Stroke

AHA SCIENTIFIC STATEMENT

# Care of the Patient With Acute Ischemic Stroke (Endovascular/Intensive Care Unit-Postinterventional Therapy): Update to 2009 Comprehensive Nursing Care Scientific Statement

## A Scientific Statement From the American Heart Association

*Endorsed by the American Association of Neuroscience Nurses*

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**ABSTRACT:** Ischemic stroke remains the fifth leading cause of death in the United States. Nurses play a pivotal role in the care of patients throughout the continuum. With the advances in stroke care, including mechanical thrombectomy, the American Heart Association/American Stroke Association charged the writing panel to complement the 2009 clinical practice guideline, "Comprehensive Overview of Nursing and Interdisciplinary Care of the Acute Ischemic Stroke Patient," with current evidence-based nursing care. This update is 1 of a 3-part series focusing on emergency medical services/emergency care, endovascular/intensive care unit care, and postacute care. The aim of this scientific statement is to review and present current evidence, complications, best practices, and clinical practice strategies to provide current comprehensive scientific information for nursing care in the neuroendovascular area and intensive care unit in conjunction with medical treatments, including intravenous thrombolysis and mechanical thrombectomy.

**Key Words:** AHA Scientific Statements ■ intensive care units ■ ischemic stroke ■ mechanical thrombolysis ■ nursing care ■ thrombolytic therapy



Ischemic stroke is the fifth leading cause of death in the United States, maintaining a rate of 37.1/100 000 people in 2018, and the leading cause of disability. The following statistics are according to the 2020 American Heart Association (AHA) Heart Disease and Stroke Update[1]:

*Approximately 610 000 of these are first attacks and 185 000 are recurrent attacks (GCNKSS [Greater Cincinnati/Northern Kentucky Stroke Study], National Institute of Neurological Disorders and Stroke [NINDS], and National Heart, Lung, and Blood Institute; GCNKSS and NINDS data for 1999 provided July 9, 2008; unpublished estimates compiled by the National Heart, Lung, and Blood Institute).*

*Of all strokes, 87% are ischemic, 10% are intracerebral hemorrhage, and 3% are subarachnoid hemorrhage (GCNKSS, NINDS, 1999; unpublished National Heart, Lung, and Blood Institute tabulation).*

*On average, every 40 seconds, someone in the United States has a stroke (AHA computation based on the latest available data).*

Intravenous thrombolysis remains the standard treatment of acute ischemic stroke (AIS). After a series of positive results from randomized international clinical



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trials published in early 2015, mechanical thrombectomy (MT), with or without intravenous thrombolysis, became an additional standard of care in the United States for AIS large vessel occlusion.[2] Approximately 30% of patients with AIS have large vessel occlusion; MT has immense potential to prevent severe disability and mortality.[3] On the basis of results from DAWN (Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention With Trevo) and DEFUSE (Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke), practitioners increased the number of patients with stroke identified for MT.[4,5] Because of this, the number of patients receiving MT has increased over the past 5 years.

Nurses continue to play a pivotal role in the care of patients with stroke through coordination of care across the continuum.[6] The addition of MT for stroke treatment calls for updated nursing clinical practice for these patients. The AHA/American Stroke Association charged the writing panel to update the 2009 scientific statement, "Comprehensive Overview of Nursing and Interdisciplinary Care of the Acute Ischemic Stroke Patient"[6] with a current scientific statement on nursing care for the patient with AIS after reperfusion therapy with intravenous thrombolytic or MT. Research is continuing to emerge in the literature on nursing care of patients with AIS undergoing these therapies. The aim of this statement was to review and present current evidence, complications, and best practices, including clinical practice guidelines, to provide comprehensive information for nursing care in the endovascular area and intensive care unit (ICU) in conjunction with medical treatment, including intravenous thrombolysis. This scientific statement is in union with the scientific statements of emergency department acute care and acute care on the stroke unit. Practitioners will find information presented on care in the endovascular area, complications with MT and intravenous thrombolytic therapy, and care in the ICU.

## ENDOVASCULAR NURSING CARE

Interventional nurses are responsible for the preprocedural, periprocedural, and postprocedural nursing care of this population. Nurses anticipate the needs of the patient, recognize potential complications of the procedure, and maintain patient safety. Patients with stroke with disabling symptoms attributable to large vessel occlusions are at high risk for neurological deterioration, airway compromise, and hemodynamic complications. During the MT procedure, the interventional nurse plays a key role in assessing for the prevention, early identification, and monitoring of signs of decline; administration of procedural medications; procedural documentation; and preprocedural/postprocedural transition-of-care communication with emergency departments, transferring organizations, and ICU staff.

**Table 1. Mallampati Classification**

| Mallampati classification | Visualization |
|---|---|
| Class I | Soft palate, fauces, anterior pillar, and posterior pillar |
| Class II | Soft palate, fauces, and entire uvula |
| Class III | Soft palate and base of uvula |
| Class IV | Hard palate only, soft palate not visible |

The interventional team generally consists of 2 to 3 staff in addition to the proceduralist. The staff members include nursing and radiology. The neurointerventional nurse performs the role of circulator or sedation nurse. The radiology technologists assist with obtaining angiographic imaging; they may also document the procedure or be assigned the circulator role. Depending on the organization requirement, anesthesiologists or nurse anesthetists assist with airway management, administration of anesthesia, and stabilization of the patient. This role may vary depending on the patient, practitioner availability, and local clinical practices such as the use of general anesthesia versus moderate (conscious) sedation.

### Preprocedural Care

Before the start of the procedure, at a minimum, the nurse verifies documentation by a provider of the patient's history and physical examination, as well as airway assessment to predict the ease of endotracheal intubation with a Mallampati score (Table 1) and determination of the American Society of Anesthesiologists physical status classification to predict the anesthetic and surgical risk according to the patients' physical health and comorbidities (Table 2).[7–9] Before the procedure, recognition of patients who may require more aggressive airway management is critical. Patients with decreased mental status, posterior circulation involvement, high National Institutes of Health Stroke Scale (NIHSS) score, or major comorbid cardiopulmonary disease are more likely to require extra support and intubation. For patients undergoing MT procedures under moderate sedation, it is reasonable to provide supplemental oxygen to maintain oxygen saturation >94%; however, there are no data to show a benefit in patients with stroke who are not hypoxic.[10] Informed consent for the procedure should be obtained if required.

Practice guidelines support performance of a preprocedural nursing assessment.[7,9,11,12] This information is obtained during hand-off communication with the emergency department, acute stroke team, or transferring organization. The information includes a review of the patient's history and physical examination, medications, allergies, nil per os status (if possible), and weight; performance of neurological and cardiopulmonary assessments; and assessment of vital signs, including heart rate,

**Table 2. Current Definitions and American Society of Anesthesiologists Classification**

| ASA classification | Definition | Adult examples, including, but not limited to: |
|---|---|---|
| ASA I | A normal, healthy patient | Healthy, nonsmoking, no or minimal alcohol use |
| ASA II | A patient with mild systemic disease | Mild diseases only without substantive functional limitations. Examples include (but not limited to) current smoking, social alcohol drinking, pregnancy, obesity (30 kg/m²<BMI<40 kg/m²), well-controlled diabetes/hypertension, mild lung disease |
| ASA III | A patient with severe systemic disease | Substantive functional limitations; ≥1 moderate to severe diseases. Examples include (but not limited to) poorly controlled diabetes or hypertension, COPD, morbid obesity (BMI ≥40 kg/m²), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD and undergoing regularly scheduled dialysis, premature infant PCA <60 wk, history (>3 mo) of MI, CVA, TIA, or CAD/stents |
| ASA IV | A patient with severe systemic disease that is a constant threat to life | Examples include (but not limited to) recent (<3 mo) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD, or ESRD and not undergoing regularly scheduled dialysis |
| ASA V | A moribund patient who is not expected to survive without the operation | Examples include (but not limited to) ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology, or multiple organ/system dysfunction |
| ASA VI | A patient declared brain-dead whose organs are being removed for donor purposes | |

ARD indicates acute respiratory distress; ASA, American Society of Anesthesiologists; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; CVA, cardiovascular accident; DIC, disseminated intravascular coagulation; ESRD, end-stage renal disease; MI, myocardial infarction; PCA, postconceptional age; and TIA, transient ischemic attack.

*The addition of E denotes emergency surgery: (an emergency is defined as existing when delay in treatment of the patient would lead to a significant increase in the threat to life or body part).[7]

blood pressure, pulse oximetry, ventilatory status, and pain assessment.[11,12] Practice guidelines also support identification of a history of airway compromise or prior adverse reactions to sedation or anesthesia if known.[7,9,11,12] In addition, hand-off communication includes information on treatments completed before acceptance into the endovascular suite and responses. Although no single evidence-based standard for frequency of vital signs and neurological assessments exists, it is reasonable to assess at least every 30 to 60 minutes before the MT procedure or more frequently when intravenous thrombolytics are administered. The frequency of post–intravenous thrombolytic assessments follows the current recommendation (Table 3). When intravenous antihypertensive or vasopressor medications are administered to manage blood pressure, frequent assessments follow the AHA/American Stroke Association guidelines.[10] An NIHSS score is documented before MT.[9] Best practice demonstrates that the NIHSS should be completed at hand-off communication with the transferring department. The neurological nursing assessment includes a baseline focused assessment on the cardinal symptoms with which the patient presented. This allows the nurse to recognize whether the patient deteriorates and to anticipate when an additional neurological assessment would need to be completed. Before the procedure, it is reasonable for nurses to perform and document a limited baseline assessment of the patient's level of arousal, cranial nerves, motor and sensory response, and coordination.

In anticipation of any endovascular intervention, including MT, via a transradial or femoral artery approach, a baseline neurovascular assessment of the patient's extremities is obtained before the procedure. The neurovascular assessment of the extremity includes assessment of pulses distal to the anticipated arterial access site, capillary refill, skin color, and temperature. Most commonly, the Allen test or Barbeau test is used as a baseline assessment of the radial artery for a transradial approach.[13] Abnormalities identified in the preprocedural assessment are relayed to the physician before the procedure, keeping in mind that time is of the essence.[7,9,11,12]

## Periprocedural Care

Universal protocol, or time-out, is completed and documented according to the organization's policy immediately before MT. Periprocedural monitoring follows current practice guidelines, which support the assessment of vital signs, including electrocardiographic rhythm, pulse, blood pressure, respiratory rate, blood oxygen level ($Spo_2$) by pulse oximetry, end-tidal carbon dioxide by capnography, pain level, anxiety level, and level of consciousness once the patient arrives in the procedure room. Vital signs and level of conscious assessments are performed every 5 minutes during the procedure.[7,11,12]

The principles of blood pressure management during MT entail maintaining sufficient cerebral perfusion pressure to collaterals to an ischemic penumbra. This is accomplished while mitigating the risk of complications from excessive hypertension that can lead to intracerebral hemorrhage, especially once the cerebral artery is recanalized, and possible end-organ damage. Hypotension, conversely, may lead to failure of collateral perfusion and extension of the infarct. Patients with stroke

**Table 3. Monitoring Frequency**

| | Assessment | Frequency |
|---|---|---|
| Thrombectomy (MT) (no thrombolytic) | | |
| Before the procedure | Vital signs,* neurological check, arteriotomy site, distal pulse/circulation | Every 30 min |
| During the procedure | Vital signs,† neurological check when indicated | Every 5 min |
| After the procedure | Vital signs,† neurological check | Every 15 min for 2 h, every 30 min for 6 h, every 1 h for 16 h |
| | Arteriotomy site, distal pulses/circulation | Every 15 min for 1 h, every 30 min for 1 h, every 1 h for 4 h |
| Thrombectomy (MT) (with intravenous thrombolytic) | | |
| Before the procedure | Vital signs,* neurological check | Every 15 min for 2 h, every 30 min |
| During the procedure | Vital signs,† neurological check when indicated | Every 5 min |
| After the procedure | Vital signs,* neurological check | Every 15 min for 2 h, every 30 min for 6 h, every 1 h for 16 h |
| | Arteriotomy site, distal pulses/circulation | Every 15 min for 1 h, every 30 min for 1 h, every 1 h for 4 h |

MT indicates mechanical thrombectomy.
*Blood pressure, heart rate, respiratory rate, and blood oxygen level ($Spo_2$).
†Blood pressure, heart rate, respiratory rate, $Spo_2$, and end-tidal carbon dioxide by capnography.

commonly present with elevated blood pressure but are otherwise hemodynamically stable. Specific goals for blood pressure parameters during and immediately after MT procedures are a topic of intense interest and research.[14–21] The optimal range of blood pressure for the best outcomes is not known. Some observational studies show an association between lower blood pressures and worse outcomes, whereas others have not.[22–28] No studies have addressed the treatment of low blood pressure in patients with stroke. According to the AHA/American Stroke Association 2019 clinical practice guidelines, in patients for whom MT is planned who have not received intravenous thrombolytics, it is reasonable to maintain a blood pressure <185/110 mm Hg before the procedure.[10] For those patients who received intravenous thrombolytics before MT, the guidelines recommend a goal of <180 mm Hg systolic.[10] Options for treating hypertension in patients undergoing MT such as labetalol, nicardipine, or clevidipine are listed in Table 4. Spontaneous circulatory collapse or cardiac arrest, although possible, is uncommon.[6] The occurrence of either may indicate other medical conditions such as acute myocardial infarction, atrial fibrillation, or congestive heart failure.

In MT procedures without anesthesia providers present, the sedation nurse may administer procedural sedation under the direction of a practitioner privileged in sedation. The sedation nurse monitors the patient according to the current recommendations of the American Society of Anesthesiologists. Nurses should reference the organization's policy and procedure when administering moderate sedation.[9,12] Levels of consciousness are stated in American Society of Anesthesiologists practice guidelines.[7] With moderate sedation, no interventions are required to maintain a patent airway, and spontaneous respirations are adequate.[7] During the procedure, assessment and documentation of depth of sedation are according to the organization's facility-specific objective scale (eg, American Society of Anesthesiologists Continuum of Sedation Scale, Ramsay Sedation Scale). Nurses should be educated on the scale.[12] Reversal medications for opioid and benzodiazepine medications should be readily available in the procedure room. Nurses administering sedation and analgesia should be experienced and certified in advanced cardiac life support and airway management.[7,9,12] Certification for sedation providers may be required by an organization or by some states.[12] Emergency equipment should be kept in the endovascular suite or at a central location in the event of unforeseen complications such as cardiac arrest or vessel perforation resulting in acute hemorrhage. Airway equipment, including suction with tubing and oral and nasal airways, should be immediately available in the endovascular suite. Nursing staff also should be knowledgeable in caring for patients with neurological emergencies such as increases in intracranial pressure (ICP), external ventricular drainage, and blood pressure management.[9]

In MT with anesthesia provided by an anesthesiologist or nurse anesthetist, the interventional nurse may fill the circulator role. As a circulator, nurses may be required to retrieve endovascular devices during the procedure. Therefore, nurses must have education on the products used in the endovascular area. Familiarity with these devices will help with quick retrieval during the procedure and may positively affect the time to recanalization.[9]







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**Table 4. Treatment Recommendations for Blood Pressure Management in AIS**

| COR IIb | LOE C-EO |
|---|---|
| Patient otherwise eligible for emergency reperfusion therapy except that BP is >185/110 mm Hg | |
| Labetalol 10–20 mg intravenous over 1–2 min, may repeat 1 time or | |
| Nicardipine 5 mg/h intravenous, titrate up by 2.5 mg/h every 5–15 min, maximum 15 mg/h; when desired BP reached, adjust to maintain proper BP limits; or | |
| Clevidipine 1–2 mg/h intravenous, titrate by doubling the dose every 2–5 min until desired BP reached; maximum of 21 mg/h | |
| If BP is not maintained <185/110 mm Hg, do not administer alteplase | |
| Management of BP during and after alteplase or emergency reperfusion therapy, maintain BP <180/105 mm Hg | |
| Monitor BP every 15 min for 2 h from the start of alteplase therapy, then every 30 min for 6 h, and then every hour for 16 | |
| If systolic BP 180–230 mm Hg or diastolic BP >105–120 mm Hg | |
| Labetalol 10 mg intravenous followed by a continuous infusion 208 mg/min; or | |
| Nicardipine 5 mg/h intravenous, titrate up to desired effect by 2.5 mg/h every 5–15 min, maximum 15 mg/h; or | |
| Clevidipine 1–2 mg/h intravenous, titrate by doubling the dose every 2–5 min until desired BP reached; maximum of 21 mg/h | |
| If BP not controlled or diastolic BP >140 mm Hg, consider intravenous sodium nitroprusside | |

Different treatment options may be appropriate in patients who have comorbid conditions that may benefit from rapid reductions in BP such as acute coronary event, acute heart failure, aortic dissection, or preeclampsia/eclampsia. AIS indicates acute ischemic stroke; BP, blood pressure; COR, Class of Recommendation: and LOE, Level of Evidence.

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## Postprocedural Care

The postprocedural monitoring phase begins at completion of the MT procedure and sheath removal, once hemostasis is achieved. Sheath removal time and time of hemostasis should be documented in the medical record. Current evidence supports completing a repeat neurological assessment immediately after the procedure.[9] If the patient received intravenous thrombolytics, it is reasonable for vital sign and neurological monitoring after MT to follow the same manufacturer's guidelines for intravenous thrombolytic therapy: every 15 minutes for 2 hours, every 30 minutes for 6 hours, and every hour for 16 hours.[6,9] Standardization leads to a decrease in errors; therefore, even if thrombolytics were not given, it is reasonable for the nurse to restart monitoring vital signs and neurological status every 15 minutes for 2 hours, every 30 minutes for 6 hours, and every hour thereafter according to current ICU standards of care.

Hemostasis may be achieved through manual pressure or a closure device. If manual pressure is used, compression should be for 15 to 20 minutes for a femoral artery approach. For a transradial artery approach, 10 minutes is recommended to achieve hemostasis.[9] The length of time that the affected extremity is immobilized depends on the location of the vascular access site and whether hemostasis was obtained with manual compression or a vascular closure device.[9] When a compression band is used for transradial approach, nurses must follow the manufacturer's recommendation for release of pressure.

Nurses monitor for access complications such as arterial spasm, pain, swelling, bruising, erythema, bleeding, hematoma, pulsatile mass, and drainage from the puncture site.[9,30] The affected extremity is also assessed for neurovascular compromise.[9,30,31] The neurovascular postprocedural assessment includes assessment of pulses distal to the arterial access site, capillary refill, skin color, temperature, sensation, and motor function.[9] The combination of pulse oximetry and plethysmography may be used to assess circulation distal to the transradial access site.[30,31] These serial assessments are compared with preprocedural baseline assessments. Changes from baseline assessment are verified and communicated to the proceduralist or the admitting team. Current practice supports that vascular access site and neurovascular assessments be completed and documented frequently.[31] Best practice is for extremity assessments to be completed and documented every 15 minutes for 1 hour, every 30 minutes for 1 hour, and every hour for 4 hours. These assessments continue seamlessly on transfer.

# COMPLICATIONS

## Mechanical Thrombectomy

MT is also associated with intraprocedural or postprocedural complications. These complications may be ischemic or hemorrhagic and symptomatic or asymptomatic. Reported procedure-related complication rates noted in trials varied between 4% and 29% and in prospective studies and registries between 7% and 31%.[32] Device-related complications include vasospasm, arterial perforation and dissection, and device detachment or misplacement during the procedure.

## Intraprocedural Complications

Vessel perforation or dissection can result in subarachnoid hemorrhage, made worse if the patient has recently received thrombolytic therapy or had been on antithrombotic therapy before the AIS. Embolization to a new or target vessel territory may occur during the procedure, thereby extending the stroke territory. When recanalization cannot be achieved, this may lead to extension of the infarcted tissue, resulting in subsequent cerebral edema and increased ICP. Intracerebral hemorrhage also may contribute to increased ICP during the procedure.[32]

Other complications may be attributed to medications administered during the procedure such as sedation/anesthetic medications and imaging contrast. Administration of anesthetic medications may precipitate changes

in heart rate and blood pressure. Allergic reactions to anesthetic medications and contrast medium may occur. Contrast-induced nephropathy may also occur.[32] Intracranial hemorrhage and cerebral edema may lead to postprocedural increases in ICP. Hemorrhage may occur secondary to MT or postoperatively as late as ≥72 hours.

### Postprocedural Complications

Procedural complications also may be related to the arterial access site. These complications include injury to the vessels accessed for the procedure or injury to the nerves in the soft tissue surrounding the puncture site. Postprocedural access site complications may lead to hemorrhage, including retroperitoneal, or development of a pseudoaneurysm.[32] Failure of the arterial closure device may contribute to access site complications, which may lead to bleeding or artery closure, potentially with emergent endarterectomy required to remove the device. Embolization distal to the access site may lead to ischemia of the affected limb. Localized infection and ecchymosis at the access site also may occur.[32]

Radial artery occlusion occurs in 1% to 10%.[33] There are conflicting opinions about the need for baseline assessments for a transradial approach because of the lack of predictability of postprocedural complications.[31,33] Radial artery occlusion can be asymptomatic as a result of collateral ulnar circulation and can spontaneously recanalize in 2 to 3 days as assessed with ultrasonography. If symptoms occur, they are usually pain at the insertion site, reduction in limb function, or paresthesia.[33]

Stroke programs should have standardized nursing assessments after the procedure to assess improvement or decline in patient condition, including complications. Stroke programs should have standardized practitioner alert processes and methods to handle patient deterioration. Complications may be life-threatening and may lead to increased length of stay in the hospital. Complications can cause delay in rehabilitation for the patient and increase costs. Although some complications may not be preventable, complications may be minimized with early detection and appropriate management.[32]

### After Intravenous Thrombolytic Intervention

The most frequent complications that nurses may encounter after intravenous thrombolytic therapy are intracranial hemorrhage, systemic hemorrhage, and angioedema. Nurses should be educated on the potential complications and be able to anticipate treatment. Treatments are based on current evidence.

### Intracranial Hemorrhage

Intracranial hemorrhage is separated into symptomatic and asymptomatic on the basis of clinical deterioration with an increased NIHSS score between 2 and 4 points in the first 36 to 48 hours after intravenous thrombolytic therapy. In the NINDS trial, symptomatic hemorrhage occurred in 6.4% of patients treated with thrombolytic versus 0.6% of placebo-treated patients treated within 3 hours. The ECASS III trial (European Cooperative Acute Stroke Study III) showed that symptomatic hemorrhage occurred in 2.4% of patients treated with thrombolytic and 0.2% of placebo-treated patients. Patients with symptomatic intracerebral hemorrhage may have mortality up to 83%.[34] Risk factors for symptomatic intracranial hemorrhage include older age, greater stroke severity, higher baseline glucose, hypertension, congestive heart failure, renal impairment, diabetes, ischemic heart disease, atrial fibrillation, baseline antiplatelet/anticoagulant use, lower platelet counts, preexisting leukoaraiosis, chronic white matter disease, early ischemic changes on imaging, and microhemorrhages on magnetic resonance imaging.[35]

### Systemic Hemorrhage

The NINDS trials found that serious systemic hemorrhage occurred in ≈1.6% of patients treated with intravenous recombinant tissue plasminogen activator. Major systemic bleeding complications after intravenous thrombolytic therapy are retroperitoneal, genitourinary, and gastrointestinal hemorrhages.[35] Minor bleeding complications may also occur such as oozing from gums and venipuncture sites, as well as hematuria and hemoptysis.[35]

### Orolingual Angioedema

Post–intravenous thrombolysis orolingual angioedema is noted in 1.3% to 5.1% of patients and can be unilateral or bilateral. When unilateral, tongue swelling is generally contralateral to the affected hemisphere. Researchers found that the risk of angioedema increased with the use of angiotensin-converting enzyme inhibitors and frontal, insular strokes.[35] Initial treatment for angioedema after intravenous thrombolytic has not been determined; therefore, nursing staff may anticipate standard treatment for anaphylaxis. This includes corticosteroids, antihistamines, and possible intubation.[10] Underlying mechanisms should be assessed to determine the best treatment for the patient. A summary of potential complications after intervention is given in Table 5.

## ICU NURSING CARE

Because the patient with AIS treated with intravenous thrombolysis with or without MT is particularly vulnerable to developing complications that can lead to secondary brain injury, this population usually requires intensive monitoring and possible interventions.[36] Early recognition of complications and neurological deterioration







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**Table 5. Complications of Endovascular Mechanical Therapy From the Randomized Controlled Trials**

| | MR CLEAN (n=500, 233/267), n (%) | ESCAPE (n=315, 165/150), n (%) | EXTEND-IA (n=70, 35/35), n (%) | SWIFT PRIME (n=196, 98/98), n (%) | REVASCAT (n=206, 103/103), n (%) | THERAPY (n=108, 55/53), n (%) | THRACE (n=412, 204/208), n (%) | PISTE (n=65, 33/32), n (%) | All trials (n=1872, 926/946), n (%) |
|---|---|---|---|---|---|---|---|---|---|
| Access site complications | | | | | | | | | |
| Groin hematoma/hematoma at puncture site | … | 3 (1.8) | 1 (2.9) | … | 11 (10.7) | … | 3 (2) | … | 18/507 (3.6) |
| Groin pseudoaneurysm | … | … | … | … | 1 (1) | … | … | … | 1/103 (1) |
| Hemorrhagic | | | | | | | | | |
| sICH | 18 (7.7) IVT-1 7 (6.4) | 6 (3.6) EC IVT-4 (2.7) | 0 (0) IVT-3 (3.1) | 0 (0) IVT-3 (3.1) | 5 (4.9) EC 2 (1.9) IVT-2 (1.9) SM IVT-2 (1.9) EC | 4 (9.3) EC IVT 6 (9.7) | 7 (4) EC 4 (2) IVT-3 (2) | 0 (0) SM IVT 0 (0) | 40/926 (4.3) 37/926 (4) |
| SAH | 2 (0.9) IVT-0 (0) | 1 (0.6) | … | 4 (4) IVT-1 (1) | 5 (4.9) IVT-2 (1) | … | 8 (4) IVT-2 (1) | … | 20/803 (2.5) |
| IVH | … | … | … | 1 (1) | … | … | 8 (4) | … | 9 (1) |
| Extracranial nonpuncture site, other | 0 (0) | … | … | … | … | … | … | 1/33 (3) | 1/266 (0.4) |
| Device-related complications | 26 (11.2) | 18 (10.9) | 4 (11.4) | 5 (5) | 30 (29) | … | … | … | 88/634 (13) |
| Arterial perforation | 2 (0.9) | 1 (0.6) | 1 (2.9) | 1 (1) | 5 (5.9) | 1 (1.8) | 1 (1) | 0 (0) | 12/926 (1.3) |
| Arterial dissection | 4 (1.7) | 1 (0.6) | … | … | 4 (3.9) | … | 5 (3) | 0 (0) | 14/738 (2) |
| Vasospasm | … | … | … | 4 (4) | 4 (3.9) | … | 33 (23) | … | 41/408 (10) |
| Distal arterial embolization/ new ischemic event in a new vascular territory | 20 (8.6) | 8 (4.9) | 2 (5.7) | … | 5 (4.9) | … | 9 (6) | 0 (0) | 44/773 (6) |
| Mortality | | | | | | | | | |
| Early mortality (7 d) | 27 (11.6) | NR | NR | NR | 10 (9.7) | NR | 14(6.9) | NR | 51/540 (9) |
| Late mortality (90 d) | 49 (21) | 17 (10.4) | 3 (9) | 9 (9) | 19 (18.4) | 6 (12) | 26 (13) | 7 (21) | 136/926 (15) |

EC indicates ECASS (European Cooperative Acute Stroke Study); ESCAPE, Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness; EXTEND-IA, Extending the Time for Thrombolysis in Emergency Neurological Deficits–Intra-Arterial; IVH, intraventricular hemorrhage; IVT, intravenous thrombolysis; MR CLEAN, Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands; NC, NINDS criteria; NR, not reported; PISTE, Pragmatic Ischaemic Thrombectomy Evaluation; REVASCAT, Randomized Trial of Revascularization With the Solitaire FR Device Versus Best Medical Therapy in the Treatment of Acute Stroke Due to Anterior Circulation Large Vessel Occlusion Presenting Within Eight Hours of Symptom Onset; SAH, subarachnoid hemorrhage; sICH, symptomatic intracerebral hemorrhage; SM, SITS-MOST (Thrombolysis with alteplase for acute ischaemic stroke in the Safe Implementation of Thrombolysis in Stroke Monitoring Study); SWIFT PRIME, Solitaire FR With the Intention For Thrombectomy as Primary Endovascular Treatment for Acute Ischemic Stroke; THERAPY, The Randomized, Concurrent Controlled Trial to Assess the Penumbra System's Safety and Effectiveness in the Treatment of Acute Stroke; and THRACE, Trial and Cost Effectiveness Evaluation of Intra-Arterial Thrombectomy in Acute Ischemic Stroke.





allows faster intervention, thereby minimizing permanent neurological disability. The ICU allows frequent nursing care assessment and monitoring. Nursing care strategies for the ICU after intravenous thrombolysis and MT include individualizing patient care, maintaining hemodynamic stability to optimize cerebral perfusion, and using neuroprotective practices to minimize the risk of reperfusion injury.[37]

## After the Intervention

Nursing interventions suggested for clinical practice after intravenous thrombolysis and MT focus on airway, breathing, circulation, and neurological and supportive care. Nurses' recognition of changes in patient status and early interdisciplinary care team management may minimize AIS complications and improve patient outcomes. Both frequent neurological monitoring and hemodynamic monitoring occur for ICU admissions.[36] Monitoring parameters, presented previously, are found in Tables 3 and 6. These parameters guide nursing assessment and care of the post–intravenous thrombolysis and MT patient population. ICU nurses should anticipate hand-off communication to contain critical information such as presenting symptoms, area of infarct, intervention, postintervention NIHSS score, time of hemostasis of access point after MT, when indicated, and plan of care. Assessments should be standardized and follow current evidence. This may be accomplished through clinical pathways or order sets.

## Assessment of Patient

### *Airway Assessment*

AIS is associated with a high rate of respiratory complications.[38] A common respiratory concern of the patient with AIS is an inability to either maintain or protect a patient airway because of altered mental status.[36] In addition to continuous oxygenation monitoring, nursing assessment includes awareness of potential clinical signs and symptoms for endotracheal intubation. Considerations include

**Table 6. Nursing Care of the Patient With Stroke Undergoing Endovascular Treatment**

| Nursing care | |
|---|---|
| Before the procedure | Preprocedural assessment* |
| | Discuss sedation with physician, document BP plan |
| | NIHSS score before procedure |
| | Vital signs† and neurological assessment at least every 30–60 min |
| | Monitoring equipment in procedure room: devices to measure BP, $Spo_2$, $Etco_2$; cardiac monitor, oxygen, masks and cannulas, suction and tubing, oral and nasal airways; emergency equipment: defibrillator, crash cart; reversal agents for benzodiazepines and opioids |
| During the procedure | Nursing performs neurological assessment, POCT |
| | Supplemental $O_2$ during moderate procedural sedation/analgesia unless contraindicated |
| | Obtain baseline vital signs,‡ pain level, LOC |
| | Team performs universal protocol |
| | Without anesthesia present, RN obtains vital signs‡ at start of procedure and every 5 min after administration of sedation |
| | RN monitors adverse medication side effects, level of sedation, changes in neurological status, procedure complications; updates physician with changes |
| | RN knowledgeable in neurological emergencies (ie, ICP increases, EVD drainage, BP management) |
| After the procedure | Obtain postprocedural NIHSS score |
| | Perform vital signs† and neurological assessment, arteriotomy site, pulse/circulation assessments per recommendations in Table 4 |

BP indicates blood pressure; EVD, external ventricular drain; $Etco_2$, end-tidal $CO_2$; ICP, intracranial pressure; LOC, level of consciousness; NIHSS, National Institutes of Health Stroke Score; POCT, point-of-care testing; RN, registered nurse; and $Spo_2$, blood oxygen level.

*Vital signs, medical history, allergies, medications, laboratory results, nil by os status, Mallampati score and American Society of Anesthesiologists classification, history of difficult airway, and previous adverse reactions to sedation or anesthesia.

†Blood pressure, heart rate, respiratory rate, and $Spo_2$.

‡Blood pressure, heart rate, respiratory rate, $Spo_2$, and end-tidal carbon dioxide by capnography.

reduced level of consciousness, signs of increased ICP, respiratory failure, seizures, and cerebral and pulmonary edema.[37] Furthermore, preserved consciousness with weakened oropharyngeal function, slurred or slow speech, and inability to manage secretions are reasonable indicators for intubation.[39] Assessment for angioedema continues in the ICU. ICU nurses evaluate patients closely for throat or mouth edema and look for any difficulty in breathing attributable to angioedema.[6,10]

Baseline assessment of lung sounds should be completed. Current AHA/American Stroke Association clinical practice guidelines continue to support that oxygen concentrations should be maintained at >94%.[10] The guideline does not support the routine use of oxygen therapy, indicating that there is no benefit to supplemental oxygen in patients who are not hypoxic.[10]

Patients with AIS should have nothing by mouth until an effective swallow is confirmed with an evidence-based swallow screening tool (see the Early Enteral Nutrition section). Although current clinical practice guidelines found no evidence to support having the head of the bed in a flat-lying position, others recommend that the head of the bed be elevated between 15° and 30° to prevent airway obstruction or aspiration.[39] The degree of elevation is determined by the care team according to the patient's condition.

### *Hemodynamic Assessment*

Hemodynamic goals after intravenous thrombolysis and MT follow current evidence-based practice.[10,35] Goals include individualization of parameters based on the patient's degree of revascularization, collateral blood flow to ischemic brain tissue, extent of infarction on postprocedural imaging, and risk of hemorrhagic transformation.[37] Blood pressure parameter goals should be identified by the practitioner and documented in the medical record. Nurses recognize that avoiding extremes in blood pressure in the initial 24 hours after stroke onset is best practice.[39] Health care organizations that deviate from current manufacturers' recommended frequency should base the decision on risk assessment data of their population. Cardiac monitoring is indicated at minimum for the first 24 hours after stroke to observe for dysrhythmias.[37] Cardiac monitoring may be extended for longer periods of time to assess for dysrhythmias such as atrial fibrillation.[6]

### *Neurological Assessment*

Few experimental studies have evaluated monitoring frequency in patients with AIS. Therefore, monitoring should be guided by the risk for complications. Many organizations include neurological assessment after MT with neurovascular assessments, which are completed during the first 6 hours after the procedure. Neurological assessment may include the patient's level of arousal, cranial nerves, and motor responses.[36] In addition, the patient's presenting symptoms must be assessed and documented. Nurses can consider including the NIHSS to examine the patient's global neurological status, stroke severity, and prognosis.[40]

It is advisable for nurses to incorporate conservative measures to minimize causes of increased intercranial pressure.[39] Basic nursing measures include avoiding patient straining when coughing or suctioning or during a bowel movement, reducing excessive environmental stimuli, and clustering nursing activities. Any change in neurological assessment justifies notification of the provider and probable emergent radiographic study such as noncontrast computed tomography or magnetic resonance imaging of the head.

## SUPPORTIVE CARE

Both fever and extremes in glycemic control are associated with worse outcomes after stroke. Guidelines suggest prompt fever treatment and avoidance of

hypoglycemia and hyperglycemia.[10] Evaluation of fever should include a workup for both an infectious and a noninfectious source. Differentials include pulmonary and urinary tract infections, sepsis, endocarditis, pulmonary embolism (PE) from deep vein thrombosis (DVT), and medications. A central fever should remain a diagnosis of exclusion.[37] The literature supports prompt fever treatment and includes nursing measures to reduce and maintain normothermia. First-line therapy for fever is antipyretic medications. The use of cooling devices may be considered for refractory fevers.[37,38] Although treating fever is a nursing priority, there is no good evidence to suggest that induced therapeutic hypothermia is of benefit in the care of the AIS patient population.

Current evidence promotes avoidance of hypoglycemia and hyperglycemia in patients with AIS. Intravenous insulin is commonly used to control blood glucose in patients with stroke in the ICU setting. It is prudent for nurses to maintain glucose in the range of 140 to 180 mg/dL. In addition, nurses should avoid and immediately treat hypoglycemia (<60 mg/dL).[37–39]

Patients with AIS are also at risk for skin breakdown resulting from immobility and bowel and bladder dysfunction. Patients should undergo comprehensive skin assessment, be repositioned frequently, and be placed on a pressure-relieving mattress. Efforts should be made to minimize moisture and sheer injury to preserve skin integrity. The causes of bowel and bladder dysfunction in the setting of AIS are multifactorial and should be investigated if patients are experiencing urinary retention, constipation, or bowel and bladder incontinence.

## Venous Thromboembolism Prophylaxis

Venous thromboembolism (VTE), a collective term for DVT and PE, is one of the leading causes of morbidity and mortality after acute stroke. A DVT can lead to the development of a PE.[41] Patients with ischemic and hemorrhagic stroke have a relatively high risk of VTE; the risk is elevated in the first 120 days after stroke.[42] Predisposing factors that increase the risk of VTE include immobility, hemiparesis, and advanced age.[42] Patients with AIS without VTE prophylaxis have a 75% chance of developing VTE, either a DVT or a PE.[43] An earlier study found that the chance of developing a PE is as high as 20% if the patient is hemiplegic.[44]

This common complication of stroke can be prevented by selecting the appropriate VTE prophylaxis to reduce morbidity and mortality.[45] Prophylaxis with unfractionated heparin or a low-molecular-weight heparin in combination with intermittent pneumatic compression has been shown to prevent VTE more successfully in patients with acute stroke, provided that no hemorrhagic complication is present.[46] Early mobilization is also effective as a prevention strategy for patients with stroke.[47] The timing of early mobilization is not well established. The type and amount of mobilization are unclear and vary with stroke severity and whether the patient received thrombolysis. One study found that most patients with stroke are actively mobilized in bed within 12 hours of admission; if a thrombolytic is given, clinical guidelines recommend delaying early mobilization for 24 hours to enhance reperfusion.[48] Other evidence supports that early mobilization decreases poststroke complications, including after intravenous thrombolytics.[38]

If VTE is suspected, the standard imaging tests of choice for DVT and PE include Duplex ultrasonography and computed tomographic pulmonary angiogram, respectively. Randomized studies and meta-analyses revealed that VTE prophylaxis should be initiated as soon as possible in patients with AIS.[44,49] Dual pharmacological and mechanical therapy is recommended; intermittent pneumatic compression is also strongly recommended for patients with limited mobility.[50]

## Early Enteral Nutrition

Patients with stroke are at an increased risk for malnutrition caused by dysphagia. Malnutrition is a common and detrimental poststroke condition that results from the body not receiving enough nutrients.[51] Malnutrition influences stroke outcomes and serves as an independent predictor of morbidity and mortality for patients with stroke.[51] It has been widely recognized that early nutrition may significantly decrease the risk of death after stroke.[52] The prevalence of malnutrition ranges from 6.1% to 62% for stroke.[53] Because malnutrition and dysphagia are likely to coexist for patients with stroke, it is necessary for nurses to assess swallowing function. The National Institute for Health and Care Excellence recommends that all patients with an acute stroke have a swallowing screen before any intake of food, medication, and fluids.[54]

If the swallowing screen on admission reveals difficulty swallowing, a complete swallowing assessment should be performed by a speech and language specialist within 24 to 72 hours of admission.[54] An assessment of nutrition requirements by a dietitian is also required to determine nourishment status for patients with dysphagia.[51] To prevent undernourishment after stroke, a decision should be made with the patient or family for enteral feeding within the first 72 hours of admission.[51] Early enteral feeding provides protein, vitamins, and minerals, offsetting malnourishment. In addition, it offers nutritional support for patients who have difficulty swallowing and are unable to meet their nutritional requirements.

# GOALS OF CARE

A sudden onset of an acute stroke can lead to overwhelming cognitive and functional changes, which

can increase patient suffering and decrease quality of life.[55] To understand the goals of care, early communication with the patient and family by the care team is essential. When identified, early palliative care consultations can likely decrease patient suffering by concentrating on holistic patient care.[55] The goal of palliative care is to provide specialized patient-centered care that focuses on improving the critically ill patient's goals and quality of life.[56] It is important for health care providers to match the treatment options to the patient's preferences. All health care providers should consider incorporating palliative care early during the stroke admission as routine care and not solely for life-limiting illness.[57] Applying palliative care guidelines and shared decision making provides nurses with a framework to eliminate barriers in communication and to standardize care for the severely ill patient with stroke.[58]

## SUMMARY

Nursing care of the patient with AIS after interventional treatment is an ongoing topic of discussion and research. Research includes the appropriate time frame for assessments and interventions for both the intravenous thrombolytic and the MT populations. It is imperative that nursing continues to collaborate in stroke research. As more information is gleaned from research and experience, evidence-based nursing practices change and improve patient outcomes.

## ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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*Modest.

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