Neuro-ICU

Management of patients with acute stroke
European Society of Intensive Care Medicine
Intensive Care Academy 2018

first-line assessment and treatment

- Securing the airway and optimising oxygenation
- Haemodynamic stabilisation, intravenous access and fluid administration
- Basic monitoring (including the rapid determination of blood glucose)
- Obtaining a clinical history
- Carrying out a physical examination
- Treatment of symptoms such as agitation, vomiting, and pain
- Recognition of contraindications to acute treatments, including thrombolysis and endovascular therapy
- Initiation of diagnostic procedures and interventions

Mechanism of stroke

- Microangiopathic or lacunar stroke
- Systemic embolism
- Large artery thrombosis or embolism
- Dissection of cervical arteries

Which stroke patients should be admitted to the ICU?

- A requirement for intubation and/or mechanical ventilation
  - Impaired level of consciousness (GCS ≤8) and/or evidence of brainstem dysfunction and/or any other cause of a compromised airway
  - To prevent aspiration pneumonia in any of the above
  - As an adjunct therapy for elevated ICP and/or in the presence of significant cerebral oedema
  - Acute respiratory failure e.g. due to neurogenic or cardiogenic pulmonary oedema
  - Generalized tonic-clonic seizures or status epilepticus
  - Episodes of apnoea

Which stroke patients should be admitted to the ICU?

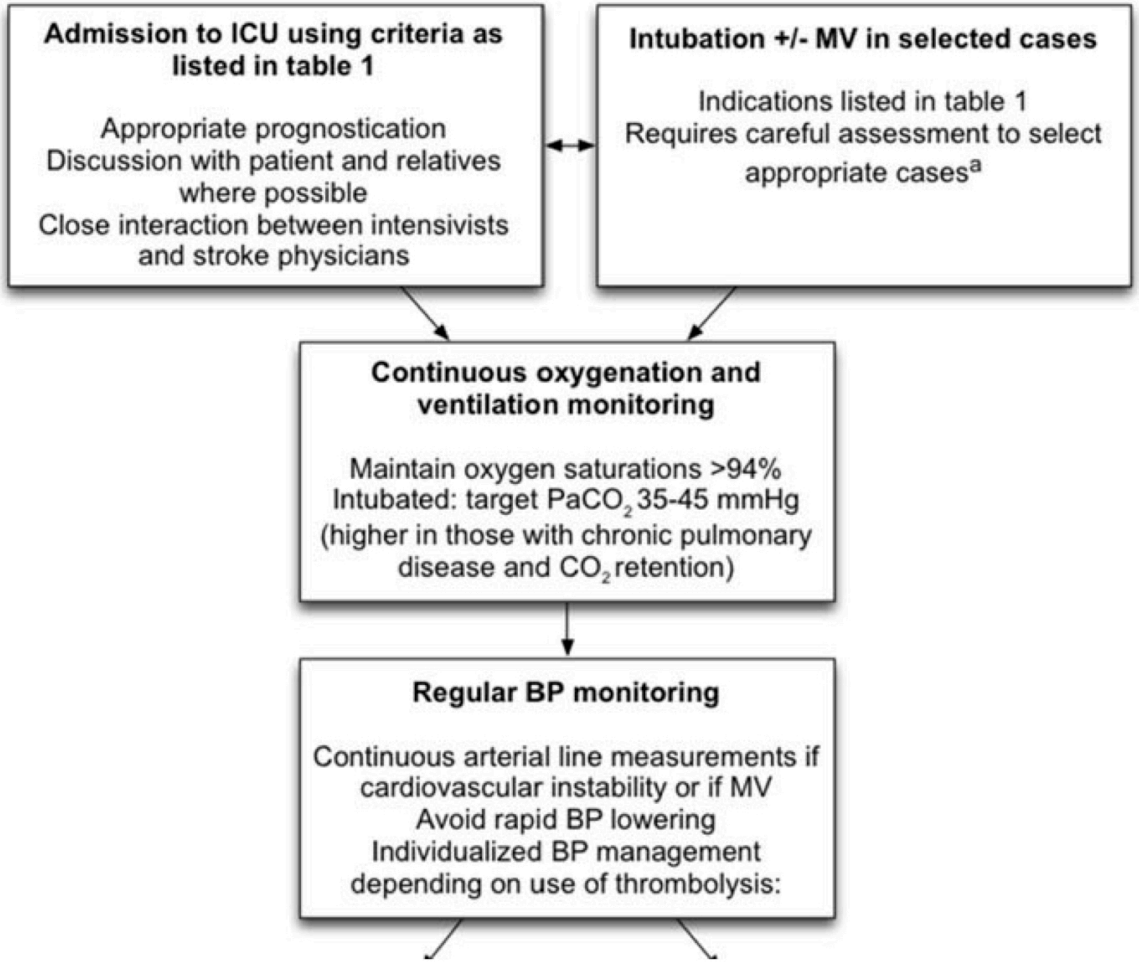
- Severe stroke (National Institutes of Health Stroke Scale (NIHSS) Score >17)
- Reperfusion therapy (intravenous or intraarterial), in the presence of multiorgan failure and/or to manage the complications of therapy (e.g. haemorrhagic transformation), and in those undergoing local intraarterial therapy
- Large middle cerebral artery infarct volume (>145cm^3), which predicts a malignant course
- Uncontrolled derangements of blood pressure that are difficult to manage in a ward setting

Which stroke patients should be admitted to the ICU?

- Organ support, including renal replacement therapy, noninvasive ventilation, and/or cardiac dysfunction
- Postoperative monitoring and management following decompressive craniectomy
- Management of patients with massive stroke and high mortality risk in whom organ retrieval/harvesting is planned

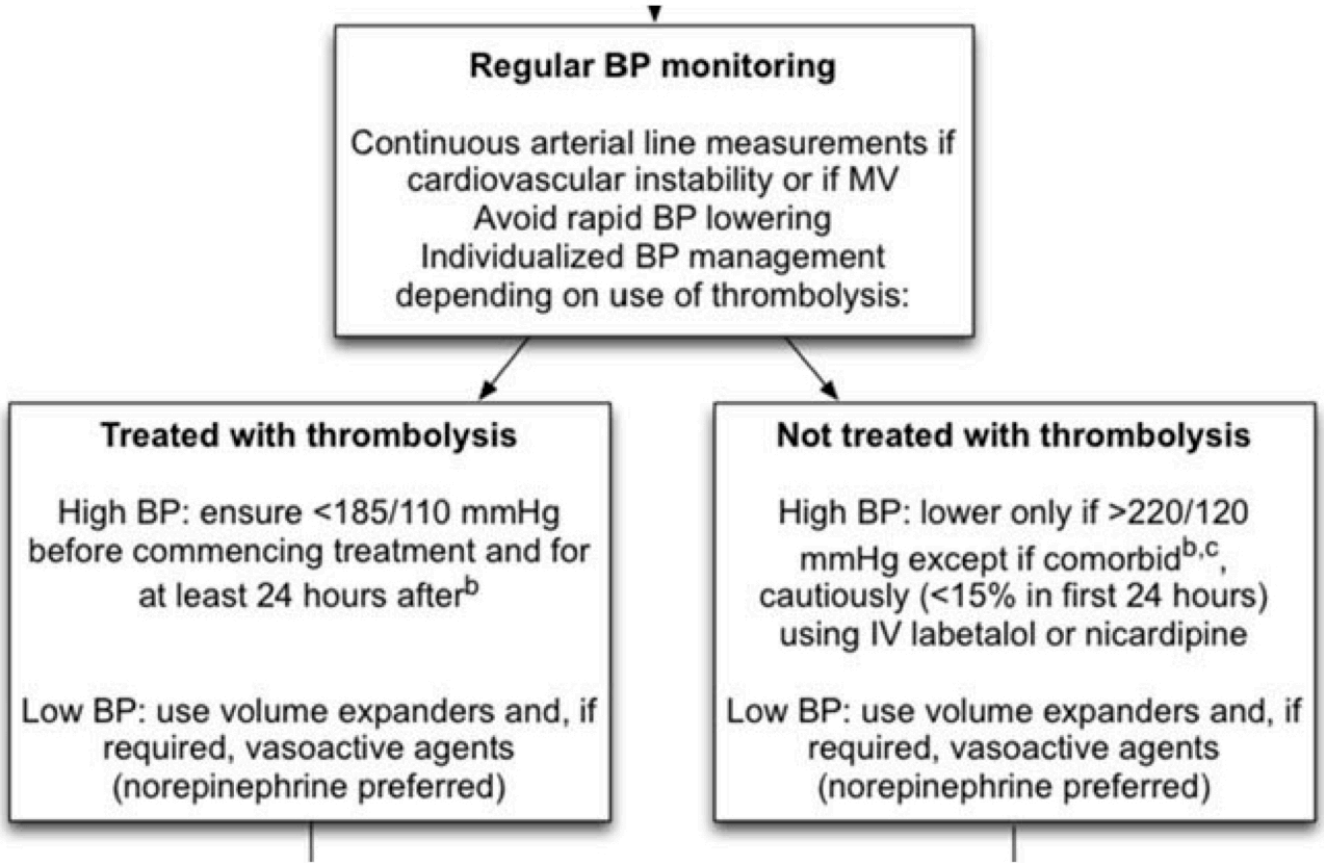
- A Cochrane systematic review involving 28 trials of 5,855 patients found stroke patients who receive organised inpatient care in stroke units are more likely to be alive, independent, and living at home one year after the stroke. PMID 19743737

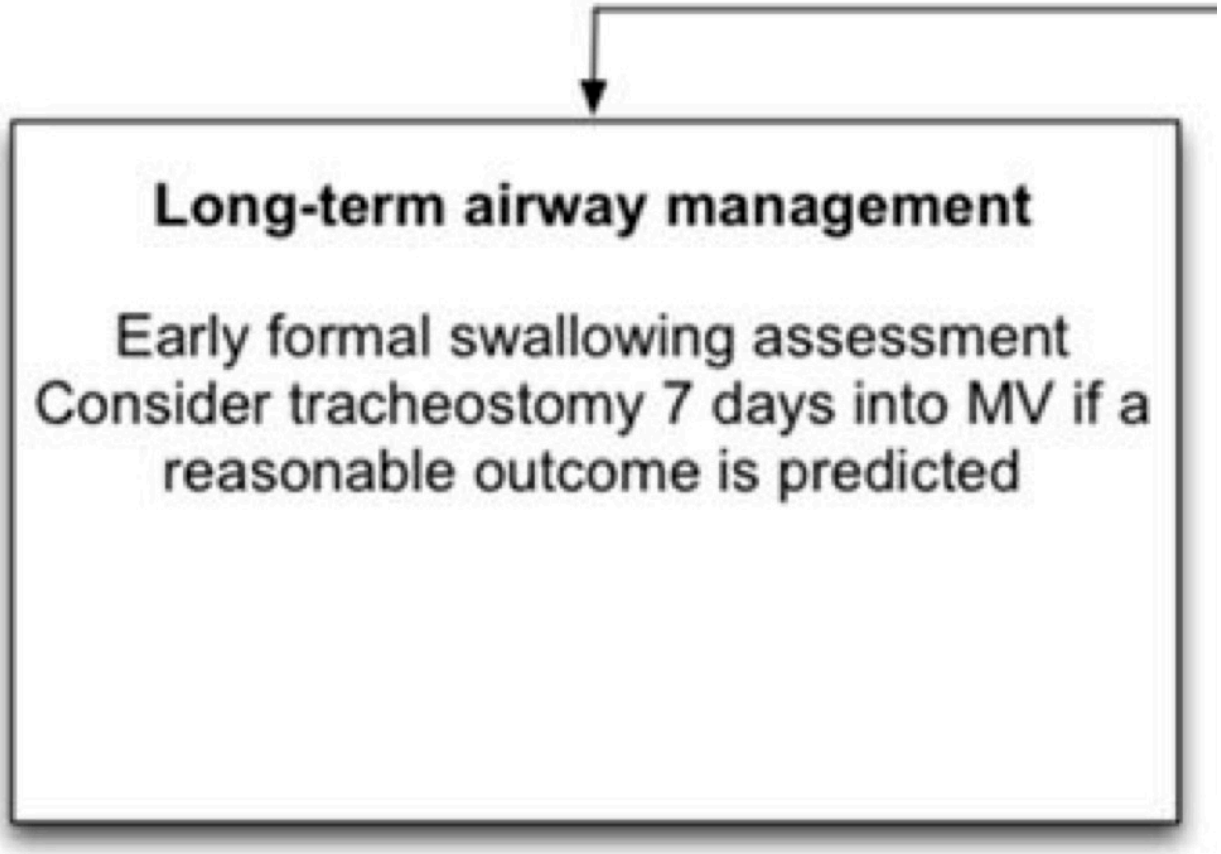
Management in ICU

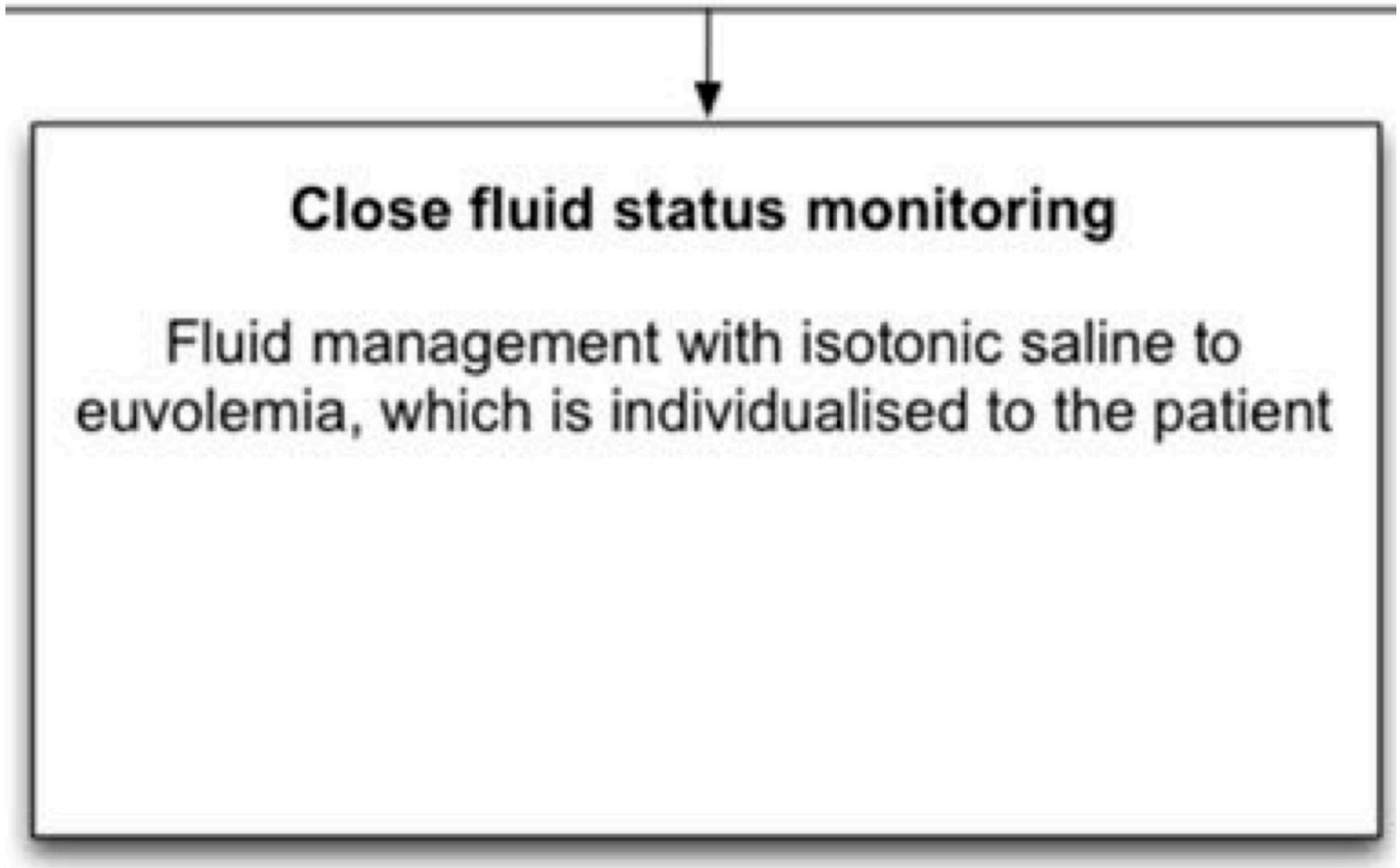


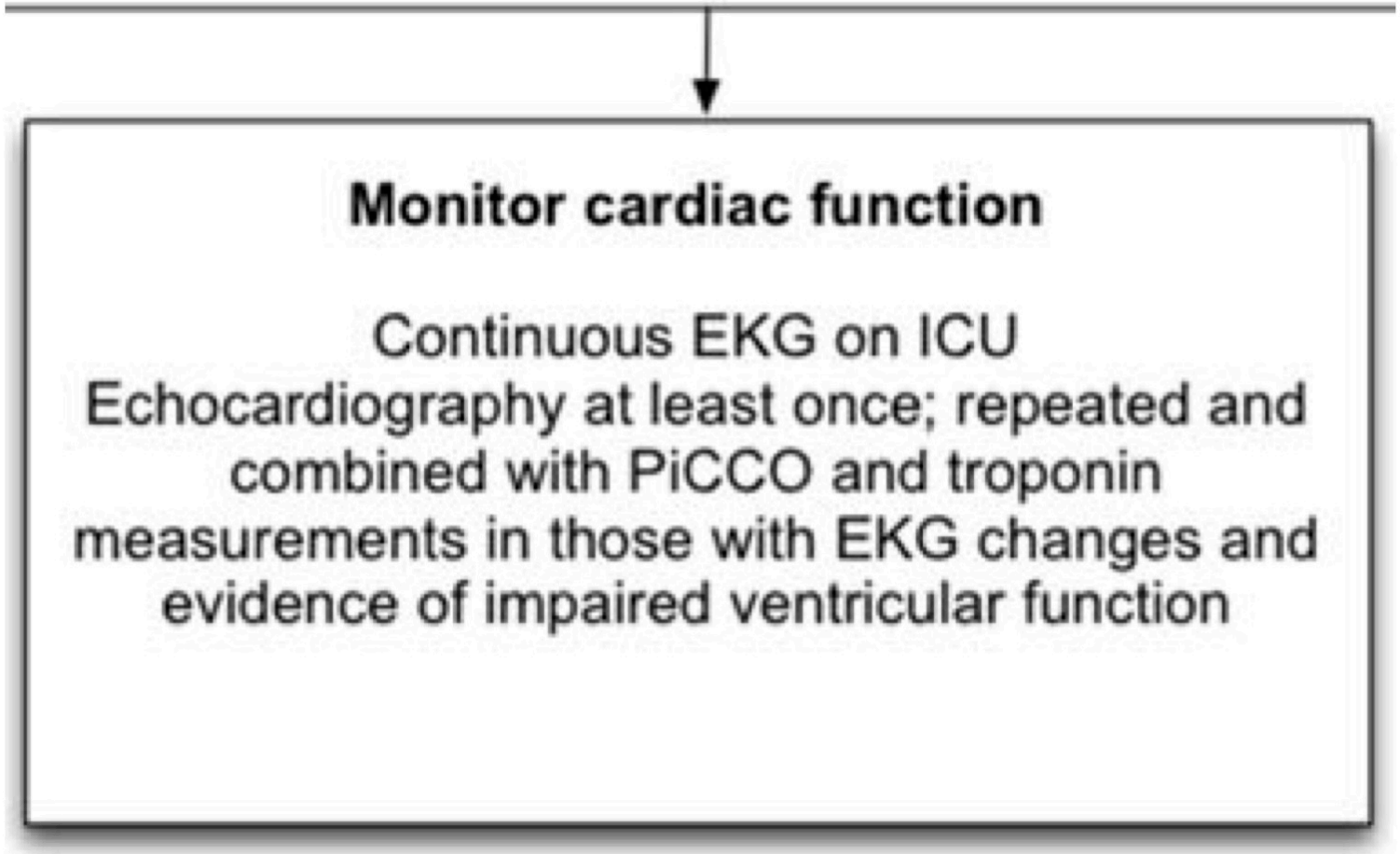
- **Cerebral perfusion and the penumbra**
  Adequate cerebral perfusion is crucial in preserving the penumbra, where cerebral autoregulation is impaired, and the cerebral blood flow (CBF) is passively dependent on mean arterial pressure (MAP); post-stenotic flow requires stable circulatory conditions.

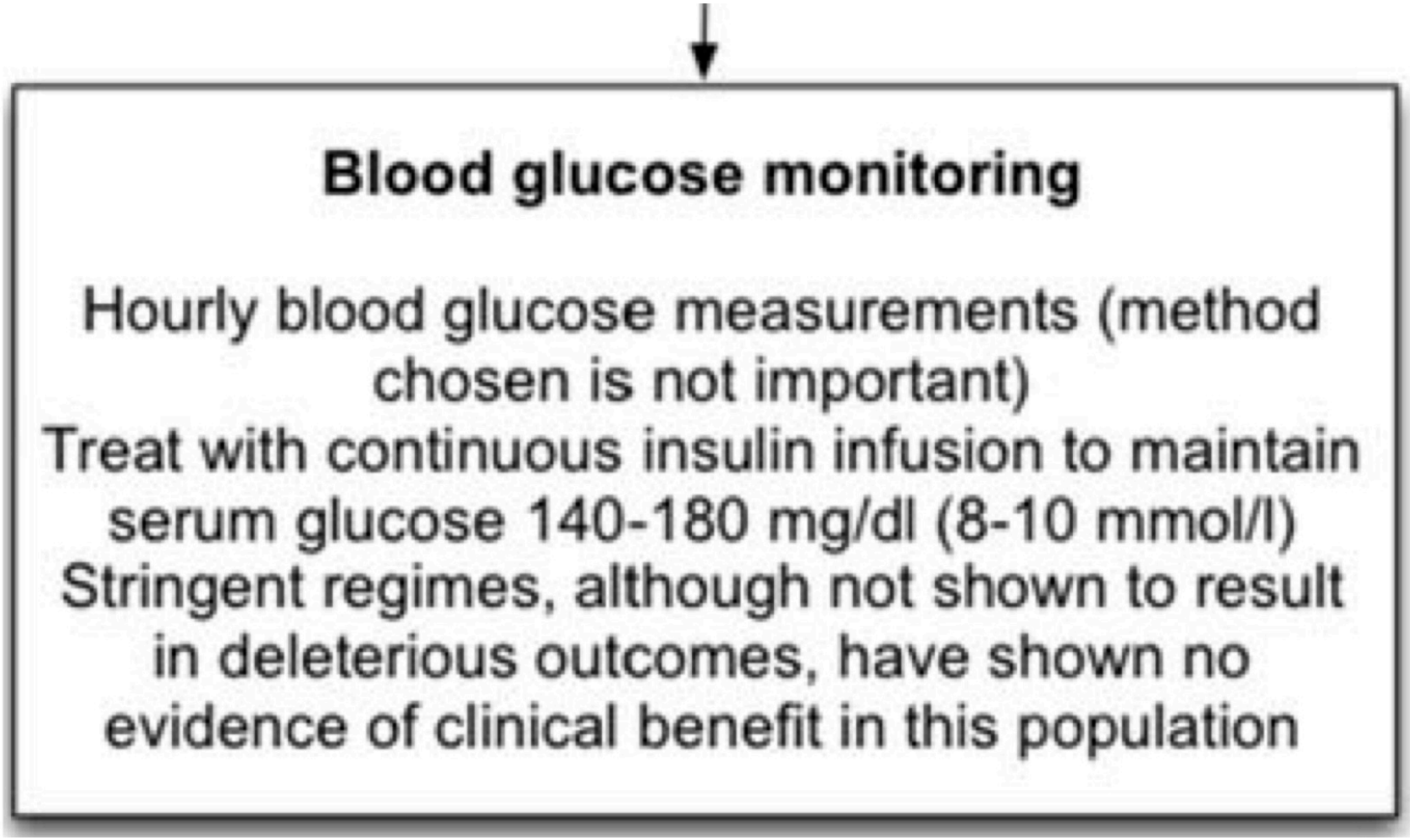
- Blood pressure lowering should always be cautious, i.e. <15% in the first 24 hours in those not receiving thrombolysis (more aggressive blood pressure lowering is permitted prior to thrombolysis).


Regular BP monitoring
Continuous arterial line measurements if cardiovascular instability or if MV
Avoid rapid BP lowering
Individualized BP management depending on use of thrombolysis:
Treated with thrombolysis
High BP: ensure <185/110 mmHg before commencing treatment and for at least 24 hours after[b]
Low BP: use volume expanders and, if required, vasoactive agents (norepinephrine preferred)
Not treated with thrombolysis
High BP: lower only if >220/120 mmHg except if comorbid[b,c], cautiously (<15% in first 24 hours) using IV labetalol or nicardipine
Low BP: use volume expanders and, if required, vasoactive agents (norepinephrine preferred)


Long-term airway management
Early formal swallowing assessment
Consider tracheostomy 7 days into MV if a reasonable outcome is predicted

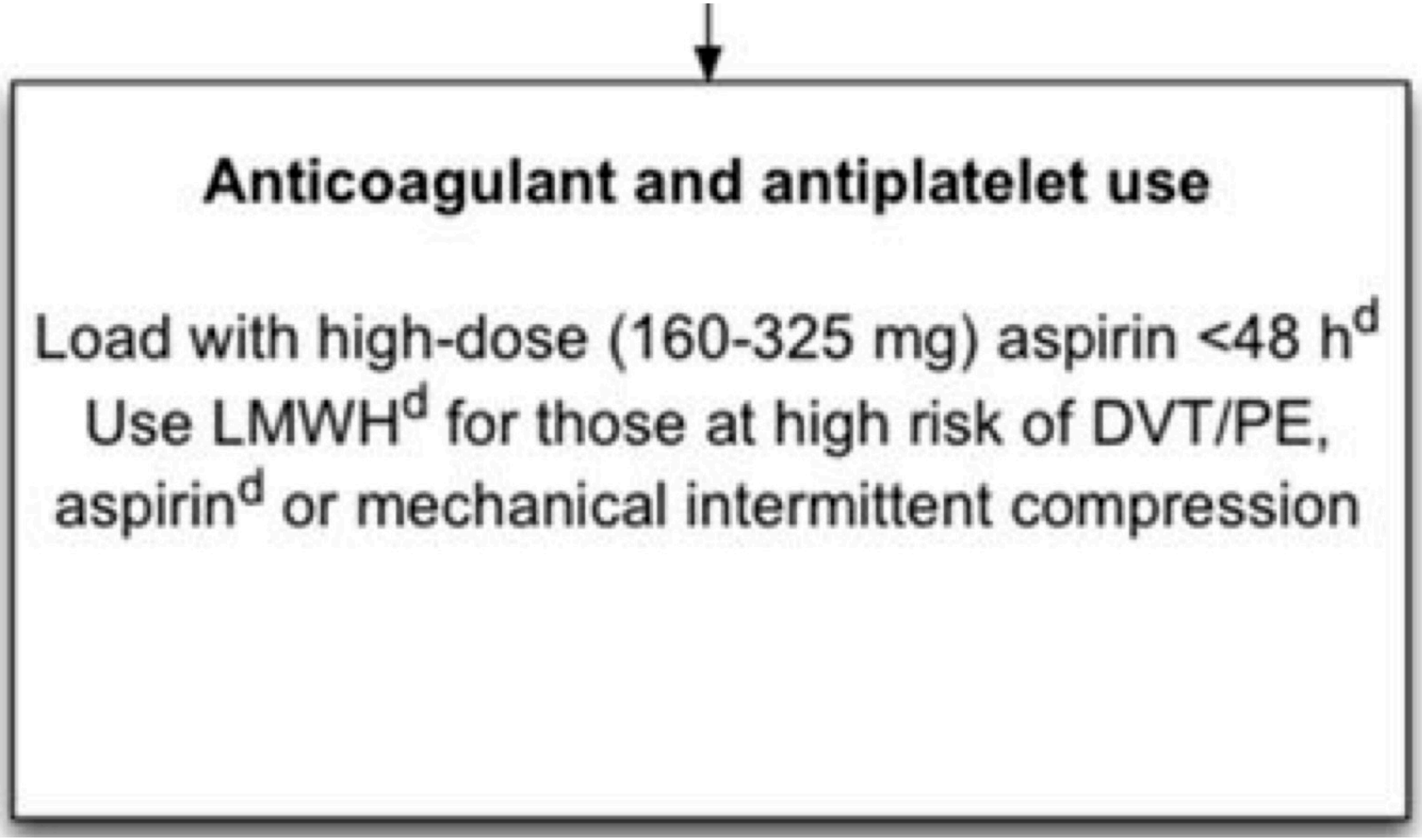

Close fluid status monitoring
Fluid management with isotonic saline to euvolemia, which is individualised to the patient


Monitor cardiac function
Continuous EKG on ICU
Echocardiography at least once; repeated and combined with PiCCO and troponin measurements in those with EKG changes and evidence of impaired ventricular function


Blood glucose monitoring
Hourly blood glucose measurements (method chosen is not important)
Treat with continuous insulin infusion to maintain serum glucose 140-180 mg/dl (8-10 mmol/l)
Stringent regimes, although not shown to result in deleterious outcomes, have shown no evidence of clinical benefit in this population

Control temperature

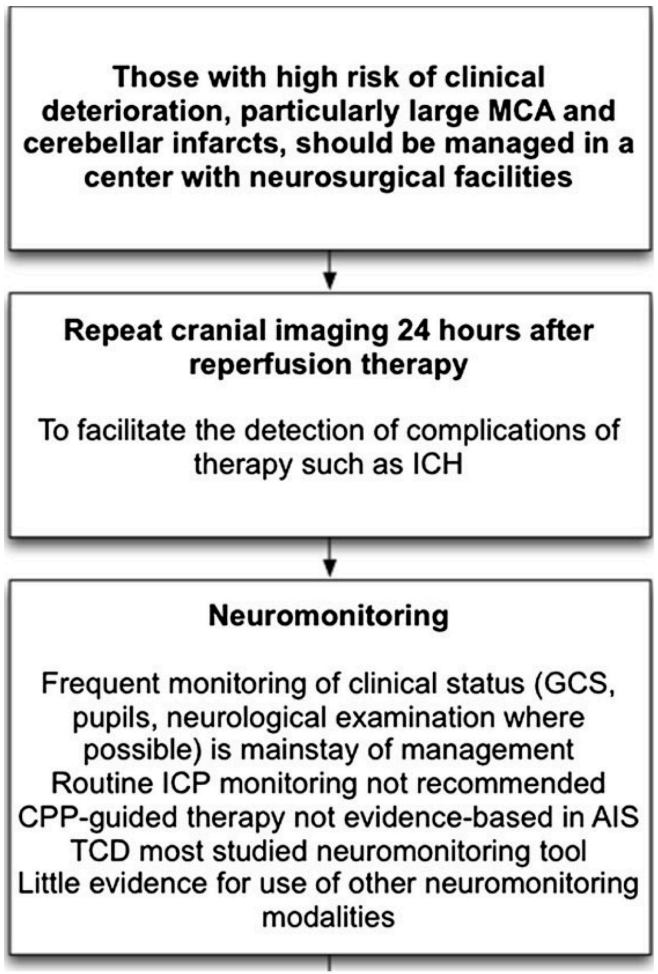
Avoid pyrexia >37.5°C[b]
Investigate and treat suspected infections
Treat temperatures >37.5°C with regular paracetamol (acetaminophen) initially (dosage according to local guidance), then if not responsive IV metamizole, rapid infusions of cold saline 4°C and automatic cooling systems


Anticoagulant and antiplatelet use
Load with high-dose (160-325 mg) aspirin <48 h[d]
Use LMWH[d] for those at high risk of DVT/PE,
aspirin[d] or mechanical intermittent compression

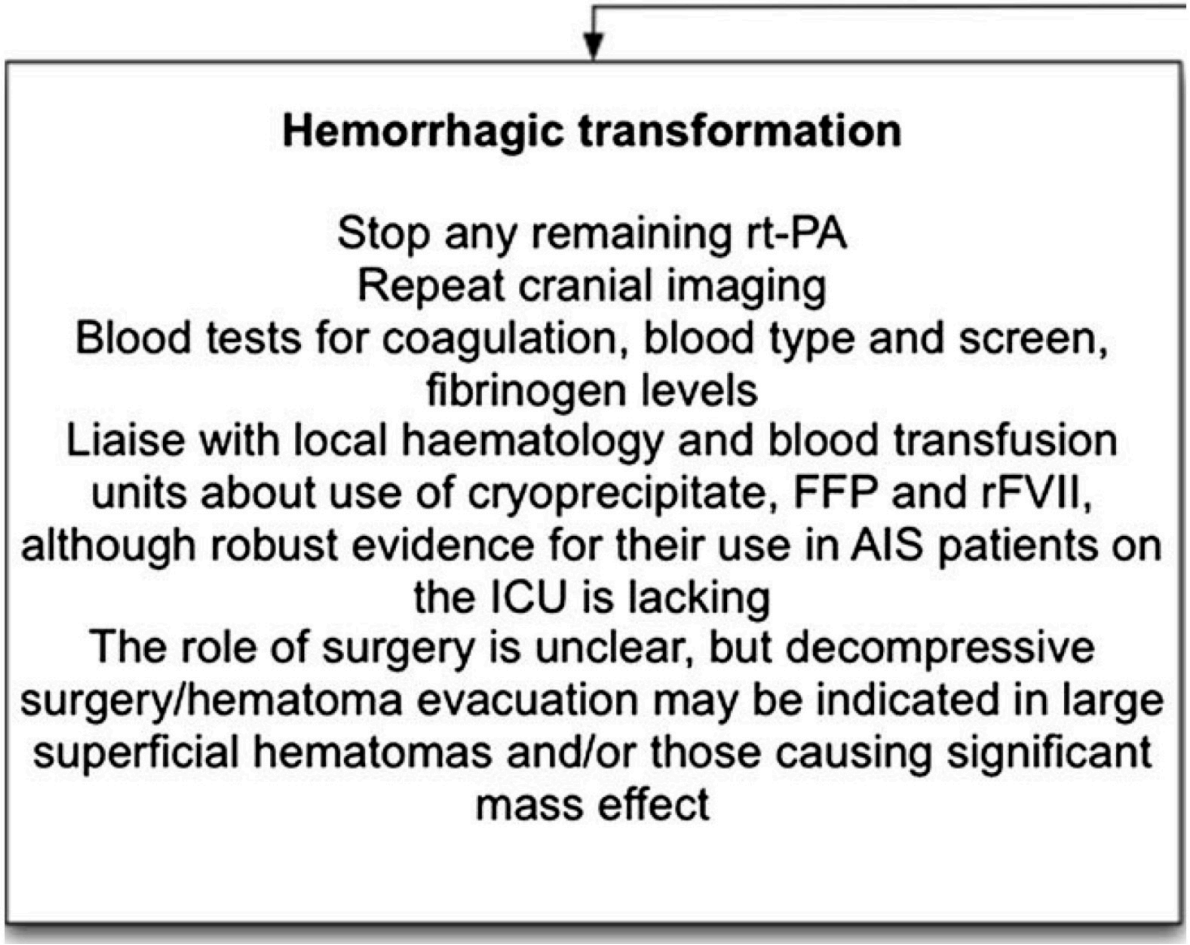
Blood transfusion

No robust data to support specific hemoglobin thresholds or targets for AIS on the ICU
Avoiding anemia is key, and so is avoiding aggressive transfusion approaches where possible

- Management of intracranial issues and complications in acute ischemic stroke on the intensive care unit


Those with high risk of clinical deterioration, particularly large MCA and cerebellar infarcts, should be managed in a center with neurosurgical facilities
Repeat cranial imaging 24 hours after reperfusion therapy
To facilitate the detection of complications of therapy such as ICH
Neuromonitoring
Frequent monitoring of clinical status (GCS, pupils, neurological examination where possible) is mainstay of management
Routine ICP monitoring not recommended
CPP-guided therapy not evidence-based in AIS
TCD most studied neuromonitoring tool
Little evidence for use of other neuromonitoring modalities

Management of specific complications


Hemorrhagic transformation
Stop any remaining rt-PA
Repeat cranial imaging
Blood tests for coagulation, blood type and screen, fibrinogen levels
Liaise with local haematology and blood transfusion units about use of cryoprecipitate, FFP and rFVII, although robust evidence for their use in AIS patients on the ICU is lacking
The role of surgery is unclear, but decompressive surgery/hematoma evacuation may be indicated in large superficial hematomas and/or those causing significant mass effect

Raised ICP and cerebral edema

Monitor clinical status closely for neurological deterioration (suspect if pupillary abnormalities, drop in GCS by >1 point, progression of edema on imaging)
Surgical decompression for malignant MCA infarction must be considered as soon as possible and within 48 hours in 18-60 year olds; outcomes are worse with increasing age but consider surgery in older patients
Ventriculostomy and suboccipital decompressive craniotomy for acute hydrocephalus associated with cerebellar AIS should be performed as soon as possible
Treat signs of raised ICP aggressively with medical therapies[a] as a temporizing measure only
Do not use osmotic diuretics prophylactically

Table 3: Medical management of intracranial hypertension in stroke

Treatment modality	Comment
Hyperventilation	Should only be used as a temporising measure, as it can increase cerebral ischaemia due to cerebral vasoconstriction
Mannitol and hypertonic saline	Evidence demonstrating improved outcomes in stroke is lacking Hypertonic saline appears to be more effective than mannitol in reducing intracranial pressure Should only be used as a temporising measure only, and should not delay surgery Should not be used as prophylaxis before the detection of cerebral oedema
Thiopental	Can promptly and significantly reduce ICP in acute crises Requires intracranial pressure, electroencephalography, and invasive haemodynamic monitoring
Therapeutic hypothermia	Has been used in patients with cerebral oedema unresponsive to other medical therapies A trial of surgery combined with therapeutic hypothermia is ongoing

Surgery

- If performed within 48 hours of symptom onset in those between 18-60 years old, mortality is reduced from 78% to 29% and a significant improvement in functional outcomes is observed
- Equal benefit is seen in those with dominant and non-dominant hemisphere infarctions

Lancet Neurol. 2007 Mar;6(3):215-22.**Early decompressive surgery in malignant infarction of the middle cerebral artery: a pooled analysis of three randomised controlled trials.**

Surgery

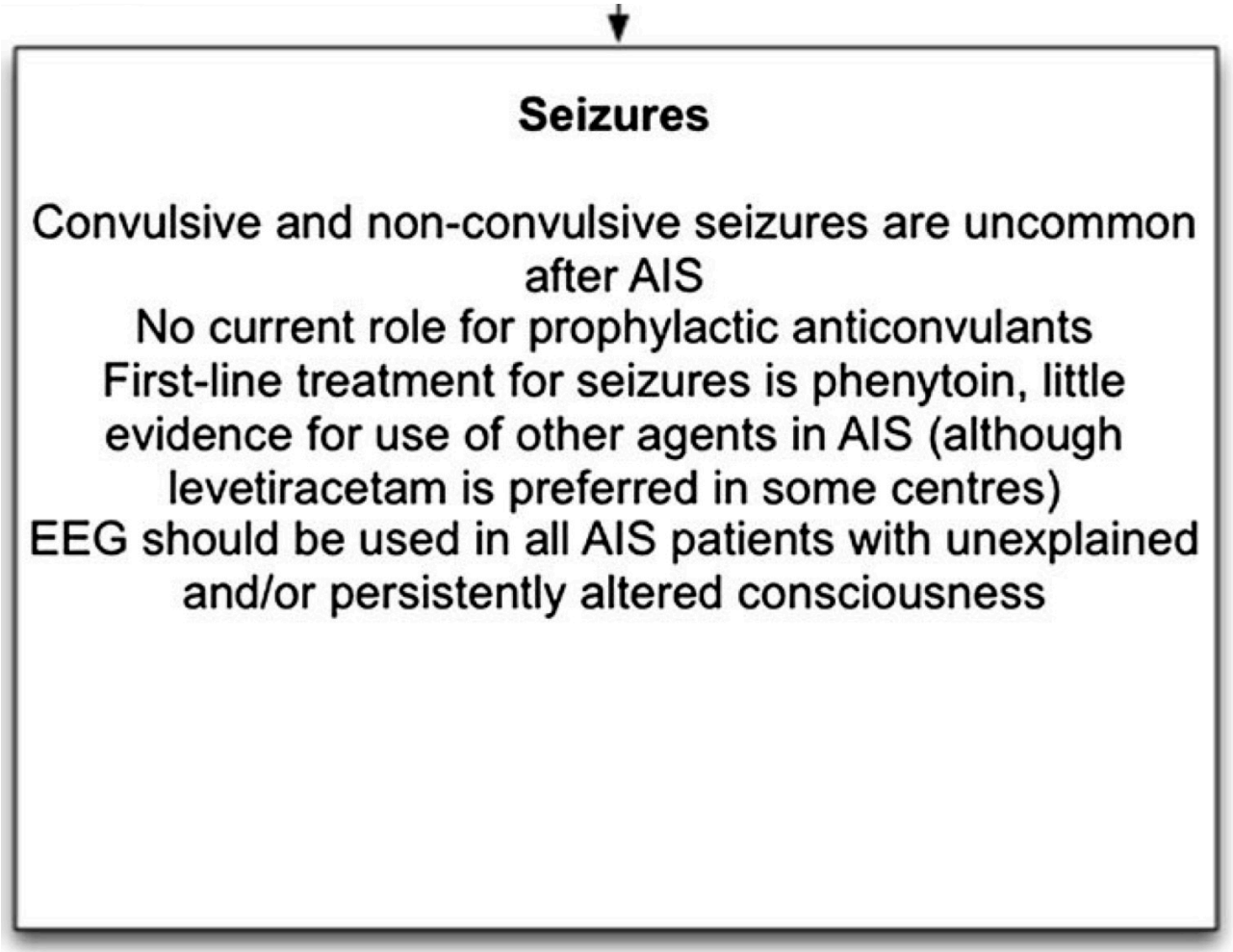
- There is no clear influence of prior intravenous thrombolysis administration on outcomes following surgery, although antiplatelet administration appears to increase bleeding complications
- Although the evidence base supports surgery within 48 hours of symptom onset, in some centres this is not applied so rigidly in that patients may be offered surgery on day 3, for example. Liaison with your local neurosurgical team is critical
- In patients between 61 and 82 years old, a similar survival benefit from surgery is shown (mortality is reduced from 70% to 33%), but surgery is associated with an increased proportion of severely disabled survivors

Surgery for cerebellar infarction

Consensus guidelines from the American Stroke Association recommend the following:

- Suboccipital craniectomy with dural expansion, with or without resection of necrotic tissue, in those who deteriorate due to a cerebellar infarction
- In the presence of hydrocephalus, placement of a ventricular catheter, followed by suboccipital craniectomy

Stroke. 2014 Apr;45(4):1222-38. doi: 10.1161/01.str.0000441965.15164.d6. Epub 2014 Jan 30.
Recommendations for the management of cerebral and cerebellar infarction with swelling: a statement for healthcare professionals from the American Heart Association/American Stroke Association.


Seizures
Convulsive and non-convulsive seizures are uncommon after AIS
No current role for prophylactic anticonvulants
First-line treatment for seizures is phenytoin, little evidence for use of other agents in AIS (although levetiracetam is preferred in some centres)
EEG should be used in all AIS patients with unexplained and/or persistently altered consciousness

Stroke mimics

Table 2: Stroke mimics

Condition	Comments
Hypoglycaemia	Can produce hemiplegia and aphasia as well as the more common symptoms of confusion and reduced level of consciousness
Intracranial space occupying lesions	Tumours, cerebral abscess, and intracranial bleeding such as a subdural hematoma may produce a stroke-like presentation. More acute presentations in the setting of tumours may be due to intratumoural haemorrhage, seizures or the development of obstructive hydrocephalus
Seizures and the postictal state	Todd's paresis usually follows partial motor seizures, but can result from generalised seizures too. Can also be a complication of a stroke
Migraine	Can mimic a stroke in the presence of a hemiplegic migraine, or can itself precipitate a stroke
Encephalopathies and metabolic disorders	Hyperglycaemia can result in focal neurological deficits and seizures. Hypertensive encephalopathy may present with headaches and cortical blindness. Hyponatremia and hepatic encephalopathy may also cause stroke-like presentations
Sepsis	Relies on a thorough systemic examination for diagnosis and identification of a focus of infection. Sepsis can be a risk factor for stroke itself, for example mycotic emboli, and when co-existing, differentiating the two is difficult
Drug toxicity	Examples include lithium, carbamazepine and phenytoin
Functional disorders	Often presents with acute weakness or sensory disturbance that is triggered, for example by a panic attack. An inconsistent clinical examination is key to diagnosis

Patient 1

- **A 59-year-old man**
- **found by his wife at about 11.00 hour lying in front of the couch,**
- scanty and mumbling verbal response
- unable to stand up or move his left arm
- Ten minutes before, he had appeared quite normal

- At 12.45 you see the patient on admission to the emergency department.
- Blood has been taken for routine emergency tests via a peripheral intravenous cannula, inserted by the emergency physician.
- blood pressure 190/110 mmHg
- irregular pulse rate without detectable P waves on the ECG
- mean pulse rate of 101 beats/min
- respiratory rate of 18 breaths/min
- Oxygen saturation 99% during administration of 2 l/min O2 via a nasal cannula

Neurological examination

- conjugated eye deviation to the right
- lower facial paresis
- dysarthria
- anosognosia
- severe left sided hemiparesis (arm: 0/5, leg 2/5)
- hemihyperalgesia
- the right plantar reflexes are extensor.

- He is awake, responsive, and has no pupillary abnormalities.
- PMH: MI three years before
- present medication : metoprolol and pravastatin.
- There are no further relevant diseases, in particular no hypertension or diabetes; he had stopped smoking after the myocardial infarction.

- Q. What is your diagnosis? What are your next steps of acute management?

- A. The most probable diagnosis is a large right hemispheric infarction due to cardio- embolic (note the finding of atrial fibrillation) occlusion of the M1 segment of the middle cerebral artery.

- Q. What are your next steps of acute management?

- To exclude haemorrhage, a CT has to be performed.
- You try to minimise any delay because the patient still fits the time window for thrombolysis.
- In this case, even ultrasound neurovascular diagnostics should be omitted.
- You tolerate the elevated blood pressure.

- The diagnosis is confirmed by the CT scan, which shows, besides normal parenchymal structures, a hyperdense middle cerebral artery (MCA) sign on the right side.
- Thrombolysis was started immediately and the patient is transferred to the ICU at 13.20 hours. The patient's weight is assessed as 80 kg, and 75 mg of rtPA is prepared (0.9 x 80 kg – >73 mg rtPA). 7.5 mg (10%) are given as an intravenous bolus, followed by continuous infusion of the remaining dose over one hour.
- In ICU, standard monitoring is applied and a second peripheral venous line is inserted. Neither the 12 channel ECG nor the subsequent laboratory results support the diagnosis of acute or subacute myocardial infarction. The patient is frequently observed clinically; the temperature, blood glucose, and the oxygen saturation are monitored closely and kept in normal range. Also the blood pressure is kept in the high normal range after starting the thrombolysis.

- Q. If the time of admission was 15.50, what decision would you have reached concerning recanalising measures?

- A. There is evidence that patients treated within up to 4.5 h after onset may benefit from intravenous rtPA thrombolysis. However, beyond 4.5h up to 6h, if the infarcted area is more than 1/3 of the MCA territory as assessed by CT early signs or, if available, stroke MRI, the risk of bleeding in the infarcted area may exceed the expected benefit. In conclusion, our patient would not be assessed as suitable for thrombolysis if the admission was delayed until 15.50.

- At 20.00 the patient's condition has not improved. The morning after, the patient is deeply unconscious and shows a slightly dilated right pupil with delayed reactivity.
- Q. What are your differential diagnoses and how do you proceed?

- A. The most likely explanation is an early mass effect due to developing oedema or extended haemorrhage within the infarcted area. A cranial CT (CCT) has to be performed without delay to clarify the differential diagnosis and quantify the mass effect.

- CCT now shows a space-occupying infarction of the whole right MCA territory with compression of the lateral ventricles and a midline shift of 4 mm.
- Q. What are your treatment options?

- If the necessary expertise is available in your hospital or within a reasonable distance, decompressive surgery should be considered.
- This intervention has been shown to reduce mortality, morbidity, and improve clinical outcome in patients with severe MCA infarction and significantly reduce the need for intensive care.
- If available, an intraparenchymal device for measuring ICP should be implanted to guide ICP management. Before hemicraniectomy can be performed or if surgical treatment is not available, elevated ICP has to be decreased primarily by administering hypertonic solutions.
- If ICP and CPP cannot be normalised by these measures consider additional treatment options, e.g. barbiturates, hypothermia.

Patient 2

- **A 68-year-old male, awoke with weakness of the right arm and leg,**
- He also noted speech difficulties.
- He remembers that he had a transient blindness affecting the left eye three and eight days before.
- He is a heavy smoker and has a history of arterial hypertension treated with enalapril;
- He also suffers from left-sided intermittent claudication (on walking more than 100 metres.)
- On examination you find a 4/5 hemiparesis on the right side and a mild aphasia.
- The blood pressure on admission is 205/105 mmHg.

- Q. Which stroke mechanism do you suspect?

- A. The patient's history is highly suspicious of left internal carotid atherothrombosis with previous arterio-arterial embolic events (transient ipsilateral amaurosis). The actual neurological deficit may have developed following blood pressure decrease during sleep with hypoperfusion of the left hemisphere or the surrounding zones, respectively.

- Q. What are your thoughts about further management?

- A The acute management essentially does not differ from standard practice. Special emphasis however, has to be placed on maintaining a high to high-normal blood pressure.

- CCT shows a hypodensity of the surrounding zone between the anterior cerebral artery (ACA) and the MCA territory on the left as well as some lacunar infarctions in the basal ganglia on both sides.
- Extracranial Doppler examination reveals a 85-90% stenosis at the origin of the left internal carotid artery, stenoses of both external carotid arteries, and a collateralised occlusion of the right vertebral artery.

- Q. How do you interpret these findings?

- Q. What are the guidelines for your further treatment?

- A. Following the guidelines for general ischaemic stroke treatment, special effort has to be made to maintain an adequate arterial blood pressure. Thrombolysis is not appropriate because the time of infarct onset is unclear (during sleep) and there is already early demarcation of infarcts.

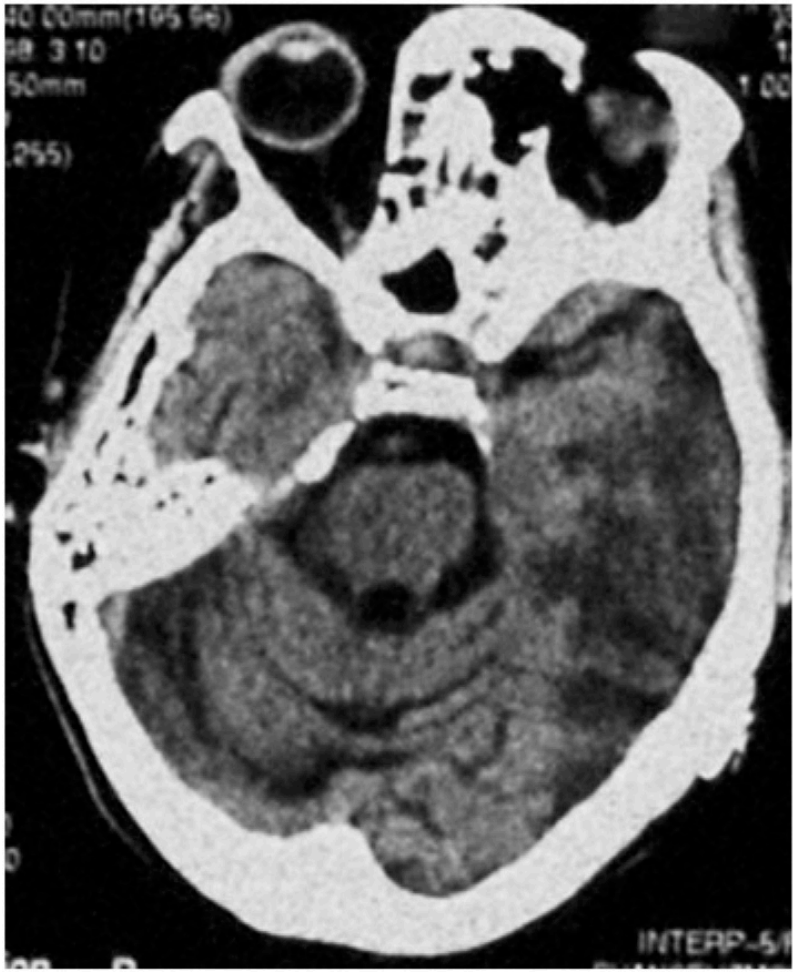
- The patient is transferred to the ICU for monitoring including continuous blood pressure measurements. Intravenous saline is running and as an embolic source is suspected 1000 units/h of heparin is being infused via a peripheral line.
- The aPTT 4 hours later is noted to be 56 sec. While initially the arterial blood pressure ranges between 205/110 and 160/90 mmHg, it falls to 120/60 mmHg at 3.00.
- The patient awakes and is only able to produce incomprehensible sounds and not able to move his right arm. You are called by the nurse and now find that his aphasia has worsened as well as his hemiparesis (1/5- 2/5).

- Q. In the event that the patient does not improve within a few minutes of raising arterial blood pressure to 135/80 mmHg with 500 ml of intravenous fluid (crystalloid or colloid), how would you proceed?

- A. If there is insufficient increase in blood pressure, consider low-dose pressors, e.g. 0.2 mg/h of norepinephrine. If the patient does not improve clinically in spite of effective blood pressure elevation (>160/90 mmHg), perform an emergency Doppler control.
- If you find the vessel occluded now, consider emergency carotid endarterectomy (CEA), if available in your hospital.

Patient 3

- A 56-year-old woman, brought to our hospital with irritability, aphasia, and ataxic gait, deteriorating over previous week. A brain computed tomography revealed a hypodense area on the left temporal lobe. Ten hours later she developed convulsive status epilepticus and loss of consciousness. She was treated with phenytoin and transferred to the ICU, mechanically ventilated and sedated with propofol.
- Her past medical history was marked for a hearing deficit, for which a cochlear implant had been inserted 2 years earlier, and for an episode of loss of consciousness 6 months earlier. She was functional with daily activities. The patient was childless. Three out of her four sisters had died at early age.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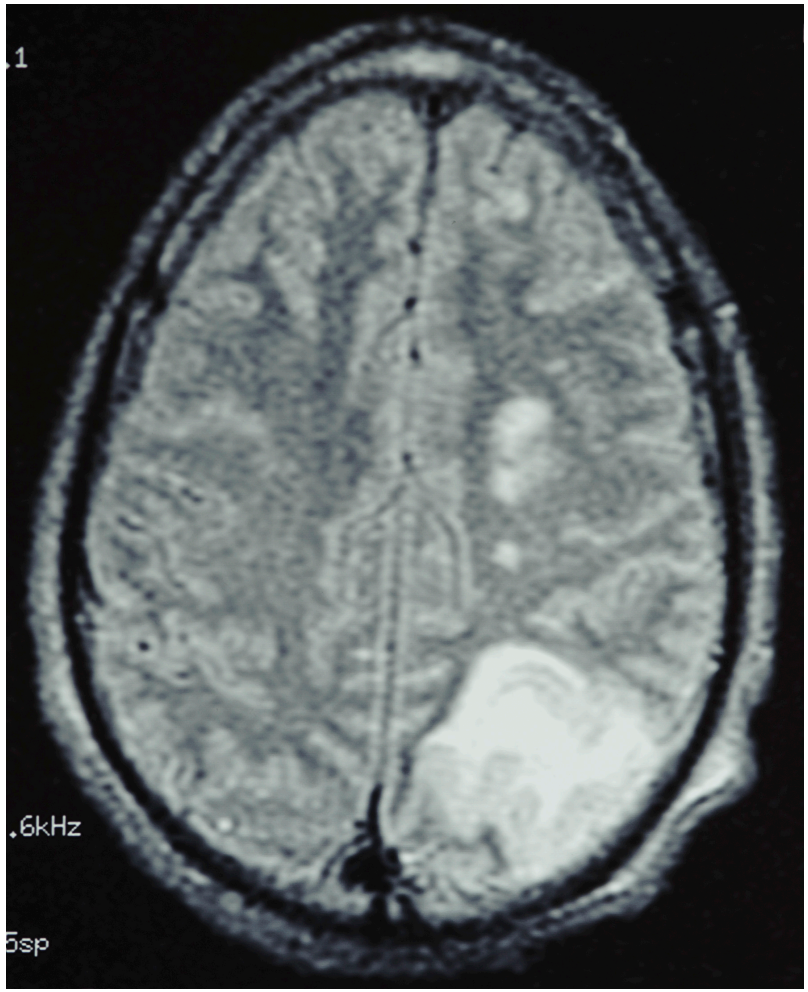
- Arterial blood gases showed lactic acidosis, lac>3mmol/L despite administering fluids.

- What is your doagnosis?

Patient 4

- A 23-year-old man was transferred to the emergency department after a motor-vehicle accident with haemorrhagic shock due to splenic rupture. He was managed with emergency laparotomy and splenectomy and was admitted to the intensive care unit for postoperative monitoring. Computerized tomography (CT) scans of the brain, neck and chest were normal. The following day, on attempted awakening, the patient was agitated and unable to move his right arm.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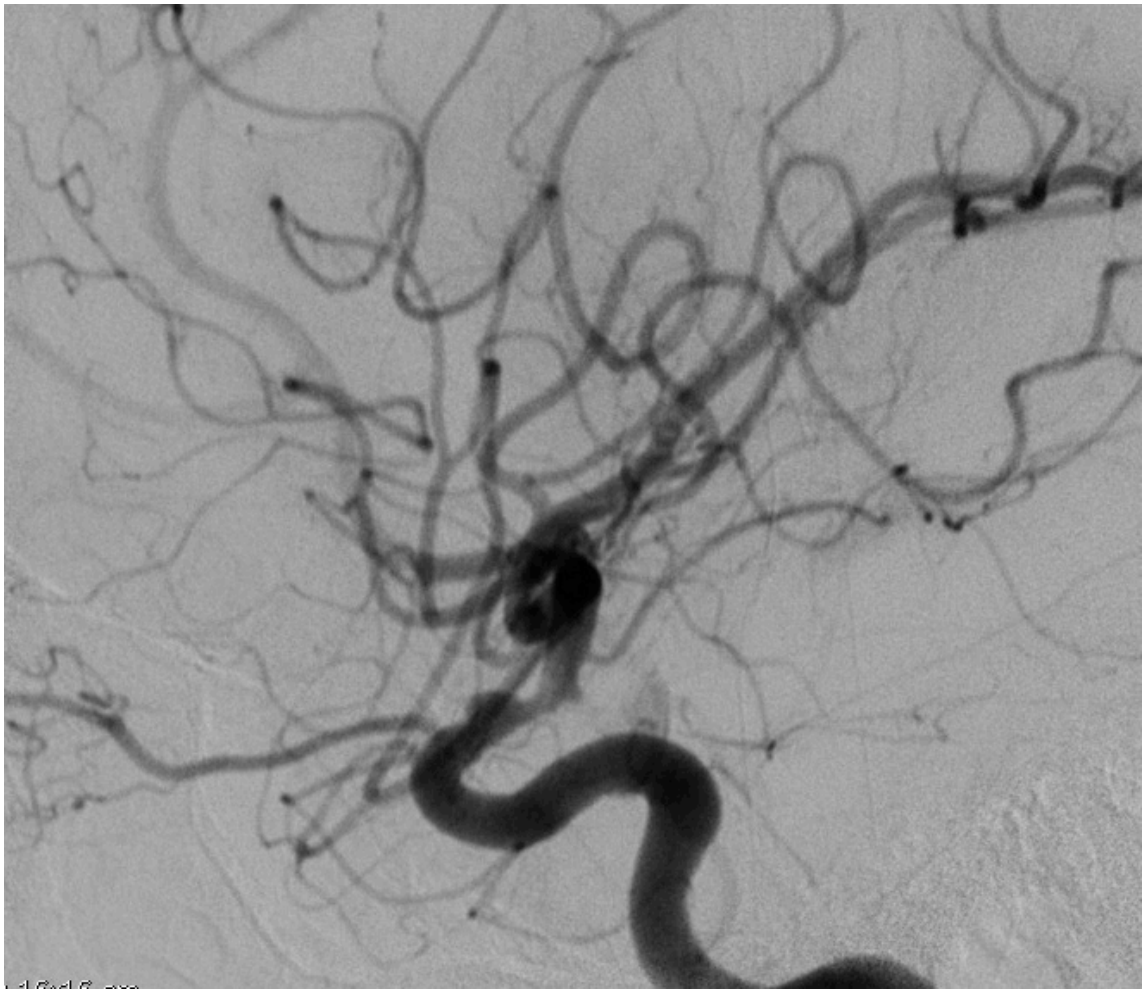
- What would you do next?



- Thank you

Other differential diagnoses of ischaemic stroke include:

- **Subarachnoid haemorrhage:** sudden occipital headache, meningism, detection of subarachnoid blood on cranial CT and/or in cerebrospinal fluid (CSF).
- **Neoplasm:** neurological deficit developing over many days/months, sometimes with acute exacerbation: e.g. due to worsening oedema or haemorrhage in brain tumours.
- **Sinus (sagittal) venous thrombosis:** early seizures, headache, typical risk factors (head or neck trauma, prior or current malignancy, diabetes, dehydration, prior or current hypercoagulability).
- **Meningitis/vasculitis:** fever, meningism, typical CSF findings.
- **Multiple sclerosis:** symptoms that usually develop over days but in rare cases, symptoms and neurological deficits may develop within hours.
- **Postictal paresis**: Todd's paresis.
- **Migraine**
- **Eclampsia (peripartum).**

- Tremendous research efforts
- only four aspects of *acute* stroke therapy have been shown to improve patient outcomes:

- Stroke care in specialised units (Stroke units)
- Platelet inhibitors such as acetylsalicylic acid within 72 hours
- Intravenous thrombolysis within 4.5 hours
- Hemicraniectomy within 48 hours (see reference below)

- Donnan GA, Fisher M, Macleod M, Davis SM. Stroke. Lancet 2008; 371(9624): 1612- 1623 Review. PMID 18468545

ICU or not?

- Large, space-occupying hemispheric infarct
- Space-occupying cerebellar infarct
- Basilar artery thrombosis
- Septic embolic infarction secondary to bacterial endocarditis
- Stroke associated with cardiothoracic surgery
- Pre- and post-intervention care of stroke-related angiography.

Respiratory failure
Cardiovascular instability
Coma
Seizures which are not quickly controlled
Elective intubation for diagnostic/therapeutic procedures.

- First line assessment and treatment are closely inter-related and include the following tasks:
  - Securing the airway and optimising oxygenation
  - Haemodynamic stabilisation and fluid administration
  - Basic monitoring (including rapid determination of blood glucose)
  - Treatment of patient discomfort (such as agitation, vomiting, etc) that

Ideally, all stroke patients should be treated on a stroke unit