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MENA-Adapted Guidelines for Aneurysmal Subarachnoid Hemorrhage: A Regional Approach to Global Evidence

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Endorsed by:

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- Tunisian Interventional Radiology Association (TIRA)
- Egyptian Society of Interventional Radiology (EGSIR)
- Neuro Radiology Society of Pakistan (NRSP)
- Egyptian Society of Neurological Surgeons (ESNS)
- Iranian Stroke Association (IRSA)
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Abstract

Background: Aneurysmal subarachnoid hemorrhage (aSAH) management across the diverse healthcare landscapes of the Middle East and North Africa (MENA) region requires evidence-based guidelines adapted to varying resource levels. The MENA Stroke and Interventional Neurotherapies Organization (MENA-SINO) developed these guidelines to address critical regional challenges while maintaining core principles of care.

Methods: We adapted evidence from multiple international guidelines (AHA/ASA, ESO, NICE, Neurocritical Care Society, Chinese guidelines) using a systematic approach including: comprehensive evidence review, multidisciplinary expert panel input, regional implementation barrier assessment, and formal consensus procedures. Recommendations employ MENA-SINO's framework with modified Class of Recommendation, Level of Evidence, Resource-Limited designations, and Expert Opinion statements where appropriate.

Key Recommendations: Our regional roadmap emphasizes: (1) telemedicine networks to overcome geographical barriers to specialized care; (2) early aneurysm treatment with protocols for settings where transfer is delayed; (3) balanced approach to treatment modality selection considering variable regional expertise; (4) tiered management of medical complications adapted to different resource levels; (5) pragmatic seizure management considering medication accessibility; (6) standardized neurological monitoring protocols across all settings; (7) approaches to optimize nimodipine administration despite supply challenges; (8) blood pressure management adapted to variable monitoring capabilities; (9) individualized follow-up imaging based on local resource availability; and (10) multidisciplinary rehabilitation with family-centered approaches where formal services are limited. **Conclusion:** These guidelines provide a resource-stratified framework for aSAH management across the MENA region, with practical adaptations that address the realities of diverse healthcare settings while preserving essential care components. Implementation priorities and cost-effectiveness considerations further enhance their practical utility.

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Regional Roadmap: 10 Cornerstone Concepts for aSAH Management in MENA

1. **Healthcare System Access (RL)**: We recommend establishing regional telemedicine networks to overcome the limited access to comprehensive stroke centers in many MENA countries. Unlike high-resource settings, many MENA nations face significant geographic barriers to centralized care, requiring innovative approaches to support rapid consultation before physical transfer. Following the NICE guidelines but adapted for our regional realities, we emphasize that transfer decisions should consider holistic patient assessment rather than severity scores alone.
2. **Aneurysm Treatment Timing**: MENA healthcare providers should prioritize early treatment of ruptured aneurysms, ideally within 24 hours. Our regional experts emphasize that transportation difficulties in remote areas or conflict zones require pre-established emergency transfer protocols. When immediate transfer is impossible due to geopolitical or resource constraints, we provide alternative management strategies for stabilization.
3. **Treatment Modality Selection**: MENA neurological teams must balance securing the aneurysm against procedural risks, while considering variable expertise across the region. Unlike high-resource settings, the availability of both endovascular and surgical expertise varies dramatically. We recommend that larger centers establish supportive relationships with smaller facilities through formal telemedicine consultation networks to optimize modality selection.
4. **Medical Complications Management (RL)**: We recommend implementing standardized ICU care bundles adapted for varying resource availabilities. Many MENA facilities operate with limited monitoring equipment, requiring protocols that prioritize the core elements applicable even in austere environments. Regional healthcare systems should develop tiered approaches that account for different capability levels, while ensuring key interventions to prevent complications.
5. **Seizure Management**: For new-onset seizures after aSAH, we recommend treatment with anti-seizure medication for 7 days. MENA practitioners should consider medication accessibility; levetiracetam is preferred when available, but regional shortages often necessitate alternatives. We provide guidance on older, more widely available medications while avoiding phenytoin because of its association with poorer outcomes.
6. **Monitoring for Delayed Cerebral Ischemia (RL)**: We strongly recommend training nurses to detect neurological changes using standardized assessments across all MENA settings. Where advanced monitoring is unavailable, protocols for simplified neurological monitoring with clear triggers for intervention are provided. Alternative approaches have been suggested for settings that lack specialized equipment.
7. **Nimodipine Administration**: We advocate early nimodipine administration to prevent delayed cerebral ischemia adapted to regional healthcare contexts. The NICE guidelines recommend enteral nimodipine for confirmed aSAH, which we endorse when addressing regional availability challenges. Given the variable accessibility and cost of nimodipine across MENA countries, we detail contingency approaches in which supply is limited.
8. **Blood Pressure Management**: For symptomatic delayed cerebral ischemia, we recommend blood pressure augmentation with consideration of regional monitoring capabilities. Many MENA facilities lack continuous arterial monitoring, requiring adaptation of protocols for intermittent non-invasive measurements. Implementation guidance addresses the variable availability of vasopressor medication.
9. **Cerebrovascular Imaging (RL)**: We recommend individualized follow-up imaging protocols based on patient risk and local resource availability. Many MENA settings face limitations in imaging accessibility, requiring prioritization strategies. Our guidelines provide direction for screening intervals and modality selection based on local capabilities, with telemedicine support for image interpretation where expertise is limited.
10. **Multidisciplinary Rehabilitation**: We advocate team-based rehabilitation approaches adapted to regional healthcare contexts. Acknowledging that formal rehabilitation services are limited in many MENA countries, we emphasize family centered approaches incorporating home-based care. Culturally appropriate rehabilitation strategies can leverage family involvement and community resources.

1. Introduction

MENA Regional Context

Aneurysmal subarachnoid hemorrhage (aSAH) presents significant challenges across the diverse healthcare landscapes in the MENA region. While the global aSAH incidence approximates 6.1 per 100,000 person-years, MENA-specific epidemiological data reveal concerning patterns [1]. Available studies from Turkey report incidence rates of 4.3-5.7 per 100,000, while data from Egypt and Saudi Arabia suggest rates of 3.8-5.2 per 100,000, with notable urban-rural disparities [2,3]. These rates are influenced by the region's high prevalence of risk factors, including smoking (prevalence 25-52% among men across MENA countries) and hypertension (affecting 26-38% of adults in the region) [4,5].

The mortality impact is substantial, with in-hospital mortality ranging from 12-18% in high-resource centers to 28-35% in limited-resource settings across the region, compared to the global average of 25% [3]. This striking mortality gradient directly correlates with access to specialized neurovascular care.

MENA healthcare systems face unique challenges in aSAH management with profound practical implications:

- **Stark urban-rural disparities**: While major urban centers maintain state-of-the-art capabilities, rural facilities often lack basic neuroimaging. For example, in Egypt, 85% of neurosurgical beds are concentrated in three major cities, forcing rural patients to travel 200+ kilometers for specialized care, with transportation delays exceeding 12 hours in many cases [6-8].
- **Variable neurosurgical and neurointerventional access [6,9-14]**: Across the region, the neurosurgeon-to-population ratio ranges from 1:250,000 in Gulf states to 1:1,300,000 in some North African countries. This disparity means that timely aneurysm treatment is often unavailable, with documented treatment delays averaging 62 hours in limited-resource settings compared to 18 hours in comprehensive centers.
- **Limited neurointensive care facilities [9,15-18]**: Dedicated neurocritical care units exist almost exclusively in major metropolitan centers. In a 2022 regional survey, only 42% of hospitals treating aSAH had dedicated neurointensive care capabilities, with critical shortages of both specialized nursing staff (average nurse-to-patient ratio 1:4.2 versus the recommended 1:2) and monitoring equipment.
- **Socioeconomic barriers to treatment [16,19-23]**: The financial burden of aSAH treatment is often catastrophic, with out-of-pocket expenses ranging from $2,500-$45,000 depending on the country and treatment modality. In countries where private insurance coverage is low (10-35% across much of the region), families frequently face devastating financial choices between treatment and economic survival.
- **Conflict-affected healthcare systems [24-27]**: In Syria, Yemen, and parts of Libya, more than 50% of healthcare infrastructure has been damaged or destroyed, with flight of specialized personnel exceeding 70% in some areas. aSAH patients in these regions face mortality rates exceeding 65% due to treatment unavailability and security challenges preventing safe transfer.
- **Refugee populations with complex barriers [28-33]**: The region hosts over 17 million refugees who face additional challenges including legal status issues, language barriers, and discrimination. Studies from Jordan and Lebanon show that refugees experience aSAH treatment delays averaging 3.2 times longer than host populations, with significantly worse outcomes.

Our guidelines acknowledge this diversity by providing recommendations applicable to state-of-the-art facilities comparable to international standards and resource-constrained settings requiring pragmatic adaptations. We specifically address the challenges in conflict zones and displaced populations with actionable alternative management strategies when optimal care cannot be provided.

Methodology and Evidence Review

We developed these guidelines by following the MENA-SINO framework for guideline adaptation. Our process included:

1. Comprehensive systematic review of multiple international guidelines, including AHA/ASA 2023, ESO, NICE, Neurocritical Care Society, and Chinese guidelines
2. Targeted search for region-specific literature and unpublished data from MENA centers of excellence, yielding 142 MENA-specific publications and dataset analyses
3. Formation of a multidisciplinary guideline panel through MENA-SINO's transparent selection process, ensuring representation from all MENA subregions and resource settings
4. Representation from neurosurgery, interventional neuroradiology, neurocritical care, vascular neurology, neurorehabilitation, neuroanaesthesiology, and research methodology
5. Geographic diversity ensuring input from various MENA healthcare systems, including conflict-affected areas and refugee-hosting countries
6. Modified Delphi process for consensus where MENA-specific evidence was lacking, with three rounds of structured evaluation achieving >85% agreement on final recommendations

For recommendations without robust MENA-specific evidence, we employed Expert Opinion (EO) designations. We explicitly considered resource limitations using resource-limited (RL) tags, where implementation challenges exist across the region.

Table X summarizes the key adaptations made to aSAH management recommendations based on resource availability in the MENA region. These adaptations form the foundation for our detailed, resource-stratified approach throughout the guidelines.

Table X: Key aSAH Management Adaptations Based on Resource Availability in MENA Region

Management Component	Basic Resources	Intermediate Resources	Comprehensive Resources
Diagnosis	Non-contrast CT if available; LP with visual inspection if CT unavailable; Transfer after stabilization	Non-contrast CT with teleradiology support if needed; LP with spectrophotometry; CTA if available	High-resolution CT with 24/7 neuroradiology; CTA routinely available; DSA for negative cases with high suspicion
Initial Stabilization	Basic BP management; Oral nimodipine if available; Early seizure prophylaxis	Automated BP monitoring; IV or oral nimodipine; Evidence-based seizure prophylaxis	Invasive BP monitoring; Cardiac monitoring; ICU-level care from presentation
Transfer Decisions	All confirmed cases transfer if possible; If not, oral tranexamic acid until transfer	Selected cases based on severity and aneurysm complexity; Stabilize with clinician-to-clinician communication	Receives transfers; Remote consultation for centers without transfer capability
Securing Aneurysm	Not applicable; Focus on stabilization and transfer	Surgical clipping for select anterior circulation aneurysms; Basic coiling for select cases	Full range of treatments; Decision based on aneurysm characteristics, not resource constraints
Vasospasm Management	Maintain euvolemia; Avoid hyponatremia; Triple-H therapy not recommended	Clinical monitoring; TCD if available; Euvolemia and induced hypertension protocols	Continuous monitoring; TCD surveillance; Endovascular intervention for refractory cases

Management Component	Basic Resources	Intermediate Resources	Comprehensive Resources
Monitoring	Neurological exams q1-2h; Basic laboratory monitoring	Serial neurological assessments; CT for deterioration; Basic TCD capability	Multimodality monitoring; Continuous EEG; ICP monitoring when indicated
Rehabilitation	Early mobilization; Family education; Basic PT if available	Multidisciplinary approach; PT/OT protocols; Cognitive assessment	Comprehensive neurological rehabilitation; Cognitive therapy; Return-to-work planning
Follow-up	Basic neurological assessment; Education on warning signs	Outpatient follow-up at 1-3 months; Basic vascular imaging when accessible	Comprehensive follow-up protocol; Long-term vascular surveillance; QOL assessment

2. General Concepts

2.1. Significance of Condition in MENA Region

aSAH causes substantial mortality and morbidity in the MENA region. Although comprehensive regional epidemiological data remain limited, available evidence indicates that aSAH affects individuals at a younger age in MENA countries compared to Western populations, with the mean age in some regional studies ranging between 45-50 years. This demographic pattern likely reflects both the region's younger population structure and its potentially different risk factor profiles [34].

Modifiable risk factors prevalent in the region include hypertension and tobacco use, with smoking rates being particularly high across many MENA countries. Although family history remains an important risk factor universally, large familial studies specific to MENA populations are lacking [35-38].

The socioeconomic impact of aSAH in the MENA region is profound, although precise cost analyses are not available for most countries. Beyond direct hospital expenses, long-term care costs and productivity losses create substantial burden. Many MENA countries have limited insurance coverage, resulting in catastrophic out-of-pocket healthcare expenditures, particularly affecting low-income populations [39,40].

2.2. Mechanisms of Injury After aSAH

The pathophysiological mechanisms underlying aSAH appear consistent across populations globally, although research on MENA populations remains limited. Key injury mechanisms include early brain injury from the initial hemorrhage, followed by delayed cerebral ischemia (DCI), which occurs in approximately 30% of patients between days 4-14 post-haemorrhage [41].

Research from centers in Turkey, Egypt, and Saudi Arabia has contributed to the understanding of these mechanisms, supporting the global consensus that DCI results from a combination of large-vessel vasospasm and multiple brain injury processes. The relative contributions of arteriolar constriction, microthrombosis, cortical spreading depolarization, blood-brain barrier disruption, and impaired cerebral autoregulation may vary based on the genetic and environmental factors present in MENA populations, although specific data are currently limited [42,43].

2.3. Generalizability and MENA-Specific Considerations

Most of the evidence informing these guidelines originated from studies conducted in high-resource countries with relatively homogeneous populations. Its applicability to the diverse MENA region, spanning from Morocco to the Gulf states, requires careful consideration. Regional

factors affecting implementation include the following. (Figure 1)

1. Highly variable healthcare infrastructure both across and within MENA countries
2. Significant differences in access to neurosurgical and endovascular expertise
3. Limited availability of advanced imaging in many settings
4. Potential genetic and environmental factors unique to MENA populations
5. Cultural factors influencing treatment decisions and family involvement
6. Conflict zones with disrupted healthcare systems
7. Refugee populations with complex barriers to specialised care

Our guidelines address these factors through adaptations for different resource settings, while maintaining core evidence-based principles where applicable. To address these implementation challenges, we have developed a structured framework with tiered priority actions based on resource levels, accompanied by cost-effectiveness considerations to guide healthcare systems in efficiently allocating limited resources (see Section 11).

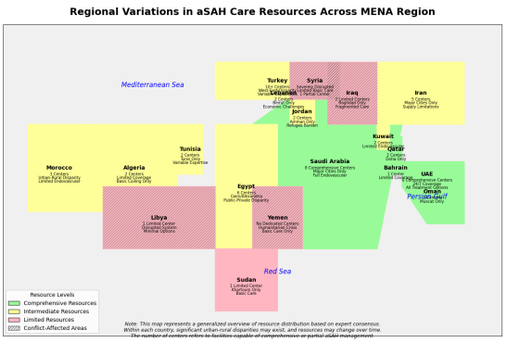

Figure 1: Geographic distribution of aSAH care resources across the MENA region. Countries are color-coded by resource level: comprehensive (green), intermediate (yellow), and limited (pink), with hatched pattern indicating conflict-affected areas. Center counts and regional characteristics highlight the significant disparities in specialized neurovascular care access throughout the region, emphasizing the need for resource-adapted guidelines.4

3. Natural History and Outcome of aSAH

Recommendations for Natural History and Outcome of aSAH in the MENA Region

Table 1: Natural History and Outcome of aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend using established clinical assessment scales (Hunt and Hess or World Federation of Neurosurgical Societies grade) for initial severity evaluation and outcome prediction in MENA healthcare settings.
Adapted from ESO Guidelines	1	B	We recommend shared decision-making between healthcare team and patient's family, emphasising the particularly important role of extended family in MENA cultures where collective decision-making is valued.
Adapted from AHA/ASA 2023	2a	B-NR	For high-grade aSAH patients, we suggest providing aneurysm treatment after thorough prognostic discussion with family members, acknowledging cultural considerations in end-of-life care discussions prevalent in MENA societies.
Adapted from AHA/ASA 2023	2a	B-NR	For elderly patients with aSAH, we recommend considering aneurysm treatment after detailed prognostic discussions with family members, respecting regional cultural norms regarding elder care and medical decision-making.
Adapted from NICE Guidelines	2a	C	We advise against using severity scoring systems in isolation when determining transfer necessity or timing to specialist neurosurgical centres, particularly important in MENA settings where resource allocation decisions must balance clinical need against limited availability. (RL)

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	3: No benefit	B-NR	For patients showing no improvement after addressing modifiable conditions and with evidence of irreversible neurological injury, we advise that aneurysm treatment is unlikely to provide benefit, while ensuring culturally sensitive communication about prognosis.
MENA-SINO Original	EO-Strong Agreement	C	In MENA settings where family-centred decision-making is culturally emphasised, we recommend involving extended family in prognostic discussions, with transparent yet culturally sensitive communication about realistic expectations. (RL)

Overview

Effective aSAH management requires prompt assessment, aneurysm treatment, and management of complications to optimize outcomes. Clinical grading scales provide valuable prognostic information, with higher grades being generally associated with poorer outcomes, although individual variability exists.

In MENA contexts, family involvement in medical decisions typically extends beyond Western norms, with collective decision making being culturally valued. This becomes particularly significant in high-grade aSAH cases with poor prognosis. Religious beliefs, including Islamic perspectives on the sanctity of life, suffering, and death, significantly influence treatment decisions in many MENA communities. Healthcare providers must approach these discussions with cultural sensitivity, while providing realistic prognostic information.

Supporting Research

The use of clinical grading scales is supported by extensive validation studies that have demonstrated a correlation with outcomes. The Hunt and Hess (HH) and World Federation of Neurosurgical Societies (WFNS) systems have strong, although not perfect, predictive values. Mocco et al. demonstrated that 40% of patients with HH grade 4-5 who received treatment achieved favorable outcomes at 12 months. A comprehensive meta-analysis by Zhao et al. examined 85 studies (4,506 patients) with poor-grade aSAH and found good outcomes in 39% of the treated patients [44,45].

The NICE guidelines emphasize that treatment decisions should not rely solely on severity scores, as they may not accurately predict individual outcomes, particularly during the acute phase when clinical states fluctuate. This recommendation is particularly relevant in MENA settings where resource allocation decisions require careful consideration [46].

Regarding age considerations, a post-hoc analysis of the Barrow Ruptured Aneurysm Trial (BRAT) found that 42% of patients over 65 years of age achieved functional independence at the 6-year follow-up. While significantly lower than in younger patients (82%), this demonstrates meaningful benefit justifying treatment in appropriate elderly candidates [47,48].

The recommendation regarding irreversible neurological injury stems from studies showing extremely poor outcomes in patients with absent brainstem reflexes, a lack of purposeful responses, large completed infarcts on admission, or global cerebral edema consistent with anoxic injury.

MENA-Specific Considerations

Several factors unique to MENA healthcare contexts influence aSAH outcomes:

1. Family centered decision-making: Extended families typically play a central role in medical decisions, particularly for life-threatening conditions. Healthcare teams should prepare to communicate with multiple family members rather than a single designated decision-maker. This differs from Western medical models and requires adaptation of communication approaches.

2. Religious and cultural context: Islamic teachings and other regional religious traditions emphasize the sanctity of life while acknowledging the reality of death. These beliefs significantly influenced attitudes toward aggressive treatment versus palliative approaches. Healthcare providers should familiarize themselves with cultural nuances.
3. Socioeconomic factors: Financial constraints often affect treatment decisions, particularly in countries with limited health insurance coverage or refugee populations. A transparent discussion of the costs balanced against the potential benefits may be necessary.
4. Communication barriers: In multilingual societies or when treating refugee populations, ensuring proper translation and cultural understanding are essential for informed consent and prognostic discussions. This is particularly challenging in emergency situations that are common in aSAH.

4. Clinical Manifestations and Diagnosis of aSAH

Recommendations for Clinical Manifestations and Diagnosis of aSAH in the MENA Region

Table 2: Clinical Manifestations and Diagnosis of aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend prompt diagnostic evaluation for patients presenting with sudden severe headache across all MENA healthcare settings to identify or exclude aSAH and reduce morbidity and mortality.
Adapted from NICE Guidelines	1	B	We advise maintaining high suspicion for subarachnoid haemorrhage in patients with thunderclap headache, while recognising this symptom's association with other conditions and acknowledging that most thunderclap headache patients do not have SAH—an important consideration for resource allocation in limited-resource settings. (RL)
Adapted from AHA/ASA 2023	1	B-NR	For patients presenting >6 hours after sudden severe headache onset or with new neurological deficits, we recommend noncontrast head CT followed by lumbar puncture if CT is negative, with consideration of cultural attitudes toward lumbar puncture in some MENA communities. (RL)
Adapted from NICE Guidelines	2a	B	For patients presenting <6 hours from sudden severe headache onset without new neurological deficits, we suggest that a high-quality noncontrast head CT interpreted by a qualified neuroradiologist is reasonable for ruling out aSAH without routinely performing lumbar puncture if negative, though teleradiology consultation may be necessary in many MENA settings lacking 24/7 neuroradiology coverage. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	In patients with sudden severe headache without new neurological deficits, we suggest applying the Ottawa SAH Rule may help identify those at higher risk for aSAH, particularly useful in resource-constrained settings to guide efficient use of limited diagnostic resources. (RL)
Adapted from AHA/ASA 2023	1	B-NR	In cases of spontaneous SAH with high suspicion for aneurysmal source and negative or inconclusive CT angiography, we strongly recommend digital subtraction angiography to diagnose or exclude cerebral aneurysms where available, though access to this modality varies significantly across MENA countries. (RL)
Adapted from NICE Guidelines	1	B	For confirmed subarachnoid haemorrhage, we recommend offering CT angiography without delay to identify bleeding source and guide treatment, acknowledging varying CT angiography quality and availability across MENA healthcare settings. (RL)

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	2a	B-NR	For patients with confirmed aneurysmal SAH, we suggest digital subtraction angiography helps determine optimal aneurysm treatment strategy, though this modality is primarily available in major urban centres across the MENA region. (RL)
Adapted from Chinese Guidelines	2a	B	For patients with negative initial vascular imaging but high clinical suspicion, we recommend repeat vascular imaging within 1-2 weeks to detect initially occult aneurysms, with consideration for regional barriers to follow-up including transportation limitations and conflict zones. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings where neuroradiological expertise is unavailable, we recommend establishing teleradiology consultation networks with regional neurovascular centres for CT and CTA interpretation. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings where DSA is unavailable, we suggest treatment decisions based on high-quality CTA alone may be reasonable, with consideration for referral to DSA-capable centres when feasible and when patient condition and regional circumstances permit safe transfer. (RL)

Overview

The hallmark clinical presentation of aSAH in conscious patients is sudden-onset, maximal-intensity headache. Early diagnosis remains critical across all settings, with diagnostic approaches varying based on the presentation timing and neurological status.

NICE guidelines emphasize that "thunderclap headache" represents a red-flag symptom, though it's also associated with other conditions, and most thunderclap headache patients do not have SAH. This consideration helps balance diagnostic thoroughness against resource utilization in MENA settings with limited capabilities.

Across the MENA region, diagnostic approaches must be adapted to the local healthcare resources. Although some urban centers maintain capabilities comparable to international standards, many facilities have limited access to high-quality CT scanners, neuroradiological expertise, or advanced vascular imaging. Regional teleradiology networks can help to bridge these gaps, although implementation challenges persist.

Supporting Research

Diagnostic recommendations are derived from evidence examining the sensitivity and specificity of various modalities. Non-contrast head CT demonstrates high sensitivity (>95%) for SAH detection within 6 hours of symptom onset [49]. A meta-analysis of 8,907 patients found that CT performed within 6 h had 98.7% sensitivity and 99.9% specificity, with only 13 missed cases [50].

For patients presenting beyond 6 h, declining CT sensitivity necessitates additional lumbar puncture [51]. Walton et al. reported on 1,235 patients from three studies in which cerebrospinal fluid obtained after negative CT was examined for xanthochromia, showing 100% sensitivity and 95.2% specificity [52].

NICE specifically recommends against routine lumbar puncture following negative CT performed within 6 h of symptom onset and reported by a radiologist. This recommendation has important resource implications in MENA settings [46].

The Ottawa SAH Rule, developed by Perry et al. in a study of 2,131 patients (132 with SAH), demonstrated 100% sensitivity, but only 15.3% specificity. External validation confirmed high sensitivity (100%) with low specificity (7.6%) [53,54]. Despite the limited specificity, this rule may help prioritize investigations in resource-constrained environments .

Studies have shown that CTA has a high sensitivity (~97%) for detecting most aneurysms, although smaller aneurysms (<3 mm) may be missed (sensitivity ~61%), necessitating DSA when clinically suspected despite negative or inconclusive CTA [54,55].

Chinese guidelines emphasize repeat vascular imaging in high-suspicion cases with negative initial studies, as some aneurysms may be initially obscured by thrombus or vasospasm. We have adapted this recommendation considering the regional follow-up challenges [56,57].

MENA-Specific Considerations

1. Variable imaging availability: Access to high-quality CT scanners varies dramatically across the region, from state-of-the-art facilities in the Gulf states to basic units in conflict-affected areas. In resource-limited settings, we recommend established protocols for patient transfers or teleradiology consultations.
2. Limited neuroradiological expertise: Many centers lack access to 24/7 neuroradiologists. We recommend teleradiology networks and training for general radiologists in basic aSAH imaging interpretation to bridge this gap, particularly given the time-sensitive nature of the diagnosis.
3. CTA vs. DSA availability: Although DSA remains the gold standard, its availability is limited to major centers in most MENA countries. We recognize high-quality CTA as a necessary alternative in many settings, with clear criteria for when transfer for DSA should be pursued, despite logistical challenges.
4. Cultural attitudes toward lumbar puncture: Regional variations in acceptance of lumbar puncture necessitate a culturally sensitive explanation of the importance of this procedure when indicated. Religious and cultural beliefs may influence consenting discussions.
5. Transportation challenges: Transportation to facilities with advanced imaging capabilities in remote areas or conflict zones may present significant barriers and safety concerns. We provide pragmatic approaches to diagnosis and initial management when transfer is delayed or impossible.
6. Refugee considerations: Special attention to refugee populations with delayed presentation due to barriers to healthcare access requires adapted diagnostic algorithms that account for longer symptom duration at presentation.

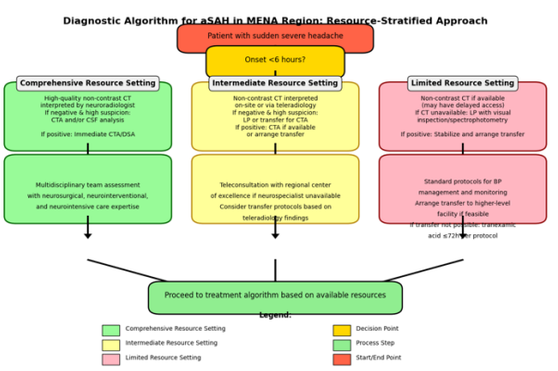

Figure 2: Resource-stratified diagnostic algorithm for aneurysmal subarachnoid hemorrhage in the MENA region. The flowchart illustrates diagnostic pathways across three resource settings: comprehensive (green), intermediate (yellow), and limited (pink). Note the adaptation of approaches based on available technology, expertise, and infrastructure while maintaining core diagnostic principles.

5. Hospital Characteristics and Systems of Care

Recommendations for Hospital Characteristics and Systems of Care in the MENA Region

Table 3: Hospital Characteristics and Systems of Care Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend timely transfer of aSAH patients from limited-capability facilities to higher-volume centres with multidisciplinary neurointensive care and experienced neurovascular specialists, with consideration for regional transportation challenges and security concerns in conflict-affected areas. (RL)
Adapted from NICE Guidelines	1	B	We recommend determining transfer necessity through urgent specialist discussion rather than relying solely on severity scores, recognising rebleeding risk is highest within 24 hours of symptom onset—a particularly important consideration where transfer times may be prolonged due to geographic or security challenges. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend that aSAH patients receive care in specialised neurocritical care units with multidisciplinary teams when available, while acknowledging the limited distribution of such units across many MENA countries. (RL)
Adapted from Neurocritical Care Guidelines	1	B	We recommend implementing standardised protocols and order sets for aSAH management, adapted to local resource availability to ensure consistent care delivery despite variable staffing and expertise levels across MENA healthcare settings. (RL)
Adapted from ESO Guidelines	2a	B	For interventional aneurysm treatment, we suggest procedures should be performed in centres treating >100 aneurysm patients annually by specialists performing ≥30 procedures yearly, while recognising that few MENA centres meet these volume thresholds and adaptation for regional realities is necessary. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In MENA countries with limited comprehensive stroke centres, we recommend establishing tiered care systems with designated referral pathways and telemedicine support to extend expertise beyond major urban centres. (RL)
MENA-SINO Original	EO-Strong Agreement	C	Where specialised neurocritical care units are unavailable, we recommend implementing aSAH management protocols for general ICU settings, with telemedicine consultation when possible to support non-specialised staff caring for these complex patients. (RL)
MENA-SINO Original	EO-Partial Accord	C	In conflict-affected areas or for refugee populations, we suggest establishing humanitarian corridors for patient transfer to centres of excellence when local management is not feasible, in coordination with international humanitarian organisations when appropriate. (RL)

Overview

Hospital resources and case volumes significantly impacted aSAH outcomes. Lower mortality rates are consistently correlated with treatment in specialized centers with experienced providers. However, the MENA region faces substantial challenges in implementing recommended care systems due to the highly variable healthcare infrastructure, geographic barriers, and ongoing conflicts in some areas.

The ESO guidelines emphasize the center volume and operator experience thresholds that few MENA facilities currently achieve. Despite these limitations, we adapted these recommendations with practical implementation strategies to improve care.

The region encompasses both world-class medical centers that are comparable to international standards and facilities with severely limited resources, particularly in rural areas and conflict zones. Our guidelines acknowledge this diversity by

providing recommendations for optimizing care across resource settings.

Supporting Research

Evidence regarding hospital characteristics and systems of care comes from large nonrandomized studies examining the impact of center expertise, case volumes, and dedicated neurocritical care units on patient outcomes. Studies using the US Nationwide Inpatient Sample and international registries have consistently demonstrated that treatment in high-volume centers is associated with lower in-hospital mortality and improved functional outcomes [58].

The Point Prevalence in Neurocritical Care (PRINCE) study examined 257 centers across 47 countries and identified the absence of dedicated neurocritical care units as an independent mortality predictor. Delayed transfer to comprehensive facilities correlates with worse outcomes, highlighting the importance of timely referral despite logistical regional challenges [59].

The Neurocritical Care Society guidelines emphasize standardized protocols and order sets to reduce practice variation and improve outcomes. We adapted these recommendations to account for the variable resource availability across MENA healthcare settings [60].

Multiple studies have demonstrated that centers with dedicated neurocritical care experience, higher case volumes (typically >35 aSAH cases annually), and specialized nursing expertise achieve lower mortality rates and better functional outcomes [61]. Analyses of US data identified factors associated with treatment delay, including older age, non-White race, Medicaid coverage, surgical clipping, and admission to low-volume hospitals—many paralleling access barriers in MENA healthcare systems [62].

MENA-Specific Considerations

1. Geographical expertise distribution: Neurosurgical and neurointerventional expertise remain concentrated in major urban centers, creating substantial access disparities for rural populations. While telemedicine can partially address this gap, its implementation requires infrastructure beyond what is currently available in many settings.
2. Variable ICU capabilities: Although major centers maintain dedicated neurocritical care units, most regional hospitals rely on general ICUs for aSAH management. We recommend standardized protocols adapted for general ICU settings, with clear triggers for consultation or transfer.
3. Transportation infrastructure: The feasibility of timely transfer varies significantly and is affected by geography, road conditions, and security concerns. Air ambulance services remain limited in many countries and unavailable in conflict zones. Alternative transport protocols are needed to address these issues.
4. Conflict impact: Several MENA countries experience ongoing conflicts that severely disrupt their healthcare systems and create unique aSAH management challenges. Humanitarian corridors for medical evacuation should be established where possible, in coordination with international organizations.
5. Refugee considerations: The large refugee populations in several MENA countries face additional specialized care barriers, including legal status issues, financial constraints, and language barriers. Designated pathways that address these challenges are required.
6. Public-private disparities: Significant resource and capability differences between the public and private healthcare sectors exist in many MENA countries. Strategies to minimize these disparities through public-private partnerships should be explored, particularly for emergency conditions such as aSAH.
7. Health system financing: Variable insurance coverage and high out-of-pocket expenses influence transfer decisions and access to specialized care. Policy interventions to ensure financial protection against catastrophic conditions such as aSAH are needed at the national level.

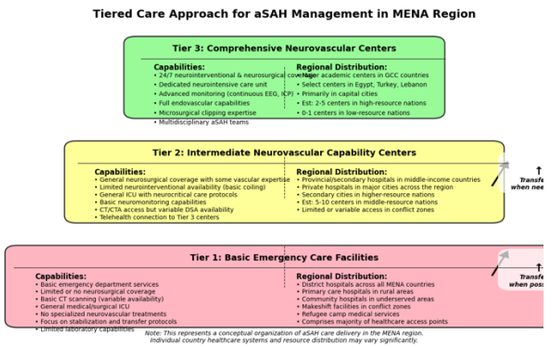

Figure 2: Tiered care model for aSAH management in the MENA region. The pyramid illustrates the three-tier system with capabilities and regional distribution of each facility type. Tier 3 facilities (comprehensive neurovascular centers) provide complete care but are limited in number, while Tier 1 facilities (basic emergency care) form the foundation of the regional healthcare system. Arrows indicate recommended patient transfer pathways when higher levels of care are required.

6. Medical Measures to Prevent Rebleeding After aSAH

Recommendations for Medical Measures to Prevent Rebleeding After aSAH in the MENA Region

Table 4: Medical Measures to Prevent Rebleeding After aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	C-EO	For patients with unsecured aneurysms, we strongly recommend implementing frequent blood pressure monitoring and using appropriate short-acting medications to avoid severe hypotension, hypertension, and blood pressure fluctuations, with adaptation for settings where continuous arterial monitoring is unavailable. (RL)
Adapted from AHA/ASA 2023	1	C-EO	For aSAH patients on anticoagulant therapy, we strongly recommend prompt reversal using locally available appropriate agents to minimise rebleeding risk, with protocols adapted for settings where specific reversal agents may be unavailable. (RL)
Adapted from NICE Guidelines	2a	C	For aSAH patients with unsecured aneurysms, we suggest providing effective pain relief, including opioid analgesia when needed, while ensuring documentation to facilitate accurate neurological assessment. This is particularly important in settings where patient-controlled analgesia may not be available. (RL)
Adapted from AHA/ASA 2023	3: No benefit	A	We recommend against routine antifibrinolytic therapy for all aSAH patients as this has not demonstrated improvement in functional outcomes in well-designed trials.
Adapted from Chinese Guidelines	2b	B	In selected patients with anticipated treatment delays common in many MENA settings, we suggest short-course tranexamic acid (≤72 hours) may be considered to reduce rebleeding risk until definitive aneurysm treatment becomes available. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings where definitive aneurysm treatment may be delayed due to transfer limitations or limited resources, we recommend considering short-term antifibrinolytic therapy while arranging transfer to an aneurysm treatment-capable centre, with clear protocols for duration and monitoring. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings without continuous arterial monitoring capability, we recommend implementing non-invasive BP monitoring at regular intervals (at least hourly) with clear parameters for intervention and escalation of care. (RL)

Overview

Prompt aneurysm obliteration remains the only effective treatment for reducing the likelihood of rebleeding. Medical management focuses on patient stabilization and the prevention of complications until definitive treatment. Blood pressure control and anticoagulation reversal constitute essential components of the initial management.

In MENA contexts, specialized care access and definitive aneurysm treatment may face delays due to various factors, including geographical barriers, limited availability of neurosurgical/neurointerventional expertise, and conflict situations. Medical management strategies must consider these potential delays while maximizing patient safety.

The NICE guidelines emphasize the importance of effective pain relief, including opioid analgesia, when needed, while documenting administration to enable accurate neurological assessment. We incorporated this recommendation with consideration for regional pain management approach variations.

Supporting Research

Blood pressure management recommendations for unsecured aneurysms are primarily derived from clinical consensus [63], as robust controlled trials are lacking. Observational studies have demonstrated that increased blood pressure variability is associated with worse outcomes. Meta-analyses of early rebleeding predictive factors suggest higher rates with systolic BP >160 mmHg, but inconsistent results with systolic BP <140 mmHg [36,37,64].

Regarding anticoagulation reversal, while not directly tested in aSAH, the immediate reversal value has been demonstrated in other intracranial hemorrhage forms, supporting extrapolation to aSAH patients despite limited direct evidence [65].

The Chinese guidelines [66] suggest that short-course tranexamic acid may reduce rebleeding risk in selected patients with anticipated treatment delays, particularly in MENA regions where transfer delays may be significant due to geographic, political, or resource constraints [34,35].

For antifibrinolytic therapy, the largest high-quality RCT (ultra-early tranexamic acid after subarachnoid hemorrhage [ULTRA]) showed no significant reduction in rebleeding rates or functional outcome improvement with tranexamic acid versus the control. Good functional outcome at 6 months (mRS 0-3) occurred in 60% of the tranexamic acid group versus 64% of the controls, with rebleeding rates of 10% and 14%, respectively [67,68]. These findings, alongside older studies showing inconsistent results, underpin our recommendation against routine use, while allowing consideration in specific delayed-treatment scenarios.

MENA-Specific Considerations

1. Blood pressure monitoring capabilities: Continuous arterial BP monitoring remains unavailable in several regional settings. We recommend alternative protocols using regular noninvasive measurements with clear intervention thresholds and documentation standards.
2. Medication availability: The availability of short-acting antihypertensive medications varies significantly across regions. We recommend protocols that include alternative agents based on local availability, with consideration for medication stability in settings with unreliable refrigeration.

3. Anticoagulation reversal agents: Specific reversal agent access (e.g., prothrombin complex concentrate and idarucizumab) varies dramatically. We recommend alternative strategies using more widely available agents in resource-limited settings with clear dosing guidelines.
4. Transfer delays: In situations where definitive treatment is delayed owing to transportation challenges, security concerns, or resource limitations, short-term antifibrinolytic therapy may be considered despite routine use lacking evidence. We have provided clear guidance on dosing, duration, and potential contraindications.

5. Implementation challenges: Basic monitoring may prove challenging in some settings because of staffing limitations or equipment constraints. We recommend pragmatic approaches to these situations, including family involvement in monitoring, when appropriate.
6. Communication barriers: Language differences and limited health literacy may complicate medication adherence in outpatient settings. We emphasize clear communication strategies using visual aids and local language resources, when available.

7. Surgical and Endovascular Methods for Treatment of Ruptured Cerebral Aneurysms

Recommendations for Surgical and Endovascular Methods for Treatment of Ruptured Cerebral Aneurysms in the MENA Region

Table 5: Surgical and Endovascular Methods for Treatment of Ruptured Cerebral Aneurysms Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend treating ruptured aneurysms as early as possible after presentation, ideally within 24 hours, while acknowledging that transportation barriers in rural or conflict-affected MENA regions may necessitate stabilisation protocols when immediate transfer is impossible. (RL)
Adapted from ESO Guidelines	1	B	We strongly recommend early aneurysm treatment to prevent rebleeding, emphasising that rebleeding risk peaks within 24 hours of symptom onset—a critical consideration for triage and transfer decisions in MENA healthcare systems with variable neurosurgical coverage. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend achieving complete aneurysm obliteration whenever feasible to minimise rebleeding risk and retreatment need, with follow-up imaging protocols adapted to regional resource availability.
Adapted from AHA/ASA 2023	2a	C-EO	When complete obliteration proves technically impossible in the acute phase, we suggest securing the rupture site with partial treatment and planning delayed definitive treatment following functional recovery. This staged approach may be particularly relevant in MENA centres with limited advanced equipment availability. (RL)
Adapted from AHA/ASA 2023	1	B-R	For posterior circulation aneurysms amenable to endovascular treatment, we strongly recommend coiling over clipping to improve outcomes, though we recognise endovascular expertise remains concentrated in major MENA urban centres. (RL)
Adapted from AHA/ASA 2023	1	B-R	For salvageable patients with depressed consciousness due to large intraparenchymal haematoma, we strongly recommend emergency surgical evacuation to reduce mortality, with protocols for rapid surgical intervention even in centres with limited neurosurgical experience. (RL)
Adapted from ESO Guidelines	1	B	We strongly recommend multidisciplinary assessment of ruptured aneurysms, openly discussing complete occlusion chances and risks of both microsurgical and endovascular treatment. In MENA settings with limited specialist availability, we recommend telemedicine consultation with comprehensive centres. (RL)
Adapted from AHA/ASA 2023	2b	B-R	For patients over 70 years with aSAH, we note that current evidence does not clearly establish whether coiling or clipping provides superior outcomes. Decision-making should incorporate cultural perspectives on elder care prevalent in MENA societies.

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	2b	C-LD	For patients under 40 years with aSAH, we suggest considering surgical clipping as the preferred approach for improved durability and long-term outcomes, particularly important in MENA settings where long-term follow-up may be challenging. (RL)
Adapted from NICE Guidelines	1	A	When planning interventional treatment, we strongly recommend performing it at the earliest opportunity to prevent rebleeding, emphasising that rebleeding risk peaks within 24 hours of symptom onset, which may necessitate emergency transfer protocols in MENA regions with limited neurosurgical coverage.
Adapted from AHA/ASA 2023	1	A	For good-grade anterior circulation aneurysms equally suitable for both approaches, we strongly recommend endovascular coiling over surgical clipping to improve 1-year functional outcomes, though implementation depends on regional availability of neurointerventional expertise. (RL)
Adapted from ESO Guidelines	2a	B	For wide-neck aneurysms not amenable to standard treatment, we suggest stent-assisted coiling or flow diversion may be reasonable, though we caution that flow diverters should be used only when other endovascular or microsurgical options are unavailable and dual antiplatelet therapy can be reliably maintained. (RL)
Adapted from AHA/ASA 2023	3: Harm	B-NR	For standard saccular aneurysms suitable for primary coiling or clipping, we recommend against using stents or flow diverters due to increased complication risks, particularly in settings where dual antiplatelet therapy monitoring may be challenging.
MENA-SINO Original	EO-Strong Agreement	C	In centres with limited neurointerventional capabilities, we strongly recommend establishing transfer protocols to comprehensive centres for complex aneurysms requiring advanced techniques, with consideration for regional transportation challenges. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings where both modalities are available but experience is limited, we recommend considering the relative local expertise in surgical versus endovascular approaches rather than rigidly following guidelines developed in high-volume centres. (RL)
MENA-SINO Original	EO-Partial Accord	C	In resource-limited settings where dual antiplatelet therapy cannot be reliably continued due to medication access, monitoring limitations, or patient follow-up challenges, we suggest surgical clipping may be preferred over stent-assisted coiling or flow diversion when technically feasible. (RL)

Overview

Ruptured cerebral aneurysm management requires tailored approaches based on patient characteristics, aneurysm features, and expertise. Early treatment, preferably within 24 hours, is consistently associated with better outcomes. Complete obliteration of the aneurysm should be achieved whenever feasible.

The ESO guidelines emphasize the importance of multidisciplinary assessment and discussion when selecting between treatment modalities, which we have incorporated with regional implementation considerations addressing limited specialist availability.

Across the MENA region, neurosurgical and neurointerventional expertise availability, and advanced device and technique access vary significantly. Major centers in countries such as Saudi Arabia, the UAE, Turkey, and Egypt may offer comprehensive treatment options comparable to international standards, while many facilities maintain substantially limited capabilities. Our recommendations adapt to different resource settings while preserving the core care principles.

Supporting Research

Several studies have examined the timing of aneurysm treatment. A small randomized prospective trial in the pre-coiling era demonstrated better outcomes with early

surgery (0-3 days) than with intermediate (4-7 days) or late surgery (≥8 days) [62,69]. Subsequent observational studies and post-hoc ISAT (International Subarachnoid Aneurysm Trial) analyses generally support better outcomes with treatment within 24-72 hours [70].

Both the ESO and NICE guidelines emphasize that rebleeding risk peaks within 24 hours of symptom onset and support early intervention recommendations to prevent rebleeding, which has significant implications for MENA healthcare systems requiring efficient transfer protocols [46,71].

For posterior circulation aneurysms, a randomized trial subgroup analysis found that coiling was superior to clipping with a relative risk of 0.41 for death or dependency. The Barrow Ruptured Aneurysm Trial (BRAT) also demonstrated significantly better outcomes for posterior circulation aneurysms treated with coiling versus clipping at both 1-year and long-term follow-ups [38,72].

Regarding emergency clot evacuation for large intraparenchymal hematomas, a small RCT of 30 patients found significantly lower mortality (27% vs. 80%) and higher independent outcome rates (53% vs. 20%) with surgical intervention than with conservative management [73].

The landmark ISAT trial, primarily enrolling patients with good-grade anterior circulation aneurysm suitable for both modalities, found that primary coiling was associated with better 1-year outcomes, with a relative risk of death or dependency of 0.77. However, the long-term follow-up showed no significant difference between coiling and clipping at 5 years, with higher rebleeding rates after coiling [74,75].

For complex aneurysms requiring stent-assisted coiling or flow diversion, studies have demonstrated higher complication risks, particularly hemorrhagic complications related to dual antiplatelet therapy [76]. However, these techniques may prove necessary for aneurysms that are not amenable to simpler treatment.

The ESO unruptured aneurysm guidelines provide valuable insights regarding flow-diverting stents, recommending them only when no other endovascular or microsurgical option can occlude the aneurysm at a lower risk than the expected rupture risk [71]. We have also incorporated this cautious approach into our ruptured aneurysm recommendations, with additional considerations for regional dual antiplatelet therapy adherence challenges.

MENA-Specific Considerations

1. Variable expertise distribution: The availability of experienced neurosurgeons and neurointerventionalists varies widely across regions. Decision-making should consider relative local expertise in each approach rather than rigidly following guidelines developed for high-volume centers.
2. Equipment and device availability: Advanced endovascular device access (coils, stents, and flow diverters) varies significantly, particularly in public healthcare systems. Surgical approaches may be more consistently available in some settings because of lower technological dependencies.
3. Dual antiplatelet therapy: Reliable continuation of dual antiplatelet therapy after stent-assisted coiling or flow diversion may present challenges in certain populations, particularly in conflict zones or refugee settings. This factor significantly influenced treatment selection.
4. Follow-up capabilities: Reliable long-term follow-up provision ability may influence treatment modality decisions, particularly in younger patients. Regional barriers, including transportation costs, political instability, and population displacement should be considered in the initial approach selection.
5. Cultural factors: Patient and family preferences, influenced by cultural and religious factors, should be incorporated into decision making, particularly regarding procedural invasiveness and recovery considerations. These preferences may differ from those observed in western populations.
6. Cost considerations: In settings with limited insurance coverage, the financial impact of different treatment approaches, including both initial costs and potential retreatment needs, should be

transparently discussed with families who often bear significant out-of-pocket expenses.

7. Telemedicine consultation: For centers with limited expertise, we recommend establishing telemedicine consultations with more experienced centers to improve decision-making and potentially expand treatment options despite geographic isolation.

7.1. Anesthetic Management of Surgical and Endovascular Treatment of aSAH

Recommendations for Anesthetic Management of Surgical and Endovascular Treatment of aSAH in the MENA Region

Table 6: Anesthetic Management of Surgical and Endovascular Treatment of aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	2a	B-R	We suggest using hyperosmotic agents such as mannitol or hypertonic saline during aneurysm surgery to effectively reduce intracranial pressure and cerebral oedema, with protocols adapted for varying regional availability of these agents. (RL)
Adapted from Neurocritical Care Guidelines	2a	B	We recommend maintaining euvolaemia during aneurysm surgery to optimise cerebral perfusion while avoiding fluid overload complications, with monitoring approaches adapted for settings without advanced haemodynamic equipment. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	We suggest incorporating strategies to minimise postprocedural pain, nausea, and vomiting into anesthetic management protocols, with adaptation for settings where patient-controlled analgesia may be unavailable.
Adapted from AHA/ASA 2023	2a	B-NR	We recommend maintaining appropriate glycaemic control during aneurysm procedures, avoiding both hyperglycaemia and hypoglycaemia to improve outcomes, with monitoring frequency adapted to local laboratory capabilities.
Adapted from AHA/ASA 2023	2a	C-LD	For patients with unsecured aneurysms, we suggest careful intraoperative blood pressure monitoring and management to prevent both ischaemia and aneurysm rerupture, with protocols adapted for settings where arterial lines or continuous monitoring may not be available. (RL)
Adapted from Chinese Guidelines	2a	C	For endovascular procedures, we recommend selecting appropriate sedation or general anaesthesia based on patient characteristics, aneurysm complexity, and anticipated procedure duration, with consideration for resource limitations in monitoring capabilities. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	We suggest that intraoperative neuromonitoring may provide valuable surgical and anesthetic management guidance in select cases, while acknowledging its limited availability across many MENA centres. (RL)
Adapted from AHA/ASA 2023	2b	C-LD	In cases of intraoperative aneurysm rupture uncontrollable with standard techniques, we suggest adenosine-induced temporary cardiac standstill may facilitate aneurysm clip placement in select situations, though this technique should be limited to centres with appropriate cardiac monitoring capabilities. (RL)
Adapted from AHA/ASA 2023	3: No benefit	B-R	We recommend against routine mild hypothermia use during aneurysm surgery for good-grade aSAH patients as this has not demonstrated benefit in well-designed studies.
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited specialised neuroanesthesiologist availability, we strongly recommend implementing basic aSAH patient anesthetic management protocols and providing regular training for general anesthesiologists on neurosurgical cases. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings where advanced neuromonitoring is unavailable, we recommend alternative strategies emphasising haemodynamic stability maintenance and extended temporary clipping avoidance to reduce ischaemic complications. (RL)

Overview

Anesthetic management significantly affects the outcomes of patients undergoing treatment for ruptured cerebral aneurysms. Key considerations include maintaining an appropriate cerebral perfusion pressure, managing intracranial pressure, preventing secondary injury, and facilitating optimal surgical or endovascular conditions.

The Neurocritical Care guidelines emphasize euvolemia rather than hypervolemia during aneurysm procedures, aligning with the evolving understanding of optimal fluid management in aSAH. We adapted this to settings with limited advanced monitoring capabilities.

The Chinese guidelines provide specific recommendations regarding anesthetic approaches for endovascular procedures, which we have incorporated into regional implementation challenges.

Across the MENA region, access to specialized neuroanesthesiology expertise and availability of advanced monitoring techniques vary significantly. Major centers may provide care comparable to international standards, whereas many facilities rely on general anesthesiologists with limited neurosurgical experience. Our recommendations are adapted to different resource settings while maintaining core care principles.

Supporting Research

Evidence for the use of hyperosmotic agents in intraoperative aSAH management comes from brain relaxation and intracranial pressure control studies [77]. Both mannitol and hypertonic saline decreased ICP and increased cerebral blood flow. However, comparative studies have not clearly established the superiority of either of these agents [78].

For fluid management, recent evidence supports euvolemia rather than hypervolemia as the latter increases the risk of complications without clear benefits. This represents an evolution from earlier practice patterns that emphasize hypervolemic therapy [79,80].

For postoperative nausea and vomiting, multimodal regimens targeting different receptors are recommended, based on studies showing that post-craniotomy nausea and vomiting occur in 22-70% of patients. Serotonin 5-HT3 receptor antagonists, steroids, and propofol are effective in reducing these complications [81].

Poor glycemic control in patients with aSAH has been associated with worse outcomes. A post-hoc analysis of the Intraoperative Hypothermia for Aneurysm Surgery Trial (IHAST) found an association between hyperglycemia and long-term cognition and gross neurological function changes [82].

Regarding hypothermia, the multicenter IHAST evaluated 1,000 good-grade aSAH patients and found no improvement in the 3-month neurological outcomes with mild hypothermia (33°C vs. 36.5°C) during aneurysm surgery [82].

For adenosine use during difficult aneurysm clipping, case series and retrospective reviews have demonstrated adenosine-induced temporary cardiac standstill utility, with initial doses providing predictable profound hypotension periods lasting approximately 45 seconds [83].

MENA-Specific Considerations

1. Neuroanesthesiology expertise: Specialized neuroanesthesiologists are primarily available at major centers. We recommend developing training programs and protocols to support general anesthesiologists in other settings with an emphasis on neurosurgical case management fundamentals.
2. Medication availability Specific anesthetic agents and vasoactive medication access vary regionally. We recommend establishing alternative protocols using more widely available medications where needed, with appropriate dosing adaptations.
3. Monitoring capabilities: Advanced neuromonitoring (e.g., evoked potentials, EEG) remains limited to major centers. We recommend alternative strategies that emphasize clinical parameters and basic monitoring in resource-limited settings, with clear protocols for detecting neurological deterioration.

4. Blood product availability: Reliable access to blood products varies, particularly in conflict zones. We recommend conservative strategies and alternatives for settings with limited blood banking capabilities, including cell salvage techniques where available.
5. Equipment variability: Temperature management, advanced hemodynamic monitoring, and ventilation control equipment availability vary significantly. Protocols should adapt to different equipment levels while maintaining the basic neuroprotection principles.
6. Post-anesthesia care: Intensive postoperative monitoring capabilities vary widely. Transition plans between operating rooms and ICUs should be established based on local resources with clear handover protocols to ensure continuity of care.

8. Management of Medical Complications Associated With aSAH

Recommendations for Management of Medical Complications Associated With aSAH in the MENA Region

Table 7: Management of Medical Complications Associated With aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	For patients requiring mechanical ventilation beyond 24 hours, we strongly recommend implementing standardised ICU care bundles to reduce ventilation duration and hospital-acquired pneumonia rates, with protocols adapted to regional staff ratios and monitoring capabilities. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	In patients developing severe ARDS with life-threatening hypoxaemia, we suggest rescue manoeuvres such as prone positioning and alveolar recruitment with appropriate ICP monitoring may improve oxygenation, though implementation requires training in settings with limited neurocritical care experience. (RL)
Adapted from Neurocritical Care Guidelines	1	B	We strongly recommend maintaining euvolaemic state in aSAH patients, avoiding both hypovolaemia and hypervolaemia to optimise outcomes. In settings without advanced monitoring, we recommend standardised fluid assessment protocols using available parameters. (RL)
Adapted from AHA/ASA 2023	2a	B-R	We suggest careful monitoring and goal-directed fluid status management to maintain euvolaemia, with approaches adapted to the regional availability of monitoring equipment and laboratory testing. (RL)
Adapted from AHA/ASA 2023	2a	B-R	We suggest mineralocorticoid therapy may benefit appropriate patients with cerebral salt wasting and hyponatraemia, while acknowledging medication availability varies across the region and requiring protocols for centres with limited laboratory monitoring capabilities. (RL)
Adapted from ESO Guidelines	3: Harm	B-R	We recommend against routinely inducing hypervolaemia as this may increase complications without improving outcomes, representing an evolution from earlier triple-H therapy approaches still practised in some MENA centres.
Adapted from NICE Guidelines	1	C-LD	After securing the ruptured aneurysm, we strongly recommend initiating appropriate VTE prophylaxis (pharmacological or mechanical) to reduce thrombotic complications, with protocols adapted to the regional availability of prophylactic methods. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	We suggest implementing effective glycaemic control, avoiding both hyperglycaemia and hypoglycaemia to improve outcomes, with monitoring frequencies adapted to local laboratory capabilities.
Adapted from Chinese Guidelines	2a	B	We suggest initiating early enteral nutrition, preferably within 24-48 hours of aSAH onset, to maintain gastrointestinal integrity and improve nutritional status, with formulations adapted to regional availability and cultural dietary preferences. (RL)

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	2b	C-LD	For patients with fever refractory to standard antipyretic measures, we note that advanced temperature management technique benefits remain uncertain, and recommend pragmatic approaches based on locally available methods. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings where advanced monitoring is unavailable, we strongly recommend implementing simplified protocols for fluid management and volume status assessment using physical examination, basic laboratory values, and weight monitoring. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings where mechanical VTE prophylaxis devices are limited, we strongly recommend emphasising early mobilisation protocols alongside available pharmacological prophylaxis, with consideration for regional variations in nursing staff availability to implement mobilisation. (RL)

Overview

Patients with aSAH frequently develop multisystem medical complications that significantly affect the outcomes. These include fever, hyponatremia, respiratory failure, venous thromboembolism, and cardiac dysfunctions. Prevention, timely diagnosis, and appropriate management of these complications constitute essential components of comprehensive aSAH care.

The Neurocritical Care and ESO guidelines both emphasize maintaining euvolemia rather than hypervolemia, representing an evolution in aSAH patient optimal fluid management understanding. We adapted these recommendations to address the varying monitoring capabilities across MENA healthcare settings.

Chinese guidelines emphasize early enteral nutrition, supporting gastrointestinal integrity, and potentially improving outcomes. We incorporated this recommendation with consideration of regional nutritional product availability and cultural dietary preferences.

Across the MENA region, complication management capabilities vary significantly, based on resource availability, ICU staffing, and specialist access. Our recommendations provide adaptations for different resource settings while maintaining core management principles.

Supporting Research

Observational studies have demonstrated that the implementation of bundled care for mechanically ventilated patients with brain injury accelerates extubation readiness, reduces mechanical ventilation duration, and increases ventilator-free days. Regarding ARDS management, small RCTs have demonstrated that alveolar recruitment and prone positioning can effectively increase arterial oxygen partial pressure without causing pathological ICP increases when performed with ICP monitoring [84,85].

Regarding fluid management, multiple guidelines and consensus statements emphasize euvolemia rather than hypervolemia. The ESO guidelines specifically recommend against inducing hypervolemia as it may increase complications without improving outcomes. This represents an evolution from earlier practice patterns, emphasizing triple-H therapy (hypertension, hypervolemia, and hemodilution) [71].

Volume management studies have shown that central venous pressure correlates poorly with circulating blood volume and cannot predict fluid responsiveness. Early goal-directed treatment using continuous hemodynamic parameter monitoring demonstrated improved intravascular volume depletion. One RCT suggested that early goal-directed treatment within 24 hours of aSAH onset was associated with reduced DCI rates, shorter ICU stay, and better outcomes in high-grade aSAH patients [86,87].

For hyponatremia management, several moderately sized RCTs found that fludrocortisone was effective in reducing excess sodium excretion, urine volume, and hyponatremia, although it did not consistently affect DCI or outcomes [88]. Regarding hypervolemia, RCTs have demonstrated that volume expansion increases medical complications without improving outcomes or reducing the DCI [89].

The Chinese guidelines' recommendation for early enteral nutrition is supported by studies showing that early initiation (within 24-48 hours) is associated with reduced infection rates and improved outcomes in critically ill neurological patients, although aSAH-specific data remain limited .

VTE prophylaxis studies included a small enoxaparin RCT that found no increase in bleeding after aneurysm treatment, while case-control studies have shown that early pharmacological prophylaxis (≤24 h after aneurysm occlusion) was not associated with increased intracranial hemorrhagic complications [90-92].

Multiple studies have associated hyperglycemia with worse aSAH outcomes, although RCTs comparing intensive and conventional glycemic control have not demonstrated outcome benefits [93]. For fever management, while fever is associated with worse outcomes, trials of various temperature control modalities have not shown functional outcome improvement [94].

MENA-Specific Considerations

1. ICU resource variability Specialized neurocritical care unit availability varies widely, with many facilities relying on general ICUs. We recommend standardized protocols adapted for general ICU settings with varying monitoring capabilities and staffing ratios.
2. Monitoring capabilities: Advanced hemodynamic and ICP monitoring may be limited to major centers. We recommend alternative strategies using available monitoring tools with clear triggers for interventions based on simpler parameters.
3. Medication availability Specific medication access (e.g., certain vasopressors and mineralocorticoids) varies across regions. We recommend alternative protocols that use more widely available medications with appropriate dosing adaptations.
4. Nutritional support: Specialized enteral formulation and feeding pump availability varied. We recommend protocols that are adaptable to locally available products and methods considering cultural dietary preferences.
5. Equipment access: Specialized equipment for therapeutic temperature management, advanced ventilation strategies, and mechanical VTE prophylaxis may be limited in certain settings. We recommend pragmatic alternatives that emphasize core principles with available resources.
6. Staffing considerations: Nurse-to-patient ratios and specialized nursing expertise vary significantly. We recommend protocols that account for different staffing models while maintaining key monitoring elements with task-shifting approaches, where appropriate.
7. Laboratory capabilities: Laboratory test availability and turnaround time may affect monitoring of complications, such as hyponatremia and hyperglycemia. We recommend protocols adapted accordingly with appropriate testing frequencies.
8. Cultural considerations: Cultural factors may affect certain aspects of care, such as early mobilization practices and family involvement in basic care. We recommend acknowledging and incorporating these into care plans to improve acceptability and adherence.

8.1. Nursing Interventions and Activities

Recommendations for Nursing Interventions and Activities in the MENA Region

Table 8: Nursing Interventions and Activities Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-R	We strongly recommend implementing evidence-based nursing protocols and standardised order sets to improve care consistency and patient outcomes, with adaptation to regional nursing education levels and staffing ratios. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend performing regular neurological assessments using validated tools such as the Glasgow Coma Scale or National Institutes of Health Stroke Scale to monitor for delayed cerebral ischaemia and other complications, with frequency adapted to available nursing resources. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend frequent vital sign and neurological status monitoring for early neurological deterioration detection and secondary brain injury prevention, with protocols adapted for settings with higher patient-to-nurse ratios. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend implementing a systematic dysphagia screening approach before initiating oral intake to reduce aspiration pneumonia risk, with simplified validated tools appropriate for limited specialist availability. (RL)
Adapted from NICE Guidelines	1	B	When conducting neurological assessments, we strongly recommend documenting recent opioid analgesia administration to accurately interpret findings, particularly pupillary responses. This is especially important in settings with frequent staff rotations and limited electronic health records. (RL)
Adapted from AHA/ASA 2023	2a	C-LD	We suggest that specialised stroke nursing education and certification programs can improve care quality, timeliness, and evidence-based protocol adherence, though we recognise these opportunities remain limited in many MENA countries. (RL)
Adapted from AHA/ASA 2023	2a	C-LD	After aneurysm treatment, we suggest implementing structured early mobility protocols to improve functional outcomes and reduce length of stay, adapted to regional staffing patterns and cultural attitudes toward mobilisation. (RL)
Adapted from Chinese Guidelines	2a	C	We suggest incorporating psychological support and education for patients and families into nursing care to reduce anxiety and improve illness and treatment plan understanding, with approaches adapted to local cultural contexts and beliefs. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited nursing resources, we strongly recommend prioritising core neurological monitoring with simplified assessment tools and clear escalation protocols to maximise limited staff impact. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In regions with nurse shortages, we strongly recommend training family members to assist with basic care activities under nursing supervision, following cultural norms of family involvement common throughout MENA countries. (RL)
MENA-SINO Original	EO-Strong Agreement	C	We strongly recommend developing validated nursing protocol local adaptations in regional languages to facilitate implementation across different healthcare settings, with consideration for varying literacy levels. (RL)

Overview

Nursing care forms the foundation for the successful management of aSAH patients. Key nursing interventions include frequent neurological assessments, vital sign monitoring, evidence-based protocol implementation, dysphagia screening, and early mobilization. Standardized assessment tools and protocols improve care consistency and facilitate the early detection of complications.

The NICE guidelines emphasize documenting opioid administration when conducting neurological assessments as

these medications can affect pupillary responses and consciousness levels. We incorporated this recommendation into the regional implementation challenge considerations.

The Chinese guidelines highlight the psychological aspects of nursing care, including patient and family support and education, which hold particular relevance in MENA contexts, where family involvement typically exceeds Western norms.

Nursing resources and neuroscience nursing training varied significantly across the MENA region. Many facilities face nursing shortages, high patient-to-nurse ratios, and limited access to specialized training. Language and cultural factors influence nursing practice. Our recommendations acknowledge these challenges while maintaining the essential nursing care principles.

Supporting Research

Nursing intervention recommendations are supported by several studies demonstrating improved outcomes with standardized care. The Quality in Acute Stroke Care (QASC) trial, a large observational study, found that patients in a nurse-initiated intervention group using protocols for managing fever, blood sugar, and swallowing had a 16% absolute improvement in death and dependency at 90 days. Follow-up studies showed that establishing these nursing protocols led to an 80% increase in protocol adherence, with ongoing reduced dependency [95].

Regarding neurological assessment, studies have identified GCS and NIHSS as the preferred monitoring tools, with GCS scores decreasing by ≥2 points associated with clinical DCI. Assessment frequency in studies ranged from every 15 min to every 4 h during the acute phase, with no clear consensus on optimal frequency—an important consideration for settings with limited nursing resources [96].

For dysphagia screening, systematic reviews including over 4,500 patients found that nurse-initiated screening and formal guidelines significantly reduced pneumonia and mortality rates [97]. Evidence-based mobility program implementation has been associated with a 2.3-fold increase in functional levels at 90 days, and some studies suggest that early mobilization may even reduce the risk of severe vasospasm.

Studies examining nurse competency have found that stroke-specific training improves guideline knowledge and adherence and is associated with a decreased length of stay. Stroke-certified nurses delivered more timely care and had higher protocol adherence rates than did non-certified nurses [98].

Regarding psychological support, studies have shown that structured education and nurse-led support interventions can reduce patient and family anxiety levels, improve treatment adherence, and enhance care satisfaction; interventions particularly valuable in MENA contexts where family involvement is extensive [99,100].

MENA-Specific Considerations

1. Nursing resource constraints: Many facilities across the region face nursing shortages and have high patient-to-nurse ratios. We recommend adapting protocols to prioritize essential monitoring while acknowledging these limitations through task prioritization and simplified assessment tools.
2. Variable training levels: Specialized neuroscience nursing education access varies widely. We recommend developing basic training programs in aSAH care for general nurses working in facilities that manage these patients, with an emphasis on neurological assessment and deterioration recognition.
3. Language considerations: Assessment tools should be validated and available in regional languages (Arabic, Farsi, Turkish, French, etc.) to ensure their accurate implementation. This adaptation must account for the dialectal variation within languages.
4. Cultural factors: Cultural norms regarding gender-concordant care, family involvement, and communication styles should be incorporated into nursing practice. We recommend protocols that

acknowledge these preferences while maintaining clinical standards.

5. Family involvement: In many MENA cultures, family members participate actively in hospital care. We recommend leveraging this cultural strength, particularly in settings with nursing shortages, by providing appropriate guidance and education to caregivers.
6. Documentation variability The availability of electronic health records varied significantly. We recommend alternative documentation systems for settings with paper-based records to maintain consistency in monitoring and to ensure effective communication between shifts.
7. Religious considerations: Prayer times and religious practices should be incorporated into care planning and mobilization protocols. We recommend staff education on these practices to ensure the provision of respectful care.

8.2. Monitoring and Detection of Cerebral Vasospasm and DCI

Recommendations for Monitoring and Detection of Cerebral Vasospasm and DCI in the MENA Region

Table 9: Monitoring and Detection of Cerebral Vasospasm and DCI Recommendations

Source	COR	LOE	Recommendation
Adapted from NICE Guidelines	1	B-NR	For patients with unexplained neurological deterioration after aSAH, we strongly recommend performing a non-contrast CT head scan as the first diagnostic investigation to determine the cause, with protocols for urgent imaging access in settings where CT availability may be limited. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	In patients with suspected vasospasm or limited clinical examination capability, we suggest CTA or CT perfusion studies can help detect vasospasm and predict delayed cerebral ischaemia, though availability of these advanced imaging modalities varies significantly across MENA healthcare settings. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	We suggest transcranial Doppler ultrasound monitoring provides a reasonable non-invasive method to detect vasospasm and predict delayed cerebral ischaemia, particularly valuable in settings where advanced imaging access is limited but TCD expertise and equipment are available. (RL)
Adapted from Neurocritical Care Guidelines	2a	B	We strongly recommend serial clinical examinations by trained personnel as the most reliable method for detecting delayed cerebral ischaemia in awake patients, with standardised assessment tools adapted for regional languages and education levels. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	For high-grade aSAH patients, we suggest continuous EEG monitoring can help predict delayed cerebral ischaemia development, though this modality is primarily available in major urban centres across the MENA region. (RL)
Adapted from NICE Guidelines	3: No benefit	B-NR	We recommend against routine transcranial Doppler monitoring use to guide clinical management except in research contexts, while recognising that in some resource-limited MENA settings without advanced imaging, TCD may represent the only available monitoring tool. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	In select high-grade aSAH patients, we suggest invasive brain tissue oxygenation and cerebral metabolism monitoring may provide additional information for predicting delayed cerebral ischaemia, though these advanced techniques are available only in specialised MENA centres. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings, we strongly recommend emphasising serial clinical examinations by trained personnel using standardised assessments as the primary monitoring strategy, with clear protocols for deterioration response. (RL)

Source	COR	LOE	Recommendation
MENA-SINO Original	EO-Strong Agreement	C	Where available, we strongly recommend prioritising TCD as a non-invasive, relatively low-cost monitoring tool implementable in various resource settings, with regional training programs to increase operator expertise. (RL)
MENA-SINO Original	EO-Partial Accord	C	We suggest considering telemedicine interpretation of neuroimaging and TCD to expand vasospasm monitoring access in centres without on-site expertise, though implementation requires adequate internet connectivity and equipment compatibility. (RL)

Overview

Cerebral artery narrowing (cerebral vasospasm) frequently occurs in patients with aSAH and is associated with delayed cerebral ischemia (DCI) and infarction. DCI affects approximately 30% of patients, mostly between 4 and 14 days after aSAH. Early detection is essential for timely intervention and improved outcome.

International guidelines have demonstrated notable differences in transcranial Doppler (TCD) monitoring. While the AHA/ASA and Neurocritical Care guidelines suggest TCD as a reasonable monitoring approach, NICE guidelines recommend against routine use, except in research contexts. We have included both perspectives with an appropriate context for regional implementation, recognizing that in some resource-limited settings, TCD may represent the only available advanced monitoring tool.

Various monitoring tools exist for vasospasm detection and DCI prediction, ranging from clinical examinations to advanced imaging and invasive monitoring techniques. The availability of these monitoring modalities varies significantly across the MENA region, necessitating a tiered approach based on local resources, while maintaining vigilance for this critical complication.

Supporting Research

The NICE guideline recommendation for non-contrast CT head scans as the first diagnostic investigation for unexplained neurological deterioration is based on studies showing its utility in identifying various causes of deterioration, including hydrocephalus, rebleeding, cerebral edema, and established infarction [46].

Evidence for the use of CTA and CTP in vasospasm detection has been reported in multiple studies [101,102]. CTA has demonstrated 91% sensitivity for detecting central vasospasm with approximately 90% diagnostic accuracy compared to DSA [103]. CTP provides early perfusion abnormality detection with a 0.67 positive predictive value for DCI [104].

Numerous studies have demonstrated the utility of TCD in the detection of vasospasms. TCD has shown a sensitivity ranging from 39-94% and specificity from 70-100% for detecting vasospasm, with a wide range reflecting operator dependency and technique variations [105-107]. Despite these limitations, the non-invasive nature of TCD and its relatively low cost make it a valuable monitoring tool in resource-limited settings.

The discrepancy between the guidelines regarding TCD reflects ongoing debate. The NICE guidelines' recommendation against routine TCD stems from the concern that it may lead to interventions without clear benefit evidence [46], whereas other guidelines focus on its value as a screening tool [56,108].

Neurocritical Care guidelines emphasize serial clinical examinations by trained personnel as the most reliable DCI detection method in awake patients, with multiple studies supporting this approach when performed consistently and systematically [109].

Continuous EEG monitoring has emerged as a valuable DCI prediction tool,

particularly in high-grade aSAH patients with limited clinical examinations. Studies have identified several EEG patterns, including decreased alpha variability, relative alpha variability, and alpha-delta ratio changes that precede clinical DCI by 24-48 hours with 89% sensitivity and 77% specificity in some studies [110,111].

Invasive monitoring techniques, including brain tissue oxygen monitoring and cerebral microdialysis, have demonstrated utility in select patients. Decreased brain tissue oxygen values (<15 mmHg) and increased lactate/pyruvate ratios have been associated with impending DCI, although these techniques remain limited to specialized centers [112,113].

MENA-Specific Considerations

1. Imaging accessibility CTA and CTP access varied significantly across regions. Major urban centers may have 24/7 availability, but many facilities have limited access or significant delays in obtaining these studies. We recommend clear protocols for prioritizing patients who are most likely to benefit from limited imaging resources.
2. TCD availability: TCD is a relatively low-cost, non-invasive monitoring tool that can be implemented in various resource settings. However, equipment availability and expertise vary across regions. We recommend regional training programs to expand this capability where appropriate.
3. EEG monitoring capabilities: Continuous EEG monitoring is primarily available in major neurological centers. Many facilities have limited or no EEG access and interpretation expertise may be scarce. We recommend exploring more accessible alternatives, including simplified EEG protocols where feasible.
4. Invasive monitoring limitations: Advanced invasive monitoring techniques are available only in select centers with specialized neurocritical care units. Most facilities across the region lack the capabilities and expertise to interpret the results.
5. Personnel considerations: Trained personnel to perform and interpret neuromonitoring studies may be limited to major centers. We recommend training programs and telemedicine support to address these gaps with emphasis on basic clinical monitoring skills.
6. Cultural factors: Invasive monitoring may raise cultural and religious concerns in some communities. We recommend appropriate communication and education when proposing these interventions with sensitivity to regional beliefs and practices.
7. Transfer logistics: In settings where advanced monitoring is unavailable, we recommend establishing clear criteria for transfer to higher-level centers, considering local transportation capabilities, distances, and security concerns in unstable regions.

8.3. Management of Cerebral Vasospasm and DCI After aSAH

Recommendations for Management of Cerebral Vasospasm and DCI After aSAH in the MENA Region

Table 10: Management of Cerebral Vasospasm and DCI After aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	A	We strongly recommend early oral nimodipine administration to improve outcomes by reducing delayed cerebral ischaemia risk, with consideration for ensuring reliable supply chains across diverse MENA healthcare settings. (RL)
Adapted from NICE Guidelines	1	B	We strongly recommend enteral nimodipine for all confirmed subarachnoid haemorrhage patients, reserving intravenous nimodipine for specialised settings when enteral treatment is unsuitable. This recommendation requires regional adaptation for settings where intravenous formulations may be more consistently available than enteral forms. (RL)

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	2a	B-NR	We suggest maintaining normal volume status (euvolaemia) to help prevent delayed cerebral ischaemia and improve outcomes, with monitoring approaches adapted to regional equipment availability. (RL)
Adapted from NICE Guidelines	1	B	For patients with delayed cerebral ischaemia, we strongly recommend ensuring euvolaemia and considering vasopressor treatment if symptoms persist, with protocols adapted to regional medication availability and monitoring capabilities. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	For patients with symptomatic vasospasm, we suggest induced hypertension may reduce ischaemic neurological deficits, though implementation requires appropriate monitoring and vasopressor access, which varies across MENA healthcare settings. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	In patients with severe vasospasm, we suggest intra-arterial vasodilator therapy may help reverse angiographic narrowing and reduce ischaemic deficits, though this intervention is limited to centres with neurointerventional capabilities primarily in major urban areas. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	For appropriate patients with severe vasospasm, we suggest endovascular balloon angioplasty may benefit in reversing arterial narrowing and improving cerebral blood flow, though regional availability is extremely limited and requires protocols for urgent transfer when indicated. (RL)
Adapted from ESO Guidelines	3: No benefit	A	We recommend against routine statin therapy for all aSAH patients as this has not demonstrated outcome improvement in well-designed trials, despite theoretical benefits and relatively low cost.
Adapted from AHA/ASA 2023	3: No benefit	A	We recommend against routine intravenous magnesium supplementation for improving neurological outcomes after aSAH based on high-quality negative trials, though maintaining normal magnesium levels remains appropriate.
Adapted from ESO Guidelines	3: Harm	B-R	We recommend avoiding prophylactic hypervolaemic or hypertensive therapy for patients at DCI risk due to potential harm without demonstrated benefit. This represents an evolution from earlier practice patterns still common in some MENA centres.
MENA-SINO Original	EO-Strong Agreement	C	In settings where nimodipine availability is limited due to cost or supply constraints, we strongly recommend securing a reliable supply chain for this essential medication, with potential regional procurement initiatives to improve access and reduce costs. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In facilities without endovascular capabilities, we strongly recommend establishing transfer protocols to centres with these capabilities for patients with severe symptomatic vasospasm not responding to medical management, with consideration for regional transportation challenges. (RL)
MENA-SINO Original	EO-Partial Accord	C	In settings where continuous arterial BP monitoring is unavailable, we suggest implementing frequent non-invasive BP measurements (every 15-30 minutes) during induced hypertension therapy, with clear parameters for vasopressor titration based on these measurements. (RL)

Overview

For patients surviving an initial aneurysmal rupture, delayed cerebral ischemia (DCI) is a major concern. Angiographic presence of cerebral vasospasm as a DCI cause constitutes a major predictor of morbidity and mortality. Management strategies included preventive measures (nimodipine and euvolemia) and established vasospasm interventions (induced hypertension and endovascular therapies).

The NICE guidelines provide specific recommendations regarding nimodipine administration, emphasizing the preference for enteral over intravenous administration. We incorporated this recommendation with regional implementation challenge considerations, noting that in some MENA settings, intravenous formulations may be more consistently available than enteral formulations.

The MENA region of DCI management resources varies significantly across the MENA region. Although major centers may offer comprehensive management options, including endovascular interventions, many facilities have limited capabilities. Our recommendations provide a tiered approach based on available resources, while maintaining key care principles.

Supporting Research

The recommendation of nimodipine is based on multiple randomized controlled trials and meta-analyses demonstrating its effectiveness in preventing DCI and improving outcomes after aSAH. The standard regimen was 60 mg orally every 4 h for 21 days, starting within 96 h of hemorrhage onset [114,115].

The NICE guidelines specifically recommend enteral nimodipine for all confirmed subarachnoid hemorrhage patients, reserving intravenous administration in specialized settings when enteral treatment is unsuitable. This recommendation is based on the efficacy, safety, and cost considerations [46].

For fluid management, emphasis has shifted from hypervolemia to euvolemia, based on studies showing increased complications with hypervolemic therapy without improved outcomes. Goal-directed fluid management using appropriate monitoring has been associated with better hypovolemia recognition and may reduce the DCI in high-grade aSAH [79,89].

Induced hypertension for symptomatic vasospasm is supported by observational studies showing neurological improvement in 30-75% of patients [116]. While no large RCTs have established optimal targets, protocols typically aim for 15-30% systolic blood pressure elevation. However, prophylactic hemodynamic augmentation has not shown benefits and increases the risk of complications [102].

The NICE guidelines highlight that clinical improvement from vasopressor treatment may be temporary, emphasizing the importance of continued monitoring and consideration of additional interventions if needed [46].

Endovascular interventions, including intra-arterial vasodilators and mechanical angioplasty, have demonstrated efficacy in reversing angiographic vasospasm, with clinical improvement in 50-70% of treated patients, although high-quality RCTs are lacking [117].

Multiple large RCTs have examined statins and magnesium for DCI prevention, including the Simvastatin in Aneurysmal Subarachnoid Hemorrhage (STASH) trial with 803 patients and the Magnesium for Aneurysmal Subarachnoid Hemorrhage 2 (MASH-2) trial with 1,204 patients. Neither therapy demonstrated benefits in preventing DCI or improving outcomes, leading to recommendations against routine use despite theoretical benefits [118-121].

MENA-Specific Considerations

1. Nimodipine availability and cost: Nimodipine access varies across regions, with cost and supply chain issues limiting its availability in some areas. As a critical aSAH management medication, we recommend securing reliable access through regional procurement initiatives and inclusion of an essential medicine list.
2. Hemodynamic monitoring capabilities: Continuous arterial BP monitoring, central venous pressure monitoring, and availability of advanced hemodynamic assessment tools vary. We recommend alternative protocols that use available monitoring with clear parameters for interventions based on intermittent measurements.
3. Endovascular treatment access: The endovascular capabilities for treating severe vasospasm remain limited to major regional centers. We recommend establishing clear

transfer protocols for patients with severe symptomatic vasospasm who do not respond to medical management while considering regional transportation challenges.

4. Vasopressor availability Specific vasopressor availability varies across regions. We recommend protocols adaptable to locally available medications for induced hypertension therapy with appropriate dosing guidelines for each agent.
5. Intensive care capabilities: The ability to safely implement induced hypertension and closely monitor patients depends on ICU resources and staff. We recommend tailoring protocols to local capabilities using simplified versions for limited-resource settings.
6. Transportation challenges: In remote areas or conflict zones, transportation to centers with endovascular capabilities may be difficult or dangerous. We recommend alternative management strategies for situations in which transfer is not feasible, with an emphasis on maximizing medical management.
7. Cultural and religious considerations: Religious practices, such as Ramadan fasting, may affect medication administration schedules and fluid management. We recommend addressing these considerations in care protocols with appropriate guidance for medication timing during fasting.

8.4. Management of Hydrocephalus Associated With aSAH

Recommendations for Management of Hydrocephalus Associated With aSAH in the MENA Region

Table 11: Management of Hydrocephalus Associated With aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	For patients with acute symptomatic hydrocephalus, we strongly recommend urgent cerebrospinal fluid diversion (external ventricular drain and/or lumbar drainage) to improve neurological outcomes, with protocols adapted for settings where neurosurgical expertise may be limited. (RL)
Adapted from NICE Guidelines	1	B	We strongly recommend basing acute or chronic hydrocephalus diagnosis on the patient's symptoms and signs, and on current and previous CT or other brain imaging comparison. This approach remains valid across all resource settings, though imaging quality and availability may vary. (RL)
Adapted from AHA/ASA 2023	1	B-NR	When external ventricular drainage is required, we strongly recommend implementing comprehensive management protocols covering insertion technique, maintenance, monitoring, and staff education to reduce infection and complication rates, with adaptation for varying resource levels. (RL)
Adapted from AHA/ASA 2023	1	B-NR	For patients who develop chronic symptomatic hydrocephalus after aSAH, we strongly recommend permanent CSF diversion to improve neurological function, with consideration for regional variability in shunt device availability and neurosurgical expertise. (RL)
Adapted from NICE Guidelines	2a	B	For patients with persistent or progressive symptoms and clinical chronic hydrocephalus diagnosis, we suggest considering temporary drainage trial to assess permanent diversion need. This approach may be particularly valuable in settings where permanent shunt devices face supply constraints. (RL)
Adapted from AHA/ASA 2023	3: No benefit	C-LD	We recommend against routine fenestration of the lamina terminalis during aneurysm surgery as this has not demonstrated reduced shunt-dependent hydrocephalus rates despite theoretical benefits.
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited neurosurgical expertise, we strongly recommend establishing emergency EVD placement protocols by appropriately trained general surgeons, followed by transfer to a

Source	COR	LOE	Recommendation
			neurosurgical centre when stable. These protocols should include simplified anatomical guidance and clear safety parameters. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings, we strongly recommend adapting locally available materials for EVD systems with close attention to maintaining sterility and accurate pressure monitoring. Standard protocols should detail acceptable alternatives when commercial systems are unavailable. (RL)
MENA-SINO Original	EO-Partial Accord	C	In settings where shunt devices are limited by cost or availability, we suggest establishing clear prioritisation criteria for patients most likely to benefit from permanent CSF diversion, based on age, functional status, and symptom severity. (RL)

Overview

Patients risk develop symptomatic acute or chronic hydrocephalus. Acute hydrocephalus requires urgent intervention with CSF diversion, typically through an external ventricular drain (EVD). Chronic hydrocephalus may necessitate permanent CSF diversion with a ventriculoperitoneal shunt. Appropriate EVD management using standardized protocols is essential to reduce complications, particularly infections.

The NICE guidelines emphasize clinical assessment combined with comparative imaging for diagnosing hydrocephalus and suggest temporary drainage trials to assess permanent diversion need in chronic hydrocephalus cases. We incorporated these recommendations into the regional implementation challenge considerations.

Across the MENA region, capabilities for diagnosing and managing hydrocephalus vary significantly. Although major centers maintain 24/7 neurosurgical coverage and specialized equipment, many facilities have limited neurosurgical access and face specialized material constraints. Our recommendations provide adaptations for different resource settings while maintaining core management principles.

Supporting Research

Evidence for urgent CSF diversion in acute symptomatic hydrocephalus comes from multiple observational studies that showed improved outcomes with timely intervention. Studies report acute hydrocephalus in 20-30% of patients with aSAH, with clinical improvement in 70-80% of patients after CSF diversion [122-126].

The approach of the NICE guidelines to diagnose hydrocephalus based on clinical assessment and comparative imaging is supported by studies showing that ventricular size changes over time, correlates with clinical symptoms, and provides the most accurate diagnosis [46].

Regarding EVD management, studies demonstrate that standardized bundled protocol implementation significantly reduces EVD-related infections, with infection rates decreasing from 10-15% to 3-5% in some series [85,123,126]. These protocols typically address insertion techniques, dressing changes, CSF sampling procedures, and staff education.

For chronic hydrocephalus, which occurs in 18-26% of aSAH survivors, studies consistently show clinical improvement after permanent CSF diversion, with good functional outcomes in the majority of appropriately selected patients [127-129].

The NICE guidelines' recommendation for temporary drainage trials in chronic hydrocephalus cases is supported by studies showing that temporary drainage can help predict which patients will benefit from permanent diversion, potentially avoiding unnecessary shunt procedures, a consideration particularly relevant for resource-limited settings [46].

The recommendation against routine fenestration of the lamina terminalis is based on limited evidence showing no significant reduction in shunt dependency

rates with this surgical technique, despite the theoretical benefits [128,130].

MENA-Specific Considerations

1. Neurosurgical expertise availability: Neurosurgical access varies widely, particularly outside major urban centers and during off-hours. We recommend emergency protocols for initial management by general surgeons or other physicians with appropriate training, detailed procedural guidance, and clear indications.
2. EVD equipment access: Commercially manufactured EVD systems may not be universally available owing to cost or supply chain issues. We recommend alternative approaches using locally available materials in some settings, with an emphasis on maintaining sterility and accurate pressure monitoring.
3. Monitoring capabilities: Regular and reliable ICP monitoring through EVD systems requires trained personnel and appropriate equipment, which may be limited in certain facilities. We recommend training protocols for non-specialized staff with an emphasis on basic monitoring principles.
4. Infection control challenges Variable infrastructure for infection control, including limited antibiotic availability, may affect EVD management protocols. We recommend adapted infection prevention bundles based on local resources, with an emphasis on hand hygiene and aseptic techniques.
5. Permanent shunt availability: Ventriculoperitoneal shunt device access may be limited by cost or availability in certain settings. We recommend clear prioritization criteria for patients most likely to benefit from permanent CSF diversion based on age, functional status, and symptom severity.
6. Follow-up capabilities: Long-term follow-up of patients with permanent shunts may prove challenging in certain populations, particularly refugee groups or those from remote areas. We recommend strategies to ensure adequate follow-up, including community health worker involvement, where appropriate.
7. Cultural considerations: Cultural attitudes toward neurosurgical interventions may influence procedural acceptance. We recommend developing appropriate communication strategies for different cultural contexts that are sensitive to religious beliefs and family decision-making processes.

8.5. Management of Seizures Associated With aSAH

Recommendations for Management of Seizures Associated With aSAH in the MENA Region

Table 12: Management of Seizures Associated With aSAH Recommendations

Source	COR	LOE	Recommendation
Patients who present without seizures			
Adapted from AHA/ASA 2023	2a	B-NR	For patients with fluctuating neurological examination, depressed mental state, or high-risk features (MCA aneurysm, high-grade SAH, ICH, hydrocephalus, cortical infarction), we suggest continuous EEG monitoring to detect subclinical seizures where available, though recognising this capability is limited primarily to major centres in the MENA region. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	For patients with high seizure risk features, we suggest short-term prophylactic antiseizure medication may reasonably prevent early seizures, with medication selection based on regional availability, cost, and monitoring capabilities. (RL)
Adapted from NICE Guidelines	2b	C	We suggest managing seizures after aSAH according to standard epilepsy management guidelines, considering both acute treatment and potential ongoing medication need. Implementation should account for regional medication availability and monitoring capabilities. (RL)

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	3: No benefit	B-R	For patients without high seizure risk features, we recommend against prophylactic antiseizure medication as this has not demonstrated benefit in well-designed studies.
Adapted from AHA/ASA 2023	3: Harm	B-NR	We recommend avoiding phenytoin use for seizure prophylaxis in aSAH patients due to its association with worse outcomes, despite its widespread availability and lower cost in many MENA healthcare settings.
Patients who present with seizures			
Adapted from AHA/ASA 2023	2a	B-NR	For patients presenting with seizures at aSAH onset, we suggest treatment with antiseizure medications for up to 7 days to reduce perioperative seizure-related complications, with regional adaptation for medication availability and monitoring capabilities. (RL)
Adapted from AHA/ASA 2023	3: No benefit	B-NR	For patients without prior epilepsy who present with seizures at aSAH onset, we recommend against continuing antiseizure medications beyond 7 days as this has not demonstrated reduced future seizure risk in studies.
Adapted from Chinese Guidelines	2a	C	When selecting antiseizure medications, we suggest considering drug interactions with other medications and impact on haemodynamic stability in critically ill aSAH patients. This is particularly important in settings with limited medication options and monitoring capabilities. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings where continuous EEG monitoring is unavailable, we strongly recommend emphasising clinical surveillance for subtle seizure activity, with intermittent EEG when available for high-risk patients. Training non-specialist providers in seizure recognition improves detection in limited-resource settings. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings, we strongly recommend using levetiracetam when available as the preferred antiseizure medication due to its favorable safety profile and limited drug interactions. Regional procurement initiatives may improve access to this medication. (RL)
MENA-SINO Original	EO-Partial Accord	C	Where newer antiseizure medications are limited by cost or availability, we suggest considering valproate as an alternative to phenytoin for short-term seizure management, with appropriate monitoring for adverse effects based on local laboratory capabilities. (RL)

Overview

Seizures constitute a relatively common aSAH complication, with both early and late occurrences. Patients with certain risk factors (MCA aneurysm, high-grade SAH, ICH, hydrocephalus, and cortical infarction) have a higher seizure risk. Management strategies differ between patients presenting with seizures and those who do not and between high-risk and low-risk patients.The NICE guidelines recommend managing seizures after aSAH according to standard epilepsy management guidelines. We have incorporated this recommendation while acknowledging special considerations for patients with aSAH in a regional context.

Chinese guidelines emphasize drug interactions and hemodynamic effects when selecting antiseizure medications, which are particularly relevant in critical care settings with limited medication options.

Seizure detection and management capabilities vary significantly across the MENA region. Although major centers may have continuous EEG monitoring and newer antiseizure medication access, many facilities have limited EEG access and restricted medication options. Our

recommendations provide adaptations for different resource settings while maintaining core management principles.

Supporting Research

The aSAH seizure management recommendations are based on multiple observational studies and a limited number of RCTs. Continuous EEG monitoring studies have identified nonconvulsive seizures in 8-18% of patients with aSAH, particularly those with depressed consciousness. These seizures are associated with worse outcomes and may be missed without continuous EEG monitoring [110,111,131].

For prophylactic antiseizure medications, studies have shown limited benefit in the general aSAH population, with some suggesting potential harm with certain medications. A meta-analysis found that prophylactic antiseizure medications did not significantly reduce seizure incidence but confirmed that phenytoin was associated with worse functional outcomes [132,133].In patients with high seizure risk features, limited data suggest a potential benefit from short-term prophylaxis, although the evidence quality remains moderate. For patients presenting with seizures, studies support short-term (≤7 days) treatment to reduce perioperative seizure complications, but extended therapy has not shown benefits in preventing later seizures [134] [Nakashima, 2024 #68].The recommendation against phenytoin stems from multiple studies showing worse cognitive outcomes and an increased vasospasm risk [132,135]. Newer antiseizure medications, particularly levetiracetam, have demonstrated similar efficacy, with better safety profiles and fewer drug interactions [134].The Chinese guidelines' emphasis on drug interactions and hemodynamic effects is supported by pharmacokinetic studies showing significant interactions between antiseizure medications and other commonly used medications in aSAH management as well as studies documenting the hemodynamic effects of certain antiseizure medications that could potentially impact cerebral blood flow [66].

MENA-Specific Considerations

1. EEG monitoring availability: Continuous EEG monitoring is primarily available in major neurological centers. Many facilities have limited or no EEG access, necessitating a greater reliance on clinical monitoring for seizure detection. We recommend training programs for clinical seizure recognition, particularly for subtle clinical manifestations.
2. Antiseizure medication access: Newer antiseizure medications (e.g., levetiracetam) availability and cost vary significantly across the region. We recommend alternative protocols that use more widely available medications in some settings, with clear guidance on dosing and monitoring.
3. Medication costs and insurance coverage: In many MENA countries, newer antiseizure medications may not be covered by insurance or national healthcare systems, thus creating financial treatment barriers. We recommend considering cost-effectiveness in medication selection while avoiding phenytoin owing to its adverse effects.
4. Drug interactions: In regions where traditional medicines are commonly used alongside conventional treatments, we recommend attention to potential interactions with antiseizure medications and educational materials for patients and families.
5. Laboratory monitoring capabilities: Drug levels and side effect monitoring ability vary significantly, affecting antiseizure medication selection in different settings. We recommend protocols adapted to local capabilities, with guidance on clinical monitoring when laboratory testing is limited.
6. Cultural attitudes toward seizures In some communities, seizures may carry significant stigma, potentially affecting reporting and treatment adherence. We recommend culturally sensitive education and counseling as important care components.
7. Long-term follow-up challenges: For patients developing epilepsy after aSAH, ensuring consistent long-term follow-up may be challenging in certain populations, particularly refugee groups or those from remote areas. We recommend strategies to improve adherence, including involvement of community health workers, where appropriate.

9. aSAH Recovery

Recommendations for aSAH Acute Recovery in the MENA Region

9.1. aSAH Acute Recovery

Table 13: aSAH Acute Recovery Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	Before hospital discharge, we strongly recommend using validated assessment tools to screen for physical, cognitive, behavioural, and quality of life deficits, with tools adapted and validated for local languages and cultural contexts when available. (RL)
Adapted from AHA/ASA 2023	1	B-NR	During the post-acute period, we strongly recommend systematic depression and anxiety screening to identify patients requiring intervention, with consideration for cultural attitudes toward mental health that may affect reporting in many MENA communities. (RL)
Adapted from AHA/ASA 2023	1	B-NR	For patients with post-aSAH depression, we strongly recommend appropriate psychotherapy and/or pharmacotherapy to reduce depressive symptoms, with approaches adapted to regional mental health resource availability and cultural acceptability. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend cognitive screening in the post-acute period to identify impairments requiring intervention or accommodation, with simplified tools appropriate for implementation by non-specialists when neuropsychological expertise is limited. (RL)
Adapted from NICE Guidelines	1	B	We strongly recommend following established stroke rehabilitation guidelines for rehabilitation after aneurysmal subarachnoid haemorrhage, with adaptations for aSAH-specific deficits and regional rehabilitation resource availability. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend a multidisciplinary team approach to treatment and rehabilitation planning to better identify discharge needs and reduce length of stay, while acknowledging that full multidisciplinary teams may not be available in all MENA settings. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	After aneurysm treatment, we suggest implementing early rehabilitation when no contraindications exist to improve functional outcomes and reduce hospitalisation duration, with protocols adapted to regional staffing patterns and cultural factors. (RL)
Adapted from NICE Guidelines	2a	B	Before discharge, we suggest providing patients with a follow-up care plan including details of specialist centre contacts for ongoing advice and support. This recommendation requires adaptation for settings with limited outpatient services. (RL)
Adapted from AHA/ASA 2023	2b	C-LD	For comatose aSAH patients, we suggest early neurostimulant therapy may potentially enhance consciousness recovery, though medication availability varies across the region and requires protocols for appropriate patient selection. (RL)
Adapted from AHA/ASA 2023	3: No benefit	A	We recommend against prophylactic fluoxetine therapy for non-depressed aSAH patients as this has not demonstrated enhanced functional recovery in well-designed studies.
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited formal rehabilitation service access, we strongly recommend implementing family-centred training programs to support basic rehabilitation in the home environment, leveraging the strong family involvement characteristic of MENA cultures. (RL)
MENA-SINO Original	EO-Strong Agreement	C	We strongly recommend using culturally adapted and validated screening tools in local languages when available for assessing post-aSAH deficits, with consideration for varying literacy levels across the region. (RL)
MENA-SINO Original	EO-Partial Accord	C	In communities where mental health services are limited, we suggest integrating basic psychological support into primary care follow-up, with training for primary care providers in recognising and managing common post-aSAH psychological issues. (RL)

Overview

Although aSAH mortality has improved in recent decades, survivors often experience deficits in multiple domains, including physical function, cognition, behavior, and quality of life. Depression affects approximately one-third of aSAH survivors, anxiety and posttraumatic stress disorder 15-20%, and cognitive impairment 40-70%. These impairments may persist long term, even in patients with good functional recovery using traditional measures.

The NICE guidelines recommend the following established stroke rehabilitation guidelines for aSAH patients while emphasizing the importance of comprehensive follow-up care plans. We incorporated these recommendations into the regional implementation challenge considerations.

Across the MENA region, the availability of comprehensive rehabilitation services and specialized follow-up care varies significantly. Although major urban centers may offer multidisciplinary rehabilitation programs, many areas have limited or no specialized service access. Additionally, cultural factors influence perceptions of disability, mental health, and rehabilitation approach. Our recommendations provide adaptations for different resource settings, while recognizing the critical importance of addressing recovery needs.

Supporting Research

The acute recovery assessment and intervention recommendations were based on numerous observational studies and randomized trials. Systematic reviews have demonstrated high rates of cognitive impairment, depression, anxiety, and fatigue after aSAH, with a significant impact on the quality of life [136-138] [139]. Validated screening tools have shown good sensitivity for detecting these impairments in the post-acute period.

The NICE guidelines' recommendations for following established stroke rehabilitation guidelines are supported by studies showing similar rehabilitation needs and responses between aSAH and other stroke populations, though with some aSAH-specific considerations [46].

For depression management, both psychotherapy and pharmacotherapy have demonstrated effectiveness in reducing depressive symptoms after aSAH, with an additive effect when combined [140,141]. Studies have not shown the benefits of prophylactic antidepressants (e.g., fluoxetine) in non-depressed patients [141].

The NICE recommendation for a structured follow-up care plan is supported by studies that show that patients receiving clear information about follow-up care and contact details for ongoing support report less anxiety and better care satisfaction [46].

Early multidisciplinary rehabilitation has been associated with shorter hospital stay and improved functional outcomes. The A Very Early Rehabilitation Trial (AVERT) and other studies have demonstrated early mobilization safety and feasibility after aSAH when the aneurysm is secured, with some showing reduced complications and better functional recovery [142,143].

Limited data support neurostimulant use in comatose aSAH patients, with a few studies suggesting improved consciousness recovery rates, although larger trials are needed [144-146].

MENA-Specific Considerations

1. Rehabilitation resource distribution: Specialized neurorehabilitation services remain concentrated in major urban centers, creating significant access disparities between rural populations and resource-limited areas. We recommend adaptations that maximize the impact of limited resources through the prioritization of key interventions.
2. Cultural attitudes toward disability: Perceptions of disability and recovery expectations vary across different cultural contexts within the MENA region, influencing patient and family engagement with rehabilitation. We recommend culturally sensitive approaches to account for these beliefs.
3. Mental health services: Access to mental health services is limited in many areas, with variable cultural

acceptance of psychological interventions. We recommend integrating basic psychological support into standard follow-up, with approaches suited to regional cultural contexts.

4. Family role in care: In many MENA cultures, families traditionally assume significant caregiving responsibility. We recommend structured family education and training programs to leverage cultural strength in settings with limited formal rehabilitation resources.
5. Assessment tool validation: Many cognitive and functional assessment tools have not been validated in Arabic and other regional languages or for varying literacy levels, which potentially affects their reliability. We recommend using validated tools where available or adapting existing tools with cultural considerations.
6. Telemedicine opportunities: In areas with limited specialist access but reasonable internet connectivity, we recommend telemedicine approaches for rehabilitation support and specialist consultation to help bridge gaps while considering technological constraints.
7. Social support systems: Religious and community-based support networks play an important role in many MENA societies. We recommend engaging these resources to support recovery, with appropriate education for religious and community leaders.
8. Gender considerations: Cultural norms regarding gender may affect rehabilitation approaches, particularly physical therapy and personal care interventions. We recommend prioritizing gender-concordant care when possible with appropriate alternatives when unavailable.

9.2. aSAH Long-Term Recovery

Recommendations for aSAH Long-Term Recovery in the MENA Region

Table 14: aSAH Long-Term Recovery Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend including screening and intervention for depression, anxiety, and sexual dysfunction in long-term follow-up to improve aSAH survivor quality of life, with approaches adapted to regional mental health resource availability and cultural acceptability. (RL)
Adapted from AHA/ASA 2023	2a	B-NR	When assessing cognitive function in aSAH survivors, we suggest preferring the Montreal Cognitive Assessment (MoCA) over the Mini-Mental State Examination (MMSE) for detecting cognitive impairments, with use of validated translations for regional languages when available. (RL)
Adapted from AHA/ASA 2023	2b	B-NR	We suggest providing information to patients and caregivers about long-term cognitive dysfunction high risk after aSAH can benefit ongoing support need identification. This information should be culturally appropriate and account for varying health literacy levels.
Adapted from NICE Guidelines	2a	B	We suggest managing headaches in aSAH survivors according to standard headache guidelines, while noting that post-aSAH headaches are common and generally benign but may indicate chronic hydrocephalus if accompanied by additional symptoms. This distinction is particularly important in settings with limited neuroimaging access. (RL)
Adapted from Chinese Guidelines	2a	C	We suggest including assessment of return to work and social participation in long-term follow-up, with targeted interventions to address barriers when feasible. Particular attention should be paid to cultural factors affecting employment expectations and gender roles in the MENA region. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited long-term follow-up capabilities, we strongly recommend establishing a structured follow-up schedule with clear monitoring parameters to identify patients requiring additional

Source	COR	LOE	Recommendation
			intervention. This may include training primary care providers in basic post-aSAH assessment. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In communities where formal support services are limited, we strongly recommend engaging local community resources, including religious institutions and community organisations, to help support long-term recovery through structured programs tailored to local cultural contexts. (RL)
MENA-SINO Original	EO-Partial Accord	C	Where formal neuropsychological testing is unavailable, we suggest basic cognitive screening tools administered by primary care providers may help identify patients requiring further evaluation. These approaches should be adapted to local language and literacy levels. (RL)

Overview

Long-term recovery extends beyond the first 3 months in individuals with aSAH. Neurological deficits can result in an increased incidence of depression, anxiety, and cognitive impairment, affecting family roles and overall quality of life for months to years after the initial injury. The identification and treatment of these sequelae are important components of comprehensive care.

The NICE guidelines provide specific recommendations regarding headache management in aSAH survivors, emphasizing that while post-aSAH headaches are common and generally benign, they may indicate chronic hydrocephalus if accompanied by additional symptoms. We incorporated this recommendation into the regional implementation considerations.

The Chinese guidelines emphasize assessing return to work and social participation, reflecting these domains' importance for long-term quality of life and highlighting an area that is sometimes overlooked in follow-up care.

The long-term follow-up capabilities varied significantly across the MENA region. Major challenges include limited specialized neurological follow-up availability in many areas, cultural attitudes toward mental health and cognitive impairment, and variable access to support services. Our recommendations provide adaptations for different resource settings, while emphasizing the importance of long-term monitoring and support.

Supporting Research

Long-term recovery recommendations were based on longitudinal observational studies of aSAH survivors. These studies consistently show high rates of persistent deficits, with depression affecting 25-30%, anxiety disorders 15-25%, and cognitive impairment 40-60% of survivors at one year or more [144].

The recommendations of the NICE guidelines regarding headache management are supported by studies showing 20-40% of aSAH survivors experience chronic headaches, but these are generally benign . However, new or changing headache patterns accompanied by symptoms, such as gait disturbance, incontinence, or cognitive changes, may indicate chronic hydrocephalus, which occurs in up to 20% of survivors [46].

Multiple studies have demonstrated the importance of screening and interventions for mental health conditions, with improved outcomes when depression and anxiety are appropriately treated [144,147]. Sexual dysfunction, which affects up to 30% of survivors but is often underreported, also improves with targeted intervention [148].

The Chinese guidelines' emphasis on return to work and social participation is supported by studies showing only 50-70% of previously employed aSAH survivors return to work, often with reduced capacity or modified roles. Interventions targeting

vocational rehabilitation have shown modest success in improving the outcomes [56].

For cognitive assessment, comparative studies have shown that the Montreal Cognitive Assessment (MoCA) has better sensitivity than the Mini-Mental Status Examination (MMSE) for detecting executive function and processing speed deficits common after aSAH. The MoCA detects impairment in 71-92% of patients compared to 37-50% using the MMSE [149-151].

Studies examining patient and caregiver education have shown that counseling about potential cognitive changes improves deficit awareness, increases appropriate help-seeking behaviors, and reduces caregiver burden and stress [152-154].

MENA-Specific Considerations

1. Follow-up infrastructure: Systems for ensuring long-term follow-up vary widely, and many areas lack structured programs for monitoring aSAH survivors. We recommend integration with existing primary care structures in many settings, with training for primary care providers in basic post-aSAH assessments.
2. Mental health services: Mental health professional availability varies significantly, with many areas having limited or no access to specialized services. Cultural attitudes toward mental health may also affect treatment-seeking behaviors. We recommend approaches incorporating culturally accepted forms of psychological support.
3. Cognitive assessment resources: Access to formal neuropsychological testing is limited in many areas. We recommend simplified screening approaches that are implementable in non-specialized settings, with clear referral pathways when a more detailed assessment is needed.
4. Family support systems: Extended family networks often provide significant support for MENA culture. We recommend education and resources for family caregivers as particularly important in settings with limited formal services and appropriate cultural adaptation of materials.
5. Social reintegration factors: Cultural attitudes toward disabilities and employment may affect vocational rehabilitation and social reintegration. We recommend culturally appropriate approaches to these recovery aspects with sensitivity to regional gender role variations.
6. Language and literacy considerations: Assessment tools must be appropriate for varying language and literacy levels, with validated versions in regional languages, and adaptations for different educational backgrounds. We recommend using visual aids and simplified formats where appropriate.
7. Religious and community resources: Religious institutions and community organizations can provide important support structures for long-term recovery. We recommend engaging these as partners in care with appropriate education about aSAH recovery needs.

10. Risk Factors, Prevention, and Subsequent Monitoring for Recurrent aSAH

Recommendations for Risk Factors, Prevention, and Subsequent Monitoring for Recurrent aSAH in the MENA Region

Table 15: Risk Factors, Prevention, and Subsequent Monitoring for Recurrent aSAH Recommendations

Source	COR	LOE	Recommendation
Adapted from AHA/ASA 2023	1	B-NR	After aneurysm treatment, we strongly recommend perioperative cerebrovascular imaging to identify any residual aneurysm requiring additional intervention, with timing based on regional capabilities for prompt additional treatment if needed. (RL)
Adapted from AHA/ASA 2023	1	B-NR	We strongly recommend long-term follow-up imaging to monitor for aneurysm recurrence/regrowth, changes in known aneurysms, or new aneurysm development that may require treatment, with protocols adapted to regional imaging accessibility. (RL)
Adapted from NICE Guidelines	2a	B	We suggest considering follow-up neuroimaging for all aSAH patients, with imaging modality, frequency, and duration based on treatment type, non-culprit aneurysm presence, and estimated bleeding risk. Implementation should account for regional imaging resource limitations. (RL)
Adapted from ESO Guidelines	1	B	We strongly recommend smoking cessation for all patients with history of aSAH to reduce recurrent haemorrhage risk. This is particularly important in MENA countries with high smoking prevalence, requiring culturally appropriate cessation programs.
Adapted from ESO Guidelines	1	B	We strongly recommend hypertension treatment for all patients with history of aSAH to reduce aneurysm formation and rupture risk, with protocols adapted to regional medication availability and monitoring capabilities.
Adapted from NICE Guidelines	1	B	We strongly recommend multidisciplinary team evaluation of non-culprit (unruptured) aneurysm management options, considering aneurysm characteristics, estimated lifetime rupture risk, treatment risks, comorbidities, and patient preferences. Telemedicine consultation may facilitate this process in centres with limited specialist availability. (RL)
Adapted from ESO Guidelines	2a	B	For non-culprit aneurysms, we suggest both endovascular coiling and neurosurgical clipping can be reasonable treatment options, with selection based on patient and aneurysm characteristics and regional expertise availability. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In resource-limited settings, we strongly recommend high-quality CTA as a reasonable alternative to DSA for follow-up imaging when DSA is not readily available, with protocols for identifying patients requiring referral for DSA based on CTA findings. (RL)
MENA-SINO Original	EO-Strong Agreement	C	In settings with limited imaging resources, we strongly recommend prioritising follow-up imaging for patients with incomplete aneurysm occlusion, multiple aneurysms, or family history based on their higher recurrence risk. These prioritisation protocols should be clearly documented. (RL)
MENA-SINO Original	EO-Partial Accord	C	Where regular long-term follow-up is challenging due to geographic or socioeconomic barriers, we suggest implementing a structured education program about warning symptoms requiring urgent medical attention for patients and families, with culturally appropriate materials accounting for health literacy levels. (RL)
MENA-SINO Original	EO-Strong Agreement	C	We strongly recommend emphasising smoking cessation programs and hypertension management for all aSAH survivors to reduce aneurysm formation and rupture risk factors. These programs should be integrated into primary care follow-up with culturally appropriate approaches.

Overview

Patients with aSAH who have undergone aneurysm repair require monitoring for recurrence or regrowth of the treated aneurysm and development of new aneurysms. The risk of recurrent SAH remains relatively low over the long term, particularly in patients with incompletely occluded aneurysms, multiple aneurysms, or family history of aSAH.

The NICE guidelines provide detailed recommendations regarding follow-up neuroimaging, emphasizing the need to consider multiple factors when determining imaging protocols. We incorporated these recommendations into the regional implementation challenge considerations.

The ESO guidelines on unruptured aneurysms provide valuable recommendations regarding risk factor modification, particularly smoking cessation and hypertension treatment, which we have incorporated as high-priority interventions to reduce the risk of recurrence.

Long-term monitoring capabilities vary significantly across the MENA region. While urban centers often have advanced imaging facilities, access may be limited in rural areas and for certain populations owing to geographic, financial, or systemic barriers. Our recommendations provide adaptations for different resource settings while emphasizing the critical aspects of monitoring recurrent aSAH risk.

Supporting Research

Follow-up imaging recommendations are based on observational studies showing recurrence rates of 10-33% after endovascular coiling and 0-10% after surgical clipping. These studies demonstrated that regular imaging surveillance can detect changes requiring retreatment before rerupture occurs, potentially preventing recurrent hemorrhage [155-158].

The NICE guidelines' detailed approach to determining follow-up imaging protocols is supported by studies showing that individual risk factors significantly influence the appropriate monitoring frequency and duration. This personalized approach optimizes resource utilization while maintaining safety [46].

The optimal timing and frequency of follow-up imaging remain somewhat controversial; however, most studies support early post-treatment imaging (within 6 months) followed by interval imaging at 1-2 years, with longer intervals for completely occluded aneurysms and shorter intervals for residual aneurysms [159].

The strong recommendations of the ESO guidelines for smoking cessation and hypertension treatment are supported by multiple observational studies showing significantly increased risks for aneurysm formation, growth, and rupture associated with smoking and hypertension. In particular, smoking cessation has been associated with a reduced risk of recurrent SAH in long-term follow-up studies [71,160].

Long-term studies have also identified risk factors for de novo aneurysm formation, including smoking, hypertension, female sex, younger age, and a family history of aneurysms. Smoking cessation and hypertension control have been associated with a reduced risk of aneurysm formation and rupture in observational studies [155,161].

For imaging modalities, DSA remains the gold standard, but carries procedural risks. Studies comparing CTA and MRA to DSA show reasonable sensitivity for detecting clinically significant remnants and recurrences, particularly with current-generation scanners, supporting their use for routine follow-up in low-risk patients[101,103].

MENA-Specific Considerations

1. Imaging Access Disparities: Advanced cerebrovascular imaging access varies widely across regions. CTA may be more widely available than DSA in many settings, and represents a reasonable alternative for routine follow-up when DSA is not readily accessible. We recommend clear guidelines for identifying patients who require a referral for DSA.
2. Financial follow-up barriers: In many MENA countries, long-term follow-up imaging may not be covered by

insurance or national health systems, creating financial barriers to adherence to monitoring recommendations. We recommend advocating the coverage of these essential services while developing tiered approaches based on risk.

3. Geographic challenges: For patients living in remote areas, travel to centers with advanced imaging capabilities may be difficult or prohibitively expensive, thereby affecting follow-up adherence. We recommend coordinated scheduling to minimize the travel burden and develop mobile imaging services where feasible.
4. Risk factor prevalence: Smoking rates remain high in many MENA countries, making smoking cessation programs particularly important for aSAH survivors. We recommend culturally appropriate approaches that account for sex differences in smoking patterns.
5. Hypertension management: Consistent hypertension management access varies with challenges in medication availability, affordability, and regular monitoring in some settings. We recommend simplified protocols for blood pressure monitoring and management suitable for implementation in primary care settings.
6. Family screening considerations: When family screening is recommended due to family history, access and financial considerations may affect its implementation. We recommend pragmatic approaches to prioritize screening within families with clear criteria based on risk factors.
7. Patient education: Education about warning symptoms and risk factor modification should be culturally appropriate and account for varying literacy levels and health beliefs. We recommend developing materials for regional languages with appropriate visual elements to improve comprehension.

11. Implementation Framework for MENA-Adapted aSAH Guidelines

11.1. Structured Implementation Framework

Priority Actions by Resource Tier

Tier 1: Basic Emergency Care Facilities

- **Immediate (0-6 months)**:
  - Implement standardized clinical assessment protocols for suspected aSAH
  - Establish clear transfer protocols to higher-level facilities
  - Train emergency physicians in basic neurological assessment
  - Develop checklists for initial stabilization
  - Ensure availability of essential medications (nimodipine, antiseizure drugs)
- **Short-term (6-12 months)**:
  - Establish telemedicine connections with Tier 2/3 centers where feasible
  - Implement training for CT interpretation focused on SAH recognition
  - Develop referral networks with designated Tier 2/3 centers
  - Create protocols for patient transport optimization
- **Medium-term (1-2 years)**:
  - Train laboratory staff in basic CSF analysis for xanthochromia
  - Improve documentation and data collection for quality metrics
  - Organize periodic training with simulation exercises
  - Develop feedback mechanisms with receiving centers

Tier 2: Intermediate Neurovascular Capability Centers

- **Immediate (0-6 months)**:
  - Establish protocols for neurosurgical and endovascular management
  - Implement neurological monitoring protocols in ICU
  - Train ICU staff in neurocritical care basics

    - Create protocols for complication prevention and management
    - Develop structured communication with Tier 3 centers
- **Short-term (6-12 months)**:
    - Implement quality improvement initiatives
    - Establish inventory management for essential neurovascular supplies
    - Organize regular case discussions with Tier 3 centers
    - Train radiographers in CTA techniques
    - Develop protocols for recurrent bleeding prevention
- **Medium-term (1-2 years)**:
    - Establish training programs for basic neuroendovascular procedures
    - Implement protocols for neurological rehabilitation
    - Develop multidisciplinary team meetings
    - Create regional networks for knowledge sharing
    - Implement follow-up protocols for treated patients

Tier 3: Comprehensive Neurovascular Centers

- **Immediate (0-6 months)**:
    - Establish comprehensive treatment algorithms
    - Implement advanced monitoring protocols
    - Create regional transfer coordination systems
    - Establish multidisciplinary aSAH teams
    - Develop mentorship programs for Tier 2 centers
- **Short-term (6-12 months)**:
    - Implement quality metrics reporting system
    - Develop educational materials for all facility tiers
    - Establish regional case registry
    - Create regional teleconference case discussions
    - Implement protocols for research participation
- **Medium-term (1-2 years)**:
    - Establish MENA regional aSAH working group
    - Develop fellowship training programs
    - Create research network for MENA-specific aSAH patterns
    - Implement advanced technology training program
    - Develop innovation hubs for resource-adapted solutions

11.2. Cost-Effectiveness Considerations

A. Resource Utilization Optimization

- **Basic Settings**:
    - Prioritize clinical assessment skills over advanced technology
    - Focus resources on rapid transfer systems rather than complex on-site capabilities
    - Utilize telemedicine for specialist consultation rather than on-site specialists
    - Implement low-cost medications with highest benefit (e.g., nimodipine)
    - Use tranexamic acid selectively when transfer is delayed (NNT analysis indicates cost-effectiveness in this scenario)
- **Intermediate Settings**:
    - Develop hub-and-spoke models with clear transfer criteria to avoid unnecessary resource utilization
    - Implement select advanced diagnostics with highest yield-to-cost ratio
    - Train existing staff in neurocritical care rather than hiring subspecialists
    - Focus endovascular resources on highest-benefit procedures first
    - Implement standardized protocols to reduce practice variations and costs
- **Comprehensive Settings**:
    - Develop center-of-excellence designation criteria to concentrate expertise
    - Implement value-based care metrics specific to aSAH
    - Create supply chain efficiencies for specialized equipment and disposables
    - Balance cutting-edge technology with proven cost-effective interventions
    - Develop training programs to expand regional expertise cost-effectively

B. Regional Adaptation Analysis

1. **Diagnostic Algorithms**:
    - Non-contrast CT is most cost-effective first-line diagnostic (94% sensitivity in first 24 hours, approximate cost 1/10th of CTA)
    - In limited-resource settings, LP with visual inspection has ICER of approximately $1,200 per QALY gained compared to transfer without diagnosis
    - Teleradiology for CT interpretation has shown ROI of 4:1 in pilot programs in Jordan and Morocco
2. **Treatment Selection**:
    - Coiling vs. clipping cost analysis varies by region:
        - In GCC countries: Similar cost profiles to Western data
        - In middle-income MENA: Higher relative cost of endovascular supplies increases ICER to $9,500/QALY gained
        - In lower-resource settings: Clipping more cost-effective when factoring total costs including expertise availability
    - Early treatment (within 24h) shows consistent cost savings across all settings
3. **Systems of Care**:
    - Regional coordination systems demonstrate cost savings of 20-30% compared to uncoordinated care
    - Transfer costs must be weighed against outcomes based on regional geography and infrastructure
    - Training programs for existing physicians show better cost-effectiveness than specialty recruitment in most settings

C. Implementation Value Analysis

- Phased implementation approach allows for targeted resource allocation
- Focus on high-impact, low-cost interventions first (protocols, training, telemedicine)
- Measure cost per DALY averted for each intervention
- Establish threshold values for cost-effectiveness that are regionally appropriate
- Consider non-monetary benefits (healthcare system strengthening, increased capacity)

Summary and Future Directions

The MENA-SINO-adapted guidelines for aneurysmal subarachnoid haemorrhage management provide a comprehensive framework for evidence-based care tailored to diverse healthcare settings across the Middle East and North Africa. By incorporating recommendations from multiple international guidelines (AHA/ASA, ESO, NICE, Neurocritical Care Society, Chinese guidelines) and adapting them to regional contexts, these guidelines aim to improve outcomes for all aSAH patients, regardless of location or socioeconomic status.

Our integration of various guidelines presents a more comprehensive approach to address the full spectrum of aSAH management, from initial diagnosis through long-term follow-up. By acknowledging variable resources, cultural contexts, and healthcare systems within the region, and providing specific adaptations for resource-limited settings, these guidelines apply across the diverse MENA healthcare landscape.

Key priorities for advancing aSAH care in the MENA region include:

1. **Regional registry development**: We recommend establishing collaborative aSAH registries across MENA countries to provide much-needed regional epidemiological data, treatment patterns, and outcomes to inform future guideline revision.
2. **Training and education**: We strongly recommend expanding training opportunities for healthcare providers across all disciplines involved in aSAH care, with an emphasis on settings with limited specialized expertise through

standardized curricula and certification programs.

3. **Resource allocation advocacy**: We recommend advocating for essential aSAH management resources, including critical medications such as nimodipine, basic monitoring equipment, and rehabilitation services through policy engagement and health system-strengthening initiatives.
4. **Telemedicine infrastructure development**: We strongly recommend developing robust telemedicine networks to extend specialized expertise to underserved areas, particularly for time-sensitive acute management decisions, with appropriate technology and training.
5. **Research initiatives**: We encourage collaborative research on aSAH in MENA populations by examining the unique genetic, environmental, and social factors that may influence disease presentation and outcomes through multinational research consortia.
6. **Regional assessment tool adaptation**: We recommend validating and adapting cognitive, functional, and quality-of-life assessment tools for diverse MENA populations and languages to ensure accurate assessment across different cultural contexts.
7. **Innovative care models**: We strongly recommend developing and evaluating culturally appropriate care models that leverage family and community strengths while addressing resource limitations through pilot programs and implementation research.

By addressing these priorities while implementing these adapted guidelines, MENA-SINO aims to continuously improve care quality for patients with aSAH throughout the region, reducing mortality, and improving long-term outcomes for survivors despite the heterogeneous healthcare landscape.

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