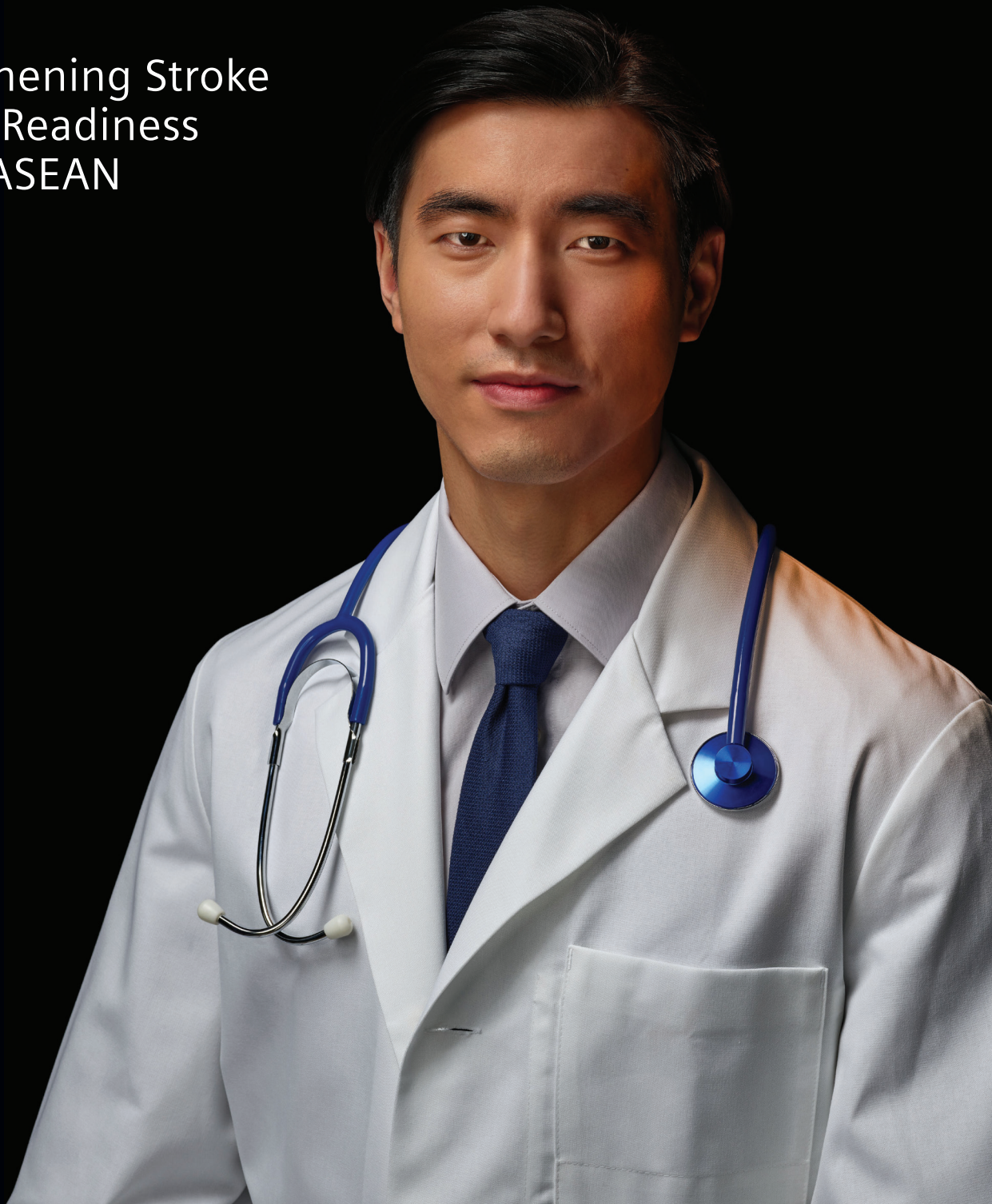


ASEAN Stroke Response Insights Report

Strengthening Stroke
System Readiness
Across ASEAN





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Executive Summary

The ASEAN Stroke Response Insights Board convened on June 15, 2026, bringing together Advisors from six Southeast Asian countries representing Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam to discuss and deliberate on stroke care readiness and identify priorities for system improvement across the region. Key findings revealed that while significant progress has been made in establishing stroke services infrastructure, substantial disparities exist in access, workforce capacity, and funding mechanisms across the region.

Stroke care readiness by country

- Indonesia has made substantial progress with 231 districts now thrombolysis-capable and 81 thrombectomy-capable under the national stroke program, yet services remain concentrated in Western regions, leaving Eastern Indonesia underserved.
- Malaysia has established multidisciplinary stroke teams and advanced neuroimaging in major stroke centres but faces geographic disparities limiting rural access. Inter-hospital transfer delays and workforce constraints remain critical bottlenecks.
- In the Philippines, stroke care is mostly concentrated in private hospitals while government facilities lack advanced imaging. Manila and its surrounding area of 20–30 million people remain underserved.
- Singapore has achieved a 5–6-fold reduction in stroke mortality since the 1990s through comprehensive planning, efficient emergency medical services (EMS), and consolidated stroke centres that could be reached within 15 minutes. Primary gaps exist at the community level rather than in hospital infrastructure.
- Few comprehensive stroke care centres exist in Thailand; patients outside urban areas face 1–2-hour transfers to comprehensive facilities, making timely intervention difficult. Siriraj Hospital deployed the Mobile Stroke Unit (MSU) program, which operates 24/7, integrating EMS, telemedicine, AI-assisted stroke recognition, and prehospital CT imaging to shorten treatment delays before hospital arrival.

- In Vietnam, the experience of the Stroke International Services Hospital (SIS) in Can Tho City, improved intravenous tissue plasminogen activator (IV tPA) coverage in the Mekong Delta region, with mortality due to hemorrhagic stroke significantly reduced. The SIS experience demonstrates how successful public-private partnerships can support improvements in stroke care, offering relevant learnings that could be adapted for other ASEAN countries of similar geography and level of stroke readiness.

Common challenges across ASEAN

Structural delays dominate the stroke care pathway, with most time loss occurring at pre-hospital stage and during inter-facility transfers. Transportation delays and slow reporting processes are barriers to timely imaging. All countries are faced with limited public awareness of stroke symptoms, which may contribute to delays throughout the entire stroke care pathway. Workforce shortages, particularly neurointerventional nurses and neurovascular surgeons, represent a constraint across the region. Additionally, expanded reimbursement mechanisms are critical enablers; inadequate insurance coverage and government funding directly impede equitable access to stroke care.

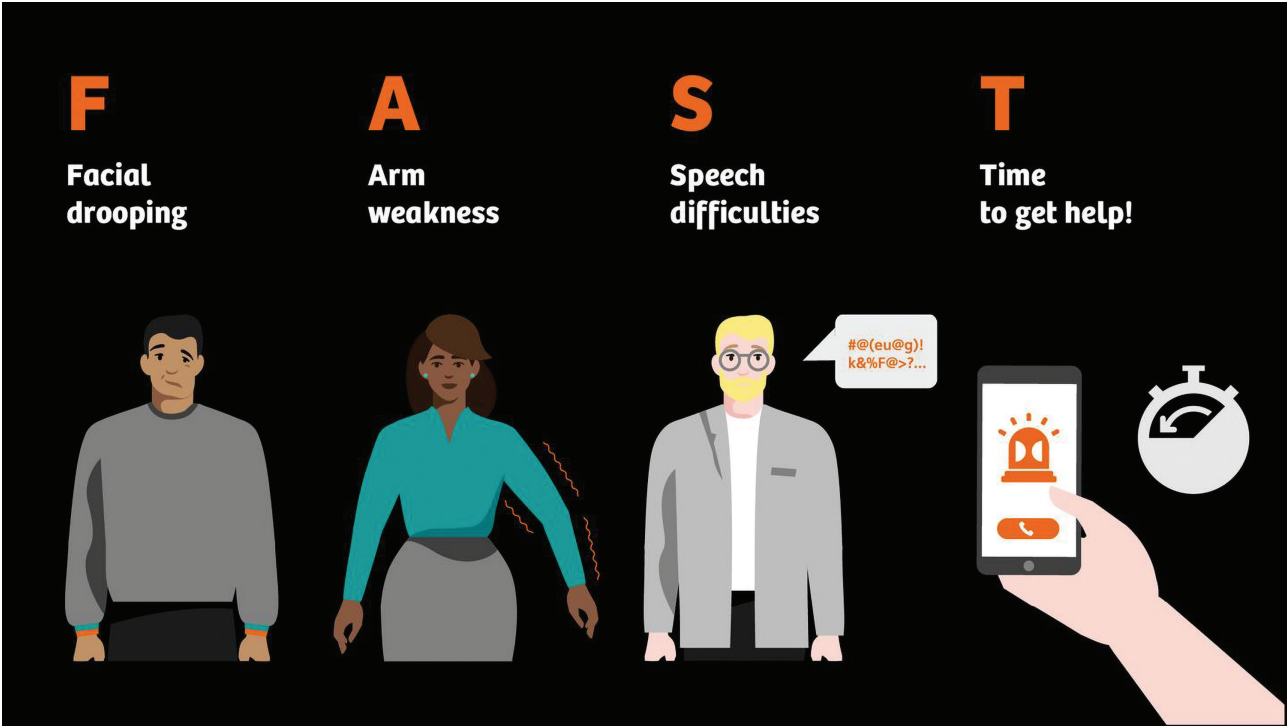
Immediate priorities for advancing stroke readiness

Five common priorities were identified.

- Strengthen referral pathways and inter-hospital coordination, moving from proximity-based to capability-based routing and treating networks as unified systems.
- Reduce door-to-treatment times by eliminating unnecessary patient transfers by bypassing the emergency department to CT suites where potential stroke patients can undergo diagnosis and treatment.
- Invest in building capabilities by prioritising training of neurointerventional nurses and neurovascular surgeons rather than advanced imaging devices alone.
- Leverage artificial intelligence for near-term applications including automated large vessel occlusion detection, ischemic penumbra assessment, and tele-stroke support for remote hospitals.
- Strengthen community support for stroke survivors and improve public recognition of FAST and stroke symptoms.

Call to Action

The Advisors underscored the importance of strengthening regional collaboration and knowledge-sharing by adopting proven cases like Vietnam’s SIS, Indonesia’s hub-and-spoke system, and Singapore’s comprehensive planning approach. They called for governments to commit to increased funding and broaden national health insurance coverage, recognising these investments as essential to achieving equitable stroke care and elevating stroke readiness throughout the ASEAN region.



Introductions

Across Southeast Asia, countries face distinct challenges and opportunities in strengthening stroke prevention, treatment and care. The ASEAN Stroke Response Insights Board brought together advisors from Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam to share perspectives on current gaps, emerging priorities and opportunities to advance stroke response across the region.

(Note: The discussion sections herein follow the alphabetical order of the Advisors’ countries.)



	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
Stroke care landscape	National program targeting 514 district/cities; 231 districts thrombolysis-capable, 81 thrombectomy-capable as of April 2026.	Multidisciplinary stroke teams in major centres; advanced neuroimaging (CT, MRI, angiography); progressive adoption of mechanical thrombectomy.	Stroke care concentrated in private hospitals; government facilities lack advanced imaging; PhilHealth does not cover thrombectomy; workforce shortage	Five to six fold reduction in stroke mortality since the 1990s; three consolidated comprehensive stroke centres reachable within 15-20 minutes; efficient EMS	Has a nationwide Stroke Service Plan under the Ministry of Public Health. Few comprehensive stroke care centres; patients outside urban areas face one to two hour transfers; efforts to establish referral systems with regional hospitals.	SIS experience in Can Tho serving 17–20 million in Mekong Delta; door-to-groin time improved 25% over 7 years; diamond-level stroke care achieved.
Challenges and bottlenecks	Thrombectomy-capable hospitals are mostly located in the West; geographic disparity; structural delays at pre-hospital level; private insurance delays; inadequate reimbursement; Low public awareness on the recognition of stroke symptoms.	Low public awareness; delayed patient presentation; geographic disparities limiting rural access; workforce shortages; inter-hospital transfer delays; inadequate rehabilitation services.	Low insurance coverage; high out-of-pocket costs; lack of EMS infrastructure; few public stroke-ready hospitals; inadequate funding for emergency stroke care.	Low public awareness of FAST; ageing population; lack of stroke care in private hospitals; manpower challenges (lack of round-the-clock staffing for nurses, cath lab staff).	Few comprehensive stroke centres; geographic disparity; transportation delays; non-neurologist physicians at referring hospitals may delay diagnosis; resource constraints; limited public awareness; delayed activation of EMS; workforce shortages.	Geographic barriers in Southwest regions; long transfer time to advanced stroke care facilities; low public awareness of stroke severity; limited comprehensive stroke centres in underserved regions.
Evidence-based standardized protocol		Supports astandardised framework; national stroke pathways established; progressive adoption of evidence-based protocols.		Supports intervention-first approach with simplified imaging requirements.	Supports selective patient selection via imaging.	Supports meticulous patient selection and imaging-based interventions.
Use of AI		Detect LVOs; perfusion analysis; patient selection for reperfusion therapies; optimise workflow through automated notifications; case prioritisation and coordinated communication; remote rapid imaging interpretation and decision support; predictive analytics, resource planning, outcome prediction, and quality improvement.	Select patients who are thrombectomy eligible; systems at the pre-hospital level.	Detect stroke events; diagnose the ischemic penumbra, LVO, infarction with plain CT.	Use of AI in stroke recognition; detect LVO; interpret CT, CTA, and perfusion imaging; automate ASPECTS scoring; optimise workflow; intelligent patient triage; predict outcome estimation and stroke care planning; identify gaps in care.	Device to alert physicians when patients are showing symptoms of stroke; streamline patient administration at the hospital or an alert system to follow up with patients.
Priorities	Strengthen referral pathways; move to capability-based routing; train neurointerventional nurses; ensure 24/7 capability at comprehensive centres.	Train EMS with standardized tools; direct-to-CT pathways; define clear imaging protocols; develop hub-and-spoke models; audit doorto-imaging times; strengthen community support.	Extend national insurance to cover thrombectomy; establish advanced services in government hospitals; recruit and train neurovascular surgeons; distribute specialists to provinces.	Improve public recognition of FAST and stroke symptoms; strengthen community awareness; reduce delays in emergency service activation.	Establish comprehensive stroke centres every 60–80 km; develop interhospital referral systems; improve EMS and transfer networks; train non-neurologist physicians; develop alert systems.	Strengthen interhospital networks and referral systems; apply relevant learnings from the SIS experience to strengthen stroke care in other major cities; expand the; engage the public through education; improve stroke detection and early notification.



**Country Perspectives and
System-level Challenges:
Stroke Care Landscape in ASEAN**

1.1 Indonesia

Stroke is a major cause of death and disability in Indonesia. The stroke burden is exacerbated by an ageing population and the increasing prevalence of other comorbidities. The dominant delay in stroke care is structural rather than clinical, with most time loss occurring at the pre-hospital level and inter-facility transfer. Transfer-related delays accumulate through multiple factors: recognition, triage, imaging, communications, ambulance transport, re-registration, repeat imaging, and suite preparation.

The Ministry of Health aims to build a national stroke system that could handle stroke across 514 district/cities to cover the nation (Program Pengampuan Stroke). As of April 2026, significant progress has been achieved with 231 districts now thrombolysis-capable and 81 thrombectomy- and coiling-capable. By 2027, the goal is for all cities to be thrombolysis-capable. However, the geographic distribution of services remains highly uneven, with all 81 fully thrombectomy-capable districts concentrated mostly in the West (Java and a few provincial capitals), leaving Eastern Indonesia (Papua, Maluku, and Nusa Tenggara Timur) with limited coverage.

1.2 Malaysia

Stroke remains one of the leading causes of mortality and long-term disability in Malaysia, with an increasing burden driven by population ageing and rising prevalence of cardiovascular risk factors including hypertension, diabetes mellitus, obesity, dyslipidemia, and smoking. Over the past decade, Malaysia has made significant progress in strengthening stroke readiness through the development of dedicated stroke units, implementation of national stroke pathways, increasing availability of intravenous thrombolysis, and gradual expansion of mechanical thrombectomy services.

Major tertiary centres have established multidisciplinary stroke teams capable of delivering comprehensive stroke care, supported by advances in neuroimaging, emergency stroke workflows, neurocritical care, and rehabilitation services. However, access to comprehensive stroke care remains uneven. Advanced stroke services and thrombectomy-capable centres are largely concentrated in major urban areas, creating disparities in access for patients living in peripheral and rural regions. Delays in patient presentation, inter-hospital transfers, and limitations in specialist workforce capacity continue to affect treatment rates and outcomes.

Universiti Malaya Medical Centre, as a major academic tertiary referral centre, provides round-the-clock access to mechanical thrombectomy and complex neurovascular interventions, supported by state-of-the-art biplane angiography platforms. The institutional focus extends beyond acute intervention to include education, research, quality improvement, and regional capacity building.



1.3 Philippines

The Philippines has a universal healthcare system that is still developing. Most hospitals are private practices, with bigger hospitals predominantly private. Most thrombectomy patients are treated in private hospitals as advanced imaging devices are not available in government hospitals. Procedures at private hospitals are expensive.

The national health insurance (PhilHealth) does not cover stroke treatment, with no reimbursement mechanism for the procedure yet in place. There is also a manpower shortage: the population in the capital of Manila and the surrounding urban areas is around 20–30 million; there are only five neurovascular surgeons capable of performing thrombectomy. Neurovascular surgeons frequently move between hospitals based on need.

While private hospitals have good systems for managing acute stroke (thrombolysis- and thrombectomy-capable), this is not representative of the whole country. Government hospitals are not yet able to provide these services. The Stroke Society of Philippines, a multidisciplinary NGO comprising neurologists, neurosurgeons, rehabilitation specialists, and nurses, is working to improve stroke care capacity and advocate for improved coverage of stroke in universal healthcare. Recent improvements include better coverage of acute stroke and thrombolysis under universal healthcare, though mechanical thrombectomy remains expensive and uncovered.

1.4 Singapore

Stroke is the number one cause of long-term disability and the most common cause of death. While the absolute number of strokes has been increasing over the past decade, mortality has reduced; comparing stroke death data from the 1990s with the most recent data shows an almost five to six-fold reduction in stroke-related mortality. The biggest enabler is comprehensive planning: in 2008–2009, hospitals developed plans of action for managing stroke. The EMS is efficient, with paramedics capable of identifying stroke patients and ferrying them to the nearest stroke hospital. A well-organised network ensures that certain groups of hospitals refer to specific comprehensive stroke centres. The Ministry of Health has consolidated comprehensive stroke care into 3 hospitals (Singapore General Hospital, Tan Tock Seng Hospital, National University Hospital) across the island, enabling patients to reach any of them within 15–20 minutes.

Stroke incidence will rise with the rapid ageing population, and this may strain the system. Additionally, stroke care in Singapore is entirely managed by the public health system, with limited participation from private healthcare in acute stroke care. Manpower challenges, particularly regarding round-the-clock staffing for stroke nurses, cath lab¹ nurses, and cath lab radiographers, represent another constraint rather than infrastructure or physician shortages.

¹ Catheterization laboratory, commonly referred to as cath lab, is an examination room in a hospital or clinic with diagnostic imaging equipment used to visualize the arteries of the heart and the chambers of the heart and treat any stenosis or abnormality found.

1.5 Thailand

Thailand has made remarkable progress in stroke care over the past decade. The country has established a nationwide Stroke Service Plan under the Ministry of Public Health, supported by the National Health Security Office, ThaiEMS 1669⁴ And an expanding network of primary, intermediate, and comprehensive stroke centres. Siriraj Hospital has developed one of Thailand's leading comprehensive stroke programs, providing 24/7 acute stroke services, advanced neuroimaging, intravenous thrombolysis, mechanical thrombectomy, stroke ICU care, and multidisciplinary rehabilitation. More recently, Siriraj Hospital has focused on strengthening the prehospital phase through the Mobile Stroke Unit⁵ (MSU-SOS) program, which operates 24/7, integrating EMS, telemedicine, AI-assisted stroke recognition, and prehospital CT imaging to shorten treatment delays before hospital arrival. Despite these achievements, disparities still exist between urban tertiary centres and rural hospitals, making equitable access a major priority.



There is a lack of comprehensive stroke centres distributed throughout the country. Unless patients live in the city, access to comprehensive stroke services is limited. Efforts are being made to work with regional hospitals around 80 km from Bangkok to establish referral systems. The nearest hospital capable of sending patients to a comprehensive stroke hospital takes around one-to-two hours to reach, which is problematic for timely treatment.

The main issues are the limited number of comprehensive stroke centres and transportation delays. One immediate solution is MSUs, where patients can obtain CT scans, enabling faster IV tPA administration. EMS could also be expanded, and the transfer network improved in the medium term. A longer-term goal would be to establish a comprehensive stroke centre every 60–80 km and allow establishment of an elaborate inter-hospital referral system.



1.6 Vietnam

Vietnam has a population exceeding 100 million, with more than 200,000 stroke patients annually, a number predicted to continue increasing. The ageing population, along with high rates of smoking and alcohol consumption, increases stroke risk. Vietnam has one of the highest stroke incidence and prevalence rates among Southeast Asian countries. It is also the leading cause of death.

Vietnam has achieved almost 100% regional and provincial coverage with IV tPA². However, stroke care delivery, particularly in the Southwest region and Mekong area, is a challenge. Patients from these regions must spend 6–10 hours to reach Ho Chi Minh City for advanced care.

Approximately 9 years ago, the first SIS hospital was established in Can Tho City in collaboration with Siemens Healthineers. This was the first private hospital to provide comprehensive stroke care for up to 20 million people in the Mekong area. In the first year, 13% of patients from the region who previously had to travel 6+ hours to a stroke care facility were treated locally. Over 7 years, door-to-groin³ time improved by 25%. The centre has achieved diamond level for stroke care.



² Tissue-type plasminogen activator is an enzyme that helps to break down blood clots that would otherwise block blood flow to the brain.

³ Door-to-groin time measures the critical time between a stroke patient arriving at the hospital to when a medical team makes the initial puncture in the groin to perform a mechanical thrombectomy.

⁴ ThaiEMS 1669 is an app that offers chat features and direct connection to the emergency medical services in Thailand.

⁵ Mobile Stroke Unit, Stroke One Stop or MSU SOS was an initiative launched in 2018 and has since treated over 2,900 patients. MSU-8 is the most advanced MSU launched as a collaboration between Siriraj Stroke Center, Faculty of Medicine Siriraj Hospital, Faculty of Engineering, Mahidol University, Siemens Healthineers, and RMA Automotive. MSU diagnoses and treats strokes on the spot.



Stroke System Readiness Across ASEAN

The Advisors completed a pre-meeting survey on their perspective on their health system capability, barriers and enablers to enhance stroke care in their country. They were also asked to poll on six consensus statements regarding stroke readiness in their country. The results are summarised below.

2.1 Pre-meeting Survey Results

Stroke readiness (1 = not ready; 5 = fully ready)	Average score of 4
Barriers to timely imaging	Transportation delays and slow reporting processes were reported as the primary barriers to timely imaging
Effectiveness of triage protocol	Triage protocols are moderately to highly effective in identifying and prioritising stroke patients
Stroke care capability	Protocols are established but their implementation is variable
Barriers to improving stroke readiness	Multiple barriers exist; main ones are: • limited funding • lack access to advanced imaging • lack of trained professionals • lack inter-hospital coordination
Enablers to advance stroke readiness	Main enablers are: • regional collaboration and knowledge sharing • government policy/regulatory support



2.2 Consensus Statements

Level of agreement		Agree	Disagree	No opinion	Remark
Domain 1: Delays and Bottlenecks in the Stroke Care Pathway	• A significant bottleneck in achieving rapid stroke treatment is the time required for patients to transfer across Emergency Medical Services triage and imaging wait time, which delays treatment initiation beyond the optimal window.	4			2
		5			1
Domain 2: Strengthening Stroke Systems and Care Coordination	• Establishing national hospital stroke networks and inter-hospital coordination protocols reduce delays in patient transfers for advanced care, particularly in countries without national/regional stroke center networks.	6			
		6			
Domain 3: Technology and Innovation as enablers	• Telemedicine, AI-assisted imaging interpretation, and mobile health technologies present significant opportunities to overcome geographic and resource barriers to stroke readiness in Southeast Asia.	6			
Domain 4: Priorities for Advancing Stroke Readiness	• Developing and implementing standardised, evidence-based stroke care protocols (from pre-hospital stroke care through treatment) should be the highest priority for advancing stroke system readiness across Southeast Asia.	6			

2.3 Survey Summary

While the stroke readiness of each country differed given the diversity of the countries in ASEAN in terms of the economy, geography, and culture, common themes stood out from the survey results regarding the challenges and priorities for improving stroke readiness.

- Systemic delays to timely imaging are apparent: Systemic delays to timely imaging from transportation delays to slow reporting processes exist despite having established triage protocols. This could be alleviated by implementing integrated diagnostic systems that reduce door-to-treatment time by eliminating unnecessary patient transfers and enabling simultaneous diagnostic assessment.
- Greater call for regional collaboration and knowledge sharing: Regional collaboration and knowledge sharing was identified as a priority to

enabling stroke readiness, this could be addressed through establishing national hospital stroke networks, strengthening inter-hospital coordination protocols, and sharing best practices.

- Continual infrastructure and resource optimisation: Greater infrastructure investment and resource optimisation are needed to enhance stroke readiness. This could range from improving advanced imaging capabilities to employing telemedicine, AI-assisted imaging interpretation, and mobile health technologies.
- Investing in capacity building and training to build up a comprehensive stroke care ecosystem: Continuous training and capacity building of healthcare professionals and establishing and implementing evidence-based stroke care standards are essential to deliver optimal stroke response outcomes.

A portrait of a man with dark hair, wearing blue medical scrubs, looking directly at the camera against a black background.

Health System Strengths and Bottlenecks in Stroke Readiness

3.1 Indonesia

Indonesia's reimbursement system presents a significant challenge to stroke readiness. While BPJS Kesehatan, the national health insurance, provides broad coverage, it inadequately covers stroke care costs. In addition, emergency stroke care remains inadequately funded, creating a substantial gap in the health system's capacity to respond to acute stroke needs. Few comprehensive stroke centres can afford to provide specialised stroke care, with patient co-payments, which limits access to specialised stroke care across the country. Despite efforts to expand reimbursement coverage for stroke care, progress has been limited.

Bali and Yogyakarta "hub and spoke" model demonstrates successful regional organisation, with centralised stroke centres serving surrounding islands. In particular, RSUP Dr. Sardjito General Hospital in Yogyakarta encompasses both open vascular and endovascular procedures under one team, reducing dependency on single skill sets.

3.2 Malaysia

Malaysia's healthcare system demonstrates several key strengths in stroke management. First, stroke is increasingly recognised as a medical emergency, leading to the establishment of multidisciplinary stroke teams comprising emergency physicians, neurologists, neurointerventional specialists, neurosurgeons, neuroradiologists, rehabilitation physicians, nurses, and allied health professionals. This collaborative approach has significantly improved coordination across the entire stroke pathway. Second, major centres now have access to advanced neuroimaging capabilities, including CT angiography⁶ (CTA), CT perfusion⁷, magnetic resonance imaging (MRI), and digital subtraction angiography, enabling rapid diagnosis and evidence-based treatment decisions. Third, there has been progressive adoption of reperfusion therapies, particularly mechanical thrombectomy for large vessel occlusion, supported by evolving national and institutional stroke protocols. Finally, Malaysia's strong academic and training ecosystem supports research, clinical innovation, and workforce development.

Despite these strengths, several critical bottlenecks impede optimal stroke care. The most pressing challenge is delayed patient presentation, driven by limited public awareness, delayed symptom recognition, and transportation barriers, resulting in many patients arriving outside the critical treatment window. Geographic disparities further limit access to advanced stroke services, particularly for patients in remote areas distant from comprehensive stroke centres. Additionally, workforce shortages constrain capacity: the number of stroke neurologists, neurointerventional specialists, stroke nurses, and rehabilitation professionals remains insufficient to meet the growing disease burden. Inter-hospital transfer systems also require optimisation to ensure timely access to thrombectomy-capable centres. Finally, rehabilitation capacity and long-term community support services need strengthening to adequately serve the growing population of stroke survivors.



3.3 Philippines

Large private hospitals demonstrate good systems for managing acute stroke with thrombolysis and thrombectomy capability. However, affordability limits access to treatment.

The national health insurance coverage is low, with high out-of-pocket medical expenses. There is also a lack of EMS infrastructure, few public hospitals that are stroke-ready (lack advanced scan machines and stroke services), and few stroke units and rehabilitation facilities. Emergency stroke care remains inadequately funded and poorly prioritised.

3.4 Singapore

Singapore's healthcare system is highly efficient. Administrators take a long-term planning view at the health system level to address stroke, setting up a comprehensive stroke network and rapid access to stroke care. In addition, the EMS is well trained. Stroke patients bypass the emergency department (ED) and go directly to the CT room, where neurologists and ED physicians meet them. However, the primary gaps are at the community/pre-hospital stage rather than at the hospital level.

Despite stroke affecting 1 in 4 individuals, public awareness around stroke is low. FAST⁸ recognition is not well established in the community at large; this causes delays in calling for emergency services. Physicians have taken up responsibility and improved skills to manage stroke patients better; the broader ecosystem has not caught up yet.

3.5 Thailand

Prof. Anchalee felt that her institution has a robust training program for neurologists and nurses in stroke management. Collaborative working relationships between stroke centres and training institutions are well-established. Prof. Anchalee noticed that at referring hospitals, non-neurologist physicians who may lack specialised stroke expertise could contribute to diagnostic delays and suboptimal patient assessment. This may inadvertently delay timely notification between referral hospitals and comprehensive stroke care centres.

A/Prof. Yongchai felt that universal health coverage allows nearly all Thai citizens to receive acute stroke care. The country has a well-established national Stroke Service Plan with standardised stroke pathways. There is strong collaboration among neurologists, emergency physicians, radiologists, neurosurgeons, EMS, and rehabilitation teams. There is an increasing availability of reperfusion therapies, including thrombolysis and mechanical thrombectomy. Continuous professional education is conducted through the Stroke Society of Thailand and national quality improvement initiatives. A/Prof. Yongchai also shared that improving access to imaging requires optimising the entire stroke pathway rather than focusing only on CT scanners.

⁶ CT angiography is a fast, non-invasive imaging test that combines CT X-ray technology and a contrast dye to produce 3-dimension images of blood vessels.

⁷ CT perfusion is an advanced, contrast-enhanced imaging test that measure the blood flow in the brain.

⁸ FAST is a test to quickly identify the three most common signs of stroke. F for Face: facial droop, uneven smile; A for Arm: arm numbness, arm weakness; S for Speech: slurred speech, difficulty in speaking or understanding; T for Time: call EMS to get to the hospital immediately.

3.6 Vietnam

Dr Cuong shared his experience on improving stroke readiness in underserved regions, specifically in the Southwest Mekong Delta region. The first step in establishing stroke care capacity in underserved regions is to assess the demand and patient population. A comprehensive stroke centre is justified only if there is a sufficiently large population that would benefit from advanced stroke services such as thrombolysis, mechanical thrombectomy, and acute intensive care unit capabilities. Government funding is ideal, but public-private partnerships are a practical alternative when government investment is unavailable. Industry partners such as Siemens Healthineers have demonstrated willingness to support stroke centre development. A financing approach includes requesting extended payment terms (deferred payment arrangements), transitioning to government reimbursement after the initial period once the centre demonstrates clinical value and sustainability. Leveraging industry expertise, for example, Siemens Healthineers' experience in supporting successful stroke care initiatives, including in Can Tho, could provide useful learnings for the development of stroke services in other parts of Vietnam, while considering local healthcare needs and circumstances.

3.7 Lessons from Can Tho

The SIS in Can Tho provides a strong example of comprehensive stroke care in the Mekong Delta. The SIS in Can Tho is the first fully dedicated stroke network in the Mekong Delta, Vietnam. Since being established in 2019, the centre has achieved high case volumes (approximately three to four thrombectomy cases daily, or ~1,000 cases annually). The experience in Can Tho demonstrates how consistent case volumes and collaborative learning environments can support the rapid development of thrombectomy expertise. In the case of SIS, physicians were able to develop these capabilities within six months of starting the programme. Beyond infrastructure and financing, public support is essential for the success of stroke centre initiatives. Community education and engagement help ensure that patients and families understand when they need to seek stroke care and where they can do so. The experience in Can Tho may offer useful lessons for other major cities and underserved regions across ASEAN with comparable geography, stroke burden and population density, although approaches would need to be adapted to local healthcare systems and needs.



⁶ CT angiography is a fast, non-invasive imaging test that combines CT X-ray technology and a contrast dye to produce 3-dimension images of blood vessels.

⁷ CT perfusion is an advanced, contrast-enhanced imaging test that measure the blood flow in the brain.



Challenges to Timely Imaging

4.1 Indonesia

Patients with large vessel occlusions⁹ (LVOs) in most areas must be transferred to thrombectomy-capable facilities, and these inter-facility transfers represent a critical source of delay in the imaging and treatment pathway. Beyond geography, substantial operational and clinical challenges impede timely imaging. Low public awareness of stroke symptoms delays initial recognition at home, which cascades throughout the entire care chain. Additionally, the absence of a unified EMS and stroke triage protocol means patients often arrive at hospitals without the capability to manage their condition. In-hospital workflows remain variable, with CT and CTA turnaround times and laboratory results not standardised across facilities. Most time loss occurs at the pre-hospital stage and during inter-facility transfer rather than during imaging or treatment at the receiving facility. Where eligible patients initially present rarely aligns with where they can receive definitive treatment, meaning the critical delays accumulate during transfer rather than at the treatment table.

Addressing timely imaging therefore requires system-level interventions focused on strengthening referral pathways, reducing door-in-door-out times, streamlining emergency administrative processes, and ensuring off-hours thrombectomy capability.

⁹ Large vessel occlusion is a common cause of ischemic stroke caused by the blockage of major blood vessels in the brain

4.2 Malaysia

Timely imaging remains a critical bottleneck in modern stroke care, as virtually all treatment decisions depend upon rapid and accurate neuroimaging assessment. Several systemic challenges impede the achievement of optimal imaging times. Pre-hospital stroke recognition and notification systems are often inadequate, as EMS may lack standardised assessment tools or fail to activate stroke pathways before hospital arrival. Additionally, many hospitals continue to route patients through conventional emergency department processes rather than implementing direct-to-imaging workflows, where eligible patients could bypass these steps and proceed directly to a CT scan. The absence of standardised imaging protocols also creates inconsistency across institutions, as unclear pathways regarding indications for non-contrast CT, CTA, and CT perfusion can lead to unnecessary delays and duplicative imaging.

At a systems level, regional stroke networks often lack adequate hub-and-spoke coordination, making it difficult for primary stroke centres to rapidly identify patients with suspected large vessel occlusions and transfer them efficiently to thrombectomy-capable centres. Furthermore, tele-stroke services remain underutilised in many underserved regions, limiting remote decision-making and imaging interpretation capabilities. Finally, the absence of continuous performance monitoring represents a significant challenge, as many institutions fail to audit and benchmark key performance indicators such as door-to-imaging, door-to-needle, door-to-groin puncture, and door-to-reperfusion times, thereby missing opportunities for quality improvement.



4.3 Philippines

Dr. Jay shared that imaging remains key to selecting patients for intervention, particularly in a resource-constrained setting. Unlike healthcare systems with comprehensive national healthcare insurance coverage, patients in the Philippines bear most of the out-of-pocket cost of stroke treatment, creating a significant burden on individual families. This constraint compels physicians to make selective treatment decisions based not solely on clinical eligibility but also on anticipated patient benefit. Patients often face impossible choices, expressing willingness to liquidate personal assets to access treatment, thereby placing the responsibility on physicians to determine whether intervention will provide meaningful benefit. Consequently, imaging-based patient selection becomes crucial.

4.4 Singapore

In Singapore's healthcare system, timely imaging is not a significant bottleneck due to streamlined workflow. Patients with acute stroke do not route through the ED. Instead, they are brought directly from the ambulance to the CT suite, where neurologists and ED physicians are already present to evaluate the patient. This integrated approach allows for immediate CT imaging and administration of thrombolysis, all within the same space.

Given the evolving clinical landscape, imaging requirements for acute stroke management are becoming increasingly simplified. The critical information needed is confirmation that there is no intracranial bleeding. With knowledge of stroke severity (e.g., National Institutes of Health Stroke Scale¹⁰>10) and confirmation that the patient is within 24 hours of stroke onset, neurologists have sufficient information to proceed with intervention in the cath lab.

A/Prof. Anil believes in intervention-first rather than imaging-intensive protocols given that the therapeutic benefit of intervention is substantial, comparable to the gains achieved with percutaneous coronary intervention in cardiology. While increased intervention may result in occasional complications such as symptomatic intracranial haemorrhage or futile recanalisation attempts, the overall population benefit is significant, with more patients experiencing favourable outcomes with treatment intervention.

¹⁰ National Institutes of Health Stroke Scale is a 15-item physical and mental test used by medical workers to measure how bad a stroke is. It checks things like movement, speech, and senses in less than 10 minutes. A score greater than 10 indicates a moderate-to-severe stroke.

4.5 Thailand

Prof. Anchalee shared that patient selection is necessary to balance clinical benefits with healthcare system costs. According to her, broader intervention has resulted in increased rates of haemorrhagic transformation. In some cases, acute infarction occurs after thrombectomy, suggesting that such intervention may not necessarily alter the natural history of stroke. Therefore, indiscriminate intervention may not be sustainable in a resource-limited setting. Consequently, of appropriate candidates via diagnostic imaging remains critical not only for clinical efficacy but also for economic viability.

A/Prof. Yongchai highlighted that the biggest challenges to timely imaging include limited public awareness of stroke symptoms, delayed activation of EMS, geographic barriers, and limited access to advanced imaging in remote areas. Workforce shortages, particularly vascular neurologists and neuroradiologists outside major cities, are another major issue. This is because as populations age, the growing burden of stroke also places increasing pressure on healthcare resources. Strategies to overcome these challenges include public education campaigns to encourage immediate EMS activation and EMS notifying hospitals ahead of arrival so the hospital can prepare for the patient. Establishing standardised imaging protocols across all stroke centres, enabling AI-assisted image interpretation to accelerate diagnosis, deploying MSUs with onboard CT scanners, enabling imaging before hospital arrival, strategic placement of imaging resources based on regional stroke burden, and continuous monitoring of door-to-CT and door-to-needle times using quality indicators. Where possible, the strategy should aim to “bring imaging to the patient” whenever possible rather than always “bringing the patient to imaging”.



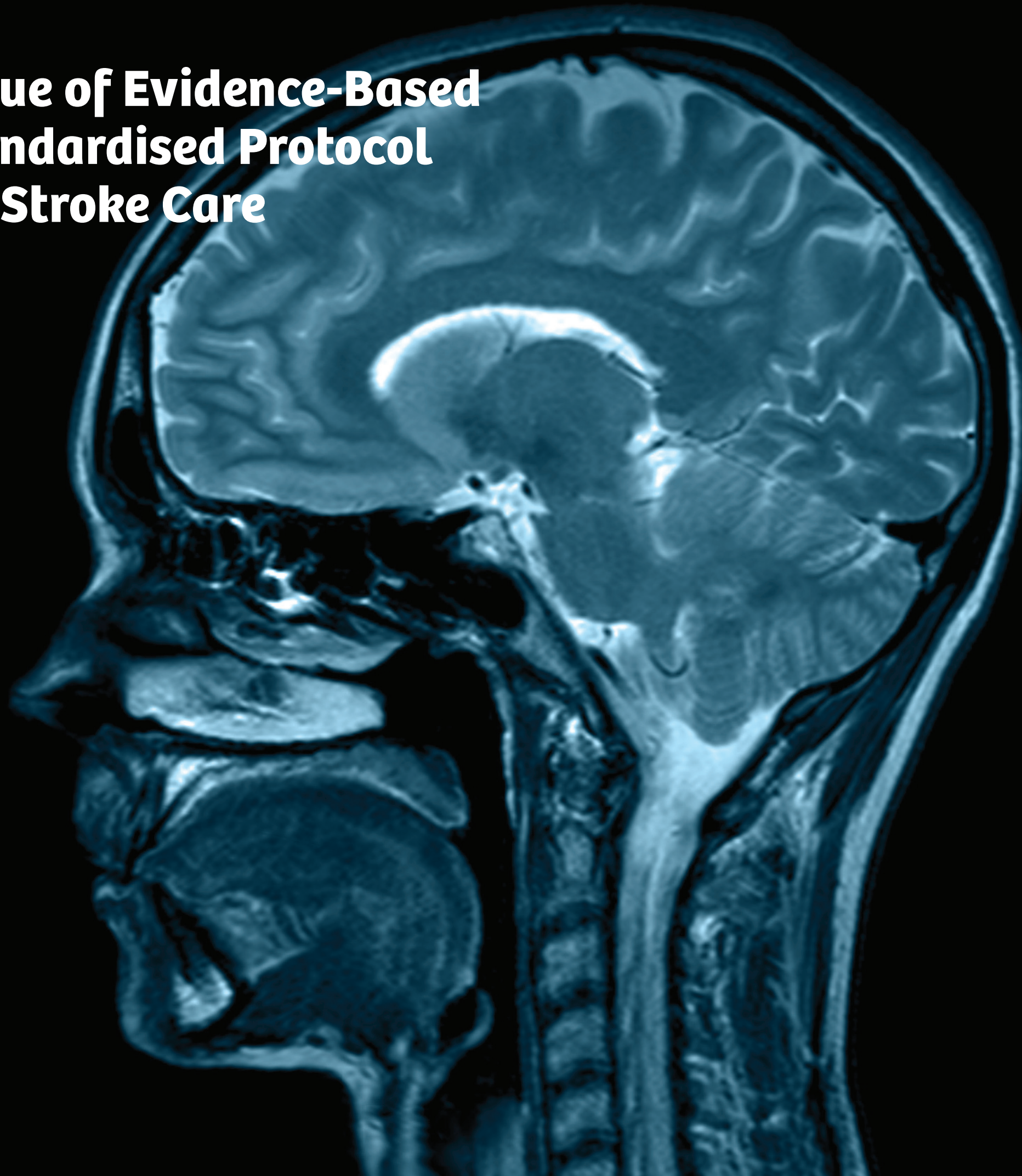
4.6 Vietnam

Geographic and infrastructure limitations further impede timely imaging. Comprehensive stroke centres remain concentrated in urban areas, requiring patients to travel substantial distances to access advanced diagnostic capabilities. Addressing this disparity necessitates strategic expansion of stroke centre infrastructure closer to patient populations, coupled with substantial investment in advanced imaging technology and trained personnel. Additionally, low public awareness of stroke severity delays hospital arrival, as many patients remain at home unaware of the critical importance of immediate medical evaluation.

According to Dr. Cuong, imaging remains a cornerstone of stroke care, given that in SIS more than 1000 patients have received MRI-guided IV tPA with no deaths due to haemorrhagic complications. Dr. Cuong spends around 10 minutes per patient to look for small vessel disease, microhaemorrhages, stroke mimics, focal infarction, and other conditions such as progressive supranuclear palsy that may present similarly to acute ischemic stroke. This meticulous imaging assessment allows him to identify appropriate candidates for IV tPA while excluding patients at high risk of bleeding complications, thereby significantly improving stroke outcomes.



Value of Evidence-Based Standardised Protocol for Stroke Care



The Advisors discussed whether a standardised evidence-based protocol for ASEAN would be beneficial, given the diversity of healthcare systems, economic resources, geography, and workforce availability across the region.

5.1 Arguments Against Standardisation

- Healthcare systems, communities, and people's expectations are heterogeneous across ASEAN
- In resource-limited settings, maximising benefits requires different patient selection strategies than in resource-rich settings
 - Different approaches to patient selection exist as Dr. Jay, Dr. Cuong, and Prof. Anchalee preferred MRI-guided interventions; while A/Prof. Anil would treat 90-year-olds with the Modified Rankin Scale¹¹ 3 to give them a chance for better improvement

5.2 Arguments for Standardisation

- Harmonisation of stroke care standards reduces variations in care, resulting in more consistent patient outcomes
- A regional framework could accelerate the dissemination of best practices
 - Leverage the experience of more established stroke care centres, shortening the learning curve and promoting more rapid implementation of evidence-based care
- Enables shared educational initiatives, certification programs, fellowships, and training exchanges
 - Regional training initiatives to close the gaps between countries
 - Foster cross-border research collaborations
 - Allow benchmarking of stroke outcomes
 - Faster dissemination of best practices
- Standardised data definitions and quality metrics facilitate benchmarking, enable collaborative research, and allow for performance monitoring across ASEAN countries

5.3 Recommended Approach

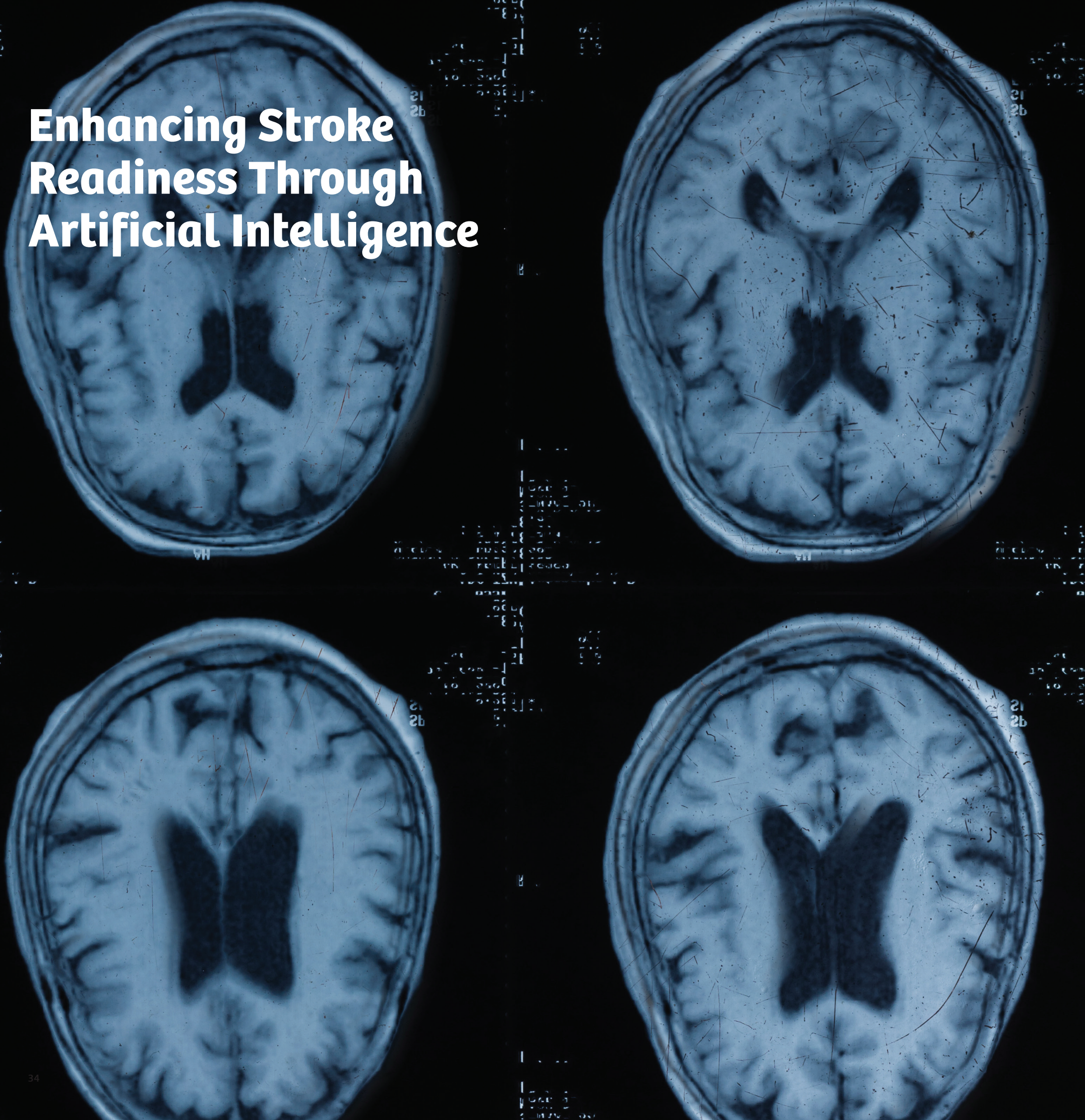
The most effective strategy would be an ASEAN-wide framework that establishes common principles and minimum standards while allowing flexibility for local adaptation. Such an approach would promote both consistency and practicality, ensuring that stroke readiness initiatives remain achievable and sustainable within individual national contexts. This framework should:

- Establish core principles applicable across ASEAN
- Define minimum standards for stroke care
- Allow country-specific adaptations based on resources and context
- Facilitate knowledge sharing and best practice dissemination
- Support workforce development through regional collaboration



¹¹ Modified Rankin Scale measures the degree of disability or dependence in the daily activities of people who have suffered a stroke or other causes of neurological disability. Grade 3 indicates moderate disability

Enhancing Stroke Readiness Through Artificial Intelligence



The Advisors discussed multiple applications of artificial intelligence (AI) in enhancing stroke readiness across ASEAN. While acknowledging that most current AI applications are rudimentary compared to theoretical potential, they identified several high-impact near-term opportunities and longer-term possibilities.

6.1 Near-term Applications

- Automated LVO detection: rapidly identify suspected LVOs on CT angiography and immediately alert stroke teams, reducing delays in decision-making and patient transfer.
- AI interpretation of CT, CTA, and perfusion imaging
- Automated Alberta Stroke Program Early CT Score¹² scoring.
- Ischemic penumbra¹³ detection on plain CT: Software such as Brainomix's AI can estimate penumbra volume on plain CT without requiring CTA.
- Perfusion analysis: AI-driven perfusion analysis can provide automated assessment of infarct core and salvageable penumbra, supporting patient selection for reperfusion therapies and improving consistency in interpretation across different centres.
- Workflow optimisation: AI to optimise workflow through automated notifications, case prioritisation, and coordinated communication among emergency physicians, radiologists, neurologists, neurointerventional teams, and intensive care units. This reduces administrative delays and improves coordination.
- Tele-stroke support for remote hospitals: AI-enhanced tele-stroke platforms can support remote hospitals by providing rapid imaging interpretation and decision support, helping to bridge disparities in access to expertise. This is particularly valuable for countries like Indonesia, Thailand, and Vietnam, where geographic distances create access challenges.
- Predictive analytics for outcome estimation and resource planning.
- Workflow optimisation through real-time notifications to stroke teams.
- Intelligent patient triage to the most appropriate stroke centre.

6.2 Future Applications

- Population-level surveillance to identify gaps in stroke care.
- Integrating AI with the national EMS system and MSU network to reduce prehospital delays and improve access to timely reperfusion therapy.
- Stroke symptom recognition and alert systems: An AI application that can recognise facial expressions and provide a FAST score to alert doctors when patients show stroke symptoms. Security cameras on streets or in homes could potentially be used to detect stroke events, with nearby healthcare professionals notified immediately.
- Wearable device for stroke detection: AI could be used with wearable devices to detect stroke events through biomarkers or other non-invasive methods.
- Patient selection: AI-driven patient selection algorithms could help optimise referral pathways and reduce unnecessary transfers.



¹² Alberta Stroke Program Early CT Score or ASPECTS scoring is a 10-point quantitative scoring system used to measure early signs of brain damage.

¹³ Ischemic penumbra refers to the area of brain tissue that is hypoperfused but remains potentially salvageable if blood flow is restored.

Immediate Priorities to Enhance Stroke Care



7.1 Indonesia

- Strengthening referral pathways and inter-hospital communication to reduce transfer delays
- Move from proximity-based referral to capability-based routing
- Send LVO patients directly to thrombectomy centres; treat the network as one system
- More funding for teams, not just devices; trained neurointerventional nurses are the constraint
- Ensure devices are deployed with adequately trained personnel
- Ensure round-the-clock capability at comprehensive stroke centres

7.2 Malaysia

- Train EMS to identify suspected stroke patients using standardised tools and activate stroke pathways before hospital arrival
- Allow eligible patients to bypass conventional ED processes and proceed directly to CT scan
- Define clear institutional pathways for indications of non-contrast CT, CTA, and CT perfusion
- Develop hub-and-spoke models with rapid identification of large vessel occlusions and efficient transfer to thrombectomy-capable centres
- Support remote hospitals with rapid imaging interpretation and decision support
- Audit door-to-imaging, door-to-needle, door-to-groin, and door-to-reperfusion times; benchmark and drive quality improvement
- Strengthening long-term community support services for stroke survivors

7.3 Philippines

- Elevate the entire ecosystem of stroke care so that all patients, regardless of financial capability, can benefit from treatment
- Extend national health insurance to cover mechanical thrombectomy and other advanced stroke treatments
- Establish advanced stroke services in government hospitals with access to thrombectomy-capable equipment
- Recruit and train neurovascular surgeons; distribute specialists to provinces beyond the capital

7.4 Singapore

- Improve public recognition of FAST and stroke symptoms to reduce delays in emergency service calls

7.5 Thailand

- Develop trigger/alert systems for patients experiencing stroke symptoms, with alerts sent directly to nearby hospitals
- Create systems that inform physicians of optimal treatment (whether the patient should undergo thrombectomy) to avoid wasting time on hospital triage
- Improve training and support for non-neurologist doctors at referring hospitals

7.6 Vietnam

- Strengthening inter-hospital networks and referral systems
- Engage the public through playbooks and other means to enable earlier stroke detection





Conclusions

The ASEAN Stroke Response Insights Board meeting revealed both the significant progress made in stroke care across Southeast Asia and the substantial challenges that remain. While each country faces unique circumstances shaped by geography, economic resources, healthcare system maturity, and workforce availability, common themes emerge:

- Stroke care readiness is a systems-level challenge: Delays are predominantly structural rather than clinical, occurring at the pre-hospital stage, during inter-facility transfers, and through administrative processes
- Capacity building is critical: Across all countries, trained personnel, particularly neurointerventional nurses and neurovascular surgeons, are the constraint
- Public awareness drives early intervention: Limited community recognition of stroke symptoms delays the entire stroke care journey
- Equitable access to stroke care: National health insurance coverage and government support are essential for equitable access to stroke care
- Regional collaboration and knowledge sharing: Leveraging expertise, knowledge sharing and adapting successful models could elevate stroke care in the region
- AI offers promising opportunities to enhance stroke care, from precise detection of LVOs and ischemic penumbra on plain CT to optimised care workflow and coordination.

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