Revised and Updated Recommendations for Acute Stroke Ready Hospitals, Primary Stroke Centers, Comprehensive Stroke Centers, and Stroke Systems of Care

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See supplemental data for a list of abbreviations

Abstract

Background: In recent years, advances in stroke care have been reported, including studies that have confirmed the efficacy and safety of endovascular therapy (EVT) for some patients with acute ischemic stroke (AIS). In light of these studies and other changes in stroke care protocols, the Brain Attack Coalition (BAC) reviewed and revised the BAC recommendations for stroke centers and stroke systems of care.

Methods: The BAC performed a literature search using terms related to stroke care, protocols, guidelines, and outcomes. The BAC also reviewed the diagnostic and treatment protocols reported in recent clinical trials of EVT for AIS. The protocol elements were then compared to the recommendations for different types of stroke centers. The BAC used a modified evidence grading tool to assess the importance and applicability of various diagnostic and treatment modalities related to stroke care and stroke systems.

Results: Modifications to several recommendations for various stroke centers are warranted. Key changes include: 1) acute stroke ready hospitals (ASRHs) should offer vascular imaging on a 24/7 basis when possible; 2) primary stroke centers (PSCs) should offer vascular imaging and at least one type of brain perfusion study for AIS on a 24/7 basis, 3) comprehensive stroke centers (CSCs) should continue to offer vascular imaging, brain perfusion, and endovascular therapies for AIS on a 24/7 basis, 4) head computed tomography (CT) and CT angiograms should be completed and interpreted within 30 and 45 minutes (respectively) of order entry at PSCs and CSCs; 5) emergency medical services (EMS) should divert selected stroke patients to the closest CSC if this can be done within 20-30 minutes, 6) the picture-to-puncture time for EVT cases should be 60 minutes or less; 7) CSCs should have at least one fellowship trained neurointensivist on their medical staff; 8) a CSC should have the capability to perform two simultaneous endovascular procedures on a 24/7 basis; 9) improved patient field triage and EMS/Stroke Systems are needed to ensure the rapid identification and transportation of patients with all types of acute strokes.

Conclusions: All levels of stroke centers and EMS should have appropriate capabilities to ensure that patients with strokes are rapidly identified, triaged and treated. EVT for patients with AIS is now a validated therapy that should be performed in a rapid manner at all CSCs.

Introduction

In the United Stated, there are currently at least 1500 PSCs, about 200 CSCs, and a growing number of ASRHs.[1, 2 3] These different types and levels of stroke centers are recognized by various national organizations, government agencies, and other entities. As care paradigms have evolved, it is important for all levels of stroke centers to adjust their capabilities, including infrastructure, staffing, and care protocols.

Therapy for patients with AIS had been largely limited to intravenous alteplase, steps to avoid peri-stroke complications, secondary prevention, and comprehensive rehabilitation efforts.[4] This began to change in December 2014 with the publication of the MR CLEAN clinical trial results, showing the efficacy and safety of endovascular clot removal (using a newer generation of stent retrievers) in patients with large vessel occlusions treated within 6 hours of stroke onset.[5] The publication of several additional clinical trials in early 2015 (ESCAPE, EXTEND-IA, SWIFT PRIME, REVASCATS) further confirmed the efficacy and safety of this treatment approach for large vessel occlusions.[6-9]

While all of these clinical trials used IV alteplase (within a 4.5 hour treatment window) in the vast majority of enrolled patients, half were treated with endovascular clot removal, typically using a stent retriever device. Most of the clinical trials used additional imaging modalities to select patients who were more likely to benefit from such therapy. In almost all cases, a coordinated care team was used to expedite care and reduce time delays between diagnosis and treatment.

In light of the positive EVT trials, and other advances in stroke care, the Brain Attack Coalition (BAC) has reviewed recommended standards, performance metrics, and care protocols for stroke centers and stroke systems to determine if revisions are needed.[10] [11]

Methods

Members of the BAC Executive Committee, which represents major national organizations involved with various aspects of stroke care, reviewed the English language medical literature related to acute stroke care as well as the five new pivotal endovascular trials outlined above. Search terms for the literature review included stroke care, stroke centers, stroke units, stroke patient triage, EMS and stroke, stroke acute care, stroke guidelines, and other published studies that BAC members were aware of that might impact or address acute care. The review focused on new studies from January 2013 through December 2016. These included major position papers from professional organizations involved in acute stroke care.

The review of the five EVT trials was focused on the following care aspects: 1) overall results, 2) diagnostic tools 3) care protocols, 4) clinical outcomes, and 5) how these trials might impact stroke systems of care. The BAC also reviewed time frames for brain and vascular imaging, as well as staffing resources for neuroscience ICUs.

The BAC used a modified evidence grading tool which was used in prior BAC publications (table 1).[4] This approach allows for evaluation of the overall efficacy, safety, and practical utility of not just therapeutic modalities, but also diagnostic tests and care paradigms. Various diagnostic and treatment modalities that pertain to acute EVT for AIS patients were then graded. These were also applied to potential modifications of stroke centers and stroke systems of care.

In addition to the evidence grading outlined above, members of the BAC Executive Committee reviewed each new recommendation for inclusion. A two-thirds majority approval was required for each recommendation. This manuscript focuses on new recommendations and care elements. Unless otherwise specified, prior recommendations for items such as educational levels, response times, acute stroke teams and stroke units, and others remain unchanged.

Results

The various types of stroke centers (ASRH, PSC, and CSC) have vastly different patient volumes, staffing, infrastructure, and capabilities. Yet all are expected to at least begin the care process for patients presenting with any type of stroke. The recommendations outlined below reflect the major changes to our Stroke Center recommendations [4, 12-14] in light of the positive results of the endovascular trials reviewed above, as well as other relevant advances in acute stroke care. Prior recommendations for the different stroke centers are not repeated here unless there were areas of controversy or recommendations in need of revision or clarification.

1. **Endovascular Therapy**

A summary of the five recent trials is in table 2. The trials had time windows of 6-12 hours after the time the patient was last known to be well, with the vast majority of patients treated within 6 hours of stroke onset. All trials showed improvements in 90 day outcomes, which appeared to correlate with the reperfusion time and status of the occluded vessel (see table 2). Positive outcomes were seen across all centers and regions in most of the studies, and the results were consistent in patients with or without baseline IV alteplase therapy (although the vast majority did receive IV alteplase within 4.5 hours of stroke onset). Furthermore, an excellent safety profile was found, with low rates of symptomatic ICH and mortality, even when endovascular therapy was combined with IV alteplase (see references 5-9). One caveat is that several studies were stopped early based on the results of interim analyses and before full enrollment was achieved.

Based on these consistent, compelling, and statistically significant results, the BAC supports acute EVT for properly selected patients with AIS (Class I, Level A, new recommendation). This recommendation includes the presence of well trained and experienced endovascular teams available 24/7 (Class 1, Level A, new recommendation) at hospitals performing such therapy. Such teams include physicians, advanced practice providers (i.e. nurse practitioners, physician assistants), nurses and technicians with experience treating and assessing patients with cerebrovascular disease and in using endovascular equipment and techniques. The BAC recommends that clot removal be performed using the current generation of stent retrievers that were used in the five clinical trials cited above. (Class 1, Level A, new recommendation).

For the initial patient evaluation, all of the EVT trials used standard diagnostic techniques to identify patients with an AIS. Since the vast majority of patients (>80%) were treated with IV alteplase, most enrolled patients met the standard IV TPA inclusion criteria also, with a 4.5 hour treatment window.[15] Vascular imaging, typically CTA, was used to further identify patients with large artery occlusions involving the distal intracranial internal carotid artery, proximal middle cerebral artery, or (in some cases) another major vessel.

Identifying patients likely to have salvageable brain, as well as excluding patients with large areas of infarcted tissue, seemed to be a key factor in improving outcomes. Three of the five trials used one or more advanced techniques to ascertain if there was salvageable brain tissue distal to the occluded vessel. These included CT perfusion, MR perfusion, MR diffusion/perfusion mismatch, and assessment of collateral flow using multiphase CTA. In two trials, the ASPECT score was used to identify and possibly exclude patients with apparent large areas of ischemic brain. The MR CLEAN study, which did not routinely use these advanced methods, had the least impressive overall outcomes, with only 33% of endovascular-treated patients achieving a mRS of 0-2 at 90 days, compared to > 60% in the other trials.[5] While other factors may have played a role in these good outcomes, improved patient selection based on brain perfusion status appears to be key .

Recent guidelines for EVT recommend using the ASPECT score to screen and select patients.[16] While the ASPECT score is inexpensive to obtain and implement, it has some practical and clinical limitations. Clinician assessment of the ASPECT score can vary considerably.[17] While in some cases the ASPECT score is a surrogate for cerebral blood flow (CBF), actual assessment of CBF and core vs penumbral tissue may provide a more accurate assessment of salvageable brain.[18] The authors of ESCAPE, EXTEND IA, and SWIFT PRIME credit improved patient selection using perfusion techniques as a key factor in achieving positive outcomes.[6] [7] [8]

Based on these results, and to help guide patient triage for endovascular therapy, we support the use of CTA or MRA (head and neck) to assess large vessel status in all patients with AIS and clinical deficits compatible with a large artery occlusion or stenosis (Class 1, Level A, new recommendation). The BAC also recommends one or more brain perfusion assessment technique (i.e. CT or MR perfusion, diffusion/perfusion mismatch, or multiphasic CTA) to aid in the selection of patients for endovascular therapy (see below for details; Class IIA, Level A, new recommendation). This is based on the utility of these techniques for patient selection and improved outcomes as seen in the recent trials. These techniques are appropriate for patients with signs and symptoms consistent with a large artery ischemic stroke. If a perfusion modality is not readily available, the use of the ASPECT score is also acceptable for patient selection (Class IIB, Level A, new recommendation). The emergent use of a brain perfusion study is not required for all patients presenting with stroke symptoms, but only for those with known or suspected large artery occlusions/stenosis.

The BAC is aware that there is continuing debate among imaging experts about precise definitions of ischemic tissue and salvageable brain using various techniques.[19-22] Until these parameters become better defined, the BAC conceptually supports the use of these techniques to aid with patient selection. This may change based on future comparative trials of various modalities for improved patient selection. The NINDS StrokeNet's DEFUSE

3 trial is testing perfusion imaging for its potential to identify patients who may benefit from reperfusion therapy outside the current time window. Specific recommendations for the availability of these imaging modalities at each level of stroke center are outlined below.

Three of the five EVT trials reported time epochs between imaging (typically head CT) and groin puncture; these varied from 51 minutes to 93 minutes.[6 23 8] It is unclear if these times included advanced imaging such as CTA and perfusion studies. Nonetheless, it is clear that rapid brain imaging is a key factor for patient selection, and rapid treatment correlates with improved outcomes. The BAC recommends a CT to groin puncture (picture to puncture) time of 60 minutes or less as a performance metric for PSCs performing endovascular therapy and at all CSCs (Class IIa, Level B, new recommendation). This recommendation is further supported by statements from other professional organizations.[24] This includes the time for advanced imaging and its interpretation. A door to groin puncture time is a reasonable alternative measure. (For patients who are transferred to a CSC- type facility after having imaging performed at another hospital, the picture to puncture time will be based on when they arrive at the receiving hospital where EVT will be performed.)

Some have advocated using a metric that is defined by hospital presentation to vessel recanalization or brain reperfusion. While this is certainly a desirable endpoint, it ignores practical and physical limitations often encountered during the peri-procedure time epoch that may cause delays in reperfusion.[25-29] It also may have the unintended consequence of motivating interventionalists to value speed at the expense of safety.

EVT may be associated with increased upfront costs due to the expense of the procedure, staffing, and other resources. Emerging studies have begun to address the overall cost-effectiveness of EVT. Overall the lifetime QALY appears to be in the range of 6.5 to 7.0 per patient treated with EVT compared to IV alteplase alone.[30] Ongoing studies will continue to analyze the cost-effectiveness of EVT in various settings.

2. Brain and Vessel Imaging

Stroke center guidelines and acute care paradigms have recommended a door to CT interpretation time of 45 minutes at any stroke center. Based on published data from a variety of care settings[31 32 33 34], as well as the correlation between improved outcomes and faster treatment times, the BAC now supports a door to CT interpretation time of 30 minutes at all levels of stroke centers. (Class IIa, Level B, new recommendation). Interpretation might occur on site or via a teleradiology protocol and platform. The CT interpretation could be done by on-call personnel who may not be radiologists, but who have been properly trained.

Based on the experience and outcomes documented in the five recent endovascular trials (cited above), it appears feasible to perform and interpret CT angiography within 45 minutes of patient arrival at a PSC or CSC. (Class IIa, Level B, new recommendation). It is recommended (but not required) that an ASRH also complete and interpret a CT and CTA within 45 minutes of patient arrival (Class IIa, Level C, new recommendation; see below for further details). CTA interpretation might occur on site or via a teleradiology mechanism.

Because the results of a CTA are often key pieces of data that drive subsequent care, the BAC supports the performance of this study in patients with AIS who meet selection criteria developed by each stroke center. Examples of such criteria might include time last known well, stroke severity, initial CT findings (i.e. hyperdense MCA sign), and co-morbidities.[35 36, 37] However, acute care and/or transfers should not be delayed at ASRHs waiting for a CTA to be completed or interpreted.

3. Neurocritical Care

In the initial 2005 CSC guideline publication, the BAC stated that a CSC should have "physicians with expertise in critical care or neurointensive care".[13] This made sense as the Neurocritical Care Society was only formed in 2002, with its first meeting in 2003, and physician certification available beginning in 2007. There are now more than 1200 fellowship trained and certified neurocritical care physicians and over 30 credentialed fellowship programs in the U.S.[38]

Based on the improved availability of fellowship trained neurointensivists, as well as data that support improved outcomes in care settings with neurointensivists[39 40 41], we recommended that a CSC should have on staff at least one fellowship trained neurocritical care physician, in addition to physicians and/or APPs and nurses with expertise in neurointensive care. (Class IIA, Level B, new recommendation) This also applies to PSCs that choose to admit and treat patients in need of neurocritical care services (i.e. patients with large ischemic strokes, ICH, SAH). The neurointensivist(s) should coordinate stroke care in the ICU or neuro-ICU, develop and implement care protocols, review outcomes, participate in educational activities, and lead process improvement initiatives.

4. Vascular Neurosurgical and Endovascular Expertise

Neurologic surgery training programs are typically focused on subspecialty areas such as vascular disease, endovascular surgery, skull-based tumors, spinal surgery, etc. Several of the prior BAC documents refer to 'vascular neurosurgical expertise' and 'neuro-endovascular expertise,' without details of how this is defined and documented. As an example of how this might be better defined, the multidisciplinary Committee of Accreditation of Subspeciality Training (CAST) has developed a process to recognize fellowship programs for vascular neurological surgery and neuroendovascular training.[42] There will be a process to recognize physicians who prospectively complete an approved program. There will also be a procedure for physicians already in practice to receive retrospective approval or credit for training and expertise in vascular neurologic surgery and/or neuroendovascular therapy.[43]

In addition (or as an alternative) to completion of a vascular neurosurgical or neuroendovascular fellowship or training (as defined by CAST), other criteria to demonstrate expertise might include a) certification by another professional organization with expertise in these areas, b) prior training in a residency with high vascular neurosurgical volumes, c) case logs, d) publication record, and e) obtaining hospital privileges for performing relevant procedures. Examples of such procedures include carotid endarterectomy, clipping and coiling of intracranial aneurysms, placement of ventricular drainage devices, and performing decompressive craniectomies.

5. Outcomes and Quality of Life

Care providers, third party payers, and especially patients and families are most concerned about outcomes and quality of life. While there continues to be some debate about elements such as number and types of patients treated at certain levels of stroke centers, outcomes and quality of life (QoL) measures should drive many of our certifications.

In that regard, there are several well formulated and published tools that appear to do an excellent job measuring outcomes and QoL. These include the Get With the Guidelines-Stroke registry, [44] [45] and other databases. [45] [46] [47] However, in many cases these measure care processes, which may or may not mirror quality of life and outcomes. Specific quality of life measures for neurologic conditions (including stroke) include the SS-QoL, Neuro-QoL, and Stroke Impact Scale, among others.[48-51] A PSC or CSC should adopt at least one QoL measure that is relevant for their patient population (Class IIa, Level C, new recommendation).[52] [49, 53, 54] If one QoL measure cannot be easily adopted, then the modified Rankin score is a reasonable surrogate.[55] While these choices may vary by organization, it will be important that the chosen measure(s) target common and clinically relevant care elements and meaningful outcomes. The PSC or CSC should perform the chosen QoL assessment at least 90 days after hospital discharge, which is consistent with other post-discharge assessments (Class IIb, Level C, new recommendation).[56-58] Another assessment one year after hospital discharge might also be considered.

6. Revisions Specific to Types of Stroke Centers

A. ASRH

All ASRHs are required to have basic head CT or MRI available on a 24/7 basis, with testing completed and read within 30 minutes (for CT) or 60 minutes (MRI) of patient presentation (Class 1, Level A; unchanged).[14] To better triage such patients and determine who might benefit from referral to a higher level of care, it is recommended (but not required) that ASRHs offer at least one cerebral vasculature imaging modality (see table 3). Local resources might influence the availability and practicality of this recommendation at some facilities (see above for details).

The vast majority of head CT scanners have the capability of performing at least basic CTA protocols.[59] [60] The intravenous infusion of contrast and software updates should not incur major new expenses (beyond the cost of the contrast) at most facilities.[61] The interpretation of the CTA (or MRA) could be done by local personnel or remotely using an available teleradiology service. Such services are commonly used to support many smaller or remote hospitals. The BAC believes this is an achievable evolution in the level of care offered at some ASRHs, and should not lead to significant costs in most cases.

The findings of a CTA (or MRA) have major implications for planning the next therapeutic intervention.[62] A patient without a large vessel occlusion might be triaged to any PSC (or CSC), while patients with a large artery occlusion should be sent to a facility that offers EVT. Vascular imaging is also important in the diagnosis and management of patients with an ICH or SAH. However, if imaging studies cannot be performed in a timely manner, transfer of the patient to a higher level of care should not be delayed. In such cases the clinical assessment should be used to make the best determination of stroke type and severity.

B. PSC

The need for PSCs to offer vascular imaging and MRI was addressed in the 2011 revised recommendations for PSCs.[4] However, in light of the positive endovascular trials and a change in the overall care paradigms, as well as the number and broad distribution of PSCs, the BAC believes that such facilities should offer additional brain imaging capabilities (see table 4). This includes vascular imaging (CTA or MRA) availability on a 24/7 basis (Class 1, Level A; revised recommendation).

The BAC also believes that PSCs should offer testing of brain perfusion status, as information from these tests helps to inform practitioners about a) which patients might benefit from reperfusion therapy, and b) which patients should be referred to another facility (e.g. CSC) for EVT (if such therapy is not readily available at the PSC). PSCs should offer at least one of these brain imaging modalities on a 24/7 basis, even if patients will not receive EVT at the PSC (Class IIa, Level B, new recommendation, see table 4). The perfusion test results should be completed and available within 60 minutes of hospital arrival. Although there is some diversity of opinion about the utility of perfusion testing to aid in patient selection, the striking success of the recent endovascular trials (the majority of which used such modalities for patient selection), combined with the lack of success of prior trials (which did not use perfusion status criteria), leads us to support such testing.

A survey conducted by the Joint Commission last year showed that approximately one-third of PSCs might offer EVT on a 24/7 basis.[63] For triage purposes, should EMS divert patients to such PSCs, or bypass them in favor of a CSC? This is an important yet complex issue. Offering EVT without having the infrastructure to treat potential complications that can occur in patients with large artery strokes is not advisable. [64, 65] Some patients may require the use of hyperosmolar therapy to treat cerebral edema, neurosurgical services for brain decompression, and neurocritical care for complications such as subarachnoid hemorrhage, vessel dissection, and respiratory support. [66]

Infrastructure necessary for a PSC to perform EVT might also include an endovascular suite with the equipment specific for brain procedures, properly trained nurses and technicians, and a relatively high case volume to ensure some degree of experience and technical expertise (Class IIb, Level C, new recommendation). Although some data from the larger EVT trials such as MR. CLEAN and ESCAPE might suggest that performing an average of one endovascular case a month might be associated with good outcomes, limitations in study design and data reporting do not support a firm volume recommendation at this time.[7 5] However, each center should closely track and report care metrics and outcomes such as door to groin times, procedural complications, and 90 day outcomes for patients treated with EVT (Class IIa, Level C, new recommendation).

Some but not all PSCs offer the services noted above. Also, a PSC cannot provide 24/7 endovascular services if there is only one neuroendovascular-trained physician on staff. How would EMS know if and when there is endovascular capability at a PSC on a day to day (or hour to hour) basis? Changing triage practices on a daily basis due to staffing issues is problematic for any integrated stroke system of care.[67]

Based on available data, the BAC recommends: a) If a PSC offers 24/7 endovascular services with the availability of other health care providers, support services, and experience as noted above, preferential triage of patients with known or suspected large artery occlusions to that PSC is recommended (Class IIa, Level C, new recommendation) if the transportation time is within 20-30 minutes (20 minutes urban, 30 minutes rural) of the time to transport the patient to the nearest CSC.[68] (These recommended time frames may vary according to state, regional, and geographic considerations). A PSC offering EVT services must also meet the relevant requirements for EVT as noted for a CSC, with the exception of doing simultaneous cases (see below). If the PSC does not offer all of the above services, the BAC recommends triage to a CSC (Class IIa, Level C) or to a closer PSC that does offer the services noted above. A PSC should report patient outcomes as noted above.

C. <u>CSC</u>

CSCs are currently required to offer brain vascular imaging, perfusion studies, and EVT on a 24/7 basis.[13] The BAC reaffirms this recommendation with a Class 1, Level A recommendation (revised). As noted above, the emerging performance metric is a picture to puncture (brain imaging to groin puncture) time of 60 minutes (metric met in at least two-thirds of cases). Data generated from the EVT trials support the importance of rapid diagnosis and therapy.

With the anticipated expansion and growth of EVT for patients with acute ischemic stroke, the need for CSCs to have the capability to treat two patients simultaneously is a real possibility.[69, 70] Experience from CSCs even before the publication of the recent trials has shown that performing two simultaneous procedures was not uncommon. Since the publication of the EVT trials, anecdotal data from many CSCs and interventionalists suggest an increase in the number of patient referrals who might benefit from such therapy. Some cities and regions have enhanced triage protocols and procedures to promote the transfer or diversion of such patients to the nearest CSC.[71 72, 73]

Based on these factors, the BAC recommends that a CSC should have the personnel, infrastructure, and staffing models to perform two simultaneous EVT cases for patients with AIS on a 24/7 basis (Class IIa, Level C; new recommendation). How this is accomplished may differ at various organizations, but having at least two staffed interventional suites and related personnel would appear to be necessary. This requirement does not mandate having two endovascular teams taking in-house call.

There continues to be discussion around the optimal number and mix of patients and procedures related to aneurysmal SAH.[74-76] Additional data relating case volume to outcomes continue to suggest improved outcomes with a greater number of cases.[75 77 78] One study of 36,600 patients reported that 'high' volume centers had reduced rates of in-hospital mortality, with an OR of 0.77 compared to low volume centers. At these centers, the case volumes for 'high-volume' of clipping/coiling ranged from > 20 cases annually to > 45 annual cases.[77]

A study of more than 32,000 patients with non-traumatic SAH found that as annual case volumes decreased by each increment of 20 patients, in-hospital mortality increased by 2-4%.[78] A meta-analysis of more than 11,600 SAH patients found that case volumes of 20 or more per year was associated with an 18% reduction in death and a 16% increase in good outcomes.[79] Another recent meta-analysis supports that case volumes in excess of 20-30 annually are associated with improved outcomes. [77]

Based on these new data, the BAC has modified our annual minimum case volumes as follows: aneurysm clipping (10), aneurysm coiling (20) and total aneurysmal SAH cases (30), with a two to three year rolling average (Class IIb, Level C, new recommendation). The clipping and coiling volumes include symptomatic and asymptomatic aneurysms. A two to three year rolling average is reasonable to reflect variations in patient volumes and referral patterns. Reporting of patient outcomes from an audited registry might serve as a surrogate or alternative to the case volume numbers cited above.

D. Stroke Systems of Care

The validation of EVT has placed a premium on proper patient identification and rapid triage to the most appropriate level of care.[67] Unfortunately, many patients still do not recognize stroke symptoms, or seek immediate medical care in response to such symptoms.[80, 81] Even when and if they do, the ability of EMS and related medical professionals to rapidly and accurately diagnose a stroke in the field remains somewhat limited.[82, 83 84, 85 86] Various field assessment scales and tools have been developed and tested to improve the diagnostic accuracy for stroke.[87, 88 89-91 92 93]

Against this backdrop is the proliferation of hub and spoke models of acute stroke triage and care, as well as the expansion of telestroke modalities ranging from 'robots' or cameras in EDs to mobile telemedicine links.[94, 95 96] Portable CT scanners in ambulances are also under investigation. [97 98 99, 100] The differentiation of large vessel from small vessel ischemic strokes based on field triage tools remains problematic. However, a number of small studies using various field triage rating and assessment scales and (in some cases) telemedicine have reported encouraging results.[101, 102 95 103] But the current data are insufficient for the BAC to make any firm recommendation about the use of a specific scale for field triage.

The BAC supports stroke identification and triage modalities that emphasize rapid and accurate screening of patients, combined with two way audio-video examination capabilities and (in some circumstances) with mobile functionality. The BAC believes these approaches offer the best potential for rapid patient assessment using existing technologies with short implementation times (Class IIb, Level C, new recommendation).[104] Many such telestroke systems are used routinely on a daily basis with good results vis-a-vis IV alteplase therapy for AIS. [105 94 106]

The use of additional technologies such as a handheld cellphone with a brief (2-3 minute) video clip, or a real-time type of video-phone connection, has the potential to enhance the availability, accuracy, and affordability of field triage. These techniques are safe, easy, and efficient. A skilled clinician performing a real-time (or reviewing a recorded) brief neurologic history and examination in most cases can make an accurate assessment about a) whether the patient is likely to be having a stroke, and b) the magnitude of the stroke in terms of size and severity. This is really the basis of most telestroke rapid assessment systems, albeit based in the ED. Adding a mobile functionality for EMS triage that occurs during transportation could address several current limitations of field triage. Issues such as patient confidentiality, suboptimal connectivity in some regions, coverage models, reimbursement, and other logistical factors will have to be addressed to make this approach feasible and widely adopted.

The preferred routing of patients with a known or suspected acute stroke (of any type) has profound implications in terms of acute care and outcomes. If the patient is stable from a cardiovascular and respiratory perspective, the BAC (and current guidelines) recommend that patients be transported to the nearest and highest level stroke center (Class IIa, Level C). [14, 16, 107] This includes additional transportation times of up to 20-30 minutes, which reflects typical delays seen in urban and rural areas, respectively. This time parameter might change based on local, geographic and other logistical limitations (weather, remote regions, etc.). Diversion times of up to 30 minutes are consistent with the recommendations of the California EMS, where 68% of the population is covered by this policy.[68]

Currently in the U.S., the majority of citizens live in states and counties with stroke systems that have specific triage and diversion protocols for patients with acute stroke.[108] Specific triage recommendations and scenarios are outlined in figure 1A and 1B, and above in the PSC section. Ongoing studies are assessing the trade-offs between transportation times, ongoing brain damage, stroke center capabilities, and treatment options.[92]

A listing of all of the above new recommendations can be found in table 5.

Discussion

The different levels and types of stroke centers provide the infrastructure for acute stroke care in the U.S. and in many other nations.[109-111] Yet, only a minority of U.S. hospitals are designated as a stroke center.[112] As advances are made in care paradigms, stroke centers should adapt and evolve to reflect current care paradigms. The recent clinical trials proving the efficacy and safety of EVT for patients with AIS has mandated a change in the capabilities of stroke centers and stroke systems of care. The above evidence-based recommendations reflect these changes, with a focus on brain and vascular imaging, assessment of tissue status, field triage, number of treated patients, and support services.

The assessment of brain perfusion status is an evolving area. There is some diversity of opinion about the optimal methodologies to use to assess salvageable brain from infarcted brain in terms of perfusion status and lesion size.[19-21, 113] The various endovascular trials used different techniques and definitions to include or exclude patients from treatment, further reflecting a range of viewpoints. However, most experts agree on the need for some type of assessment of brain perfusion status as one criterion for patient inclusion/exclusion.

The one hour metric for completing these advanced imaging studies is supported by the practical and logistical constraints found while doing these studies, as well as the biologic imperative that 'time lost is brain lost.' Several clinical trials were able to achieve a 60 minute 'picture to puncture' time frame, further proving the feasibility of such a metric, while also achieving positive clinical outcomes and an excellent safety profile.[7, 8] Studies have shown that early arrival and time to reperfusion are key predictors of a good outcome.[114] [115] Implementing care processes that work simultaneously (beginning IV thrombolytics, perform vascular imaging, notifying the EVT team, and preparing the endovascular suite) is one important aspect for meeting these time metrics.[116, 117]

Some have advocated a time metric from ED arrival to reperfusion. While this is certainly relevant in terms of patient care and outcomes, the BAC is concerned about unintended consequences such as a) not applying rigorous patient selection criteria, b) hurrying the procedure may increase the risk of complications, c) encouraging multiple futile attempts to reperfuse the brain. Based on these considerations the BAC supports, for now, the 60 minute 'picture to puncture' time metric. As an alternative, a 'door to groin' time metric might also be considered.[116]

Another key issue relates to field triage of potential stroke patients. Improving the field recognition and diagnostic accuracy of acute stroke by EMS can be challenging.[84, 87, 88] Distinguishing patients who might be candidates for IV alteplase or EVT based on field triage is even more difficult due to confusion about time of onset, concomitant medical conditions, medications, and recognition of large vessel lesions.[67] However, if EMS transports such patients to a facility that does not offer endovascular therapy, it is likely that the patient will be out of the 6-8 hours acute treatment time window. The BAC supports ongoing efforts for EMS education focused on improving stroke recognition and field triage.[84, 88, 118, 119]

The number of treated patients with aneurysms and aneurysmal SAH remains an area of discussion. The case volumes cited above are supported by some published data, yet such data are based on retrospective analyses. Furthermore, such data are largely based on hospital case numbers, which may not reflect the expertise of specific practitioners. An unintended consequence of relatively high case volumes might include closing or reduced numbers of CSCs if they cannot meet the volume requirements. However, most (but not all) data support improved outcomes with high case volumes. As an alternative to case volumes, independent and audited results to confirm high quality care and outcomes might be used as a surrogate.

Additional recommendations reflect the growth and evolution of stroke care paradigms and systems of care. These include the addition of neurointensivists at all CSCs, tracking patient-centered QoL outcomes, and the availability of vascular imaging at ASRHs and PSCs. As stroke systems of care interact with accountable care organizations, improved care and outcomes will become increasingly important. The BAC believes the changes outlined above will lead to such a result.

In conclusion, the BAC has formulated revisions to our stroke center guidelines that reflect changes in care for AIS as a response to several positive EVT trials, as well as other advances in stroke care. Once fully implemented, these changes should enhance the utility and efficiency of stroke care at these centers, with the ultimate goal of improving patient care and outcomes. The BAC is hopeful that the Joint Commission and other certifying organizations will adopt these recommendations to ensure that designated stroke centers provide the infrastructure, care, and staffing that are needed to achieve optimal patient outcomes.

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Table 1
Grading Criteria Used for Brain Attack Coalition Recommendations*

Class of recommendation	Explanation	Comment
I	Benefits of treatment, test, intervention, or personnel clearly outweigh any risks	This care element should be used in most or all cases
IIa	Benefits of treatment, test, intervention, or personnel likely outweigh any risks	It is reasonable to use this care element in the majority of cases
IIb	Benefits of treatment, test, intervention, or personnel are possibly greater than any risks	It is reasonable to consider this care element in some but not all cases
III	Risks may be equal to or greater than any benefits	This care element should not be used
Level of Evidence		
A	Treatment, test, intervention, personnel validated in multiple studies/populations with rigorous study design	Very consistent results or test accuracy in various settings
B	Treatment, test, intervention, or personnel studied in limited populations	Promising results or outcomes but somewhat limited in size or scope
C	Treatment, test, intervention, or personnel examined in few or limited studies/populations or limited clinical circumstances, case studies, or expert opinion	May need further study; recommendations largely based on expert opinion

- Revised from reference [4]

Table 2

Recent Clinical Trials of Endovascular Therapy (EVT) in Patients with Acute Ischemic Stroke

Study	Rx time window	N	IV alteplase Use (Rx group)	Imaging Tools	Baseline NIHSS score	CT to groin puncture	TICI 2B/3 perfusion status in target vessel	mRS 0-2 at 3 months: Rx group	mRS 0-2 at 3 months: control group	Mortality benefit (Rx/control group)	Sx ICH (Rx/control group)
MR CLEAN	6 hr	500	89%	CT with ASPECTS; CTA/MRA/DSA	17-18	NA	75%	33%	19%	No difference	6%/5%
ESCAPE	12 hr	316	75%	CT + multiphase CTA	16-17	51 min	72%	54%	29%	10% / 19%	3.6%/2.7%
EXTEND-IA	6 hr	70	100%	CT + CTA + CT perfusion	13-17	93 min	86%	72%	39%	9%/20%	0%/6%
SWIFT-PRIME	6 hr	196	100%	CT with ASPECTS/MRI; CTA/MRA	17	58 min	88%	60%	35%	9%/12%	1%/3%
REVASCATS	8 hr	206	68%	CT with ASPECTS	17	NA	66%	44%	28%	18.4%/15.5%	2%/2%

Rx group refers to patients who received EVT

See supplemental data for a list of abbreviations

Table 3

Vascular Imaging Options for Acute Stroke Ready Hospitals[1]

Imaging Modality	Comment
CT angiogram (head and neck)	Contrast required
MR angiogram (head and neck)	Contrast preferred
Carotid Doppler and Transcranial Doppler	Both required
Digital cerebral angiography	Unlikely to be available at ASRH

1 emergent vascular imaging is recommended but not required at an ASRH

See supplemental data for a list of abbreviations

Table 4
Recommended Imaging Modality Options at a PSC[1]

Initial Brain Imaging (availability)
Head CT (24/7)
Brain MRI (24/7)

Vascular Imaging
CT angiography—head and neck (24/7)
MR angiogram—head and neck (24/7)
Digital subtraction angiography

Tissue Status
CT perfusion study (24/7)
MR perfusion study (24/7)
MR perfusion/diffusion mismatch (24/7)
CTA-multiphase protocol (24/7)
Digital subtraction angiography
ASPECT score (24/7)[2]

[1]At least one modality available in each category; see text for time frames for performance
[2] ASPECTS is an acceptable but not preferred tissue status tool

See supplemental data for a list of abbreviations

Table 5

Summary of new and revised recommendations

1. The BAC supports acute EVT for properly selected patients with AIS (Class I, Level A). This recommendation includes the presence of well trained and experienced endovascular teams available 24/7 at hospitals performing such therapy (Class I, Level A, new recommendation).
2. Personnel performing EVT should receive proper training in the appropriate techniques (Class I, Level A, new recommendation).
3. If technically feasible, clot removal should be performed using the current generation of stent retrievers that were used in the five major clinical trials (MR CLEAN, EXTEND-IA, ESCAPE, SWIFT PRIME, REVASCATS). (Class I, Level A, new recommendation).
4. CTA or MRA (head and neck) should be used to assess large vessel status in all patients with acute ischemic strokes and clinical deficits compatible with a large artery occlusion or stenosis (Class I, Level A, revised).
5. One or more brain perfusion assessment technique (i.e. CT or MR perfusion, diffusion/perfusion mismatch, or multiphasic CTA) should be used to aid in the selection of patients for endovascular therapy. (Class IIA, Level A, new recommendation).
6. If a perfusion modality is not readily available, the use of the ASPECT score is acceptable for patient selection for EVT (Class IIb, Level A, new recommendation).
7. PSCs or CSCs performing endovascular therapy should have a CT to groin puncture (picture to puncture) time of 60 minutes or less as a performance metric (Class IIa, Level B, new recommendation). A door to groin puncture time is a reasonable alternative measure.
8. All levels of stroke centers should have a door to CT interpretation time within 30 minutes (Class IIa, Level B, revised).

9. When using CT angiography, it should be performed and interpreted within 45 minutes of arrival at a stroke center (Class IIa, Level B, revised).
10. CSC personnel should include at least one fellowship trained neurocritical care physician, in addition to physicians and/or advanced practice providers and nurses with expertise in neurointensive care (Class IIa, Level B, new recommendation).
11. A PSC and CSC should have at least one quality of life measure for patients treated and discharged (Class IIa, Level B, new recommendation) This assessment should be performed at least three months after hospital discharge (Class IIa, Level C, new recommendation).
12. Acute stroke ready hospitals should have CT or MRI imaging available on a 24/7 basis, and it should be completed and read within 30 minutes (CT) or 60 minutes (MRI) of being ordered (Class I, Level A, revised).
13. It is recommended but not required that acute stroke ready hospitals offer at least one cerebral vasculature imaging modality (CTA, MRA, carotid Doppler and transcranial Doppler, digital cerebral angiography). (Class IIa, Level B; new recommendation).
14. PSCs should have CTA or MRA available on a 24/7 basis (Class I, Level A; revised recommendation).
15. PSCs should offer at least one cerebral perfusion study to assist in patient triage for possible EVT (Class IIa, level B, new recommendation).
16. If a PSC offers 24/7 EVT, preferential triage of patients with known or suspected large artery occlusions to that PSC is recommended if the PSC has the necessary support services and sufficient case volume (Class IIa, Level C; new recommendation).
17. If a PSC does not offer EVT with the necessary support services and sufficient case volume, preferential triage of patients with known or suspected large artery occlusions to a CSC or to a closer PSC that does offer the necessary support services is recommended (Class IIa, Level C, revised).
18. CSCs should offer brain vascular imaging, perfusion studies, and EVT on a 24/7 basis (Class I, Level A; revised).

19. A CSC should have the personnel, infrastructure, and staffing models to perform two simultaneous EVT cases for patients with AIS on a 24/7 basis (Class IIa, Level C; new recommendation).
20. Stroke centers offering EVT should track and report patient outcomes (Class IIa, Level C, new recommendation).
21. For CSCs treating patients with cerebral aneurysms and/or SAH, the following minimum annual volumes are recommended: aneurysm clipping, 10 cases; aneurysm coiling, 20 cases; SAH, 30 cases (Class IIb, Level C, new recommendation).
22. Field identification and triage modalities that emphasize rapid and accurate screening of patients, combined with two way audio-video examination capabilities are recommended (Class IIb, Level C; new recommendation).
23. If an acute stroke patient is stable from both cardiovascular and respiratory perspectives, it is recommended that the patient be transported to the nearest and highest level stroke center (Class IIa, Level C).

Acknowledgements

The Brain Attack Coalition includes the following organizations and representatives.

The authors have reviewed this publication and approved its publication.

Stroke Belt Consortium (Mark J. Alberts, MD; Co-Chair of the BAC)

Centers for Disease Control and Prevention; Division for Heart Disease and Stroke Prevention (Mary G. George, MD) *The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention*

American Academy of Neurology (Lawrence Wechsler, MD)

American Society of Neuroradiology (Dheeraj Gandhi, MD)

National Association of EMS Physicians (Todd Crocco, MD)

American Association of Neurological Surgeons and Congress of Neurological Surgeons (Judy Huang, MD)

Department of Veterans Affairs (Glenn Graham, MD)

Neurocritical Care Society (Daryl Gress, MD)

Society of Neurointerventional Specialists (Lee Jensen, MD)

American Association of Neuroscience Nurses (Jalil Bentaleb, RN)

American Heart Association (Stephanie Mohl)

National Association of State EMS Officials (Peter Taillac, MD)

National Stroke Association (Matt Lopez)

American College of Emergency Physicians (Andy Jagoda, MD) *The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of ACEP*

National Institutes of Health, National Institute of Neurological Disorders and Stroke (Michael Walker, MD [BAC Chair]; Ms. Marian Emr, Ms. Margo Warren) *The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of NIH/NINDS*

The BAC acknowledges and thanks Ms. Nancy Hart for her administrative support of the BAC and expert assistance in preparing this manuscript.

Figure 1 legend

Figure 1A: Field Triage

Figure 1B: Triage from an ASRH

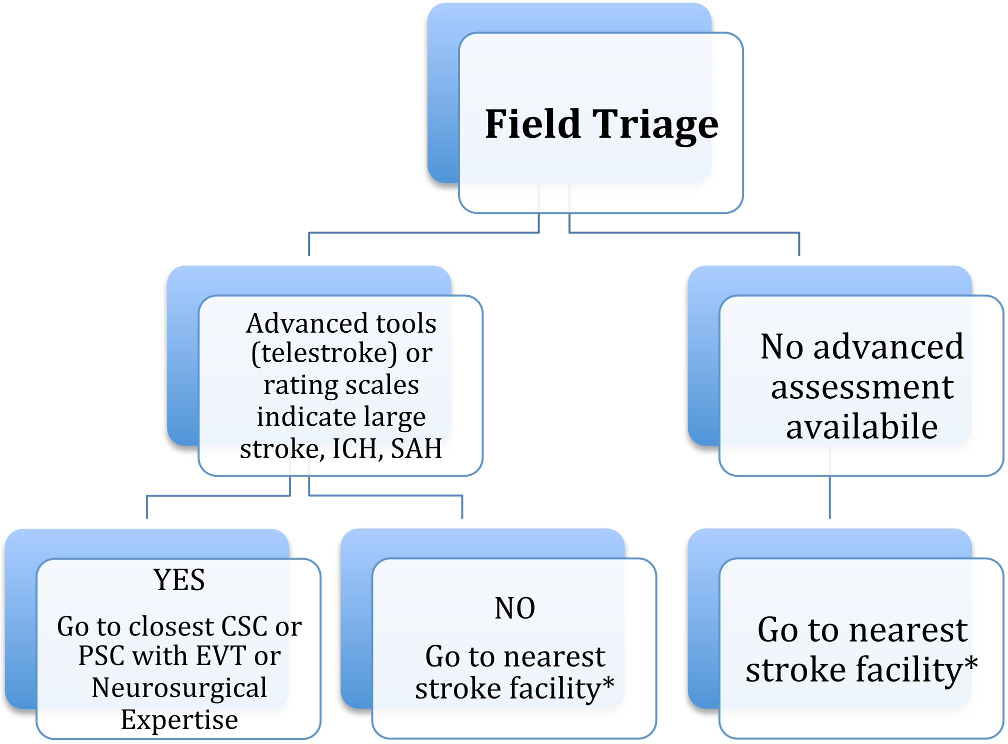
Triage recommendations assume the patient is medically stable for transportation to a higher level of care.

Preferential triage to the nearest stroke facility implies the higher level of stroke center that can be reached with an additional transportation time of no more than 20 minutes (this may vary depending on local factors, traffic, etc. (see text for details).

PSC triage recommendations are based on the availability of 24/7 EVT services, plus neurosurgery coverage and neurocritical care capability (see text for details).

ASRH, Acute Stroke Ready Hospital
CSC, Comprehensive Stroke Center
Dx, diagnosis
EVT, endovascular therapy
ICH, intracerebral hemorrhage
PSC, Primary Stroke Center
SAH, subarachnoid hemorrhage

The above abbreviations are included in the table of abbreviations



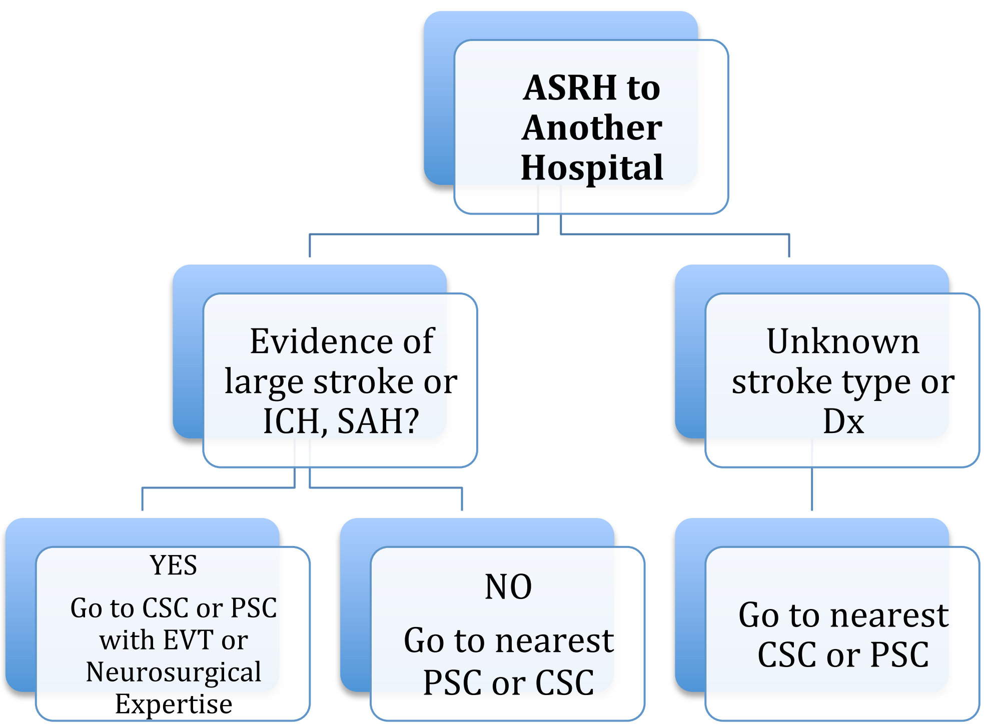


Figure 1A and 1B:

Supplemental Data

List of Abbreviations

APP – advanced practice provider
ASPECTS – Alberta stroke program early CT score
ASRH – acute stroke ready hospital
AIS – acute ischemic stroke
BAC – Brain Attack Coalition
CT – computed tomography
CTA – computed tomography angiogram
CSC – comprehensive stroke center
DSA – digital subtraction angiography
ESCAPE – Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion with Emphasis on Minimizing CT to Recanalization Times trial
EXTEND-IA – Extending the Time for Thrombolysis in Emergency Neurological Deficits–Intra-arterial trial
EMS – emergency medical services
EVT – endovascular therapy
ICH – intracerebral hemorrhage
ICU – intensive care unit
IV – intravenous
MCA – middle cerebral artery
MRA – magnetic resonance imaging angiogram
MRI – magnetic resonance imaging
MR CLEAN – the Multicenter Collaboration for endovascular treatment of acute ischemic stroke in the Netherlands trial
mRS – modified Rankin score
NIHSS – National Institutes of Health stroke scale
PSC – primary stroke center
REVASCATS – Endovascular Revascularization With Solitaire Device Versus Best Medical Therapy in Anterior Circulation Stroke Within 8 Hours trial
SAH – subarachnoid hemorrhage
SWIFT PRIME – Solitaire™ with the Intention for Thrombectomy as Primary endovascular Treatment for Acute Ischemic Stroke (SWIFT PRIME) trial
Sx – symptomatic
TICI – thrombolysis in cerebral infarction
U.S. – United States