FROM RESEARCH TO PRACTICE

An Evidence-Based Approach to the Clinical Examination

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The history and physical examination of a patient remain the cornerstones of clinical medicine. Without an adequate history and physical examination to suggest possible differential diagnoses, the subsequent investigations of the patient may be endless (and fruitless). Although we rely heavily on the clinical examination, until recently there has been little formal evaluation of the information gained from these clinical encounters. A series entitled "The Rational Clinical Exam" in the *Journal of the American Medical Association* is now making a key contribution to our understanding by critiquing and summarizing the value of the evidence obtained during the initial patient-clinician encounter.¹ In each encounter, we gather information that aids us in establishing a relationship with our patients, generating diagnoses, estimating prognoses, and initiating and monitoring our patients' response to therapy.

Generating diagnoses is an iterative process that includes information gathering and hypothesis generation. Data acquisition may begin with the chief complaint, history of present illness, past medical history, and findings from the physical examination. Information gathered at any stage in the clinical examination may be sufficient for hypothesis generation and a partial diagnosis that prompts action. With each new piece of information, the diagnoses that are considered, and their relative likelihoods, may change. Thus, we can consider components of the history and physical examination as individual diagnostic tests, from which sequential information is obtained that helps to rule in or rule out specific diagnoses. As with laboratory diagnostic tests, when considering relevant clinical skills as diagnostic tests, we must understand their properties of reliability and accuracy, and the appropriate use of likelihood ratios (LRs).

To illustrate how the history and physical examination are used as diagnostic tests, we will follow a patient

through an encounter with a general internist. Our clinical focus will be the diagnosis of cerebrovascular and peripheral vascular disease. At each step of the interaction, we will highlight the relevant clinical skills literature and the related diagnostic test properties, and demonstrate how application of this evidence increases the physician's understanding of the patient's problems, and guides subsequent management decisions.

THE SCENARIO

Mr. Jones is an 80-year-old gentleman who presents to you, his general internist, for assessment after an elevated blood pressure of 180/90 mm Hg was noted at a walk-in clinic. During this visit, you have several important objectives. The first is to verify that Mr. Jones does have hypertension. The second is to evaluate the presence of end-organ damage and search for causes of secondary hypertension. On the basis of the clinical findings, you will decide if further investigations or treatment or both are warranted. The history and physical examination can fulfill these objectives, direct you in subsequent investigations that may be necessary, and guide initial management decisions.

In taking a careful history, you ask about previous blood pressure measurements and whether Mr. Jones has ever been diagnosed with hypertension. You inquire about salt consumption, alcohol use, and the use of any over-the-counter medications, such as cold remedies, which may cause hypertension.² In a search for end-organ damage, you review symptoms compatible with angina or myocardial infarction that would indicate the presence of atherosclerotic heart disease. You ask about neurologic symptoms, searching for the presence of cerebrovascular disease, and

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you ask a series of questions to diagnose intermittent claudication using the Edinburgh Claudication Questionnaire (Table 1).³ You consider the value of asking about symptoms in diagnosing either a transient ischemic attack (TIA) or claudication, which will be addressed below in the sections entitled Cerebrovascular Disease and Peripheral Vascular Disease. You conclude by asking about risk factors for atherosclerosis (diabetes, smoking), and eliciting information on Mr. Jones' past medical and surgical history, medications, diet, exercise, and other lifestyle data.

Mr. Jones reveals that he essentially feels well, although he has experienced some deterioration in his vision over the past few years. One month ago, he had a 45-minute episode of transient left hand weakness, which resolved spontaneously. His only hospitalization was 20 years ago for a herniorrhaphy. He takes no medications, is a non-smoker, and walks 1 km daily. He lives with his wife in their home.

On physical examination, you focus on evidence of cerebrovascular or peripheral vascular disease. As the nurse has already taken Mr. Jones' blood pressure (175/95 mm Hg), and appreciating the significant "white coat" effect on blood pressure,⁴ you begin with cerebrovascular disease.

CEREBROVASCULAR DISEASE

Reliability

As you initiate the examination, you reconsider whether Mr. Jones' symptom of transient left hand weakness truly reflects a TIA. Considering an item of clinical

examination as a diagnostic test, we must understand the reliability (also termed precision) of this test. As with laboratory investigations, reliability measures the reproducibility of the test results. With clinical skills, we are concerned with the reliability of the clinical examination for the same clinician reexamining the same patient for a specific finding (measurement of intraobserver variation) and the reliability of the clinical examination when another clinician examines the same patient (measurement of interobserver variation). In either case, we are capturing the likelihood of one or several clinicians recording a specific clinical finding for an individual patient examined at the same time.¹

As we know from clinical experience, attaining reliability in the clinical examination is difficult. Consider how often the clinical history appears to change as patients relate their history first to a medical student, then to the senior resident, then to the attending physician. If we rigorously attempted to record the presence or absence of a specific item of the history with each interview, we could measure the reliability of this item by calculating the agreement between or within observers examining the patient. We could simply report the percentage of agreement among the observers as the measure of reliability. However, purely on the basis of chance, we would expect some agreement between these observers. An alternative for reporting reliability is the weighted κ statistic, which assesses the agreement between observers beyond that expected by chance.⁵ A κ value of 0 indicates no agreement beyond that expected by chance, and a κ of 1.0 reflects perfect agreement between observers.

Before deciding on a diagnosis of TIA from Mr. Jones' history of transient left hand weakness, we need to consider the reliability of the history in the diagnosis of a TIA. Given that there is no single laboratory test to confirm the diagnosis of a TIA, we rely on the history. Specific clinical criteria for the diagnosis have been summarized through expert consensus and subsequently used widely in clinical practice.⁶ Essentially, these criteria define a TIA as the rapid development of neurologic symptoms, which usually develop in less than 2 minutes (if multiple symptoms, at the same time without a march) and resolve within 24 hours. The diagnosis of a TIA is excluded if symptoms such as syncope, confusion, convulsions, focal symptoms associated with migrainous headache, or scintillating scotoma are present.⁶ The interobserver reliability of history in the diagnosis of a TIA has been assessed in a few studies.⁷⁻¹⁰

In one study, 56 outpatients who had been referred to a tertiary care center with a presumptive diagnosis of TIA were independently examined by two neurologists within a 2-day period.⁷ Irrespective of the individual items of history, at the end of the interview, the neurologists were instructed to answer the question "TIA or not?" There was 86% agreement for this diagnosis, yielding a κ value of 0.65. This indicates substantial reliability of the clinical history as a whole for the diagnosis of TIA in outpatients.⁵ Most of the disagreements pertained to the

Table 1. Edinburgh Claudication Questionnaire (from Leng and Fowkes³)*

1. Do you get a pain or discomfort in your leg(s) when you walk?
If the answer is no, the person does not have intermittent claudication, and no further questions are asked. If the answer is yes, then the following five questions are asked:
2. Does this pain ever begin when you are standing still or sitting?
3. Do you get it when you walk uphill or hurry?
4. Do you get it when you walk at an ordinary pace on the level?
5. What happens to it if you stand still? (Options: Usually continues more than 10 minutes, or Usually disappears in 10 minutes or less).
6. Where do you get the pain or discomfort? For the latter question, a drawing of the legs from front and back allows the patient to draw the affected area.

*Scoring is based on the pattern of response, with a diagnosis of claudication requiring "Yes" to questions 1 and 3, "No" to question 2, and "Usually disappears in 10 minutes or less" to question 5. Question 4 distinguishes grades of severity. Question 6 distinguishes "definite" claudication (if the calf is involved) from atypical claudication (thigh or buttocks pain in the absence of calf pain). Other patterns are not considered indicative of claudication. Reprinted by permission of the publisher from the *Journal of Clinical Epidemiology*, Volume 45, pp. 1101-1109. Copyright 1992 by Elsevier Science, Inc.

mode of onset or accompanying symptoms for the event.⁷ In a separate study, neurologists demonstrated highest agreement for the presence of motor symptoms (76.4% agreement) compared with verbal, visual, and sensory symptoms (63.6–65.3% agreement).⁸ The reliability of two neurologists in assigning a vascular territory to the symptoms (carotid, vertebrobasilar, or uncertain) was a κ of only 0.31 (fair reliability).^{5,7}

When a standardized checklist of TIA symptoms was completed before the neurologist indicated a diagnosis of TIA or not, the interobserver reliability in the diagnosis of TIA improved to a κ of 0.77, indicating substantial agreement between observers.^{5,9} Although the examiners still disagreed most frequently about the mode of onset and mode of disappearance for the episodes, there was higher agreement on the vascular territory, with a κ of 0.65.

In contrast, among in-hospital patients with stroke, assessment for a past history of a TIA by four independent neurologists was less reliable, with 29% complete agreement yielding a κ of 0.19, indicating only slight agreement between observers.^{5,10} Possible explanations for this lower reliability compared with that of the previous outpatient studies include the potential inability of ill inpatients to recall past events clearly and the greater number of assessors for these patients.

On closer questioning, Mr. Jones reveals that his episode of transient left hand weakness occurred 1 month ago. It began abruptly while he was washing dishes, causing him to drop a cup, and lasted for approximately 45 minutes. No other symptoms accompanied the weakness, and it has never recurred. From this information, you conclude that Mr. Jones did suffer a TIA last month and, given the substantial reliability of this overall assessment, are fairly confident in the diagnosis.

Accuracy

Returning now to the physical examination, you note that all of Mr. Jones' peripheral pulses are palpable, but during auscultation with the bell of your stethoscope placed between the upper thyroid cartilage and the angle of the jaw,¹¹ you note a right carotid bruit. Remembering Mr. Jones' symptoms, which were consistent with a TIA, you consider the usefulness of a symptomatic carotid bruit in predicting the degree of carotid stenosis.

In a study investigating the precision of the clinical examination for carotid bruits, a κ of 0.67 for the presence and 0.69 for the location of asymptomatic bruits was demonstrated between two experienced clinicians,¹² indicating substantial agreement.⁵ Their precision in further characterizing the intensity, pitch, and duration of the bruits was poor; κ was less than 0.4.

When evaluating items of the clinical encounter as diagnostic tests, we must consider the accuracy of the clinical findings as well as assessing their reliability. Accuracy is a measure of the correctness of the clinical examination in detecting (or not detecting) disease, when the patient

truly has (or does not have) the disease of interest. The accuracy of the clinical examination in detecting abnormalities is best assessed by comparing the clinical findings with a reference standard, referred to as the "gold standard," which is taken to represent "truth."¹³ The measurement of reliability is an inherent component of accuracy measurements. If ascertainment of a clinical finding is not reliable, the finding will not be accurate when compared with the reference standard. However, the converse is not true; for even if an item of the clinical examination is reliable, its accuracy may still be poor.

As we consider each item of the history or physical examination akin to a diagnostic laboratory test, we can determine the test properties that measure accuracy, namely, sensitivity and specificity. Sensitivity measures the ability of the clinical skills maneuver to detect the disease of interest when the disease is truly present. Conversely, specificity assesses how often the clinical examination is negative when the disease is absent.¹

Although sensitivity and specificity have been used extensively in the clinical skills literature, their usefulness is limited. The sensitivity or specificity of a clinical examination maneuver described for one population may vary in another population if the spectrum of disease severity changes as the disease prevalence varies across populations.¹ In addition, sensitivity and specificity measure accuracy from the perspective of how a diagnostic test performs in a population, as opposed to the clinically more relevant perspective of an individual patient with a given clinical finding.

A useful alternative measure of accuracy is the LR, which quantifies how a particular test result increases or decreases the probability of a patient having a specific disease. It expresses the odds that an individual item of history or physical examination would be present, or not present, in patients with the disease of interest compared with the same finding in patients without the disease. It is used in combination with knowledge about an individual patient, in order to determine the probability that this patient has (or does not have) the disease of interest.¹

We begin any patient encounter with knowledge of the prevalence of disease in the population where we practice. Using the clinical examination as the diagnostic test, prevalence represents an individual patient's pretest probability of having a disease. Once we detect a clinical finding in our patient, we can apply the LR for this clinical finding to the patient's pretest probability, to obtain the posttest probability of the disease. (This can be done through a series of calculations or using the nomogram presented in Fig. 1.) Although there are many methods of calculating the LR for any clinical finding, the simplest formula for the LR associated with a positive finding is $\text{Sensitivity} / (1 - \text{Specificity})$. Conversely, the formula $(1 - \text{Sensitivity}) / \text{Specificity}$ generates the LR when the clinical finding is absent.¹

A rough guide for the interpretation of LRs is that those above 10 or below 0.1 generate large and often con-

FIGURE 1. Nomogram for diagnostic test interpretation. A straight line is applied from the patient's pretest probability, through the diagnostic test likelihood ratio, to yield the patient's posttest probability of disease. (Adapted from: Fagan TJ. Nomogram for Bayes's theorem (C). *N Engl J Med*. 1975;293:257.)

clusive changes in the probability of a given diagnosis; LRs in the range of 5 to 10 or 0.1 to 0.2 generate moderate and usually useful shifts in pretest to posttest probability; LRs in the range of 2 to 5 or 0.5 to 0.2 generate small but sometimes important changes in probability; and LRs in the range of 1 to 2 or 0.5 to 1 will alter the probability of a given condition to a small and rarely important degree.¹ We have included the likelihood ratios associated with common clinical findings in cerebrovascular and peripheral vascular disease in Table 2.

What is the LR associated with a symptomatic carotid bruit? Using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) database, a randomized controlled trial of surgical versus medical therapy for symptomatic high-grade carotid stenosis, investigators found a sensitivity of 63% and a specificity of 61% for a carotid bruit in the presence of high-grade stenosis. The corresponding LR is 1.6 (95% confidence interval 1.4–1.8), indicating that the presence of a carotid bruit adds little information in the diagnosis of symptomatic high-grade carotid artery stenosis.¹⁴ Mr. Jones, for example, has a pretest probability of significant stenosis estimated from the NASCET study of 52%.¹⁵ If we apply the LR of 1.6 to this value, using the nomogram in Figure 1, we obtain a posttest likelihood of 63%. As these pretest and posttest values are not very different, our management of Mr. Jones is unlikely to change on the basis of the physical examination alone. As patients with high-grade stenosis have a lower incidence of stroke after carotid endarterectomy compared with medical therapy,¹⁵ you consider using noninvasive testing to help determine Mr. Jones' degree of stenosis.

Before ordering any laboratory tests, however, you continue the physical examination by moving to the precordium to complete the examination of Mr. Jones' cardiac system. Mr. Jones has a normal apical impulse and normal heart sounds. You move on to an examination for evidence of peripheral vascular disease.

PERIPHERAL VASCULAR DISEASE

In the Systolic Hypertension in the Elderly Program (SHEP) study,¹⁶ in a population demographically similar to Mr. Jones, 26% of the cohort had peripheral vascular disease by noninvasive monitoring while only 6% were symptomatic with intermittent claudication.¹⁷ Regardless of symptoms, peripheral vascular disease had an associated relative risk of death from all causes of 3.8 and death from cardiovascular causes of 3.2.¹⁷ Thus, the presence of either symptomatic or asymptomatic peripheral vascular disease will modify Mr. Jones' prognosis and subsequent interventions.

During your history taking, you used the Edinburgh Claudication Questionnaire,³ outlined in Table 1, to ascertain whether Mr. Jones had any symptoms of claudication. The questionnaire was validated using duplicate examination of each patient by two experienced clinicians as the gold standard, supplemented by noninvasive testing as required. It was found to have a sensitivity of 91%, a specificity of 99%, and an LR of 90;³ positive responses to the questions unequivocally indicate the presence of peripheral vascular disease. In this setting, the role of physical examination is to establish the severity of the disease and assess the need for surgical referral in select cases.

In asymptomatic patients such as Mr. Jones, however, physical examination has a role in establishing the

Table 2. Common Likelihood Ratios for the Clinical Examination of Cerebrovascular and Peripheral Vascular Disease

Clinical Finding (reference)	LR for a Positive Test Result*	LR for a Negative Test Result†
Carotid bruit ¹⁴	1.6	0.6
Edinburgh Claudication Questionnaire ³	90	0.1
Abnormal femoral pulse ¹⁸	7.1	0.9
Femoral bruit ¹⁸	4.7	0.8
Abnormal dorsalis pedis pulse ¹⁸	1.9	0.7
Abnormal posterior tibial pulse ¹⁹	4.6	—‡
Ankle-brachial index ²⁰ (positive test = ABI < 1.0)	8.6	0.03

*LR for a positive test result = Sensitivity/(1 – Specificity).

†LR for a negative test result = (1 – Sensitivity)/Specificity.

‡Results not given.

presence or absence of peripheral vascular disease. We will consider two studies that have assessed the diagnostic test properties of these physical findings. One trial assessed 624 hyperlipidemic patients and used noninvasive testing by Doppler ultrasound as the diagnostic gold standard for peripheral vascular disease.¹⁸ The second trial assessed 218 general medicine outpatients and compared their physical findings to the ankle-brachial index (ABI) as the gold standard diagnostic test.¹⁹

When examining the lower extremities, you begin with the femoral pulses. Neither a normal nor an absent pulse will help, but the finding of an abnormal pulse (abnormalities of either the amplitude or contour of the pulse) has an LR of 7.1 for predicting angiographically significant peripheral vascular disease.¹⁸ A femoral bruit has an LR of 4.7. Palpation of the dorsalis pedis is not useful as its LR approaches 1.0. However, absent posterior tibial pulses are associated with an LR of 4.6.¹⁹

Another useful clinical maneuver to establish the diagnosis of peripheral vascular disease is the calculation of the ABI. Bedside ankle and brachial systolic blood pressures are recorded using Doppler auscultation, and the ratio of the ankle to arm pressures is calculated. The ABI has high reliability with a κ of 0.77 to 1.0 calculated for interobserver reliability between experienced general internists.¹⁹ An index of less than 1.0 correlates with significant narrowing on angiography and has an LR of 8.6.²⁰ A value of less than 0.9 carries a threefold to fourfold relative risk of all-cause and cardiovascular death, demonstrated in two controlled clinical trials.^{17,21} In examining Mr. Jones you discover a left femoral bruit together with an abnormal left femoral pulse. The rest of the examination of his lower extremities is normal, but his ABI is 0.8.

How will you use this constellation of clinical findings? One advantage of the current literature on clinical examination is that the studies yield information on the individual items of the clinical exam that are most useful. It is tempting to use these LRs sequentially, with the posttest probability from one physical finding giving rise to the pretest probability for the next. However, as many of these physical findings coexist in an individual patient and are

not independent findings, this approach will yield an inaccurate likelihood of disease. When studies assess components of the clinical examination as independent items, this reduces the apparent accuracy of the overall examination because interrelated findings are treated as if they were independent of each other, and each finding in isolation will most likely be less accurate than the constellation of findings.

In addition, many studies of the clinical examination have not measured the accuracy of the normal clinical examination performed by clinicians, in which individual components of the examination are rarely considered in isolation. More practical studies consider a number of clinical findings together, and either measure the accuracy of the clinical examination as a whole or create clinical prediction rules based on a number of significant findings.

You decide to apply the likelihood associated with a positive ABI, as opposed to the less accurate findings of the femoral bruit or abnormal femoral pulse, to determine Mr. Jones' probability of peripheral vascular disease. From the SHEP data, you know his pretest probability of peripheral vascular disease is 26%.¹⁶ Applying the LR of 8.6 to this value, using the nomogram in Figure 1, you obtain a posttest likelihood of 75%, which indicates that Mr. Jones, more likely than not, has asymptomatic peripheral vascular disease.

CONCLUSIONS

As more than 15 minutes have passed since Mr. Jones first entered the office, you measure his blood pressure. Using the correct cuff size, and carefully following the American Heart Association guidelines,²² you record two blood pressure measurements from each arm at 1- to 2-minute intervals in the supine position, obtaining readings of 170/90 and 165/95 mm Hg in the right arm, and 175/90 and 165/90 mm Hg in the left arm. You repeat these measurements in the standing position, with comparable results. These maneuvers are important to minimize the factors that threaten the accuracy of the office blood pressure measurement.²³ You are reluctant to label

Mr. Jones with the diagnosis of hypertension based on indirect measurements from a single office visit, but your measurements, in combination with similar blood pressure values recorded at the walk-in clinic during two previous visits, increase your confidence in the diagnosis.

Having assessed Mr. Jones for the diagnosis of hypertension, cerebrovascular disease, and peripheral vascular disease, you finish the examination by looking for obvious causes of secondary hypertension, such as an epigastric systolic-diastolic bruit suggesting renovascular disease.²⁴ Considering Mr. Jones' TIA, you complete a screening neurologic examination. Discovering no further abnormalities, you review your initial objectives for this patient encounter and your subsequent findings.

First, you wanted to verify that Mr. Jones does have hypertension. On the basis of the examination, you conclude that he does and plan to discuss appropriate anti-hypertensive therapy with him. Second, you wanted to assess any evidence of end-organ damage. At the end of the encounter, you know that Mr. Jones requires further investigation for significant carotid stenosis with Doppler ultrasound of his carotids. Although asymptomatic, he has evidence of peripheral vascular disease, which you note for future discussion.

Considerable evidence regarding the utility of clinical skills is available in the literature, including data on the reliability and accuracy of elements of the history and physical examination. By approaching information from the clinical encounter as diagnostic test data, we increase or decrease our confidence in specific diagnoses. As practicing clinicians, we are aware of the prevalences of various diseases in the population we care for, which serve as baseline pretest probabilities of disease in an individual patient. During the clinical encounter, we determine the presence or absence of individual clinical findings. From clinical studies, we gain information about the reliability and accuracy of these findings. We can apply the relevant LR's to the patient's pretest probability using a nomogram to determine the probability that the patient has (or does not have) a specific disorder. Using evidence to help interpret features of the clinical examination may stimulate us to initiate or participate in future studies assessing the reliability and accuracy of the clinical examination, thereby improving our understanding of the most important, and basic, of our clinical skills.

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