

A screening procedure to detect persons with a stroke is presented and data on its effectiveness are offered.

A Screening Procedure for Stroke

Introduction

Detecting cases of stroke is a major problem in studying prospectively the epidemiology of this condition. Although the diagnosis must be made on the basis of a history and physical examination by a physician, preferably a neurologist, it is often not practical to have physicians periodically examine all members of the cohort. The interval between reexaminations should be short because the history and signs of minor events may become blurred with time, particularly among elderly persons in whom the majority of strokes occur. If the cohort is a sample of a community, the expense and logistical problems of bringing subjects and physicians together at frequent intervals are great. Also, most subjects will not have had new events of stroke, and the routine of frequent reexamination becomes onerous for subjects and physicians.

For these reasons it is desirable to have a screening procedure which is brief, can be performed in the subjects' homes, does not require a physician except in a supervisory capacity, and will categorize the sample into a large group of subjects who probably have not had stroke and a small group who probably have had stroke. The latter group of subjects can then be referred for diagnostic examination.

A screening procedure to make such categorizations was developed for a prospective study of the epidemiology of stroke. This paper describes the procedure and presents data on its effectiveness.

Procedures

The design of the epidemiologic study has been described in detail previously.¹ Briefly, the cohort comprised a probability sample, balanced by sex and race, of noninstitutionalized persons who were 65 to 74 years of age and received Old Age Assistance in Cook County, Illinois. This county includes Chicago and many of its suburbs. The subjects were initially examined by a team of physicians, field workers, and medical technicians in order to measure the independent variables and to identify cases of existing stroke. The intake phase extended from September 1965 to August 1967, during which time 3,141 persons were examined.

Insofar as possible, subjects who did not have stroke diagnosed at the initial examination have been visited every six months thereafter so as to detect new cases of stroke. The field workers making these visits were women of middle age. One had a baccalaureate degree; the others were high school graduates. None had prior experience in medical interviewing.

The screening procedure comprised a set of specific questions about symptoms of stroke and an abbrevi-

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viated neurological examination. All information was recorded on standard forms. The completed forms were mailed daily to the central office where the research supervisor compared the current findings with the results of the initial examination and previous screening visits. Subjects were referred for diagnostic examination if results of the screening visit indicated the presence of a new neurologic deficit. These subjects were asked to come to the study's clinic for examination, and transportation was provided for those who agreed. Arrangements were made for examination in the home of subjects who could not or would not attend the clinic.

The diagnostic examination comprised a detailed neurologic history and examination. The physician was furnished with a narrative summary of the reasons for referral in order that his own summary of the case would, in part, be directed specifically to the field worker's findings. Results of the diagnostic examination were recorded on standard forms and the physician also dictated a narrative summary of his findings and conclusions according to a standard outline. During the period of time covered by this report, June through December of 1969, the diagnostic examinations were performed by three physicians. One is a board-certified internist and fully-trained neurologist. The second was in his third year of residency training in neurology and, in addition, had two years of training in internal medicine. The third physician was in his second year of residency training in neurology. All results of diagnostic examinations were reviewed for completeness and adherence to criteria by a fourth, supervising neurologist.

Stroke was diagnosed if there was a history of cerebral dysfunction which was compatible with occlusive or hemorrhagic involvement of one or more neck or intracranial arteries. The deficit must have occurred suddenly, lasted at least 24 hours, and showed some degree of improvement after the time of maximal involvement. In the absence of a history, stroke was also diagnosed if the neurological examination revealed signs which could best be interpreted as residua of stroke.

Experience with the screening procedure first employed in this study indicated that the questions asked by the field workers were too general. Many persons in this elderly population have multiple complaints involving many organ systems. The field workers were taking much time to record these complaints and the results were often difficult to interpret at the central office. Thus, a revised form of

the screening procedure was initiated in June 1969. The primary questions used to detect possible cases of stroke are listed below.

1. Do you think that you have ever had a stroke?
2. Has a doctor ever said that you had a stroke?
3. Has one whole side of your body, both your arm and your leg on the same side, ever suddenly gone weak or lost its strength?
4. Has just one arm ever suddenly gone weak or lost its strength?
5. Has just one leg ever suddenly gone weak or lost its strength?
6. Has just one side of your face ever suddenly gone weak or drooped?
7. Has one whole side of your body, both your arm and your leg on the same side, ever suddenly lost its feeling, or felt numb, or like "pins and needles?"
8. Has just one arm ever suddenly lost its feeling, or felt numb, or like "pins and needles?"
9. Has just one leg ever suddenly lost its feeling, or felt numb, or like "pins and needles?"
10. Has just one side of your face ever suddenly lost its feeling, or felt numb, or like "pins and needles?"
11. Have you ever suddenly gone completely blind in just one eye, and then the eye got better again?
12. Have you ever seen double? Not just dimming or blurring, but actually seeing double?
13. Have you ever suddenly had trouble talking, and then it got better again? (If answered "yes") Were the words slurred, as if you had a mouthful of mush? Did you have trouble thinking of the words that you wanted to say?
14. Have you ever fallen to the ground for no reason at all without feeling dizzy or faint or blacking out?

A positive reply to any one of these questions led to a series of probes about when the event occurred, a description of the event, its duration, frequency and course. The field workers also asked whether or not a physician had been consulted and, if so, recorded the date, name and address. Any subject giving a positive answer to one or more of the primary questions listed above was referred for diagnostic examination unless responses to the probes showed clearly that the symptom was non-neurological or was related to a previously diagnosed disease.

The instructions and questions used to guide the field workers' neurological examination are listed below. The form provided responses for indicating both the presence of a condition and its laterality. Instructions to the subject are shown in quotation marks. In contrast to the questions listed above, these instructions were not intended to be given verbatim to the subject but were listed primarily to serve as an aid to memory for the field worker.

1. "Look straight at me." Do both eyes look straight at you?
2. Does one upper eyelid droop more than the other?
3. Does one lower eyelid droop more than the other?
4. Are nose-to-mouth lines equal and present on both sides?
5. "Smile as wide as you can." Do the lips stretch back the same on both sides?
6. "Hold arms straight out for 1 minute. Close eyes." Are both arms held straight out in front?
7. Does one arm drift more than the other?
8. "Hold wrist and fingers stiff." Bend right wrist, then left. Is one wrist weaker than the other?
9. "Touch thumb to fingers one after the other 3 times,

first with the right hand, then with the left." Is one hand much slower than the other?

10. "Rest hands with palms down. Close eyes. Where do you feel the touch?" Touch right knuckle, then left, then both at the same time. Does subject feel both touches?
11. "Stand with feet together for 1 minute. Don't hold on." Does subject lose balance or refuse to do because he will lose balance?
12. "Walk 8 feet, turn and walk back." Are there less than 6 inches between feet while walking?
13. Are both feet lifted off of floor?
14. Does subject turn with several short steps?
15. Are the toes lifted on both feet?
16. Does one leg swing out?
17. Do the arms swing equally?
18. Is subject confused about day or date, about who or where he is?
19. Is the speech abnormal?

The field workers were instructed in these procedures by the supervising neurologist, and he observed their practice by having them individually examine subjects referred for diagnostic examination. In the absence of symptoms reported on the questionnaire, subjects were also referred for diagnostic examination if the field worker's examination elicited signs of a previously undetected deficit.

Data from the routine screening visits and diagnostic examinations have been analyzed to estimate the frequency with which persons who have not had stroke were referred by the screening procedure for diagnostic examination. In order to estimate the frequency with which the screening procedure failed to identify persons who had had a stroke, a probability sample of 100 subjects was referred for diagnostic examination from the population of 267 persons with negative screening results in December 1969 and early January 1970. Since the usual procedure for referral included a note on the reason for referral and since examination of these 100 subjects resulted in a marked increase in the number of referrals, it was unavoidable that the neurologists knew that these subjects were being examined in order to check the rate of false negatives.

Results

From June 19, 1969, through December 31 of that year, 1,772 subjects were screened using the revised procedure, and 169 (9.5 per cent) had positive results. However, 37 subjects with positive results were not referred for diagnostic examination because the symptoms were associated with previously diagnosed stroke. Of the 132 subjects referred for diagnostic examination, 12.1 per cent (16 of 132) were not seen; 7 had died, 6 could not be located, 2 refused, and 1 had moved out of state. Results of the remaining 116 subjects are shown in Table 1. Since persons with stroke at initial examination were not included in this cohort, these data should not be used to estimate the prevalence of stroke or the frequency of positive screening results in the general population.

The neurologists diagnosed stroke in 32 (28 per cent) of these 116 subjects. Another 13 subjects (11 per cent) were found to have had transient ischemic attacks without evidence of completed stroke, and 71 subjects (61 per cent) were negative for stroke or transient ischemic attacks. In 16 (50 per cent) of the 32 cases of stroke, the

neurologist was able to obtain a history of a stroke. The history was equivocal or negative in the remaining cases and the diagnosis was based primarily on the presence of signs. In 47 per cent of cases (15 of 32), the neurologist was unable to obtain a history that the stroke had been previously diagnosed.

Of the 100 subjects selected to estimate the frequency with which the screening procedure failed to identify persons with stroke, diagnostic examination was completed on 92. Five subjects refused consent for the examination, 1 had died, and 2 could not be located. Seven (7.6 per cent) of the 92 subjects were found by the neurologist to have had a stroke previously undetected by this study. From these data it is calculated² that the proportion of false negatives in the total population probably lies in the 95 per cent confidence interval between .03 and .15.

The evidence on which the diagnosis of stroke was based in these seven cases is summarized below because this information is important in judging the sensitivity of the screening procedure.

BD393: No history of neurological deficit. Minimal weakness of left upper extremity found.

CW077: History of weakness in left hand occurring about 3 months ago and slowly improving since then. Weakness of the left hand and some weakness of extension at the left elbow found.

CV834: No history of neurological deficit. Right deep tendon reflexes greater than left in upper extremities and strong suggestion of a positive right toe sign found.

CM734: History of frequent episodes of weakness and numbness primarily in the left leg although similar problems have also occurred in the right leg. Markedly increased deep tendon reflexes in the right leg and decreased response to pinprick in the right leg and right arm found at examination.

GF105: History of weakness and numbness in right arm and possibly numbness of left face. Some weakness in right arm and decreased response to pinprick in right arm and left face found.

LG085: No history of neurological deficit. Slightly decreased right nasolabia fold and somewhat greater deep tendon reflexes in the right upper extremity found at examination.

MV230: History of episodic numbness in right lower extremity. Deep tendon reflexes greater in the right upper and lower extremities and minimal weakness of right lower extremity found at examination.

Only one of these cases, CW077, gave a history typical of stroke, and the deficit in this case involved only the left hand. The neurologist elicited a history of neurological deficit in three other subjects, but these histories by themselves would not be diagnostic of stroke. In none of the cases was the deficit apparently associated with significant disability.

Discussion

These data indicate that the screening procedure did categorize the sample into a large group in which the probability of stroke was low and a small group in which

Table 1—Results of Neurological Examination, by Reason for Referral, Chicago Stroke Study, June-December 1969

| "Stroke" | Reason for referral | | | Total referred | Results of diagnostic Examination | | | Per cent with CVA |
|----------|---------------------|---------------|------------------------------|----------------|-----------------------------------|----------|-----|-------------------|
| | History | | Signs of unilateral weakness | | Negative | TIA only | CVA | |
| | Unilateral weakness | Other deficit | | | | | | |
| + | + | + | + | 28 | 16 | 1 | 11 | 39 |
| + | + | + | | 6 | 4 | 0 | 2 | 33 |
| + | + | | + | 3 | 1 | 0 | 2 | 66 |
| + | + | | | 2 | 1 | 0 | 1 | 50 |
| + | | + | + | 5 | 4 | 0 | 1 | 20 |
| + | | + | | 4 | 4 | 0 | 0 | 0 |
| + | | | + | 4 | 4 | 0 | 0 | 0 |
| + | | | | 4 | 3 | 0 | 1 | 25 |
| | + | + | + | 16 | 9 | 2 | 5 | 31 |
| | + | + | | 2 | 1 | 1 | 0 | 0 |
| | + | | + | 8 | 6 | 1 | 1 | 12 |
| | + | | | 2 | 1 | 1 | 0 | 0 |
| | | + | + | 14 | 7 | 4 | 3 | 21 |
| | | + | | 11 | 7 | 3 | 1 | 9 |
| | | | + | 7 | 3 | 0 | 4 | 57 |
| | All subjects | | | 116 | 71 | 13 | 32 | 28 |

The "+" sign indicate the reasons for referral in each row of the table.

the probability of stroke was high. Of importance in judging the merits of a screening procedure that actively seeks new cases of stroke is the observation that 47 per cent of these cases (15 of 32) apparently had not had the stroke previously diagnosed and would have been missed by a stroke registry dependent upon hospital admissions or physician visits. In addition to these 32 subjects, another 37 persons also had positive screening results and would ordinarily have been referred except that the symptoms were associated with a stroke previously identified by this study. If these 37 persons were included, 45 per cent of persons with positive screening results (69 of 153) would be cases of stroke.

Diagnostic examination by neurologists of 92 subjects with negative screening results detected 7 cases of stroke that had been missed previously. Thus, the rate of false negative cases in the sample is 7.6 per cent and the rate in the population probably lies in the interval between 3 and 15 per cent, i.e., the 95 per cent confidence interval. None of these seven cases had significant disability associated with the stroke, and only one gave a history typical of stroke. However, four of the seven cases did give a history of some neurological deficit and should have been detected by the screening procedure. Thus, the opportunity exists for increasing the sensitivity of the screening procedure through improving the questionnaire. However, it seems likely that a sizeable percentage of initial strokes will remain undetected by a screening procedure because the subject cannot give a history of the event and the residual signs are so slight as to pass unnoticed except by a neurologist.

Although increasing the sensitivity of the screening procedure is desirable, the fact that it does miss a substantial proportion of cases involving only minimal disability is not a fatal deficiency. In studying the epidemiology of a condition such as stroke for the purpose of identifying risk factors, it is not necessary to detect all cases of the condition. Rather, the prerequisite is that the method of detection of cases be uniform for all subjects so that estimates of the incidence in various subgroups of the sample, e.g., persons with and without hypertension, are not differently biased.

Comparison of these results with screening procedures used elsewhere^{3,4} is difficult because of differences in the populations studied and in the procedures for diagnosing stroke. It should be noted that the present population is characterized by advanced age and little education. In addition, many of the white subjects speak English as a second language and others do not speak English at all so that histories must be obtained through interpreters. It seems reasonable to expect that results of the screening

procedure would be improved in a more literate and younger population.

Summary

A screening procedure to detect persons with completed stroke has been described, and data on its effectiveness have been presented. In this population of elderly poor persons, about 45 per cent of subjects with positive screening results were diagnosed by neurologists as having had a stroke. About 8 per cent of a sample of subjects with negative screening results were also diagnosed as having had a stroke. All of these latter cases were minor in that the persons apparently had not experienced significant disability.

It is concluded that the screening procedure is successful in categorizing the subjects into a large group in which the probability of stroke is low and a small group in which the probability of stroke is high. However, many cases of minor stroke will remain undetected by a screening procedure because the subjects cannot give a history of the event and the residual signs are so slight as to pass unnoticed except by a neurologist. Despite the lack of sensitivity in detecting minor events, the screening procedure is useful in studying the epidemiology of stroke, and detects a significantly greater number of cases in this elderly poor population than would a stroke registry based upon hospital admissions or visits to physicians.

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