Chapter 6
Acute Ischemic Stroke

Irene L. Katzan

Clinical Pearls

- Goals of management in the hyperacute and acute period are to (a) optimize cerebral perfusion and (b) minimize neuronal injury.
- Speed is critical in the evaluation and management of patients with acute ischemic stroke.
- The longer the time since the patient was last known well, the more critical becomes advanced imaging assessment of brain tissue with CT perfusion, MRI and MR perfusion to determine the risk and benefit of recanalization therapies.
- The main goals of the acute inpatient stay are to: (a) prevent neurological worsening; (b) prevent medical complications; (c) Optimize recovery, which entails initiation of physical, occupational, and speech therapies and discharge planning; (d) Initiate strategies to prevent recurrent stroke.

I.L. Katzan, M.D., M.S.
Neurological Institute, Cleveland Clinic—Cerebrovascular Center,
9500 Euclid Avenue, #S80, Cleveland, OH 44195, USA
e-mail: katzani@ccf.org

© Springer International Publishing AG 2017

B. Tousi, J. Cummings (eds.), *Neuro-Geriatrics*,
DOI 10.1007/978-3-319-56484-5_6

Introduction

Stroke poses a tremendous health burden. Each year, approximately 795,000 people experience a new or recurrent stroke. On average, someone dies of a stroke every 4 min [1]. Although stroke is a leading cause of death, most stroke patients survive, and, as a result, stroke is a leading cause of long-term disability in adults in the United States. Of stroke patients that survive 5 years, one-third are disabled, and 1 in 7 are in permanent institutional care [2]. According to projections, an additional 4 million people will have had a stroke by 2030 due to the aging of the population and shift in population demographics. This represents a 21.9% increase in prevalence from 2013.

The acute management of stroke can have a significant impact on overall outcomes. Data have shown that administration of intravenous recombinant tissue plasminogen activator (IV rtPA) significantly increases the chance of patients being left with minimal to no disability [3]. Endovascular therapy of patients with large vessel occlusion has been shown to improve outcomes [4]. Importantly, the management of patients in stroke units, which largely entails the systematic following of general management principles for stroke, has consistently been shown to reduce mortality and improve functional outcomes [5]. A systematic approach to care is applicable to almost all acute stroke patients and has a larger overall impact on outcomes after stroke than does performing hyperacute intervention in isolation, for which only a minority of stroke patients currently are eligible. This chapter reviews the approach to management of patients with acute ischemic stroke.

Although stroke patients enter the treatment process from a number of different venues, they generally come either directly to the emergency department (ED) from home through emergency medical services (EMS) or private transport or are transferred in from other hospitals. This initiates the treatment process, which can be broken into two distinct phases: hyperacute stroke evaluation and inpatient management.

Hyperacute Stroke Evaluation and Management

Hospital Arrival—Immediate Considerations

The initial evaluation of a potential stroke patient should focus on immediate evaluation of the circulation, airway and breathing [6]. Oxygen saturations should be maintained at 94% or above. Supplemental oxygen is not recommended unless oxygen saturations fall below this threshold. It is important to avoid hypotension in the setting of acute ischemia. Blood pressure (BP) medications should not be administered unless systolic blood pressure (SBP) is over 220 mmHg or diastolic blood pressure (DBP) is higher than 120 mmHg, *except* for patients who are potential candidates for reperfusion therapy (IV rtPA or endovascular recanalization). *If acute intervention is being considered, these thresholds should be reduced to SBP ≤ 185 mmHg and DBP ≤ 110 mmHg* (see section "Acute Intervention 0–3 h"). *Serum glucose should be checked on arrival*, and hypoglycemia or hyperglycemia above 200 mg/dL should

be corrected. Hypoglycemia can result in symptoms that mimic an acute stroke. Hyperglycemia has been associated with worse outcomes. Patients should be placed on continuous telemetry for at least the first 24 h of admission [7].

Clinical Manifestations (History and Physical Examination)

Once vital signs have been assessed, a physical examination should be performed. This should include a neurological assessment as well as the *completion of the National Institutes of Health Stroke Scale (NIHSS)* (Table 6.1). *The time last known well should be determined*. This is critical as it is a central eligibility criterion for hyperacute interventions.

Table 6.1 National Institutes of Health Stroke Scale [8]

1A Level of consciousness
0—Alert
1—Drowsy
2—Obtunded
3—Coma/unresponsive
1B Orientation questions
0—Answers both correctly
1—Answers 1 correctly
2—Answers neither correctly
1C Response to commands
0—Performs both tasks correctly
1—Performs 1 task correctly
2—Performs neither correctly
2 Gaze
0—Normal horizontal movements
1—Partial gaze palsy
2—Complete gaze palsy
3 Visual fields
0—No visual field defect
1—Partial hemianopia
2—Complete hemianopia
3—Bilateral hemianopia
4 Facial movement
0—Normal
1—Minor facial weakness
2—Partial facial weakness
3—Complete unilateral palsy
5 Motor function (arm) a. Left; b. Right
0—No drift
1—Drift before 5 s

(continued)

Table 6.1 (continued)

2—Falls before 10 s
3—No effort against gravity
4—No movement
6 Motor function (leg) a. Left; b. Right
0—No drift
1—Drift before 5 s
2—Falls before 5 s
3—No effort against gravity
4—No movement
7 Limb ataxia
0—No ataxia
1—Ataxia in 1 limb
2—Ataxia in 2 limbs
8 Sensory
0—No sensory loss
1—Mild sensory loss
2—Severe sensory loss
9 Language
0—Normal
1—Mild aphasia
2—Severe aphasia
3—Mute or global aphasia
10 Articulation
0—Normal
1—Mild dysarthria
2—Severe dysarthria
11 Extinction or inattention
0—Absent
1—Mild (1 sensory modality lost)
2—Severe (2 modalities lost)

Diagnostic Approach (Diagnostic Care Path)

Laboratory

Blood should be drawn on arrival and laboratory work ordered right away. At a minimum, it should include prothrombin time (PT)/Partial thromboplastic time (PTT), complete blood count (CBC) with platelets, troponins, creatinine and a pregnancy test if the patient is a female <55 years old.

Imaging

Computed Tomography (CT) Head

A noncontrast head CT should be performed as soon as possible after arrival.

Computed Tomography Angiogram (CTA)

A CTA should be done to identify the presence of large-vessel occlusion if NIHSS score ≥6 or in those with fluctuating neurological symptoms even if NIHSS score <6. This identifies patients who are potential candidates for hyperacute endovascular therapy (see below) and is also helpful in the clinical management of patients' blood pressure and hemodynamic status within the first 24–48 h. Creatinine (determined by either lab draw or point-of-care testing if available) should be ≤1.4 mg/dL; however, the need for urgent imaging to identify large-vessel occlusion may outweigh the risks of kidney injury stemming from an elevated creatinine level.

Advanced Imaging

Advanced brain imaging with magnetic resonance imaging (MRI) or CT perfusion is often performed to select patients who are candidates for endovascular therapies. Advanced imaging allows better characterization of the volume of penumbra (potentially salvageable tissue) in relation to infarcted tissue; however, there is a lack of evidence on which parameters best characterize the tissue at risk.

Therapeutics (Treatment Care Path) (Fig. 6.1)

Acute Intervention 0–3 h

Intravenous rtPA is recommended for eligible patients within 3 h of time last known well (Class A, Level 1 recommendation [7]). Patients receiving IV rtPA have a 13% absolute increased chance of being left with minimal or no disability [3]. Within the time window for IV rtPA, the benefit of treatment declines as the time between onset to treatment increases, and speed of evaluation and initiation of management are critical [9]. IV rtPA should be administered within 60 min of the patient's arrival at the hospital; the sooner IV rtPA can be administered, the better the chance of improved outcome. Because of the delay inherent in performing the CTA and interpreting the images, processes for IV rtPA administration (e.g., mixing the IV rtPA, making a final determination of eligibility) should not wait until the CTA is completed.

Inclusion and exclusion criteria for IV rtPA administration, outlined in "Scientific Rationale for the Inclusion and Exclusion Criteria for Intravenous Alteplase in Acute Ischemic Stroke" [10] should be followed (Table 6.2). An important consideration is blood pressure control. It should be consistently less or equal to SBP 185 mmHg and DBP 110 mmHg. IV tPA should not be withheld until the laboratory values become available unless there is a clinical suspicion based on history or medication use that results may be abnormal. If platelets or INR are abnormal after initiation of IV rtPA, the infusion should be discontinued.

Patients receiving IV rtPA who have large-vessel occlusion (as demonstrated on CTA) with persistent deficits may also be candidates for endovascular therapy (see section "Endovascular Therapy").

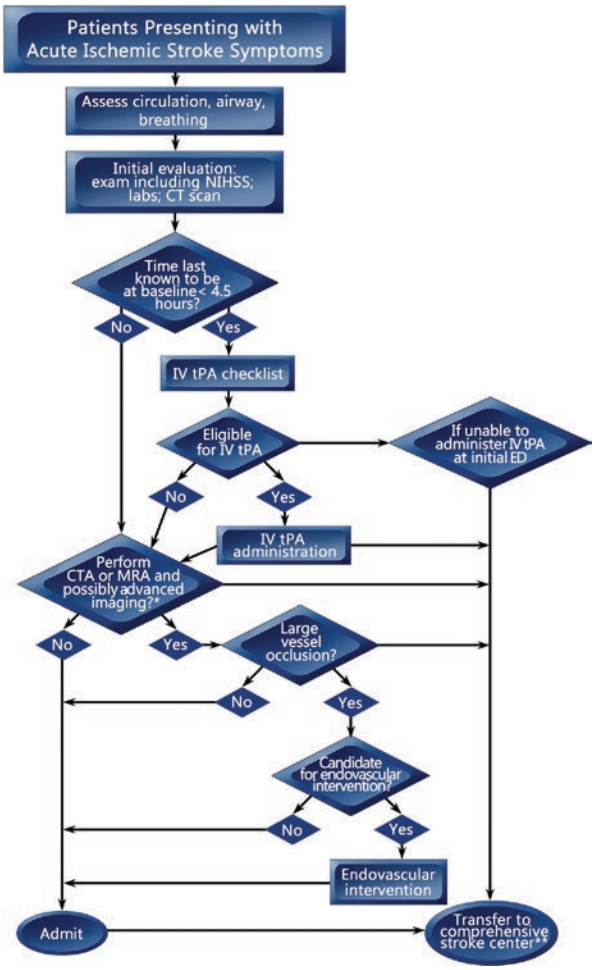

Fig. 6.1 Management of acute ischemic stroke patients during the hyperacute period. *NIHSS* National Institutes of Health Stroke Scale, *CT* computed tomography, *rtPA* recombinant tissue plasminogen activator, *CTA* computed tomography angiogram, *MRA* magnetic resonance angiogram. *Consider noninvasive intracranial vascular imaging if one of the following exists: NIHSS $\geq$ 6, there are fluctuating symptoms, or it is hospital protocol. **At multiple time-points, may transfer to stroke center with capabilities to comprehensively manage ischemic stroke patients, including endovascular intervention

Acute Intervention 3–4.5 h

IV rtPA has been shown to improve outcomes if administered within the 3–4.5-h of last known to be at baseline [11] and is recommended for patients within this time window (Class I, Level B recommendation [10]). Not surprisingly, the benefit of rtPA administration within this later window is less than if given within 3 h. Eight patients

Table 6.2 Inclusion and exclusion characteristics of patients with ischemic stroke who could be treated with intravenous rtPA within 3 h from symptom onset (derived from Demaerschalk et al. [10])

Inclusion criteria
Ischemic stroke causing measurable neurological deficit symptoms
Onset of symptoms <3 h before treatment
Age ≥ 18 years
Exclusion criteria
Significant head trauma in the previous 3 months
Stroke in the previous 3 months
Symptoms suggest subarachnoid hemorrhage
Arterial puncture at noncompressible site in previous 7 days
History of previous intracranial hemorrhage; intracranial neoplasm, arteriovenous malformation, or aneurysm
Recent intracranial or intraspinal surgery
Elevated blood pressure (systolic >185 mmHg or diastolic >110 mmHg)
Active internal bleeding
Acute bleeding diathesis, including but not limited to:
• Platelet count <100,000/mm^3
• Heparin received within 48 h resulting in abnormally elevated aPTT above the upper limit of normal
• Current use of anticoagulant with INR > 1.7 or PT > 15 s
• Current use of direct thrombin inhibitors or direct factor Xa inhibitors with elevated sensitive laboratory tests (eg. aPTT, INR, platelet count, ECT, TT, or appropriate factor Xa activity assays)
• Blood glucose concentration <50 mg/dL (2.7 mmol/L)
• Computerized tomography demonstrates multilobar infarction
Relative exclusion criteria (consider risk-to-benefit ratio of intravenous rtPA administration if any of these relative contraindications is present):
• Minor or rapidly improving stroke symptoms (clearing spontaneously)
• Pregnancy
• Seizure at onset with postictal residual neurological impairments
• Major surgery or serious trauma within previous 14 days
• Recent gastrointestinal track hemorrhage (within previous 21 days)
• Recent urinary tract hemorrhage (within previous 21 days)
• Recent acute myocardial infarction (within previous 3 months)

Notes: A physician with stroke management expertise in acute stroke care may modify this list. In rtPA candidates without recent use of oral anticoagulants or heparin, treatment with intravenous rtPA can be initiated before availability of coagulation test results but should be discontinued if INR is >1.7 or PT is abnormally elevated by local laboratory standards. In rtPA candidates without a history of thrombocytopenia, treatment with intravenous rtPA can be initiated before availability of platelet count but should be discontinued if platelet count is <100,000/mm^3

aPTT activated partial thromboplastin time, *ECT* ecarin clotting time, *INR* international normalized ratio, *PT* partial thromboplastin time, *rtPA* tissue-type plasminogen activator, *TT* thrombin time

need to be treated within 3 h and 14 patients need to be treated within 3–4.5 h for one extra person to have "mild to no disability" at 3 months [12]. The protocol for IV rtPA within the 3–4.5-h period is similar to that for acute intervention in the 0–3-h window. The criteria for selection of eligible patients have recently been loosened [10]. The following considerations apply for patients who are in the 3–4.5 h time window [10]:

- For patients taking oral anticoagulants with an INR < 1.7, *IV rtPA appears safe and may be beneficial*
- For patients with a baseline NIHSS score >25, *the benefit of IV rtPA is uncertain*
- For patients with a history of both stroke and diabetes mellitus, IV rtPA *may be as effective as treatment in the 0–3 h. window and may be reasonable*

Endovascular Therapy: 0–6 h

Intravenous rtPA is the first-line therapy for patients who meet the criteria. Endovascular therapy with stent retrievers should also be considered for patients within 6 h of symptom onset with an NIHSS score ≤6 and large-vessel occlusions documented on noninvasive imaging (Class I; Level A Recommendation) [4]. Most of the data on the benefit of endovascular recanalization involves patients who have received IV rtPA. Although the clinical efficacy of acute endovascular therapy is unclear for patients who have contraindications or fall out of the time window for IV rtPA, it is considered reasonable in carefully selected patients (Class IIa; Level C recommendation) [4]. Acute endovascular therapy requires that organized systems and infrastructure be in place, and it should be performed only at hospitals that can provide comprehensive stroke care.

Case Selection for Endovascular Therapy

Additional imaging beyond CT and CTA or MRI, and magnetic resonance angiography (MRA), such as CT perfusion or MR diffusion- and perfusion-weighted imaging, is often used for selecting patients for endovascular therapy, but currently is not required.

Characteristics of candidates for emergent endovascular recanalization include the following [4]:

Clinical

- prestroke modified Rankin Scale score ≤1
- NIHSS score ≥6
- treatment can be initiated (groin puncture) within 6 h of symptom onset
- age ≥18 years
- acute ischemic stroke receiving intravenous rtPA within 4.5 h of onset

Imaging

- Alberta Stroke Program Early CT score ≥6
- causative occlusion of the internal carotid artery or proximal middle cerebral artery

Management of Patients Receiving Acute Intervention

Patients receiving IV rtPA or endovascular intervention are at risk for hemorrhagic complications and should be followed closely in a step-down unit or neurointensive care unit (NICU). The same BP criteria should be used for patients undergoing endovascular recanalization unless specific situations warrant individualized management. In the absence of clinical data demonstrating otherwise, serial neurological assessments should be performed in all patients receiving endovascular intervention using the same protocol as for patients receiving IV rtPA.

Acute Inpatient Stay

Diagnostic Approach (Diagnostic Care Path)

Laboratory

A core set of laboratory tests should be performed in all patients admitted with ischemic stroke. They include a chemistry panel (electrolytes, renal function), (alanine transaminase (ALT), complete blood count including platelet count, cardiac enzymes, fasting lipid panel and HgA1C or fasting blood glucose. If HgA1C and a fasting lipid panel have been obtained in the past 30 days, additional testing may not be warranted.

Imaging

Determination of the stroke mechanism is necessary to initiate the appropriate secondary stroke prevention therapies. This entails diagnostic testing that includes the following:

Brain imaging—A brain MRI (with diffusion-weighted sequencing) should be considered. If patients are MRI ineligible, a noncontrast head CT is an acceptable alternative but may need to be repeated 24–48 h after symptom onset if initially negative for ischemia. Brain imaging can identify the extent and location of damage and provide some information about the possible stroke mechanism.

Vascular imaging—Carotid imaging should be performed for all patients with acute ischemic stroke unless the stroke is clearly not in the distribution of the anterior circulation, patients are not candidates for carotid revascularization or carotid imaging has been recently performed prior to hospitalization [13]. Guidelines have variously recommended gadolinium-enhanced MRA of the neck, or CTA [14] and carotid ultrasound [15] for noninvasive imaging of the extracranial carotids.

Intracranial vascular imaging is also recommended if not done during the hyperacute stroke period. Either a CTA or MRA can be performed, which will help determine the stroke mechanism and the risk of recurrent stroke.

Other Ancillary Tests

Echocardiogram—A transthoracic echocardiogram (TTE) should be obtained for all patients with ischemic stroke who are candidates for anticoagulation therapy. Transesophageal echocardiography may be considered in patients < age 55, or when there is a cardioembolic pattern on imaging without other cause (i.e., atrial fibrillation). A TTE with agitated saline or a transcranial doppler with bubble study may be performed when an intracardiac or extracardiac shunt is being considered. An echocardiogram provides information on the functional status of the heart and can identify cardiac sources of embolism. A transesophageal echocardiogram (TEE) provides better visualization of the cardiac atria and valves and is used in selected patients when the heart is the suspected source of embolism.

Cardiac monitoring—As previously discussed, all patients should have a baseline EKG on admission and should have continuous cardiac monitoring for at least the first 24 h after admission and ideally throughout their entire stay. *If atrial fibrillation is not detected in the hospital and a cardiac source of embolism is suspected, consider prolonged (>=30 days) outpatient monitoring* [16].

Additional diagnostic procedures (e.g., cerebral angiogram, transcranial doppler testing, single photon emission computed tomography (SPECT) scan, lumbar puncture) and additional laboratory testing (e.g., high-sensitivity C-reactive protein, lipoprotein A, cardiolipin antibodies, lupus anticoagulant panel, hypercoagulability panel, toxicology screening, cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy (CADASIL)/notch genotyping and testing for Fabry disease) are performed based on patient and stroke characteristics.

Therapeutics (Treatment Care Path) (Fig. 6.2)

Patients with acute ischemic stroke should be admitted to a nursing unit with nurses who have training and experience in caring for patients with stroke. Stroke units are preferred, with dedicated teams of nursing, physical therapy, occupational therapy, speech therapy, case management and social workers. Outcomes of patients placed in stroke units are improved (NNT = 18; similar to the effectiveness of IV rtPA), and this benefit can be extended to nearly all patients with stroke [5].

Prevention of Neurological Worsening

Neurological examination findings can fluctuate in the first hours to days after stroke, with early neurological deterioration occurring in 13.9–32.2% of acute stroke patients [17]. Because of this, it is important to serially assess neurological impairment using a validated stroke severity scale, such as the NIHSS.

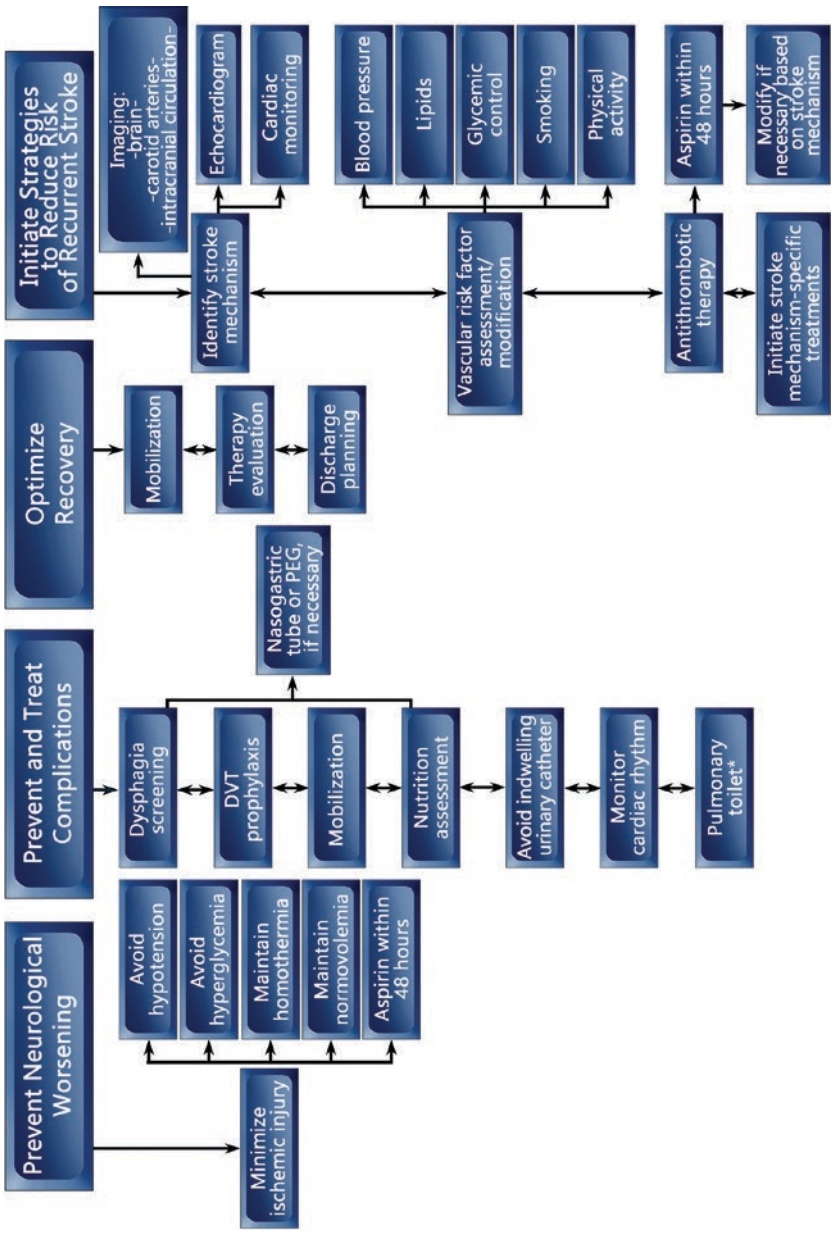

Fig. 6.2 Inpatient management of patients with ischemic stroke. *VTE* deep venous thromboembolism, *PEG* percutaneous gastrostomy tube. *Pulmonary toilet includes: elevation head of bed >30°, incentive spirometry, suction of secretions

Minimize Ischemic Injury

Cerebral perfusion should be optimized in the acute phase of stroke to minimize the extent of ischemic injury. Patients should be kept normovolemic. Because patients with acute stroke often do not have a normal oral intake of fluids, careful attention to hydration is necessary. Intravenous fluids, generally 0.9% normal saline, should be started at the time of initial presentation and continued as necessary. Blood pressure should also be carefully monitored in all patients. Generally, *home blood pressure medications should be withheld for the first 24 h after admission*. The initiation of antihypertensive agents depends on patient and stroke characteristics, but it should be considered after 24 h. Blood pressure exceeding 220/110 should be treated. The threshold for treatment with BP medication is lower for patients on anticoagulants who have received acute intervention. As described above, patients who receive IV rtPA, endovascular thrombolytic therapy or successful mechanical revascularization of an intracranial occlusion, or who are anticoagulated with either IV heparin or an oral anticoagulant, should have their blood pressure maintained at <180/105 mmHg. *Patients not receiving thrombolytic therapy, either intravenously or intra-arterially, and who are not therapeutically anticoagulated should receive 325 mg of aspirin within 24–48 h of stroke onset* (Class 1, Level A recommendation [7]).

Hyperthermia and hyperglycemia have both been associated with worse outcomes after stroke and should be treated. Treatment of fever should be swift and the source of the fever sought. Blood glucose levels should be maintained between 140 and 180 mg/dL (Class IIa, Level C recommendation [7]). More aggressive control of glucose levels in the hospital has been associated with worse outcomes [18].

Prevention of Complications

Complications after stroke are frequent and result in increased lengths of stay and worse clinical outcomes. Several standard processes should be followed in all stroke patients to minimize complication risk.

Dysphagia Screening

Dysphagia screening in stroke patients is critical to reduce adverse outcomes related to aspiration and inadequate hydration/nutrition. All patients presenting with neurological symptoms that may be due to stroke or TIA should undergo a swallow assessment prior to any oral intake, including medications (Class 1, Level B recommendation [7]).

Prophylaxis for Venous Thromboembolism (VTE)

Patients with stroke are at increased risk for the development of deep vein thrombosis. Unless a contraindication exists, ischemic stroke patients who are not anticoagulated should receive medical VTE prophylaxis (Class I, Level A recommendation

[7]). Enoxaparin has been shown to be slightly superior to unfractionated heparin in hospitalized patients with acute ischemic stroke [19], and it is the medication of choice. For patients who are at increased risk of hemorrhage, subcutaneous heparin, given TID or BID, may also be used. In addition, intermittent compression stockings (ICS) should be used on all patients, especially those who have a contraindication to medical prophylaxis (Class IIa, Level B recommendation [7]). The use of ICS in addition to medical prophylaxis further reduces the risk of VTE [20]. When intermittent compression stockings are used, they should be worn whenever the patient is in bed, both day and night.

Mobilization

Early mobilization of less severely affected patients is recommended (Class I, Level C recommendation [7]). Ideally, patients should be out of bed or in an upright position at least three times per day.

Nutrition Assessment

Patients who cannot take solid food and liquids orally should receive nasogastric (NG), nasoduodenal or percutaneous endoscopic gastrostomy (PEG) tube feeding to maintain hydration and nutrition while undergoing treatment to restore swallowing (Class I, Level B recommendation [7]). Nutritional intake should be continually monitored to ensure adequate nutrition, which is important to optimize recovery. The use of an NG tube is reasonable for the first 2–3 weeks after stroke (Class IIa, Level B recommendation [7]), although many post-acute care facilities will not accept patients with NG tubes in place. A PEG tube is another option for patients who will have prolonged impairment in swallowing and may be necessary for patients with severe neurological impairment or brainstem stroke.

Prevention of Hospital-Acquired Infections

Pneumonia is the most frequent serious complication after stroke and is associated with a three-fold increase in risk of mortality [21]. Early mobilization, aspiration precautions and pulmonary hygiene are important aspects of hospital care and include keeping the head of the bed elevated more than 30°, suctioning of secretions, incentive spirometry and bronchodilator treatments as necessary. Routine placement of indwelling bladder catheters is not recommended because of the associated risk of catheter-induced urinary tract infections (UTIs) (Class III, Level C recommendation [7]). The patient should be assessed for UTI if there is a change in the level of consciousness and no other cause of neurological deterioration is identified. Urine analysis should be used for initial screening and a culture obtained only if the urinalysis is positive.

Cardiac Monitoring

Myocardial injury, as identified by elevations of serum troponin (>0.1 μg/L) occurs in up to 20% of patients with acute stroke [22], and 2–3% of patients hospitalized with acute stroke have an associated acute myocardial infarction during their hospitalization, putting them at risk for potentially dangerous cardiac arrhythmias [23]. Cardiac monitoring can help identify the occurrence of paroxysmal atrial fibrillation, a significant cause of ischemic stroke. Patients should have continuous cardiac monitoring for at least the first 24 h after admission and ideally throughout their entire stay (Class B, Level 1 recommendation [7]).

Hemorrhagic Transformation

According to recent acute stroke management guidelines, symptomatic hemorrhage occurs in approximately 5–6% of patients after IV rtPA, endovascular therapy or anticoagulant use [7]. In patients with hemorrhagic conversion or new intracranial hemorrhage who have received thrombolysis within the past 24 h, rtPA reversal should be instituted.

Reducing Risk of Recurrent Stroke

Vascular Risk Factor Modification

Thorough assessment of vascular risk factor status and initiation of appropriate therapies should be done during hospital admission. The main risk factors are outlined below.

Blood Pressure

Hypertension is the most important modifiable risk factor and has a populational attributable risk for all stroke of 34.6% (ischemic and hemorrhagic) [24]. Antihypertensive medications have been shown to reduce the risk of recurrent stroke. The American Heart Association has recently revised their recommendations and endorse initiation of antihypertensive therapy if patients have SBP ≥140 mmHg or DBP ≥90 mmHg (Class IIb; Level of Evidence C recommendation) [16]. Resumption of BP therapy is indicated for previously treated patients with known hypertension. Diuretics, and angiotensin converting enzyme inhibitors (ACEIs) have specifically been shown to be beneficial. Other agents, such as calcium-channel blockers, alpha adrenergic blockers and beta-blockers, are additional options. The short-term goal of BP control is a reduction of 10/5 mmHg [7]. The long-term goal should be a BP of <140/90 mmHg, or <130/80 mmHg in patients

with diabetes or chronic kidney disease [25]. Many patients will require more than one agent to obtain control.

Lipids

Several studies have demonstrated an association between elevated low density lipoprotein (LDL) and stroke risk, and the administration of a high-intensity statin has been shown to reduce recurrent vascular events in patients with atherosclerotic cardiovascular disease [26], including patients with stroke [27]. Regardless of LDL levels, patients with stroke presumed to be of atherosclerotic origin should be placed on high-intensity statin therapy, either ≥40 mg atorvastatin or ≥20 mg rosuvastatin [16].

Glycemic Control

Diabetes is an independent risk factor for stroke and cardiovascular disease. Blood glucose should be carefully monitored with a goal of HgbA1C < 7% for most patients [28].

Smoking

Patients who have smoked in the last year should be advised to quit (Class I, Level C recommendation [16]). They should receive educational materials and/or formal smoking cessation counseling, or medications to assist with smoking cessation.

Physical Activity

Stroke patients should be advised to engage in physical activity as tolerated. They should be referred to a comprehensive behaviorally oriented program if they are able and willing to increase their physical activity. At least 3–4 sessions per week of moderate to vigorous -intensity exercise that last approximately 40 min is recommended (Class IIa, Level C recommendation [16]).

Antithrombotic Use

Choice of antithrombotic medications, as with other aspects of stroke care, must be individualized for each stroke patient. A comprehensive discussion of antithrombotic therapies to address a specific mechanism of stroke is beyond the scope of this care path. In general, the use of intravenous heparin or other anticoagulants to prevent early stroke recurrence or to prevent neurological deterioration is not warranted. Anticoagulation should be used, however, for *long-term* prevention of recurrent

stroke in patients with atrial fibrillation. Warfarin, dabigatran or apixaban are all indicated for long-term anticoagulation in patients with atrial fibrillation [16]. Rivaroxaban is also reasonable [16]. These are typically started at the time of discharge or two to four weeks after stroke onset, depending on the size of the infarct and the risk of hemorrhagic conversion. If warfarin is used, bridging with intravenous heparin is generally not indicated [7]. In most situations, patients should be placed on aspirin until INR becomes therapeutic ("aspirin bridge"). For patients with noncardioembolic stroke, antiplatelet agents should be used, either aspirin (50 mg, 81 mg or 325 mg), clopidogrel or the combination of extended-release dipyridamole BID plus aspirin 25 mg BID [16]. For patients who have a stroke while on an antiplatelet agent, there are little data to demonstrate that switching from one antiplatelet agent to another is more effective at reducing recurrent stroke risk. The 2014 American Heart Association guidelines on secondary stroke prevention also indicate that the combination of aspirin and clopidogrel "might be considered" for initiation within 24 h of a minor ischemic stroke or transient ischemic attack (TIA) and for continuation for 90 days *(Class IIb; Level of Evidence B recommendation)* [16].

A more extensive discussion of vascular risk factor control and management according to stroke mechanism is beyond the scope of this care path but is available in the American Stroke Association 2014 Guidelines for Secondary Prevention of Ischemic Stroke and TIA [16].

Optimize Recovery

Mobilization

Early mobilization is also an important component to improve stroke recovery, although the specific timing that mobilization should begin is unknown.

Therapy Evaluation

Physical and occupational therapy evaluation and management should be ordered for all ischemic stroke patients who have persistent functional impairments and who are not on bed rest. They provide rehabilitative services and input on appropriate discharge destination. Patients with severe strokes will benefit from range of motion exercises. Speech therapy should be ordered for patients with speech disturbance or impairment of swallowing.

Discharge Planning

Discharge planning includes the identification of discharge destination, education of patients and caregivers regarding stroke symptoms and ways to reduce recurrent events, communication to other providers and post-discharge facilities, and scheduling follow-up appointments.

Post-Discharge Management

Because the initial time period after stroke is a high risk period for post-stroke complications, readmission and depression, patients should ideally be seen by their primary care provider within one week of hospital discharge and by their neurologist within 30 days. Although this care path focuses on the acute ischemic stroke admission, patients who have had an acute ischemic stroke require close monitoring and care throughout their life.

Disclosures The author has no conflict of interest

References

1. Rich DQ, Gaziano JM, Kurth T. Geographic patterns in overall and specific cardiovascular disease incidence in apparently healthy men in the United States. Stroke. 2007;38:2221–7.
2. Hankey GJ, Jamrozik K, Broadhurst RJ, Forbes S, Anderson CS. Long-term disability after first-ever stroke and related prognostic factors in the Perth Community Stroke Study, 1989-1990. Stroke. 2002;33:1034–40.
3. The National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group. Tissue plasminogen activator for acute ischemic stroke. N Engl J Med. 1995;333:1581–7.
4. Powers WJ, Derdeyn CP, Biller J, et al. 2015 American Heart Association/American Stroke Association focused update of the 2013 guidelines for the early management of patients with acute ischemic stroke regarding endovascular treatment: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2015;46:3020–35.
5. Stroke Unit Trialists' Collaboration. Organised inpatient (stroke unit) care for stroke. Cochrane Database Syst Rev. 2007;17(4):CD000197.
6. Field JM, Hazinski MF, Sayre MR, et al. Part 1: executive summary: 2010 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2010;122:S640–56.
7. Jauch EC, Saver JL, Adams HP Jr, et al. Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2013;44:870–947.
8. National Institute of Health. National Institute of Neurological Disorders and Stroke. Stroke Scale. http://www.ninds.nih.gov/doctors/NIH_Stroke_Scale.pdf. Accessed 1 June 2016.
9. Saver JL, Fonarow GC, Smith EE, et al. Time to treatment with intravenous tissue plasminogen activator and outcome from acute ischemic stroke. JAMA. 2013;309:2480–8.
10. Demaerschalk BM, Kleindorfer DO, Adeoye OM, et al. Scientific rationale for the inclusion and exclusion criteria for intravenous alteplase in acute ischemic stroke: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2016;47:581–641.
11. Hacke W, Kaste M, Bluhmki E, et al. Thrombolysis with alteplase 3 to 4.5 hours after acute ischemic stroke. N Engl J Med. 2008;359:1317–29.
12. Saver JL, Gornbein J, Grotta J, et al. Number needed to treat to benefit and to harm for intravenous tissue plasminogen activator therapy in the 3- to 4.5-hour window: joint outcome table analysis of the ECASS 3 trial. Stroke. 2009;40:2433–7.
13. Smith EE, Saver JL, Alexander DN, et al. Clinical performance measures for adults hospitalized with acute ischemic stroke: performance measures for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2014;45:3472–98.
14. Latchaw RE, Alberts MJ, Lev MH, et al. Recommendations for imaging of acute ischemic stroke: a scientific statement from the American Heart Association. Stroke. 2009;40:3646–78.

15. Brott TG, Halperin JL, Abbara S, et al. 2011 Guideline on the management of patients with extracranial carotid and vertebral artery disease. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American Stroke Association, American Association of Neuroscience Nurses, American Association of Neurological Surgeons, American College of Radiology, American Society of Neuroradiology, Congress of Neurological Surgeons, Society of Atherosclerosis Imaging and Prevention, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of NeuroInterventional Surgery, Society for Vascular Medicine, and Society for Vascular Surgery. Circulation. 2011;124:e54–130.
16. Kernan WN, Ovbiagele B, Black HR, et al. Guidelines for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2014;45:2160–236.
17. Roquer J, Rodriguez-Campello A, Gomis M, et al. Acute stroke unit care and early neurological deterioration in ischemic stroke. J Neurol. 2008;255:1012–7.
18. Gray CS, Hildreth AJ, Sandercock PA, et al. Glucose-potassium-insulin infusions in the management of post-stroke hyperglycaemia: the UK Glucose Insulin in Stroke Trial (GIST-UK). Lancet Neurol. 2007;6:397–406.
19. Sherman DG, Albers GW, Bladin C, et al. The efficacy and safety of enoxaparin versus unfractionated heparin for the prevention of venous thromboembolism after acute ischaemic stroke (PREVAIL Study): an open-label randomised comparison. Lancet. 2007;369:1347–55.
20. Dennis M, Sandercock P, Reid J, Graham C, Forbes J, Murray G. Effectiveness of intermittent pneumatic compression in reduction of risk of deep vein thrombosis in patients who have had a stroke (CLOTS 3): a multicentre randomised controlled trial. Lancet. 2013;382:516–24.
21. Katzan IL, Cebul RD, Husak SH, Dawson NV, Baker DW. The effect of pneumonia on mortality among patients hospitalized for acute stroke. Neurology. 2003;60:620–5.
22. Parekh N, Venkatesh B, Cross D, et al. Cardiac troponin I predicts myocardial dysfunction in aneurysmal subarachnoid hemorrhage. J Am Coll Cardiol. 2000;36:1328–35.
23. Micheli S, Agnelli G, Caso V, et al. Acute myocardial infarction and heart failure in acute stroke patients: frequency and influence on clinical outcome. J Neurol. 2012;259:106–10.
24. O'Donnell MJ, Xavier D, Liu L, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. Lancet. 2010;376:112–23.
25. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. Hypertension. 2003;42:1206–52.
26. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;63:2889–934.
27. Amarenco P, Bogousslavsky J, Callahan A 3rd, et al. High-dose atorvastatin after stroke or transient ischemic attack. N Engl J Med. 2006;355:549–59.
28. American Diabetes Association. 5. Glycemic targets. Diabetes Care. 2016;39(Suppl 1):S39–46.