[31,34], which can lead to increased ICP.

Specific considerations and intra-procedural complications

- Heparinization: The NA manages systemic heparinization to prevent thromboembolic events. After a baseline activated clotting time (ACT) is recorded, an initial heparin dose of 70 to 100 units/kg is administered intravenously[30]. ACT levels are monitored regularly throughout the procedure, maintaining a target of 280 to 300 seconds (2-3 times baseline) through hourly heparin boluses as ordered[32].
- Vasospasm: Catheter and stent placement within the vessel can trigger vasospasm. To prevent or reduce this complication, vasodilators may be administered continuously during the procedure. It is essential that the anesthesiologist and NA are immediately informed when these agents are used to manage potential drug interactions with anesthetics and to maintain the patient's hemodynamic stability[32]. During vasospasm episodes, arterial BP might need to be kept slightly higher than usual to ensure adequate cerebral perfusion. However, systolic pressure generally should not exceed 160 mmHg to lower the risk of re-bleeding[40]. Nimodipine, a calcium channel blocker, is frequently used to promote vasodilation of cerebral blood vessels[38].
- Ruptured aneurysm: This constitutes a neurological emergency requiring immediate heparin reversal with protamine at a dose of 1 mg per 100 units of heparin. Concurrently, hemodynamic management involves precise arterial pressure modulation to minimize further bleeding while maintaining normocapnia or inducing transient hypocapnia to reduce intracranial pressure and support optimal cerebral perfusion. Finally, to combat increased ICP, emergency strategies include the administration of cerebral diuretics such as mannitol (0.5-1.0 g/kg) or hypertonic saline (3-5 mL/kg) and the placement of an external ventricular drain[30].

Post-procedural phase

During the recovery phase, patients are monitored for signs of neurological deterioration, vasospasm, or delayed cerebral ischemia. The patient should be transferred to an appropriate recovery setting—either the post-anesthesia care unit or an intensive care unit, depending on clinical need. Continuous and close monitoring of hemodynamic and neurological status is essential to promptly identify and manage potential post-procedural complications[31].

Following the procedure, the patient must remain on strict bed rest with the affected limb immobilized for approximately 8 hours, strictly avoiding limb flexion. The puncture site should be closely monitored for signs of bleeding or hematoma formation. Peripheral circulation of the affected limb must be regularly assessed by evaluating the dorsalis pedis and posterior tibial pulses, skin temperature, and color. The NA should also perform the '6 Ps' assessment[41]—pulselessness, pallor, pain, poikilothermia, paresthesia, and paralysis—to facilitate early detection of distal arterial occlusion and identify potential complications[32].

Nurse-led patient education is essential after discharge. The nurse must ensure the patient understands the importance of adhering to dual antiplatelet therapy for six months to prevent recurrence. Additionally, the nurse is responsible for teaching the patient how to monitor BP and reinforcing the importance of scheduled follow-up appointments at 1 to 3 months and at 6 months post-discharge[32].

Nursing care plan for patients undergoing EVT for cerebral aneurysm

Comprehensive nursing care has been shown to contribute significantly to improved clinical outcomes, including shorter hospital stays, enhanced responsive-

Table 3. Nursing care plan for nurse anesthetists during endovascular therapy

Nursing diagnosis	Goal & Expected outcome	Nursing interventions	Rationale
Risk for vasospasm related to intravascular catheter or stent placement, provoking arterial constriction[32].	To prevent or promptly detect cerebral vasospasm, thereby maintaining adequate cerebral perfusion.	1) Perform hourly neurological and vital sign assessments on patients awaiting endovascular procedures during high-risk periods to detect early indicators of vasospasm, such as changes in level of consciousness, restlessness, or confusion. 2) Maintain euvolemia and target blood pressure to support cerebral perfusion. 3) Administer nimodipine as prescribed to reduce the risk of delayed cerebral ischemia associated with vasospasm. 4) Maintain SpO_2 above 95% and monitor respiratory function closely, providing ventilatory support as needed. 5) Enforce aneurysm precautions by maintaining bed rest, elevating the head 15 to 30°, and avoiding activities that raise ICP.	Early recognition of vasospasm allows prompt intervention and reduces the risk of delayed cerebral ischemia.
Risk for hypertension related to the stress-induced physiological responses of intubation and stent deployment.	The patient will not experience complications related to acute hypertension.	1) Perform gentle and smooth intubation using a video laryngoscope. 2) Utilize a gentle technique, avoiding excessive force during blade insertion and tube placement. 3) Monitor blood pressure closely, at intervals not exceeding 2.5 minutes during the procedure. In high-risk cases, consider invasive arterial blood pressure monitoring. 4) Administer antihypertensive agents as needed to maintain blood pressure within ±20% of the patient's baseline(31,32). 5) Maintain an adequate depth of anesthesia during stent deployment to prevent severe hypertensive responses. 6) Collaborate and communicate effectively with the anesthesia and interventional neuroradiology teams.	Hypertension increases the risk of aneurysm rupture or re-bleeding during EVT.
Risk for impaired respiratory function related to residual anesthetic agents	The patient will maintain a patent airway and adequate gas exchange.	1) Monitor respiratory rate, depth, and SpO_2 continuously during the immediate post-anesthesia period. 2) Assess for signs of airway obstruction such as snoring, stridor, or the use of accessory muscles. 3) Educate the patient on deep breathing techniques to prevent post-operative respiratory complications and promote lung expansion following general anesthesia.	Early detection of respiratory depression reduces the risk of hypoxia and postoperative pulmonary complications following general anesthesia.
Risk for ICP related to neurological changes.	Maintenance of baseline neurological function and adequate cerebral perfusion, characterized by the absence of Cushing's triad and other signs of increased ICP.	1) Maintain regular vital signs and clinical monitoring, prioritizing the detection of symptomatic clusters indicative of increased ICP, such as persistent headache, nausea, projectile vomiting, papilledema, and acute deterioration in the level of consciousness(42). 2) Frequent assessment of GCS, level of consciousness, muscle strength, and sensory responses is essential, as neurological changes may indicate rising ICP. 3) Evaluate respiratory function for signs of impairment potentially caused by residual anesthetic agents. 4) Maintaining neutral head position and avoiding the Valsalva maneuver.	Early detection of neurological changes helps prevent secondary brain injury.
Risk of groin hematoma and bleeding may follow sheath removal.	To minimize the risk of hematoma and bleeding at the femoral access site post-sheath removal.	1) Obtain a blood sample to assess ACT; sheath removal may be appropriate if the ACT is below 180 seconds. 2) Assess the groin puncture site following sheath removal and manual compression for any signs of bleeding or hematoma formation. 3) Assess for distal arterial occlusion by evaluating for signs such as pulselessness, pallor, pain, poikilothermia, paresthesia, and paralysis (the "6 Ps")(41). This includes palpating the dorsalis pedis and posterior tibial pulses to ensure peripheral perfusion. 4) Promote complete bed rest and immobilization of the access limb for 8 hours to minimize the risk of post-procedural hematoma(31). 5) Provide a thorough handoff for continuous post-procedural care, emphasizing prevention of hematoma at the puncture site.	Early identification of vascular complications prevents severe bleeding and limb ischemia.

SpO_2=oxygen saturation; ICP=intracranial pressure; EVT=endovascular therapy; GCS=Glasgow coma scale; ACT=activated clotting time

ness to emergencies, and reduced complications. Key nursing diagnoses and associated interventions for the NA during the procedure are as follows (Table 3).

Conclusion

Nurses play an essential role in the safe and effective delivery of EVT for cerebral aneurysms. Nursing responsibilities range from pre-procedural assessment and intra-procedural monitoring to post-procedural care, ensuring physiological stability and early detection of complications. Through interprofessional collaboration and patient-centered education, nursing interventions are crucial for improving outcomes and reducing procedural risks in cerebrovascular patient care.

Authors' contributions

TN conceptualized the study, conducted the literature search, and drafted and refined the manuscript. RT contributed to the literature search and manuscript revision. PC supervised the study, provided oversight, and critically reviewed the manuscript. All authors reviewed and approved the final version.

Conflicts of interest

The authors declare no conflicts of interest.

Data availability statement

Data sharing is not applicable to this article.

Ethics approval and consent to participate

Not applicable.

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