Is This Patient Having a Stroke?

Larry B. Goldstein, MD
David L. Simel, MD, MHS

Context Patients suspected of having a stroke or transient ischemic attack require accurate assessment for appropriate acute treatment and use of secondary preventive interventions.

Objective To update a 1994 systematic review of the accuracy and reliability of symptoms and findings on neurological examination for the evaluation of patients with suspected stroke or transient ischemic attack.

Data Sources We identified potential articles dated between 1994 and 2005 by multiple search strategies of the MEDLINE database and review of article and textbook bibliographies along with private collections.

Study Selection Selected articles provided primary data or appropriate summary statistics of the accuracy and/or reliability of the history or physical examination for diagnosis or short-term prognosis of patients with neurological signs prompting a consideration of stroke. Articles addressing accuracy also needed to provide a final diagnosis following neuroimaging and all relevant laboratory tests.

Data Extraction The authors reviewed and abstracted data for estimating sensitivities, specificities, positive and negative likelihood ratios (LRs). Reliability assessment was based on reported kappa (κ) statistics or intraclass correlation coefficients as appropriate.

Data Synthesis The prior probability of a stroke among patients with neurologically relevant symptoms is 10%. Based on studies using modern neuroimaging, the presence of acute facial paresis, arm drift, or abnormal speech increases the likelihood of stroke (LR of ≥1 finding=5.5; 95% CI, 3.3-9.1), while the absence of all 3 decreases the odds (LR of 0 findings= 0.39; 95% CI, 0.25-0.61). The accurate determination of stroke subtype requires neuroimaging to distinguish ischemic from hemorrhagic stroke. Early mortality increases among those with any combination of impaired consciousness, hemiplegia, and conjugate gaze palsy (LR of ≥1 finding=1.8; 95% CI, 1.2-2.8 and LR of 0 findings=0.36; 95% CI, 0.13-1.0). Symptoms associated with high agreement for the diagnosis of stroke or transient ischemic attack vs no vascular event are a sudden change in speech, visual loss, diplopia, numbness or tingling, paralysis or weakness, and non-orthostatic dizziness (κ=0.60; 95% CI, 0.52-0.68). The reliabilities of individual neurological findings vary from slight to almost perfect, but can be improved with standardized scoring systems such as the National Institutes of Health Stroke Scale. Based on examination findings, stroke vascular distribution can be determined with moderate to good reliability (κ=0.54; 95% CI, 0.39-0.68).

Conclusions The history and clinical findings provide the basis for evaluating patients with possible stroke and choosing appropriate treatments. Focusing on 3 findings (acute facial paresis, arm drift, or abnormal speech) might improve diagnostic accuracy and reliability.

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PATIENT SCENARIO

The wife of a 58-year-old right-handed man calls emergency medical services because her husband abruptly developed difficulty speaking and moving his right arm (FIGURE).

WHY IS THE CLINICAL EXAMINATION OF PATIENTS WITH SUSPECTED STROKE IMPORTANT?

Since the original review of stroke published as part of the Rational Clinical Examination Series more than a decade ago, much has changed.[1] What has not changed is the staggering cost of the personal, societal, and economic consequences of strokes. The estimated direct and indirect cost of stroke in 2005 is estimated to be $56.8 billion in the United States alone.[2] More than 700 000 people in the United States have a stroke each year, of which nearly one third represent recurrent events.[3] About 163 000 annual stroke deaths make it the third leading cause of death in the United States. Between 15% and 30% of stroke survivors become permanently disabled, while 20% remain in institutional care 3 months after their stroke. Not too long ago, the clinical examination functioned primarily to catalog a patient's neurological impairments that in turn correlated with the stroke's vascular territory and likely cause. The inferences about the anatomy and etiology guided secondary preventive strategies

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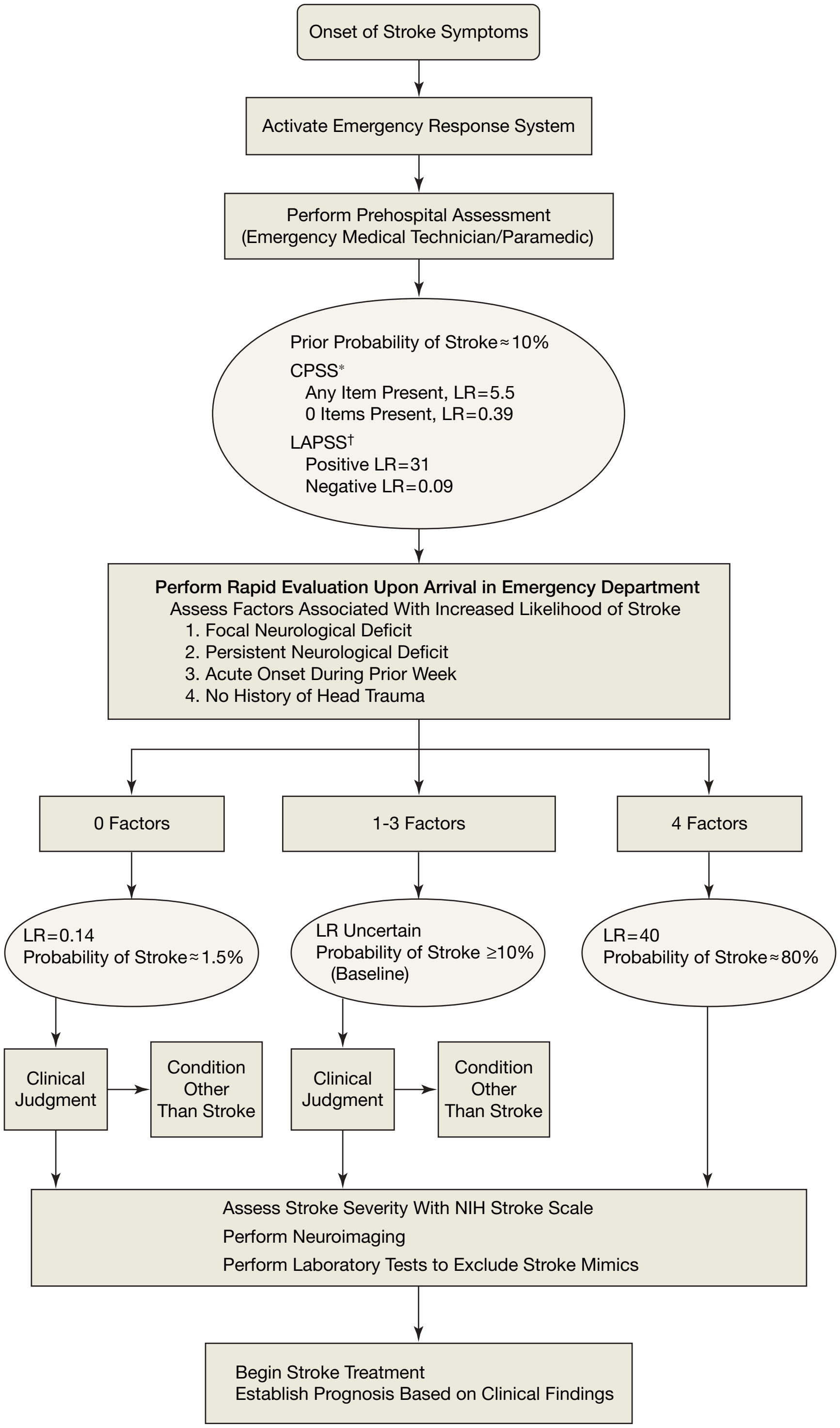
Author Affiliations: Department of Medicine (Neurology), Duke Center for Cerebrovascular Disease (Dr Goldstein); Center for Clinical Health Policy Research and Education, Duke University, and Department of Veterans Affairs Medical Center (Drs Goldstein and Simel); Department of Medicine, Duke University (Dr Simel), Durham, NC.
Corresponding Author: Larry B. Goldstein, MD, Box 3651, Duke University Medical Center, Durham, NC 27710 (golds004@mc.duke.edu).

Figure. Diagnostic Flow of a Patient Who Experiences Neurological Symptoms That Might Suggest a Stroke



*Cincinnati Prehospital Stroke Scale (CPSS); facial droop, arm drift, and abnormal speech.
†Los Angeles Prehospital Stroke Scale (LAPSS); history (age >45 years, no history of seizures, symptoms <24 h, not wheelchair bound), blood glucose 60-400 mg/dL (3.3-22 mmol/L), and examination showing unilateral facial weakness, grip weakness, and arm weakness.

and established the prognosis, rather than directing immediate treatment.

Despite the advent of modern noninvasive neuroimaging technologies, the clinical examination for stroke is now more important than ever because therapeutic interventions for patients with acute stroke and sophisticated approaches to prevent recurrent strokes now exist. Appropriate treatment and prevention depend on accurate interpretation of the patient's symptoms and clinical examination findings. For example, the risk/benefit balance for carotid endarterectomy requires an accurate assessment of symptoms to identify those with a transient ischemic attack (TIA) or nondisabling stroke.[4]

The rapid screening of patients with neurological symptoms begins with prehospital care personnel[5] because the effectiveness of reperfusion strategies for acute ischemic stroke are time-dependent. The brain can withstand profound ischemia for only limited periods, and the benefits of intravenous tissue plasminogen activator (tPA) lessens as the time from the onset of the patient's symptoms increases.[6] Public education programs have stressed the need to call emergency medical responders (eg, 911) for persons experiencing stroke symptoms. Patients, family members, and prehospital care personnel such as emergency medical technicians must recognize the symptoms and signs of strokes to minimize treatment delays. Arrival to the hospital by emergency medical transport has been associated with more rapid treatment, and thereby presumably improved outcomes.[7-10] Thus, the accuracy of the clinical examination becomes relevant not just for stroke specialists and emergency physicians, but for paramedics, nursing personnel, and emergency medical technicians who may be the first responder. When patients with stroke symptoms arrive at the hospital, a standardized neurological examination combined with neuroimaging results determine subgroups of patients who might benefit from intravenous thrombolysis vs those who may be at increased risk from thrombolytic-related bleeding.[11-13]

Experienced examiners tailor the neurological examination to address specific clinical questions because a stroke results in different symptoms and signs depending on the area of brain that has been affected. A variety of other conditions complicate diagnostic efforts by causing symptoms and signs similar to stroke (stroke mimics). In the patient example, emergency medical services were called for a patient with new focal neurological symptoms. We will observe the example patient through the emergent evaluation and highlight the clinical questions and features of the examination that increase the likelihood of accurately and reliably identifying a stroke, the stroke subtype, and the patient's prognosis.

METHODS

This review updates a 1994 report on clinical assessment of stroke[1] and is based on relevant studies identified through MEDLINE, restricted to the time since the last review. Information on the physical examination and neurological examination are difficult to identify because the Medical Subject Headings (MeSH) for the articles typically do not include obvious terms. For example, searching the terms "cerebrovascular disorders" limited to human research studies, English-language articles (1994-2005) yields 9029 articles. However, when the results of this global search are crossed with the term "neurological examination" there are 176 articles and when crossed with "physical examination," only 19 articles remain. Eliminating review articles and case reports from this reduced set left only 4 potentially relevant articles. Because of the low yield, we relied heavily on searches of the bibliographies of textbook chapters, review articles, and personal files to identify additional relevant literature for updating the role of the clinical examination since the original *JAMA* publication in 1994.

To examine the accuracy and reliability of the clinical assessment of stroke for either diagnosis or prognosis, the following general inclusion criteria were used in assessing articles: (1) the article addressed the issue of accuracy and/or reliability of history or physical examination for diagnosis or estimation of short-term prognosis (mortality or functional disability); (2) the study site and/or participants (clinicians or patients) were described; (3) the data were not limited to case reports or reviews of other studies; and (4) the primary data or appropriate summary statistics were presented.

For assessment of the accuracy of diagnosis, references included articles that also described a final diagnosis established by an expert who reviewed all clinical data, neuroimaging, and other relevant laboratory tests. These articles were evaluated for quality based on whether the clinical examination was performed masked to the neuroimaging results.[14] Articles describing prognosis in terms of functional status were included if the outcome was measured using a scale that is either comparable to a scale in common use or was validated in the context of the study.

The sensitivity (how often a diagnostic procedure detects a condition when it is present), specificity (how often a diagnostic procedure is negative when the condition is absent), and likelihood ratios (LRs) (the odds favoring the diagnosis or outcome vs not having the diagnosis) for each finding or scale was recorded from each article or was calculated based on primary data as necessary.[15,16] TABLE 1 summarizes the included studies that gave sensitivity and specificity data for the diagnosis of stroke or TIA. For studies of precision, the

Table 1. Summary of Included Studies With Sensitivity/Specificity Data

Source	Evidence Quality Level*	Country	Setting	No. of Participants	Inclusion Criteria
Kothari et al,[17] 1997	2	United States	ED	299	Clinical trial and ED patients
Kothari et al,[18] 1999	3	United States	ED and neurology service	171	Suspected stroke or stroke mimic
Kidwell et al,[19] 2000	1	United States	Field and ED	441	Suspected stroke
Karanjia et al,[38] 1997	2	United States	Neurology clinics	381	Stroke, TIA, or other neurological condition
von Arbin et al,[42] 1980	3	Sweden	Hospital	2252	Medical admissions
von Arbin et al,[66] 1981	3	Sweden	Stroke unit	206	Stroke unit admission
Panzer et al,[60] 1985	2	United States	Hospital	369	Suspected stroke
Oxbury et al,[69] 1975	3	United Kingdom	Hospital	93	Stroke
Tuthill et al,[71] 1969	3	United States	Stroke unit/ community hospital	202	Suspected stroke
Frithz and Werner,[72] 1976	3	Sweden	Hospital	344	Stroke, <70 y
Allen,[73] 1984	3	United Kingdom	Hospital	148	Stroke, <76 y
Henley et al,[74] 1988	2	United Kingdom	Hospital	172	Stroke
Fullerton et al,[75] 1988	3	Ireland	Hospital	206	Acute stroke
Britton et al,[76] 1980	2	Sweden	Stroke unit	200	Suspected stroke

Abbreviations: ED, emergency department; TIA transient ischemic attack.
*Levels of evidence[14]: level 1, the highest-quality evidence: independent, blind comparisons of test with a valid gold standard with large number of consecutive patients enrolled; level 2, high-quality study with independent, blind comparison of test with a valid gold standard with small number of consecutive patients enrolled; level 3, independent, blind comparison of test with a valid gold standard with patients enrolled in a nonconsecutive fashion, using a subset or smaller group who may have had the condition and generated definitive results on both test and gold standard.

kappa (κ) statistic (describes the agreement between paired observers beyond that predicted by chance), or the intraclass correlation coefficient (when there are more than 2 examiners) are given. Intraclass coefficients range from 0 to 1, with 0 indicating random agreement and 1 indicating perfect agreement. Random-effects estimates were used for the LR summary measures.

Table 2. The National Institutes of Health Stroke Scale*

Item	Response†
1a. Level of consciousness	0 = Alert 1 = Not alert 2 = Obtunded 3 = Unresponsive
1b. Level of consciousness questions	0 = Answers both correctly 1 = Answers one correctly 2 = Answers neither correctly
1c. Level of consciousness commands	0 = Performs both tasks correctly 1 = Performs one task correctly 2 = Performs neither task
2. Gaze	0 = Normal 1 = Partial gaze palsy 2 = Total gaze palsy
3. Visual fields	0 = No visual loss 1 = Partial hemianopsia 2 = Complete hemianopsia 3 = Bilateral hemianopsia
4. Facial palsy	0 = Normal 1 = Minor paralysis 2 = Partial paralysis 3 = Complete paralysis
5. Motor arm a. Left b. Right	0 = No drift 1 = Drift before 5 s 2 = Falls before 10 s 3 = No effort against gravity 4 = No movement
6. Motor 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. Ataxia	0 = Absent 1 = One limb 2 = Two limbs
8. Sensory	0 = Normal 1 = Mild loss 2 = Severe loss
9. Language	0 = Normal 1 = Mild aphasia 2 = Severe aphasia 3 = Mute or global aphasia
10. Dysarthria	0 = Normal 1 = Mild 2 = Severe
11. Extinction/ inattention	0 = Normal 1 = Mild 2 = Severe

*The actual form for recording the data contains detailed instructions for the use of the scale. Available at: http://www.ninds.nih.gov/doctors/NIH_Stroke_Scale.pdf. An online course for provider education is available at: http://asa.trainingcampus.net/uas/modules/trees/index.aspx.
†Score = sum of scores from each item.

RESULTS

Pre-hospital Assessment

Accuracy. Based on a prospective observational cohort study, when performed by a physician, the presence of any of 3 physical examination findings (facial paresis, arm drift, and abnormal speech) were selected from the National Institutes of Health Stroke Scale (NIHSS) as the most useful. These 3 items, selected by statistical recursive partitioning techniques, identified patients with stroke with 100% sensitivity (lower 95% confidence limit , 95%) and 88% specificity (95% confidence interval [CI], 82%-91%), positive LR=7.9 (95% CI, 5.6-11), negative LR=0 (upper 95% CI, 0.12), although the sensitivity fell to 66% with a similar specificity when this instrument was validated in the hospital setting.[17] Several schemes facilitate the rapid, accurate identification of stroke patients by emergency medical personnel.

The Cincinnati Prehospital Stroke Scale uses the 3 most important items (facial paresis, arm drift, and abnormal speech) derived from the NIHSS (TABLE 2),[17] In a prospective study, 1 of 2 emergency physicians certified in the use of the full NIHSS evaluated 171 patients (selected by a neurologist from either the emergency department or inpatient neurology service) with chief symptoms that suggested a possible stroke.[18] The examining physicians were aware of the patient's chief report, but not the presenting clinical signs or final diagnosis. Each patient also had separate examinations by 4 of 24 different emergency medical personnel, masked to all the clinical data. Based on data provided in the article, we calculated the LRs for increasing numbers of findings (0-3) for the physicians (TABLE 3). The same calculations can be done for the emergency medicine personnel, although the CIs are overstated because the findings are presented for the total number of examinations rather than unique patients. Nonetheless, the diagnostic accuracy for the emergency department physician compared to the emergency medical personnel was identical with the area under each receiver operating characteristic (ROC)=0.88. The presence of any single finding of the 3 created a sharp increase in the likelihood of stroke. After collapsing the data at a threshold of ≥1 finding vs 0 findings, the physician had an LR of ≥1 finding=5.5 (95% CI, 3.3-9.1) and an LR of 0 findings=0.39 (95% CI, 0.25-0.61); the emergency medical personnel had an LR of ≥1 finding=5.4 (95% CI, 4.1-7.0) and an LR of 0 findings=0.46 (95% CI, 0.38-0.56). Although this study did not evaluate the emergency medical personnel's diagnostic accuracy based on examinations performed in the field, this method of identifying patients with acute stroke is being widely used throughout the country and can be performed in less than a minute.

The Los Angeles Prehospital Stroke Screen (LAPSS) assesses for a unilateral arm drift, handgrip strength, and facial paresis.[19] The screen was evaluated prospectively on all noncomatose, nontrauma patients with neurological complaints compatible with stroke, who were transported by emergency medical technicians to a single hospital. The relevant neurological signs were altered consciousness, focal neurological signs, seizure, syncope, head pain, or a cluster category of weakness/dizziness/sick. The criteria for an in-the-field stroke diagnosis by the emergency medical technician were met when the patients were more than 45-years-old, had no seizure history, had symptoms for less than 24 hours, were not wheelchair bound or bedridden, had a blood glucose level between 60 and 400 mg/dL (3.3 and 22 mmol/L) and a unilateral deficit in 1 of the 3 findings previously listed. A reviewer, masked to the emergency medical personnel's evaluation, determined the final discharge diagnosis based on the emergency department chart. As compared with the final diagnosis, the

LAPSS had a sensitivity of 91% (95% CI, 76%-98%), specificity of 97% (95% CI, 93%-99%), positive LR of 31 (95% CI, 13-75), and negative LR of 0.09 (95% CI 0.03-0.27) for patients with possible stroke (TABLE 4). An analysis that included all ambulance runs showed even better specificity (and therefore a much higher positive LR) with only a slight decrement in sensitivity attributed to 2 stroke patients who were not correctly identified in the field as having a possible stroke, out of 1092 total ambulance runs (0.19%). Among all patients with neurologically relevant signs, the prevalence of stroke was 10%, which represents a useful anchor for prior probability estimates (Figure).

Reliability. The data assessing the CPSS compare emergency medical personnel with physicians for examinations performed in a controlled hospital setting rather than in the field.[18] The intraclass correlation coefficient (Pearson *r*) for the total score was 0.89 (95% CI, 0.87-0.92) among the prehospital care personnel and 0.92 (95% CI, 0.89-0.93) between the physician and the pre-hospital personnel. The greatest agreement was for arm drift (Pearson *r*=0.91; 95% CI, 0.89-0.93), followed by abnormal speech (Pearson *r*=0.87; 95% CI, 0.34-0.90) and facial palsy (Pearson *r*=0.78; 95% CI, 0.74-0.83).

Scenario. Using either the CPSS or the LAPSS, the patient would have been identified as likely to have had a stroke, triggering rapid transport to the nearest appropriate emergency department for further evaluation and treatment. Physicians should feel confident with the history and brief screening examination for stroke that is obtained by appropriately trained emergency first responders.

In the case of this patient scenario, the patient arrives at the emergency department and his wife reports that her husband has hypertension. He has no history of diabetes, seizures, or recent head trauma. He is being treated with aspirin and a diuretic. He continues to have difficulty moving his right arm along with trouble speaking.

Is My Patient Having a TIA or Stroke?

In the LAPSS study previously discussed, only 8% of 441 patients transported to the hospital for nontraumatic, noncomatose, neurologically relevant complaints had a final diagnosis of acute symptomatic cerebrovascular disease.[19] A variety of conditions can mimic TIA or stroke. Seizures,[20,21] neoplasms,[22] infection,[23] intracranial hemorrhage,[24] as well as hypoglycemia[25] and other metabolic abnormalities are among the conditions that can simulate a TIA and stroke. In another series, among 821 consecutive patients initially diagnosed with stroke, 13% were finally determined to have other conditions.[26] The most frequent causes of misdiagnosis were unrecognized seizures, confusional states, syncope, toxins, neoplasms, and subdural hematomas.

Transient Ischemic Attack. TIA is traditionally defined as a focal neurological deficit of ischemic origin of less than 24 hours duration.[27] Because most TIAs last less than 4 hours, the diagnosis is usually based on history rather than findings on examination.[28] However, many patients previously diagnosed with TIA actually had cerebral infarcts demonstrated on magnetic resonance imaging (MRI).[29] Clinically silent infarcts (and potentially infarcts associated with a classically defined TIA), may contribute to vascular dementia.[30] Traditionally defined TIA is an important marker of short- and long-term vascular risk. Of 1707 patients from a large health care plan in the United States evaluated in the emergency department and diagnosed with TIA, 5.3% had a stroke within 2 days while 10.5% had a stroke within 90 days.[31] The diagnosis of a stroke or TIA indicates the need for urgent management.

Accuracy of a TIA Diagnosis. Among patients admitted to a stroke unit for evaluation of an acute neurological deficit, a clinical diagnosis of TIA increased the odds of a final TIA diagnosis by about 20-fold (TABLE 5, positive LR=21; 95% CI, 10-42) while an alternate diagnosis greatly lowered the odds

Table 3. Comparison of Physician Assessment With That of Emergency Medicine Personnel*†

No. of Findings Present	Stroke	Nonstroke Diagnosis	LR (95% CI)
Physician assessment‡			
3	4	1	14 (1.6-121)
2	6	5	4.2 (1.4-13)
1	15	10	5.2 (2.6-11)
0	13	117	0.39 (0.25-0.61)
Emergency medical personnel§			
3	20	10	7.0 (3.3-14)
2	22	10	7.6 (3.7-16)
1	49	39	4.4 (3.0-6.4)
0	63	476	0.46 (0.38-0.56)

Abbreviations: CI, confidence interval; LR, likelihood ratio.
*Based on data from Kothari et al.[18]
†Collapsing data into a 2x2 table yields LR of ≥1 finding = 5.5; 95% CI, 3.3-9.1.
‡Data represent unique patients and stratum-specific LR.
§Data represent 4 examinations for each patient.

Table 4. Performance of Emergency Medicine Technicians on Stroke Assessment in the Field*

	Stroke Frequency/ All Patients	Positive LR (95% CI)	Negative LR (95% CI)
Ambulance runs for patients with target symptoms for possible stroke†	34/206	31 (13-75)	0.09 (0.03-0.27)
All patients transported by ambulance	36/1298	217 (90-526)	0.14 (0.06-0.31)

Abbreviations: CI, confidence interval; LR, likelihood ratio.
*Based on data from Kidwell et al.[19]
†Neurologic signs were altered consciousness, focal neurologic signs, seizure, syncope, head pain, and a cluster category of weakness/dizziness/sick.

of a TIA (LR 0.09; 95% CI, 0.02-0.34). The excellent performance of the clinical examination in this filtered population with a high probability of stroke probably does not extrapolate to the emergency setting where patients with neurologically relevant complaints have a broader differential diagnosis. In another study, about one third of patients initially diagnosed with TIA were eventually given a different diagnosis with TIA being definitely not established in an additional third.[32]

Reliability of a TIA Diagnosis. Despite its clinical importance, the reliability of the diagnosis of TIA can be poor. Agreement among experienced physicians for a patient's history of TIA is barely greater than chance (κ=0.11, see the footnote to **TABLE 6** for a guide to interpreting κ scores).[33] Some of the imprecision is due to differences in categorizing patients as having minor stroke or TIA, a distinction that has little impact on patient management. Even with a standardized protocol, disagreements frequently occur with regard to the features of the TIA. In 1 study, histories were obtained from 28 patients by pairs of neurologists.[34] Agreement in the number of TIAs was observed in about half of the cases. In two thirds of the cases there was agreement in the time of onset for the first TIA and the duration of the episode; there was agreement less than half the time in the frequency and type of symptoms. A new definition of TIA shortens the duration for qualifying episodes: "a brief episode of neurological dysfunction caused by a focal disturbance of brain or retinal ischemia, with clinical symptoms typically lasting less than 1 hour, and without [radiographic] evidence of infarction."[35] The accuracy of symptoms, signs, and the overall clinical impression using this new definition have not been studied.

There is fair agreement when minor stroke and TIA are considered together as a previous ischemic episode (κ=0.60).[33] Other studies suggest that substantial diagnostic agreement can be achieved when a standardized protocol for the 2 diagnoses is used (κ=0.65[36] and 0.77[37]). The Asymptomatic Carotid Atherosclerosis Study compared an algorithm for the diagnoses to both an on-site neurologist's diagnosis and that of an external panel of reviewers with expertise in stroke (ie, the gold standard).[38] The key symptoms were sudden change in speech, visual loss, diplopia, numbness or tingling, paralysis or weakness, and non-orthostatic dizziness. Comparing stroke or TIA vs no vascular event, there was 80% agreement between the external panel and the algorithm (κ=0.60; 95% CI, 0.52-0.68).

Stroke. The operational definition of stroke requires relevant, focal neurological symptoms with no other potential etiologies. Guideline statements from several professional societies recommend excluding systemic or other neurological processes that might cause the patient's acute deficit as part of the evaluation of the appropriateness of administering acute thrombolytic therapy.[39-41]

Accuracy of a Stroke Diagnosis. The results of studies on the accuracy of stroke diagnosis are given in Table 5. In 1 study, patients with the presence

Table 5. Estimates of the Accuracy of Classification of Stroke Type Based Solely on Clinical Data*†

Diagnosis	References	Positive LR (95% CI)	Negative LR (95% CI)
Stroke vs not stroke‡	42	40 (29-55)	0.14 (0.10-0.20)
TIA vs not TIA§	66	21 (10-42)	0.09 (0.02-0.34)
Hemorrhagic vs nonhemorrhagic stroke‖	60, 66, 78	3.1 (2.1-4.6)	0.61 (0.48-0.76)

Abbreviations: CI, confidence interval; LR, likelihood ratio; TIA, transient ischemic attack.
*Based on data from Goldstein and Matchar.[1]
†Only studies for which sensitivity, specificity, and LRs could be calculated are represented in the table.
‡Stroke vs not stroke, persistent neurological deficit of acute onset during the prior week without a history of head trauma, based on history and examination alone.
§TIA vs not TIA, focal neurological deficit with a duration of less than 24 hours, based on history and examination alone.
‖Estimates for hemorrhagic vs nonhemorrhagic stroke are summary estimates from random-effects measures.

Table 6. Precision of Elements of the Neurologic Examination of Stroke Patients

Finding	κ Score or Range*	References†
History		
Seizure at onset	0.39	33
Previous stroke	0.31	33
Transient ischemic attack	0.11	33
Vomiting at onset	0.35	33
Headache	0.36	33
Examination		
Level of consciousness	0.38-1.00	33,44,45,49-52,79
Orientation	0.19-1.00	33,44,45,48-52,79
Gaze preference	0.33-1.00	33,44,49-51,79
Visual field defect	0.16-0.81	33,44,46,49,51,79
Facial paresis	0.13-1.00	33,44-46,48-51,79
Arm strength	0.42-1.00	33,44-46,48-52,79
Leg strength	0.40-0.84	33,44-46,48-52,79
Limb ataxia	−0.16-0.69	44,49,51,52
Sensation	0.27-0.89	33,44,49,51,52,79
Language	0.54-0.84	33,44,45,49-52,79
Dysarthria	0.29-1.00	33,44,45,49,52
Neglect	0.58-0.89	44,49,51,52
Pupillary response	0.95	49
Plantar response	0.67	49
Gait	0.91	50

*The values of the κ statistic may be interpreted similar to the interpretation of correlation coefficients (κ = 0-0.20, slight; 0.21-0.40, fair; 0.41-0.60, moderate; 0.61-0.80, substantial; and 0.81-1.00, almost perfect agreement[80]).
†Among the cited studies, individual items were measured by different observers with varying degrees of experience.

of 4 findings were considered to have had a stroke if their history included a (1) persistent, (2) focal neurological deficit of (3) acute onset during the prior week, but (4) no history of head trauma.[42] This study, done before modern neuroimaging, relied on autopsy or stroke unit evaluations to establish the diagnosis in 39% of 2034 patients and consensus agreement for the remaining patients. Using this rule, emergency department physicians correctly identified 152 of 176 consecutive patients with stroke (sensitivity=86%; 95% CI, 81%-91%) and 1818 of 1858 patients without stroke (specificity=98%; 95% CI, 97%-99%). Thus, the odds of having a diagnosis of stroke increase dramatically when patients satisfy this classification rule are: positive LR of 4 findings=40 (95% CI, 29-55); negative LR=0.14 (95% CI, 0.10-0.20). Although this negative LR is low, neuroimaging studies may still be required to help diagnose conditions that may mimic stroke. Differences in the accuracy of the diagnosis of stroke based on either the interval between the onset of symptoms and time of presentation or the likelihood that the patients' symptoms and signs could be assigned to a specific vascular territory were not addressed. Data concerning the accuracy of the diagnosis for patients evaluated soon after the beginning of symptoms were lacking in this study, but the accuracy is particularly relevant given the advent of reperfusion therapies such as intravenous tPA that necessitate treatment within 3 hours of symptom onset.[39-41]

Reliability of a Stroke Diagnosis. High-quality studies of the reliability of the diagnosis of stroke are lacking.

Scenario. The prior probability of a stroke among patients with neurologically relevant symptoms is 10%. Based on his focal neurological symptoms, the LAPSS study[19] suggests that the LR for stroke is 31. Based on the clinical information obtained in the field and before the complete emergency department evaluation, the posterior probability for stroke is 78% ([from posterior odds=0.1/0.9] $\times$ 31=3.4). The emergency physician's confirmation that the patient had an abrupt onset of focal neurological symptoms and no known conditions that would increase the chances of a stroke mimic increases the likelihood of a stroke.

In the case of this patient scenario, the patient's blood pressure reading is 150/95 mm Hg. His pulse rate is 84/min and regular. He is alert, knows his age and the current month, and is able to follow simple verbal commands (NIHSS item 1a, 1b, 1c; Table 2). He has dysarthric speech (NIHSS item 10) and had difficulty naming common objects (ie, dysnomia; NIHSS item 9), but his speech is understandable. At rest, the patient tends to look only to the left, but on command he is able to look to the right (ie, a left gaze preference; NIHSS item 2). On asking him to identify your fingers at the periphery of his visual fields, you discover that he sees nothing to his right (a right homonymous visual field defect; NIHSS item 3). The right side of his face droops (a right lower facial paresis; NIHSS item 4), and when holding his arms straight out with the palms facing up his right arm drifts downward (a right-sided drift; NIHSS item 5). His right leg is slightly weak to motor testing, but does drift by a count of 5. (NIHSS item 6). He has no limb ataxia (the smoothness of movements is consistent with the amount of limb weakness; NIHSS item 7) but has diminished pain sensibility in his right arm (pin prick is described as feeling dull in his right arm as compared to his left; NIHSS item 8) . There is no evidence of spatial neglect (he is able to recognize being touched on his right arm and leg when touched on the right and left sides simultaneously; NIHSS item 11). A glucose level obtained by fingerstick was 110 mg/dL (6.1 mmol/L).

What Is the Vascular Distribution of the Stroke?

Accuracy of Determining the Stroke Distribution. Historical and objective data help localize the affected portions of the nervous system, providing clues about the likely pathophysiology and etiology (essential for rational secondary prevention).[40] Clinicians must recognize that computed tomographic (CT) scans are frequently negative during the first hours after ischemic stroke and technical limitations often impair CT imaging of posterior fossa structures. These limitations in early neuroimaging of the evolving stroke serve to emphasize the importance of the clinical examination. MRI scans, with greater sensitivity than CT, are often not available for immediate, routine patient evaluations.[43]

Reliability of Determining the Stroke Distribution. The clinical examination is most important despite its less than perfect accuracy early in the course of a stroke episode, when the initial imaging studies may not reveal the abnormality. An understanding of the reliability of the examination helps identify the clinical features that have potential utility. Clinical experience suggests that the reliability of individual elements of the neurological history and examination are important for the description of the stroke patient's neurological deficits (Table 6).[33,44-52] Obtaining historic data from stroke patients can be hampered because of the communication deficits caused by the stroke. Only 1 of these studies assessed the reliability of historical data.[33]

The reliability of historical items is generally low, ranging from slight to fair agreement between observers.[33] This is particularly noteworthy because so much of diagnosis, particularly of transient events such as TIAs, is dependent on the patient's history. The reliability of specific neurological examination findings improves when the examination is performed with knowledge of the patient's history, and when a full examination is performed in contrast to an examination aimed at a particular finding.[53] Several specific findings are assessed with high degrees of reliability (Table 6). However, in practice, anatomic diagnosis for neurological conditions requires recognition of the pattern of abnormal and normal findings, rather than a single finding.

Experienced physicians consider their own views of the reliability of given findings (ie, subjective sensory

Box. Oxfordshire Classification of Subtypes of Cerebral Infarction*

Total anterior circulation infarction syndrome (TACS)

A combination of new higher cerebral dysfunction (ie, dysphasia, dyscalculia, visuospatial disorder); homonymous visual field defect; and ipsilateral motor and/or sensory deficit of at least 2 areas of the face, arm, and leg.

Partial anterior circulation infarction syndrome (PACS)

Only 2 of the 3 components of the TACS syndrome are present, with higher cerebral dysfunction alone, or with a motor/sensory deficit more restricted than those classified as LACS (ie, confined to 1 limb or to face and hand, but not to the whole arm).

Lacunar infarction syndrome (LACS)

Pure motor stroke, pure sensory stroke, sensori-motor stroke, or ataxic hemiparesis.

Posterior circulation infarction syndrome (POCS)

Any of the following: ipsilateral cranial nerve palsy with contralateral motor and/or sensory deficit; bilateral motor and/or sensory deficit; disorder of conjugate eye movement; cerebellar dysfunction without ipsilateral long-tract deficit (ie, ataxic hemiparesis); or isolated homonymous visual field defect.

*Based on data from Bamford et al.[54]

abnormalities tend to be unreliable) when arriving at a specific anatomic diagnosis. Although neuroanatomical diagnosis can be complex, schemes have been developed that can be generally applied. For example, the Oxfordshire classification (used primarily in research settings) assigns 1 of 4 anatomic distributions (BOX).[54] When due to ischemia, the total anterior circulation infarction syndrome (TACS) reflects proximal occlusion of the internal carotid artery or trunk of the middle cerebral artery; the partial anterior circulation infarction syndrome (PACS) suggests a branch artery occlusion in the middle cerebral artery distribution; a lacunar infarction syndrome (LACS) indicates occlusion of a small penetrating vessel; and posterior circulation infarction syndrome (POCS) is consistent with vertebrobasilar distribution stroke. The reliability of this classification is moderate to good ($\kappa = 0.54$; 95% CI, 0.39-0.68).[55]

Scenario. This right-handed patient with unilateral right facial and limb weakness might have a lesion affecting contralateral central motor pathways at any level of the neuraxis above the midpons. However, when these findings are combined with an aphasia (manifest as a dysnomia), the patient's deficit is likely the result of a lesion affecting the dominant hemisphere. The greater involvement of face and arm as compared with his leg suggests an abnormality extending from the region of the Sylvian fissure toward the convexity, consistent with ischemia in the distribution of the left middle cerebral artery.

In the case of this patient scenario, the patient's examination result is consistent with a left middle cerebral artery distribution cerebral infarction fulfilling criteria for TACS. However, a neuroimaging study is necessary to help exclude a stroke mimic and to determine whether the patient may have had a brain hemorrhage. You request a brain CT scan.

Assigning Stroke Severity

Based on the information provided in Table 6, it is apparent that the reliability of specific items vary widely. During the course of care, and to guide prognosis, standardized assessments of a stroke patient's deficits improves the reliability of the routine neurological examination. Examples with supportive reliability and validity data include the Canadian Neurological Scale,[48] the Copenhagen Stroke Scale,[46] the Scandinavian Neurological Stroke Scale,[50] the Unified Neurological Stroke Scale,[56] and the NIHSS.[49] Of these, the NIHSS has been widely adopted for clinical care and research in the United States and other countries (Table 2). The scale and instructions are available as an online resource (http://www.ninds.nih.gov/doctors/NIH_Stroke_Scale.pdf, last accessed December 27, 2004). The reliability of the scale's individual items has been studied extensively (TABLE 7, data from some of these studies are included in the ranges given in Table 6). Using the highest values within each range, most items can have substantial to almost perfect levels of agreement. Using the lowest values, reliability can be as low as slight to moderate.

Recognition of the potential for limited reliability of some items has led to the development of a free online training and certification program sponsored by the American Stroke Association, in conjunction with the American Academy of Neurology (AAN) and the National Institute of Neurological Disorders and Stroke (NINDS). (http://asa.trainingcampus.net/uas/modules/trees/index.aspx, accessed December 27, 2004). With training, the NIHSS can be used reliably by non-neurologist physicians as well as nurses.[51,57] The NIHSS can also be scored with high reliability by remote observers via telemedicine (correlation between bedside and remote scores, $r = 0.955$, $P < .001$).[58]

The NIHSS scores correlate well with the size of the stroke as measured by MRI.[59] Therapeutically, a secondary analysis of the NIH tPA trial data found that the risk of intracerebral hemorrhage was independently associated with baseline stroke severity as assessed with the NIHSS divided into 5 categories (0-5, 6-10, 11-15, 16-20, and >20; odds ratio [OR] = 1.8; 95% CI, 1.2-2.9).[12] After tPA treatment, 17% of patients with a baseline NIHSS score >20 developed an intracerebral hemorrhage vs 3% to 5% with less severe strokes. Overall, those in the most severe category had the overall worst prognosis for recovery by 3 months, yet they were also the most likely to improve with tPA (OR = 4.3; 95% CI, 1.6-11.9). This information, derived from clinical observations, is helpful when discussing the risks and benefits of the treatment with patients and families.

Scenario. The example patient had an NIHSS score of 9 (item 2=1, item 3=2, item 4=2, item 5=1, item 8=1, item 9=1, item 10=1; Table 2).

In this case as the patient scenario continues, the patient's NIHSS Score was 9. He has a 22% risk of death or a poor outcome without reperfusion therapy. You need to determine whether he had a hemorrhagic or ischemic stroke to assess the appropriateness of thrombolysis.

Classifying the Stroke

Accuracy of Stroke Classification. It is not enough to determine whether the patient with an acute focal neurological deficit has had a stroke. Treatment with a thrombolytic or an antithrombotic drug is contraindicated in patients with hemorrhage. Three studies that provide information about the accuracy of history and physical examination in distinguishing hemorrhagic from ischemic strokes indicate that clinical judgment can be used to increase or decrease the likelihood of hemorrhage, but diagnostic errors occur (Table 5). In 1 study, a multivariate model showed that initial depressed level of consciousness, vomiting, severe headache, warfarin therapy, systolic blood pressure above 220 mm Hg, and glucose above 170 mg/dL (9.4 mmol/L) in a patient without diabetes increased the likelihood of hemorrhagic stroke.[60] The presence of any of these features more than doubles the odds of hemorrhage (positive LR=2.4; 95% CI, 1.8-3.2) and the absence of any of these features decreases the odds by one third (negative LR=0.35; 95% CI, 0.18-0.68). The other 2 studies described the accuracy of the physician's overall assessment without the use of a predictive model and produced results that performed similarly to the multivariate model (the results were statistically homogenous for the diagnostic OR, P=.99). Thus, the clinical judgment that a stroke is hemorrhagic has an LR=3.1 (95% CI, 2.1-4.6) while the assessment that the stroke is not hemorrhagic lowers the likelihood (LR=0.61; 95% CI, 0.48-0.76). The use of a complex discriminant score (based on specific historical and objective physical factors) modestly improves accuracy relative to clinician judgment, but is cumbersome and not clinically useful.[61] A neuroimaging study is mandatory before giving the patient a thrombolytic agent or anticoagulant.[39-41]

Reliability of Stroke Classification. Examining neurologists show only slight agreement on classifying a stroke as due to an infarct vs a hemorrhagic stroke (κ 0.38).[62]

Scenario. The patient was alert, not nauseated, did not have a headache, and was not receiving warfarin. His blood pressure was not severely elevated, and his blood glucose was normal. The chance of an intracerebral hemorrhage is low, but cannot be excluded without a neuroimaging study.

In this case, recognizing that the neuroimaging results may be inconclusive, you must consider whether there might be some other cause for his stroke and his likely stroke subtype diagnosis.

Ischemic Stroke Subtype Diagnosis

Accuracy of Ischemic Stroke Subtype. Ischemic stroke may be caused by a variety of pathophysiological conditions and mechanisms. The distinction between ischemic stroke subtypes is important to guide specific secondary prevention measures such as treatment with anticoagulants that are useful in patients with cardiogenic embolism. In contrast, anticoagulants are not useful for patients with atherothrombotic stroke.[63,64] Patients with carotid artery distribution symptoms who have an ipsilateral high-grade extracranial carotid artery stenosis benefit from carotid endarterectomy.[65] Simple clinical features useful at the bedside can help. For example, the acute onset of a focal neurological deficit in a patient with a cardiac or arterial embolic source increases the odds of embolic stroke up to nearly 11-fold (positive LR=11; 95% CI, 5.7-21), whereas the absence of these features decreases the odds of embolic stroke by approximately one quarter to one half [negative LR=0.36; 95% CI, 0.24-0.56).[66]

Reliability. Only a few studies have considered the reliability of classification of stroke type based solely on clinical findings. The available data indicate that a physician's assessment of ischemic stroke subtype based on history and physical examinations alone is not reliable. For example, the Stroke Data Bank Investigators found that agreement on classification of stroke subtypes (cardiogenic embolism, large artery atherosclerosis, tandem arterial pathology, lacunar stroke, infarct of unknown cause, parenchymatous hemorrhage, and subarachnoid hemorrhage) was poor (κ=0.15).[62] The combined poor accuracy and reliability means that radiographic and other tests are required to help identify the ischemic stroke subtype. The combination of the clinical findings and the neuroimaging results serves as the reference standard for determining the presence of an ischemic stroke.[67,68]

Scenario. After the clinical examination, accurate ischemic stroke subtype diagnosis typically requires neuroimaging and other studies (ie, echocardiography to identify a source for possible emboli).

In this case, the brain CT scan was interpreted as being normal. He was noted to have paroxysmal atrial fibrillation on a heart monitor during his CT examination. After careful review of the inclusion/exclusion criteria for intravenous tPA, he was treated beginning 2 hours after the onset of his symptoms for a presumed ischemic stroke. Noninvasive studies later showed no evidence of extracranial carotid artery stenosis.

Table 7. Reliability of NIHSS Items*

Item	κ Range
1a. Level of consciousness	0.46 to 0.68
1b. LOC questions	0.44 to 0.94
1c. LOC commands	0.41 to 0.94
2. Gaze	0.33 to 0.82
3. Visual fields	0.57 to 0.90
4. Facial palsy	0.22 to 0.74
5. Arm strength	0.77 to 0.97
6. Leg strength	0.39 to 0.98
7. Limb ataxia	−0.16 to 0.69
8. Sensation	0.39 to 0.89
9. Language	0.60 to 0.84
10. Dysarthria	0.29 to 0.72
11. Extinction/ neglect	0.53 to 0.89

Abbreviations: LOC, level of consciousness; NIHSS, National Institutes of Health Stroke Scale.
*Based on published data.[44,49,51,52]

Table 8. Prognosis Following Stroke Based on Clinical Data*

	Reference						
	69	71*	72*	73	74*	75*	76*
Score components							
Orientation		+	+	+	+	+	+
Level of consciousness	+	+	+	+	+	+	+
Neglect				+	+	+	
Language		+	+		+		+
Gaze preference	+	+	+				+
Visual field defect		+		+	+		
Facial paresis		+	+	+			+
Dysarthria				+			
Arm strength	+	+	+	+		+	+
Leg strength	+	+	+	+		+	+
Ambulation					+		
Plantar response		+					
Sensation		+	+	+	+		+
General function			+		+		+
Accuracy							
Mortality							
Sensitivity (95% CI), %	80 (55-93)	86 (77-92)	72 (63-79)	. . .	60 (48-72)	85 (76-91)	42 (26-61)
Specificity (95% CI), %	56 (41-70)	60 (51-68)	99 (97-100)		94 (87-97)	80 (72-86)	95 (90-98)
Positive LR	1.8 (1.2-2.8)	2.1 (1.7-2.7)	77 (19-305)	. . .	9.4 (4.5-20)	4.3 (2.9-6.2)	9.0 (3.7-22)
Negative LR	0.36 (0.13-1.02)	0.23 (0.13-0.42)	0.29 (0.22-0.38)		0.42 (0.31-0.58)	0.19 (0.12-0.31)	0.61 (0.44-0.84)
Disability†							
Sensitivity (95% CI), %	. . .	. . .	. . .	91 (83-95)	78 (64-88)	73 (60-83)	14 (7-26)
Specificity (95% CI), %				86 (73-93)	86 (74-93)	77 (60-88)	97 (91-99)
Positive LR	. . .	. . .	. . .	6.4 (3.2-13)	5.5 (2.8-11)	3.1 (1.7-5.8)	4.5 (1.2-16)
Negative LR				0.11 (0.05-0.21)	0.25 (0.15-0.44)	0.36 (0.22-0.56)	0.89 (0.79-0.99)

Abbreviations: CI, confidence interval; LR, likelihood ratio.
*Based on data from Goldstein and Matchar.[1] Ellipses indicate study did not provide relevant data.
†Predictions concerning disability refer to the chance of returning to independence in activities of daily living based on dichotomization into less vs more severe from impairment level scores including the indicated items as reflected in each total score's definitions provided in the source articles.

Table 9. Prognosis at 3 Months Based on the Baseline NIHSS for Patients With Ischemic Stroke*†

	NIHSS Score					
	0-3	4-6	7-10	11-15	16-22	≥23
Dead	1	2	4	9	18	34
Poor†	3	10	18	35	40	48
Good†	15	25	32	34	25	12
Excellent†	80	63	46	22	17	6

Abbreviation: NIHSS, National Institutes of Health Stroke Scale
*Based on data from Adams et al.[71] Data are presented as percentages.
†Outcome was determined based on the Glasgow Outcome Scale[81] and Barthel Index[82]: poor, Glasgow Outcome Scale<2 and Barthel Index<60; good, Glasgow Outcome Scale<2 or Barthel Index<60; excellent, Glasgow Outcome Scale≥2 and Barthel Index>60.

Prognosis

Patients with any combination of impaired consciousness, hemiplegia, and conjugate gaze palsy have a relatively higher mortality rate during the first 3 weeks after their stroke. Data from the prethrombolytic era showed that the presence of any of these findings had an LR=1.8 for death (95% CI, 1.2-2.8), while the absence of all 3 had a LR=0.36 (95% CI, 0.13-1.0).[69] Thirty-seven percent of those whose consciousness was initially impaired died, compared with no deaths among patients initially alert.[69] Several multivariable scoring systems have been developed to aggregate those findings believed by clinicians to reflect stroke severity and predict mortality (TABLE 8). These scores are calculated by adding points for abnormal clinical findings.

Predicting functional outcome among stroke survivors is more complicated than predicting survival.[70] The results of functional outcome assessments vary depending on when the assessments are performed and how outcome is measured. As with mortality, multivariate discriminant scores have also been used to predict dependency in activities of daily living (Table 8).[69,71-76] The NIHSS score not only provides a numerical summary of a patient's neurological impairments that allows monitoring for changes in the extent of deficits, but it also helps determine prognosis and the use of specific therapies. One study found that each additional point on the NIHSS, within 24 hours of stroke onset, was associated with a decrease in the likelihood of an excellent outcome at 7 days by 24% (OR=0.76; 95% CI, 0.72-0.80) and at 3 months by 17% (OR=0.83; 95% CI, 0.81-0.86).[71] As described above, the NIHSS predicts a patient's prognosis. Less than 20% of untreated patients with an NIHSS score of more than 15 at baseline recover to the point of having little or no disability.[77] Approximate point estimates predicting outcome at 3 months are based on NIHSS scores obtained within the first 24 hours of ischemic stroke (**TABLE 9**).[81,82]

Scenario. The example patient was alert, was not hemiplegic, and did not have a conjugate gaze palsy. He has a low likelihood of in-hospital mortality related to the stroke. Based on his NIHSS score of 9, he has an approximate 78% chance of having a good or excellent recovery by 3 months without treatment (Table 9). Twenty-four hours after receiving tPA, a brain CT scan showed no evidence of hemorrhage and he was administered warfarin for secondary stroke prophylaxis for an atrial fibrillation–related cardioembolic stroke. He was able to ambulate independently by the time of hospital discharge and his speech disturbance improved (NIHSS score of 4). He received outpatient physical, occupational, and speech therapy and had an NIHSS score of 2 after 3 months.

BOTTOM LINE

The history and neurological examination are critical tools for the identification and treatment of patients with suspected cerebrovascular disease. This is especially true in patients being evaluated soon after the onset of symptoms, before neuroimaging results are available, and in patients with transient symptoms in whom no parenchymal abnormality on brain neuroimaging may develop.

Among noncomatose patients without head trauma who have neurologically relevant symptoms for which stroke is a consideration, the prior probability of a TIA or stroke is approximately 10%.

The likelihood of stroke increases with the following acute neurological deficits: facial droop, arm drift, or a speech disturbance. Despite the increased odds of stroke in patients who satisfy this simple clinical rule (using the Cincinnati Pre-hospital Stroke Scale, positive LR=5.5; [95% CI, 3.3-9.1]), appropriate neuroimaging and other tests are still required to exclude other potentially treatable etiologies and to better define the stroke subtype.

Reliability is lowest for historical items and subjective findings (ie, the sensory examination). Reliability is higher for objective findings such as motor impairment. The astute clinician is aware of these differences when weighing the relative diagnostic implications.

The NIHSS is widely used for recording the clinical findings as it improves reliability and provides information helpful for determining a patient's prognosis and management. Reliability improves with experience, and Web-based resources are available for training and certification (www.asatrainingcampus.org).

Clinical findings may be suggestive of stroke type, but reliability is poor when the diagnosis is based solely on history and physical examination. Neuroimaging is required to exclude hemorrhage and other tests are necessary to help identify the ischemic stroke subtype. Ischemic stroke subtype is often never established with certainty during the process of care, so acute therapeutic decisions must sometimes be made with the knowledge that the ischemic stroke subtype diagnosis may be unreliable.

The severity of a patient's initial neurological impairments provides a useful guide for prognosis.

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