Title

Global & Community Health: Brief in-hospital cognitive screening anticipates complex admissions and may detect dementia

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[an original study for Alzheimer Disease & Associated Disorders]

TITLE: Brief cognitive screening detects baseline cognitive impairment and predicts in-hospital complexity

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SHORT TITLE / RUNNING HEAD: utility of in-hospital cognitive screening

ABSTRACT

Introduction: Brief cognitive assessments can help to risk-stratify the ill, or to detect incipient dementia in otherwise healthy patients. Patients seen by our Neurology Consult Service sometimes have poor baseline cognition, acute worsening in cognition, or an admixture of both. In this complex setting – usually the emergency department – it is not known whether standard assessments lose their accuracy, or instead preserve it, allowing us to simultaneously risk-stratify the ill and screen for dementia.

Methods: We measured performance on the six-item screener (SIS) within 24 hours of hospital arrival in one hundred consecutive English-speaking patients aged ≥ 45 years. Performance was compared to patient age, documented cognitive impairment, and proxies for in-hospital complexity, including whether or not a patient was admitted to the hospital, and the number of medical studies ordered.

Results: Those with poor SIS performance were older ($P = 0.02$), more likely to have previously-identified cognitive impairment ($P < 0.01$; sensitivity 86%, specificity 77%), more likely to be admitted to the hospital ($P = 0.04$; odds ratio = 3.6), and were subjected to more tests once admitted ($P < 0.01$).

Discussion: Poor performance on the SIS was sensitive and specific for known cognitive impairment and predicted in-hospital complexity.

Keywords: cognition; screening; dementia

INTRODUCTION

Disease-modifying therapies for dementia are under development,[1,2] but efficacy may be restricted to mild dementia.[3] This limitation motivates early identification of cognitive impairment. One approach is large-scale screening of relatively healthy community-dwelling adults, such as through primary care offices.[4] A possible alternative is suggested by evidence that cognitively impaired adults are at an increased risk of hospitalization,[5,6] and that the rate of cognitive decline accelerates after hospitalization.[7] Screening acutely ill individuals as they seek hospitalization could reduce the number needed to screen per case detected, making screening more economical. Screening results may nevertheless be difficult to interpret, because poor performance on a single in-hospital assessment may be caused by baseline cognitive impairment, an acute worsening in cognition due to the illness causing the hospital visit, or both.

In the present study, we assess the sensitivity and specificity of the six-item screener (SIS) for previously-documented cognitive impairment. The SIS tests whether one is oriented to the month, the year, and the day of the week. It also tests free recall of three spoken words (in this study, “banana”, “sunrise”, and “chair”). One point is awarded for each correct orientation question and for each freely-recalled word after a short (> 1 min) delay. In the community setting, the SIS has similar sensitivity and specificity as Mini-Mental State Examination (MMSE)[8] for dementia[9] and has previously been

used in outpatient efforts to screen for dementia[4] and inpatient efforts to stratify patients by risk of delirium.[10]

In this study, we screened patients presenting to the hospital for acute illness. Although we expect the context to worsen performance, previous emergency department measurements showed that poor performance on the SIS is correlated with poor performance on the MMSE.[11] If there nevertheless is a loss in sensitivity and specificity for baseline cognitive impairment in acute illness, rapid cognitive screening may still be useful. For example, there is increasing evidence that poor cognition in the setting of illness significantly increases the risk of morbidity and mortality.[12-14] As a secondary outcome, we therefore studied whether rapid cognitive screening with the SIS predicted patients' in-hospital complexity.

METHODS

We collected data for a quality improvement project designed to promote use of cognitive screening instruments like the SIS during consecutive patient exams by the University of California - Davis neurology consult service. For a new consultation, residents were asked to perform these assessments if the patient was at least 45 years old, communicated in spoken English (thereby excluding, e.g., the intubated and comatose), and had been in the hospital for less than 24 hours during the initial encounter. At their discretion, residents would add the patient's information to a secure list within our electronic medical records. During periodic (approximately

monthly) review, anonymized information was logged and the secure list cleared. Here, we analyze data from the first 100 patients added to that list.

The goal of this analysis was to test whether resident use of the SIS provided information about pre-hospitalization and/or in-hospital well-being. The study proposal was submitted to the University of California - Davis Institutional Review Board, and deemed to be exempt from full review.

Basic patient information that helped us gauge pre-hospitalization well-being included age, the number of medications one took at home, and whether a patient already carried a diagnosis of dementia or mild cognitive impairment (‘MCI’). Data pertinent to in-hospital well-being included vital signs the time of triage and the first measurement of white blood cell count (allowing us to tally systemic inflammatory response syndrome (SIRS) criteria), whether or not a patient was admitted to the hospital (versus discharged from the emergency department), and of those patients that were admitted, their length of stay (‘LOS’) and how many studies were ordered during their admission. The latter is a sum of imaging and lab orders placed in the EPIC electronic medical record (athenahealth, Watertown, MA, USA). Of note, EPIC aggregates some common studies into a single order. For example, a basic metabolic panel is a single order but includes measurement of serum sodium, potassium, chloride, bicarbonate, blood urea nitrogen, creatinine, and glucose.

When administering the SIS, some distraction between word registration and recall is mandatory. In 70% of our patients, this distraction was the clock-drawing task from the Mini-cog. Patients are asked to “Draw a big round clock, with all the numbers” and set it to “10 after 11”. Limited data supports the Mini-cog – which combines the clock draw with three-word recall – to screen for delirium[15,16] and cognitive impairment.[11,17] A full comparison of Mini-cog, the clock draw task itself, and the SIS is beyond the scope of this work, but measurements of well-being generally showed similar but stronger relationships to the SIS than the Mini-cog or clock draw (not shown). For completeness, the data is provided as an online supplement. For that supplement, clock drawings were scored in the standard fashion,[17] being normal only if all twelve numbers are present, each only once, in the correct order and direction, and also two hands of any length are present, with one pointing to the 11 and the other to the 2.

Performance on the SIS was dichotomized as poor (score 0 to 3) or good (4 to 6). This cut-off was chosen based on prior data showing that less than half of community-dwelling adults sampled by Callahan et al.[9] scored a 5 or 6. Although the participants of the Callahan et al. study were older, our patients were tested in the setting of a hospital visit, when performance is presumably worse. We note that our cutoff is more generous than some prior work.[11]

Statistical Analysis

Depending on whether variables were dichotomized or continuous, comparisons were based on Fisher's exact test, Welch's t-test, or generalized linear model (univariate regression, multiple regression, ANCOVA). Patient age approximated a normal distribution, but log-transformation of the LOS and the number of studies was required to approximate normal distributions before statistical comparisons were performed. In all cases, a two-tailed $P < 0.05$ was considered significant.

RESULTS

Of the 100 patients assessed, 59 were men, the mean ± standard deviation (sd) age was 68 ± 12 years, with 28 patients over the age of 75 years. Six patients had known cognitive impairment (five with dementia; the one with MCI performed poorly on the SIS, Mini-cog, and clock draw alike). Seventy-four patients were admitted to the hospital. Among our patients, ischemic stroke was the most common reason for the hospital visit (N = 28). Other common diagnoses (N ≥ 4) were transient ischemic attack, intracranial malignancy, migraine, seizure, and toxic-metabolic encephalopathy/delirium. Less-common diagnoses included hemorrhagic stroke, amaurosis fugax, transient global amnesia, ventriculomegaly, and multiple sclerosis flair. Those admitted had a LOS of (mean ± sd) 4.0 ± 4.0 days, albeit with a skewed distribution, with LOS of 1-2 days in 54%, but ≥ 7 days in 18%. For patients admitted to the hospital, (mean ± sd) 38 ± 30 studies (lab orders +

imaging orders) were ordered per patient. Most of the variance in number of studies was related to length of stay ($P < 0.001$; $R^2 = 0.47$), with roughly six additional studies ordered per additional day of hospitalization.

Those with poor performance on the SIS were more likely to have previously-documented cognitive impairment (5 of 27 had known MCI or dementia, compared to 1 of the 73 good performers; $P = 0.005$, OR = 15.8). The sensitivity and specificity for cognitive impairment was therefore 86% and 77%, respectively. As there was only one patient in our sample with MCI, the sensitivity and specificity for dementia was 80% and 76%. Those with poor SIS performance were also older ($P = 0.02$; mean ± sd of 73 ± 13 versus 66 ± 11 years). There was no significant relationship between SIS performance and the number of home medications ($P = 0.08$).

We had limited success predicting in-hospital well-being of a patient based on metrics of pre-hospitalization well-being. There was no relationship between the odds of admission, nor the number of studies ordered during an admission, nor the LOS, to either patient age ($P > 0.2$) or the number of home medications ($P > 0.2$). Similarly, a pre-existing diagnosis of cognitive impairment was neither related to the odds of admission nor the number of studies ordered ($P > 0.09$), but curiously was associated with a shorter LOS ($P = 0.017$).

In-hospital well-being, however, was related to SIS performance. Those with poor performance on the SIS were more likely to be admitted to the

hospital (24 of 27 poor performers admitted, 50 of 73 good performers admitted; P = 0.043; OR = 3.6). For context, we note that the odds ratio favoring admission was 3.9 in patients with ≥ 2 of 4 SIRS. Of those admitted, significantly more studies were ordered in poor performers (P = 0.019; mean [95%CI] of 41 [30 – 54]) than in good performers (27 [23 – 32]). Poor SIS performance was unrelated to LOS (P = 0.59) in a univariate analysis. It is not surprising, therefore, that SIS performance still predicted the number of studies ordered after adjusting for LOS in a multivariate model ($F_{(1,71)}$ = 9.70, P = 0.003) although interpretation is complicated by an interaction between LOS and SIS performance (P = 0.012). Best-fit lines for good and poor performers are shown in Figure 1, showing that more studies were ordered on poor performers, and that the disparity between good and poor performers increased with length of hospitalization. Adding SIS performance to the aforementioned univariate model comparing LOS to the number of studies allowed us to account for significantly more variance in the number of studies ordered (multiple R^2 increased from 0.47 to 0.57 (P<0.001)).

DISCUSSION

In this study, we used the SIS to rapidly screen patients for poor cognition within 24 hours of their arrival at the hospital. In this population, SIS was sensitive and specific for known baseline cognitive impairment. In addition, however, we found poor performance in 27% of our patients, of

which the majority had no known baseline cognitive impairment. While some may have undiagnosed MCI or dementia, we suspect many of the patients had an acute worsening in cognition that caused poor performance. Outpatient follow-up would help identify the cause of poor performance on a single in-hospital screen, which could be the focus of future studies.

Regardless of the underlying cause of poor SIS performance, we found that it was associated with greater likelihood of admission. In those patients admitted to the hospital, physicians ordered significantly more diagnostic studies on poor performers. This effect persisted even after accounting for hospital LOS (Fig.1), but it is unclear *why* these patients were subjected to more diagnostic testing. Perhaps an acute change in cognition is more likely in sicker patients, who will require more diagnostic workup because of the severity of their medical illness. Perhaps poor cognition, especially if it is thought to be new, will raise physician concern for a missed diagnosis, causing the scope (and presumably cost) of the diagnostic workup to blossom.

Rather than testing for fluctuating cognition with altered sensorium and inattention, we assessed orientation and memory at a single time point early in the hospital visit. We therefore cannot judge whether our poor performers may have met criteria for delirium, which is common and associated with poor memory and disorientation.[18] If some performing poorly on the SIS are delirious, they may respond to interventions effective against delirium.[19] In a practical application of this idea, Allen et al.[10] stratified

patients by their SIS score, focused their delirium prevention protocol on poor performers, and report an associated improvement in patient outcomes.

One weakness of the present study is the use of a convenience sample from our Neurology Consultation Service. We expect that the rates and underlying etiologies of poor cognition will differ between specialties, and between in-hospital and outpatient encounters, limiting generalizability of the present findings. Another weakness arises from subject recruitment: For this quality improvement project, house staff were encouraged – often with daily reminders – to use the SIS on every patient meeting inclusion criteria. However, this study was not designed to measure the proportion of eligible patients that were ultimately screened. It's conceivable that those patients intuited to have poor cognition were screened more often than patients that seemed lucid. Regardless, an over (or under) estimation of the prevalence of poor cognition is not likely to alter the two main findings of this study. First, poor cognition identified within the first day of hospitalization predicts an increase in the number of diagnostic studies ordered on subsequent days (Fig.1). Second, the SIS retains fair sensitivity and specificity for dementia when used in the setting of a hospital visit, respectively 80% and 76% in this study, compared to 89% and 88% measured in patients' homes.[9]

Additional studies are planned to test whether some of those who perform poorly on an in-hospital SIS have unrecognized MCI or dementia. Some may be delirious, and have excellent cognition at the time of outpatient follow-up. In others with well-compensated cognitive impairment,

a mild illness might be a “cognitive stress test”, causing them to falter, allowing screening tools like the SIS to reveal deficits. Such patients with baseline MCI or early dementia are those likely to receive benefit from emerging therapies,[1,2] but most are not identified without organized screening efforts.[4] Identifying them in “enriched” samples – like those patients triggering a neurology consultation – might be an expedient way to address this under-diagnosis of dementia and MCI. We suspect both diagnoses were under-identified in our sample of 100 patients. Monte Carlo simulations (not shown) informed by the age of patients in our sample and the population prevalence of MCI predict that ~10% of our sample may have MCI instead of the documented 1%. Moreover, none of our 28 patients admitted for stroke had documented premorbid dementia or MCI. The prevalence of pre-stroke MCI is not well known, but the prevalence of pre-stroke dementia is 12.0-16.8%.[20] Based on these figures, it would be uncommon (probability < 0.03) for a sample of 28 stroke patients to genuinely be free of premorbid MCI or dementia.

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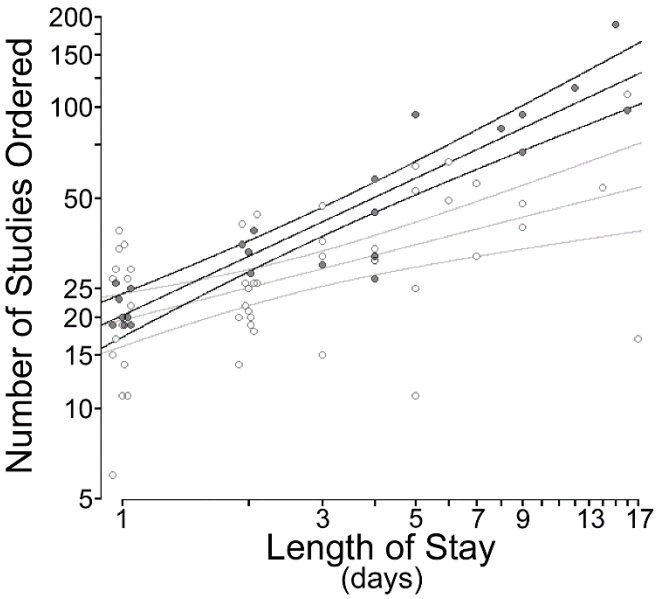
Author Contributions: D.B. and C.D. contributed to study concept and design, D.B. and other residents training at the UC-Davis Neurology department participated in the acquisition data, D.B. performed analysis and interpretation of data, and D.B. and C.D. contributed to preparation of the manuscript. We thank the members of the UC-Davis Neurology residency program, including the director Dr. Duffy, for their contributions.

FIGURES

Figure 1:



LEGENDS

Figure 1: In patients admitted to the hospital, more diagnostic studies are ordered for those with a longer length of stay (LOS), and this relationship is modified by performance on the Six Item Screener (SIS). Patients performing poorly on the SIS (score 0 to 3) are shown with filled symbols, while good performers (score 4 to 6) are shown with open symbols. To prevent overlap of points for LOS of 1 and 2 days, points are jittered slightly around their integer x-axis value. We provide best-fit lines (±95% confidence interval) for good performers (gray lines) and poor performers (black lines) alike. The intercept for both best-fit lines is nearly identical, but poor performers have a significantly steeper slope (ln(studies) = 0.65 * ln(LOS) + 3.0 *versus* ln(studies) = 0.36 * ln(LOS) + 3.0)(P = 0.012 for LOS × Performance

interaction). Based on the best-fit lines, ~40% more studies will be ordered on a poor performer than on a good performer during a 3-day hospitalization.

SUPPLEMENTAL DIGITAL CONTENT

Supplementary Dataset S1: Supplementary_Dataset_S1.xlsx