Critical Care of Stroke

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Stroke Classification

- **Hemorrhage**
  - Subdural Hematoma
  - Epidural Hematoma
  - Intraparenchymal Hematoma
  - Subarachnoid Hemorrhage

- **Ischemic**
  - Embolic
  - Thrombotic

- **Large Vessel**
- **Small Vessel**
Critical Care of Stroke

- Prompt and accurate diagnosis
- Urgent stroke treatment delivery
- Prevention of complications
Critical Care of Stroke

• Prompt and accurate diagnosis
• Urgent stroke treatment delivery
• Prevention of complications
  – Rule out focal seizure, migraine and toxic-metabolic derangement.
  – Careful history, exam findings and Diffusion-weighted MR imaging helpful in confirming recurrent or new ischemia from stroke mimics.
Primary Stroke Centers

- Key Elements
  - acute stroke teams
  - stroke units
  - written care protocols
  - integrated emergency response system
  - availability and interpretation of CT scans 24 hours everyday
  - rapid laboratory testing
  - Administrative support, strong leadership, and continuing education are also important elements

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Special Report

Recommendations for Comprehensive Stroke Centers
A Consensus Statement From the Brain Attack Coalition

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Background and Purpose—To develop recommendations for the establishment of comprehensive stroke centers capable of delivering the full spectrum of care to seriously ill patients with stroke and cerebrovascular disease. Recommendations were developed by members of the Brain Attack Coalition (BAC), which is a multidisciplinary group of members from major professional organizations involved with the care of patients with stroke and cerebrovascular disease.

Summary of Review—A comprehensive literature search was conducted from 1966 through December 2004 using Medline and Pub Med. Articles with information about clinical trials, meta-analyses, care guidelines, scientific guidelines, and other relevant clinical and research reports were examined and graded using established evidence-based medicine approaches for therapeutic and diagnostic modalities. Evidence was also obtained from a questionnaire survey sent to leaders in cerebrovascular disease. Members of BAC reviewed literature related to their field and graded the scientific evidence on the various diagnostic and treatment modalities for stroke. Input was obtained from the organizations represented by BAC. BAC met on several occasions to review each specific recommendation and reach a consensus about its importance in light of other medical, logistical, and financial factors.

Conclusions—There are a number of key areas supported by evidence-based medicine that are important for a comprehensive stroke center and its ability to deliver the wide variety of specialized care needed by patients with serious cerebrovascular disease. These areas include: (1) health care personnel with specific expertise in a number of disciplines, including neurosurgery and vascular neurology; (2) advanced neuroimaging capabilities such as MRI and various types of cerebral angiography; (3) surgical and endovascular techniques, including clipping and coiling of intracranial aneurysms, carotid endarterectomy, and intra-arterial thrombolytic therapy; and (4) other specific infrastructure and programmatic elements such as an intensive care unit and a stroke registry. Integration of these elements into a coordinated hospital-based program or system is likely to improve outcomes of patients with strokes and complex cerebrovascular disease who require the services of a comprehensive stroke center. (Stroke. 2005;36:1597-1618.)
Traditional CT scan
67 year old woman, dense right hemiparesis, intact language, NIHSS = 13, received t-PA 0.9 mg/kg at 3 hours, air lifted to UCSF, imaged with CTA/CTP at 5 hours.
CT Advantages Over MRI

- Excludes hemorrhage
- Image all relevant vessels in 15 minutes
  - May replace
    - Doppler of Neck
    - Intracranial MRA
    - Conventional angiography
- Better tolerance to patient motion
- Provides cerebral perfusion
  - May be quantitative
- More widely available
Hyperacute Infarct
- 2 days later
Hyperacute Infarct

EP T2  DWI
DI  ADC map
Advances in MRI

- Able to detect hyperacute infarct
- Best for posterior circulation
- Ability to perform perfusion
- Use of diffusion/perfusion mismatch for assessment of tissue at risk, prediction of infarct volume
Critical Care of Stroke

• Prompt and accurate diagnosis
• Urgent stroke treatment delivery
• Prevention of complications
Is ischemic?

Consider Thrombolysis or Thrombectomy

- Atrial Fibrillation, Mechanical Valve, Mural Thrombus?
  - Warfarin, or aspirin if contraindicated → Risk Factor Modification

- Carotid Atherosclerosis?
  - CEA or Stent

- Small Vessel?

- Intracranial Atherosclerosis?

- Sinus Thrombosis?
  - Anticoagulation

- Dissection?

- Other
  - Treat specific cause, consultation

Risk Factor Modification:
- Antithrombotic
- Statin
- ACE Inhibitor
Time from stroke symptom onset (hr)

0

Consider Thrombolysis Thrombectomy

3

IV t-PA

Proven Approved

6

IA pro-UK

Unproven Approved

8

Thrombectomy

Proven Unapproved
UCSF protocol for Acute Stroke

Acute Stroke at Home/Work

911; Paramedics Arrive

Transport to UCSF Call Ahead to ED

Patient Arrival in ED
- Stroke Pager Called
- Stroke CT ordered
- Labs drawn
- Family located

Stroke CT Obtained

Ischemic Stroke

IV t-PA Eligible?

Yes
- CTA: LVO?
  - Yes
    - IV t-PA 0.6 mg/kg
  - No
    - IV t-PA 0.9 mg/kg

No

Large vessel occlusion?

Yes
- Embolectomy if eligible

No

Medical Therapy

Hemorrhage - manage per hemorrhage type

ED = emergency department; LVO = large vessel occlusion; IA = intraarterial; IV = intravenous
Intravenous t-PA

• Inclusion
  – Age > 18
  – Acute stroke without improvement
  – Onset of symptoms to t-PA infusion within 3 hrs
  – Sufficient neurologic deficit

• Exclusion
  – CT: hemorrhage or major early infarct signs
  – BP > 185/110
  – prior stroke < 3 mo
  – recent surgery, trauma
  – plts < 100K, gluc <50 or >400 mg/dl, HCT < 25%
Intravenous t-PA Administration

- **Administration**
  - Two large bore IVs
  - Type and screen
  - Blood pressure monitoring
  - 0.9 mg/kg t-PA
    - 10% bolus
    - Infuse remainder over 1 hour
  - No ASA or heparin for 24 hours

- **Blood Pressure**
  - Prior to t-PA infusion
    - Labetolol 5-20 mg
    - NTP 2”
  - During infusion
    - Keep BP < 185/110 unless neurologic decline during infusion
    - Labetolol
    - Nitroprusside
NINDS t-PA Ischemic Stroke

- Intravenous t-PA -vs- placebo (N=312 each group)
  - 0.9 mg/kg t-PA IV (10% bolus, 1 hr infusion)
  - within 90 mins and 180 mins of symptom onset
  - CT exclude hemorrhage

![Graph showing survival rates](image)

- p = 0.026
- p = 0.019
- p = 0.033

- symptomatic intracranial hemorrhage
  - 6% -vs- 0.6% (t-PA -vs- placebo)

- 3% hemorrhage related death

Time from stroke symptom onset (hr)

IV t-PA

IA pro-UK

Consider Thrombolysis Thrombectomy
Intraarterial Thrombolysis
PROACT-II: mRS ≤ 2

* OR 2.13 (1.02-4.42), p=0.043
42 F, acute loss of consciousness

H/o Mitral V replacement Chronic A fib, On Coumadin, INR 2.0

Initial Non contrast CT
Note dense basilar artery

CTA coronal view confirms basilar artery thrombosis
Thrombolytics-summary

- Intravenous rtPA (0.9 mg/kg, max 90 mg) for selected patients <3 hours of onset
  (Class-I, level of evidence A)
- IA thrombolysis –option in major stroke (i.e. MCA) < 6 hrs of occlusion
  (Class-I, level of evidence B)
- IA thrombolysis, instead of IV may be used in pts with recent surgery
  (Class-IIa, level of evidence C)
- IA-tPA should not preclude receiving IV TPA
  (Class-III, level of evidence C)
Revascularization Procedures in Acute Ischemic stroke

• Clot Extraction
  MERCI (Mechanical Embolus Removal in cerebral Embolism) – device assoc with rapid opening of artery. Recanalization and safety is similar to intra-arterial pro-urokinase (PROACT II trial)
  MERCI device – FDA approved but precise clinical utility not well established
  MERCI device – reasonable intervention with intra-arterial clot extraction; unclear outcome benefit
  (Class IIB; Level of evidence B)
Revascularization Procedures in Acute Ischemic stroke

• Safety and effectiveness of carotid surgery
  – insufficient data to recommend

• Angioplasty and Stenting
  – insufficient data to recommend
Arterial Hypertension

- Indication that patient is eligible for treatment with intravenous rtPA or other acute reperfusion intervention (SBP< 185; DBP<110)  
  (Class-I, Level of evidence-B)
- Blood pressure level: Systolic 185 mm Hg or diastolic 110 mm Hg
- Labetalol IV; or Nitropaste or Nicardipine infusion
- If blood pressure does not decline and remains 185/110 mm Hg, do not administer rtPA
Anticoagulants

- Urgent anticoagulation is not recommended; not in lieu of IV thrombolysis (Class-III; Level of evidence-A)
- Not recommended in mod-large stroke (Class-III; Level of evidence-A)
- No Anticoagulation within 24 hr post-TPA (Class-III; Level of evidence-B)
Antiplatelets

• Aspirin
  Oral ASA (325 mg) in 24-48 hrs recommended
    (Class-I; Level of evidence-A)
  ASA not a substitute for IV-TPA
    (Class-III; Level of evidence B)
  ASA adjunct to IV TPA 24 hrs not recommended
    (Class-III; Level of evidence A)

• Combination antiplatelets
  ASA+clopidogrel –not recommended in acute stroke
    (Class-III; Level of evidence C)
  Outside of clinical trial –IV antiplatelet (i.e. glycoprotein IIb/IIIa receptor inhibitor) is not recommended
    (Class-III; Level of evidence B)
Critical Care of Stroke

• ICU admission:
  – Patients who present within 3-hr window and receive IV tPA.
  – Patients who present within 3-9 hr window and receive experimental therapies.
  – Patients with massive stroke and cytotoxic brain edema.
  – Stroke complicated by respiratory failure, myocardial decompensation or uncontrollable hypertension.
  – Stroke with large mismatch between core infarction and territory at risk requiring complex hemodynamic management.
Neuroprotection is the goal of Neurocritical care

- Assessment of end organ perfusion is more difficult to determine.
- The interval to end-organ failure under adverse conditions is more rapid.
- Further injury to even small regions of brain can have devastating consequences.
Critical Care of Stroke

- Prompt and accurate diagnosis
- Urgent stroke treatment delivery
- Prevention of complications
Critical Care of Stroke

- Airway
- Breathing
- Circulation
- DVT
- Investigate, Intervene, Iterate

- Edema
- Fever
- Glucose
- Heart
Critical Care of Stroke

Airway:

Indications for Endotracheal Intubation
1. Poor oral control and reduced alertness with increased risk of aspiration
2. Impaired airway reflexes

Complications of Endotracheal intubation
1. Hypotension, reduced CBF
2. Paradoxically increased ICP due to high transthoracic pressures
Critical Care of Stroke

Breathing:

• High PEEP (>10 cm H₂O) may increase ICP in patients with compliant lungs
• Permissive hypercapnia may result in unacceptable elevations of the ICP
• Induced hyperventilation should be used as a temporizing measure to control high ICP
Critical Care of Stroke

Circulation:

- The goal of systemic BP management is defined by the degree of perfusion required by the brain.
- Maintain optimal CPP at all times.
- In patients with stenosis of major vessels, induced hypertension may improve neurologic function acutely.
Blood Pressure

• Consensus exists that medications should be withheld unless SBP $>220$ mm Hg or the DBP $>120$ mm Hg
  – (Class-I; Level of Evidence-C)
• Identify causes of arterial hypotension.
• Treat hypovolemia with NS; treat arrhythmias
  – (Class-I; Level of Evidence-C)
• No data are available to guide selection of medications.
  – (Class-II; Level of Evidence-C)
Permissive hypertension

• At UCSF we discontinue all blood pressure medications that the patient was taking except for beta blockers and clonidine, which we cut by half.

• We set an upper limit of SBP in following special cases:
  – the patient exhibits cardiac ischemia evidenced by ST-elevation, or troponin increase > 1.0 microgram/L
  – the patient has other end-organ damage (acute renal failure with hematuria)
  – IV/IA t-PA is being considered, or has been given, and the blood pressure is >180/110 mmHg.
Induced Hypertension

**Rational**: Ischemic penumbra with impaired autoregulation

- Some small studies show clinical improvement with induced hypertension – increase SBP or MAP 20-30%
- More data of safety and efficacy needed
- If vasopressors are used to improve CBF, close neuro and cardiac monitoring is recommended
  - (Class-I; Level of Evidence-C)
- Drug-induced hypertension outside of clinical trial is not recommended.
  - (Class-III; Level of Evidence-B)
Critical Care of Stroke

DVT

• Pulmonary embolism: ~10% death post stroke
• DVT prevention – quality indicator
• No observed difference in Unfractionated Heparin and LMWH
• Subcutaneous anticoagulant is recommended; timing unclear (Class-I, level of evidence A)
• Intermittent compression device (with contraindication to anticoagulant) (Class-IIA, level of evidence C)
Critical Care of Stroke

Edema

- Osmotherapy: by using mannitol, hypertonic saline, or, if the patient is on hemodialysis, by simply raising the serum sodium directly.
- Potential nephrotoxicity once serum osmolarity begins to exceed 320-330 mosm.
Decompressive craniotomy

• Decompressive surgery: hemicraniectomy and duroplasty – with temporal lobe resection
• Timing is poorly define (as early as 24 hrs) – on-going trials
• Worse outcome: Age > 55; Dominant side
• Cerebellar stroke: should be considered
Decompressive craniotomy

- EVD - acute with hydrocephalus
  - (Class-1; Level of evidence-B)
- Surgical decompression
  - (Class-1; Level of evidence-B)
- Decompressive surgery for malignant edema – life saving but impact on morbidity unknown; advise family on potential poor outcome
  - (Class-IIa; Level of evidence-C)
Hemorrhagic Transformation

- CT study shows ~5% hemorrhagic transformation
- Use of antithrombotics, anticoagulants, thrombolytics increase risk
- Symptomatic Hge –same as ICH recommendation
Fever

- Sources of fever should be treated and antipyretic control fever.
  (Class-I, level of evidence C)
- Induced hypothermia for ischemic stroke is not beneficial.
  (Class-III, level of evidence B)
Critical Care of Stroke

Glucose

- Elevated Serum glucose increases tissue necrosis and edema.
- Hyperglycemia >200mg/dl is a predictor of poor outcome in ICU patients.
- Hypoglycemia (<60mg/dl) can result in focal neurological deficits.
- The goal of care is to achieve normoglycemia (80-140 mg/dl) with insulin infusion.
Critical Care of Stroke

Heart

- ST-T changes can be seen in large ischemic strokes
- Diffuse or confined to a cardiovascular territory
- Myocardial ischemia should always be excluded
- “Brain T-wave changes” do not predict cardiac morbidity
- Autonomic reciprocal innervation to the temporal lobes may produce arrhythmias in patients without pre-existing coronary disease.
Imaging

Ischemic?
- SAH?
  - SAH?
    - Aneurysm?
      - SAH Management Risk Factor Modification
  - Hypertensive ICH?
    - Investigate for cause
      - ICH Management Risk Factor Modification
  - Other
    - Specific Cause Management and Treatment

Hemorrhagic?
- SAH?
- Hypertensive ICH?
- Other

Stroke/TIA

Evidenced Based Stroke Treatment

Risk Factor Modification:
- Antithrombotic
- Statin
- ACE Inhibitor

SAH Management

Stroke/TIA Management

ICH Management

Anticoagulation

Treat specific cause, consultation

Consider Thrombolysis Thrombectomy

Aneurysm?

Carotid Atherosclerosis?

Small Vessel?

Intracranial Atherosclerosis?

Sinus Thrombosis?

Dissection?

Other

Risk Factor Modification

Warfarin, or aspirin if contraindicated

CEA or Stent

Risk Factor Modification:
- Antithrombotic
- Statin
- ACE Inhibitor

Antithrombotic

Statin

ACE Inhibitor

Risk Factor Modification
References