 Annals of Internal Medicine

3D-CAM: Derivation and Validation of a 3-Minute Diagnostic Interview for CAM-Defined Delirium

A Cross-sectional Diagnostic Test Study

Edward R. Marcantonio, MD, SM; Long H. Ngo, PhD; Margaret O'Connor, PhD; Richard N. Jones, ScD; Paul K. Crane, MD, MPH; Eran D. Metzger, MD; and Sharon K. Inouye, MD, MPH

Background: Delirium is common, leads to other adverse outcomes, and is costly. However, it often remains unrecognized in most clinical settings. The Confusion Assessment Method (CAM) is the most widely used diagnostic algorithm, and operationalizing its features would be a substantial advance for clinical care.

Objective: To derive the 3D-CAM, a new 3-minute diagnostic assessment for CAM-defined delirium, and validate it against a clinical reference standard.

Design: Derivation and validation study.

Setting: 4 general medicine units in an academic medical center.

Participants: 201 inpatients aged 75 years or older.

Measurements: 20 items that best operationalized the 4 CAM diagnostic features were identified to create the 3D-CAM. For prospective validation, 3D-CAM assessments were administered by trained research assistants. Clinicians independently did an extensive assessment, including patient and family interviews and medical record reviews. These data were considered by an expert panel to determine the presence or absence of delirium and dementia (reference standard). The 3D-CAM delirium diagnosis was compared with the reference standard in all patients and subgroups with and without dementia.

Results: The 201 participants in the prospective validation study had a mean age of 84 years, and 28% had dementia. The expert panel identified 21% with delirium, 88% of whom had hypoactive or normal psychomotor features. Median administration time for the 3D-CAM was 3 minutes (interquartile range, 2 to 5 minutes), sensitivity was 95% (95% CI, 84% to 99%), and specificity was 94% (CI, 90% to 97%). The 3D-CAM did well in patients with dementia (sensitivity, 96% [CI, 82% to 100%]; specificity, 86% [CI, 67% to 96%]) and without dementia (sensitivity, 93% [CI, 66% to 100%]; specificity, 96% [CI, 91% to 99%]).

Limitation: Limited to single-center, cross-sectional, and medical patients only.

Conclusion: The 3D-CAM operationalizes the CAM algorithm using a 3-minute structured assessment with high sensitivity and specificity relative to a reference standard and could be an important tool for improving recognition of delirium.

Primary Funding Source: National Institute on Aging.

Ann Intern Med. 2014;161:554-561. doi:10.7326/M14-0865 www.annals.org

For author affiliations, see end of text.

Delirium is common, leads to other adverse outcomes, and is costly in hospitalized older persons (1–3). Despite increasing awareness of its importance, most delirium, particularly hypoactive delirium and delirium superimposed on dementia, still goes unrecognized (1–3). Prompt recognition of delirium is the first step in appropriate management, which involves careful review for reversible contributors, prevention of complications (including ensuring patient safety), and cognitive and physical rehabilitation (1). Evidence suggests that this approach can shorten the duration of delirium and improve its associated adverse outcomes (1, 3).

The Confusion Assessment Method (CAM), developed in 1990 (4), has been widely adopted. A recent comparison of diagnostic methods suggests that the CAM is the best-performing bedside delirium assessment tool (5). Although the CAM is widely used in the literature to define delirium (6), it can be challenging to operationalize in the clinical setting because it requires cognitive assessment and substantial interviewer training. Moreover, application of the CAM varies greatly, which can lead to differential performance in detecting delirium (5).

A brief, structured assessment of mental status that operationalizes the CAM algorithm would be extremely helpful to accelerate widespread ascertainment of delirium in high-risk patients (4, 5). Therefore, our overall goal was to develop and validate the 3D-CAM, which is a new 3-minute diagnostic assessment for delirium using the CAM algorithm. Our aims were to create the 3D-CAM using model selection methods to finalize items, determine thresholds for the presence or absence of each of the 4 CAM diagnostic features, and prospectively validate the 3D-CAM by comparing it with a reference standard that included an extensive clinical evaluation in a new population of older general medicine patients with a high burden of baseline cognitive impairment and comorbid conditions.

See also:

Web-Only
Supplement

METHODS

Derivation of the 3D-CAM

We started with a data set of 4598 structured delirium assessments from a previously completed multisite trial of the delirium-abatement program conducted in 8 postacute

 © 2014 American College of Physicians
This article has been corrected. The specific correction appears on the last page of this document. The original version (PDF) is available at www.annals.org.
Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

care facilities (7). In previously published work on 3D-CAM derivation, we mapped more than 120 items from this assessment to the 4 CAM diagnostic features (8) and used item response theory (9) to identify the 36 most informative items for the identification of these features (10) (**Appendix Table 1**, available at www.annals.org).

We further reduced these 36 items using logistic regression and assembled the most useful subset from each of the 4 CAM diagnostic features to create the 3D-CAM. We used regression coefficients to determine the weight of each item and threshold for determining the presence or absence of each of the features: acute change or fluctuating course, inattention, disorganized thinking, and altered level of consciousness. For each feature, the best-performing approach weighted each cognitive testing item, patient symptom question, and interviewer observation equally. Moreover, each feature was rated as present if any one of the items (cognitive test result, reported symptom, or observation item) was rated as present. Once each feature was rated, the presence of delirium was determined by the CAM diagnostic algorithm, which required the presence of features 1 and 2 and either 3 or 4 (**Figure 1**). For more details, see the **Supplement** (available at www.annals.org).

Once we selected the items and defined the scoring algorithm for the 3D-CAM, we made a preliminary assessment of its diagnostic accuracy. From the data set of 4598 assessments, we used only the 3D-CAM items and the aforementioned algorithm to score the CAM algorithm. We then compared the presence or absence of delirium generated from this approach with the results of the full 160-item structured delirium assessment (11). In this initial derivation work, the 3D-CAM achieved 92% sensitivity (95% CI, 90% to 94%) and 93% specificity (CI, 92% to 93%) relative to the full assessment, which met our goal and allowed us to proceed with the prospective validation.

Prospective Validation Study

Study Population

We enrolled participants from a large urban teaching hospital in Boston, Massachusetts. Inclusion criteria were age 75 years or older, admission to general medicine or geriatric medicine services, ability to communicate effectively in English, no terminal conditions, expected hospital stay of 2 days or more, and no previous study participant. Experienced clinicians (clinical psychologists and advanced practice nurses) performed the screening. After approval from the attending physician was obtained, each eligible patient was approached for informed consent. If the patient was unable to provide consent, the designated surrogate decision maker was contacted. Study protocol and informed consent procedures were approved by the institutional review board.

Reference Standard Delirium Assessment

The operational reference standard diagnosis of delirium was based on an extensive face-to-face interview (45 minutes), medical record review, and input from the patient's nurse and available family members. This assessment included the reason for hospital admission and hospital course; presence of cognitive concern before and during the hospitalization; family, social, and functional history; Montreal Cognitive Assessment, a 30-item assessment that takes approximately 20 minutes to administer (12); Geriatric Depression Scale to evaluate for presence of depressive symptoms (13); and medical record review. This review included quantification of comorbid conditions using the Charlson index (14), diagnosis of dementia or mild cognitive impairment (MCI) before hospitalization, determination of functional status using the basic and instrumental activities of daily living scales (15, 16), and a list of psychoactive medications administered. If the assessment indicated potential cognitive impairment (Montreal Cognitive Assessment score ≤23) (12), the clinical assessor conducted a proxy interview to assist with determining the patient's baseline mental status relevant to a possible diagnosis of dementia versus a history of lifelong, developmental, cognitive limitations. The proxy interview included ascertainment of a cognitive concern before and during the hospitalization, ascertainment of whether specific cognitive deficits evident on testing existed before hospitalization, confirmation of functional status obtained from the medical record, and a proxy-based screening questionnaire for dementia (the AD8, which is a brief informant interview to detect dementia) (17).

The final delirium diagnoses were adjudicated by a study panel, including the clinical assessor (psychologist or advanced practice nurse), the principal study investigator, a geriatrician, and a board-certified neuropsychologist, using criteria from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (18). For patients not meeting delirium criteria, the panel adjudicated the presence or ab-

Context

Although delirium is common among hospitalized patients and is associated with adverse outcomes, it often goes unrecognized. A brief and simple means of applying the most widely used diagnostic tool for delirium, the Confusion Assessment Method (CAM), would be helpful in fostering recognition of delirium and its evaluation and treatment.

Contribution

This study validated a 3-minute version of the CAM (called the 3D-CAM) as a sensitive and specific diagnostic tool in hospitalized patients, including those with and without dementia.

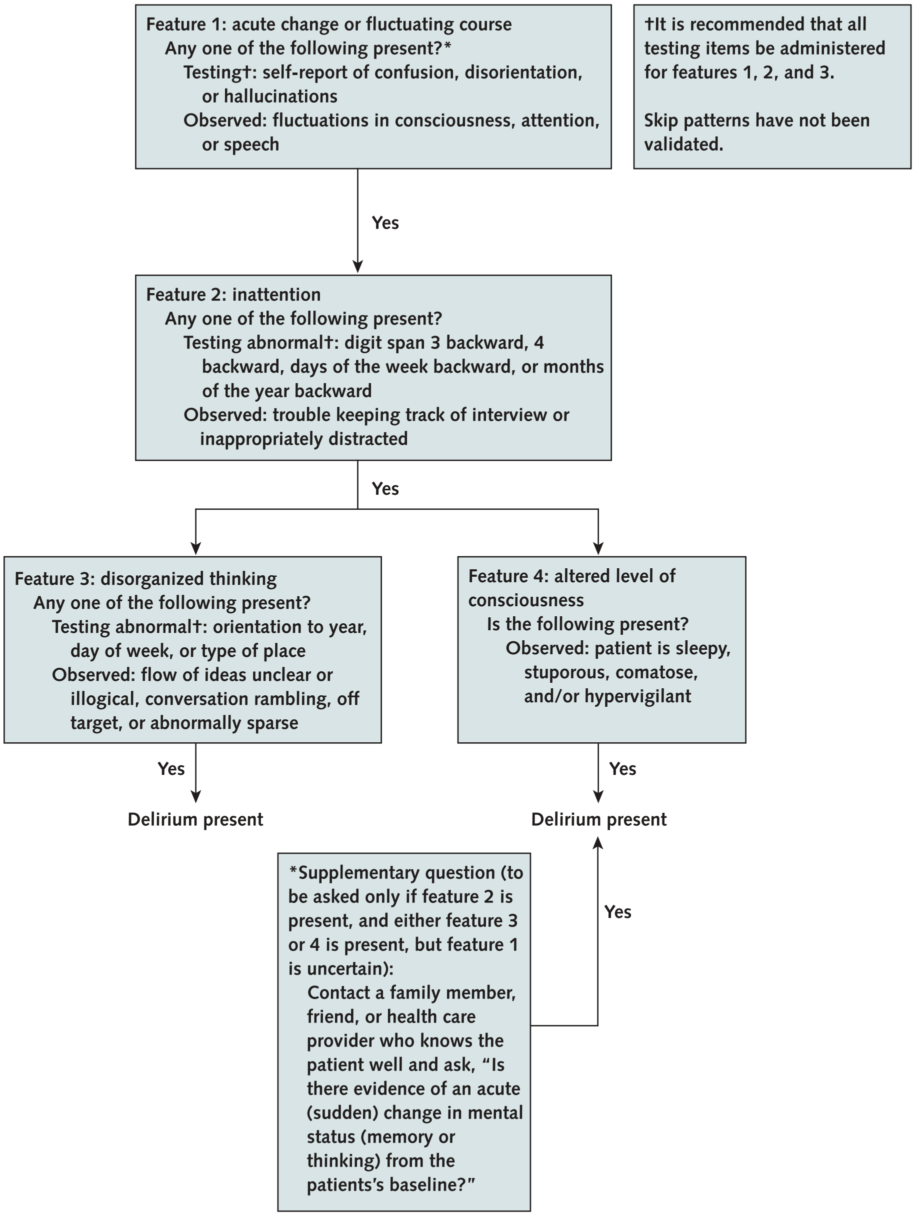
Implication

Use of the 3D-CAM should aid in the recognition of delirium in hospitalized patients.

—The Editors

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

Figure 1. **Overview of the 3D-CAM assessment.**



The CAM diagnostic algorithm is depicted, with the 3D-CAM items and scoring summarized under each CAM diagnostic feature (4).

sence of subsyndromal delirium (19), which was defined by the presence of acute change or fluctuating course plus inattention, disorganized thinking, or altered level of consciousness. The panel was blinded to the results of subsequent 3D-CAM testing. A geropsychiatrist subsequently readjudicated a 10% subsample (10 randomly selected participants with delirium and 10 without) blinded to the original results to verify the panel adjudication process. In addition to determining delirium status, the panel adjudicated the presence or absence of cognitive impairment at baseline, including dementia or MCI, using the National Institute on Aging and Alzheimer's Association criteria (20, 21). (For details of data used for adjudication of dementia and MCI, see the **Supplement**.)

3D-CAM Assessments

After the reference standard assessment, the 3D-CAM was administered by research assistants (RAs) who were blinded to the results of the reference standard. A total of 8 RAs participated in the validation study, and each evaluated between 4 and 49 participants, based on participant and RA availability. Before the start of the study, each RA had a 1- to 2-hour training session on the use of the 3D-

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

CAM, including practice in administering the instrument to each other and to actual patients. To assess interrater reliability, 50% of the participants were selected to have a second 3D-CAM assessment based on a random-number sequence. The second 3D-CAM assessment was blinded to the reference standard and first 3D-CAM assessments. All 8 RAs, representing 18 distinct pairs of raters, participated in the reliability study. Each pair evaluated between 1 to 19 participants also based on participant and RA availability. To ensure temporal proximity, all assessments (reference standard and first or second 3D-CAM assessment) were completed within a 2-hour period between 11 a.m. and 2 p.m. (**Figure 2**).

Statistical Analysis

We calculated sensitivity, specificity, and 95% CIs for the 3D-CAM delirium determination compared with the reference standard. We did subset analyses to determine diagnostic test characteristics of the 3D-CAM, stratified by the patient's baseline cognitive status (normal or MCI vs. dementia). Interrater agreement was calculated in the 50% sample with 2 independent 3D-CAM assessments as the proportion of assessments in which both raters provided the same delirium determination. We used SAS software, version 9.3 (SAS Institute), for all data analyses.

Role of the Funding Source

The National Institute on Aging had no role in the design, conduct, analysis, or decision to submit the manuscript for publication.

RESULTS

Prospective Validation Study

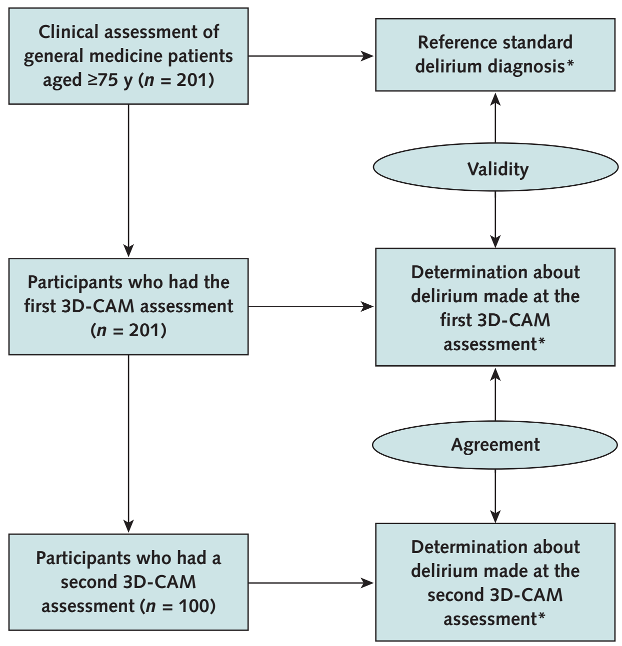
Patient Characteristics

A total of 201 patients met inclusion criteria and provided informed consent. The mean age was 84 years, 62% were women, and 88% self-reported to be white (**Table 1**). Approximately half had some college education, and 5% spoke English as a second language but were sufficiently fluent to be enrolled. The mean Charlson comorbidity score was 3.0, indicating a moderate to high number of medical comorbid conditions (14). Fifty-five percent had dependencies in 1 or more basic activities of daily living (15), and 81% had dependencies in 1 or more instrumental activities of daily living (16). On the basis of the expert panel's assessment of the operational reference standard, 28% of the patients had baseline dementia.

Overall Study Flow, Reference Standard, and 3D-CAM Assessments

Figure 2 depicts the study flow of assessments, which included the reference standard clinical evaluation for delirium, the 3D-CAM assessment, and a second 3D-CAM assessment done in a random one half of participants. All of the face-to-face components of the assessments were completed within the desired 2-hour period. The reference

Figure 2. **Study flow diagram.**



All assessments were completed within 2 hours of each other, and results were strictly blinded from the other assessors.
* Presence or absence of delirium as measured by the first 3D-CAM assessment was compared with the reference standard delirium diagnosis to determine validity and the second 3D-CAM assessment to determine interrater agreement.

standard assessment, which included patient interviews, medical record reviews, and proxy interviews, took approximately 1.5 hours to complete. On the basis of these assessments, 42 participants (21% of the sample) were diagnosed with delirium. Of these, 37 (88% of patients with delirium) had either hypoactive or normal psychomotor features, with only 5 showing hyperactive or mixed features. In the 20 patients (10 with and 10 without delirium) whose records were reviewed again by the blinded geropsychiatrist, there was 100% concordance with the expert panel's diagnosis. Compared with the reference standard assessment, the 3D-CAM was completed in a median of 3 minutes (interquartile range, 2 to 5 minutes; overall range, 1 to 15 minutes). Forty-nine participants (24%) were determined to have delirium on the basis of the 3D-CAM.

Diagnostic Test Characteristics of the 3D-CAM

Compared with the reference standard delirium diagnosis, sensitivity of the 3D-CAM was 95% (CI, 84% to 99%) and specificity was 94% (CI, 90% to 97%) (**Table 2**), resulting in a positive likelihood ratio of 16.8 (CI, 8.9 to 31.8) and a negative likelihood ratio of 0.05 (CI, 0.01 to 0.20). Of the 9 positive results determined through the 3D-CAM that were negative by the reference standard ("false-positive results"), 6 were adjudicated to have subsyndromal delirium based on the reference standard assessment (19). In post hoc analyses, we examined the effect of

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

Table 1. **Characteristics of the Prospective Validation Study Population***

Characteristic	Participants (*n* = 201)
Mean age (SD), *y*	84 (5.4)
Female	125 (62)
White	177 (88)
Education†	
Less than high school	20 (10)
High school graduate	75 (38)
College or more	100 (49)
English as a second language	10 (5)
Severe sensory impairment	
Vision	5 (2)
Hearing	18 (9)
Mean Charlson comorbidity index score (SD)‡	3.0 (2.3)
Dependence in activities of daily living§	110 (55)
Dependence in instrumental activities of daily living‖	163 (81)
Baseline cognition	
MCI	50 (25)
Dementia¶	56 (28)
Delirium by reference standard	42 (21)
Delirium psychomotor features	
Hypoactive or normal	37 (19)
Hyperactive or mixed	5 (2)

MCI = mild cognitive impairment.
* Values reported as numbers (percentages) unless otherwise indicated.
† Education status was missing in 6 (3%) participants.
‡ From reference 14.
§ From reference 15.
‖ From reference 16.
¶ Includes 1 participant with lifelong, developmental, cognitive limitations.

considering subsyndromal cases as reference standard positive results. This increased the sensitivity of the 3D-CAM to 46 of 48 (96%) and specificity to 150 of 153 (98%).

Diagnostic Test Characteristics, Stratified by Baseline Cognition

We examined the diagnostic test characteristics of the 3D-CAM, stratified by participants' baseline cognitive function (**Table 3** and **Appendix Table 2**, available at www.annals.org). In the group with either normal baseline cognition or MCI, sensitivity was 93% and specificity was 96%. In the dementia subgroup, sensitivity was 96% and specificity was slightly lower at 86%. The 95% CIs and likelihood ratios, stratified by baseline cognition, are presented in **Table 3**.

Interrater Agreement

Finally, we examined agreement across raters in the subset of 100 participants who had a second 3D-CAM assessment and were blinded to the first. This showed that the 3D-CAM had an excellent interrater agreement of 95% (**Appendix Table 3**, available at www.annals.org).

DISCUSSION

Delirium is an important clinical syndrome to detect. We currently have no brief instrument that is well-suited for widespread use across clinical settings. We therefore sought to develop and evaluate the 3D-CAM, which is a short, structured diagnostic assessment for delirium that can be administered by health care delivery staff with minimal additional training. The 3D-CAM showed strong performance characteristics in our study. It was completed in a median of 3 minutes and had excellent sensitivity and specificity relative to a reference standard delirium diagnosis in patients with and without baseline dementia. The slightly lower specificity in the dementia subgroup is attributable to a higher likelihood of false-positive results inherent in the challenging process of distinguishing symptoms and signs of delirium from dementia (22). The 3D-CAM also had excellent interrater agreement. With its brevity and ease of use, the 3D-CAM may be a useful tool for improving widespread detection of delirium in clinical settings.

Hospitalized patients are rarely formally assessed for delirium (1, 3). Studies done over the past 20 years suggest that the clinical recognition rate has not significantly changed and remains between 12% and 35% (23–27). Moreover, identified cases of delirium tend to be agitated patients who are disruptive to patient care, whereas hypoactive patients remain unrecognized. Studies have shown that hypoactive patients with delirium have either similar or somewhat worse outcomes than agitated patients with delirium (28, 29). The 3D-CAM showed excellent sensitivity in our sample, despite the fact that 88% of patients with delirium had either hypoactive or normal psychomotor features.

To improve delirium recognition in hypoactive patients, it is important to incorporate results from direct questioning of patients and mental status testing into the delirium assessment and not to rely solely on interviewer observations. In the initial validation studies, the CAM developers did a structured mental status assessment using the Mini-Mental State Examination (30) plus recall of a

Table 2. **Diagnostic Test Characteristics of the 3D-CAM Compared With the Reference Standard Delirium Assessment**

Delirium Diagnosis	Reference Standard		3D-CAM Total
	Positive	Negative	
3D-CAM			
Positive	40	9*	49
Negative	2	150	152
Reference standard total	42	159	201
Test characteristic†			
Sensitivity (95% CI), %	95 (84–99)	–	–
Specificity (95% CI), %	–	94 (90–97)	–

* Of the 9 positive results determined through the 3D-CAM that were negative by the reference standard ("false-positive results"), 6 had subsyndromal delirium based on the reference standard (19).
† The sensitivity and specificity result in a positive likelihood ratio of 16.8 (95% CI, 8.9 to 31.8) and a negative likelihood ratio of 0.05 (CI, 0.01 to 0.20) (for more details, see the **Supplement**, available at www.annals.org).

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

story or digit span before operationalizing the CAM algorithm (4). In a subsequent publication, nurses were interviewed daily about the CAM diagnostic features using observations from routine clinical care without formal mental status assessment (31). When nurses' CAM ratings were compared with those of the researchers after a structured mental status assessment, the sensitivity of the nurses' CAM ratings was only 20% per interview and 33% over the entire hospitalization (31). Thus, in the absence of mental status testing, the CAM algorithm alone did not substantially increase the rate of delirium detection. The 3D-CAM shows that excellent sensitivity for delirium can be achieved with brief mental status testing focused on attention and orientation.

The CAM for the intensive care unit (CAM-ICU) is an example of a structured assessment that incorporates a specific set of questions to operationalize each CAM diagnostic feature (32). For example, attention is assessed using 2 items: the vigilance “A” task (33) and the picture recognition task from the attention screening examination (33). Because the CAM-ICU was designed to assess delirium in intubated ICU patients, all questions are answerable using nonverbal responses, such as a nod of the head (yes or no). With its brevity and ease of use, the CAM-ICU has greatly enhanced assessment of delirium in the ICU (34). Yet, recent studies suggest that the CAM-ICU may not be optimized to non-ICU populations, in which it shows lower sensitivity than a verbal delirium assessment (35–37). For example, in a recent validation study of 406 persons evaluated in an emergency department (mean age, 73.5 years; dementia prevalence, 5.9%), the CAM-ICU showed a sensitivity of 68% to 72% (37). The recently developed and validated Brief Confusion Assessment Method, or B-CAM, provides an alternative that incorporates verbal testing with items very similar to the CAM-ICU (38). Notably, both the CAM-ICU and the B-CAM put major emphasis on the Richmond Agitation and Sedation Scale (39), which detects altered levels of consciousness. Yet, the recently published *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition,* contains a delirium definition that deemphasizes the importance of altered level of consciousness and focuses instead on assessment of attention and orientation (40), both of which are key components of the 3D-CAM. Moreover, altered level of consciousness is much less prevalent in delirium outside of the ICU. In our sample, it was present in only 8 of 42 delirium cases (19%).

Although physicians and nurses need to be trained for optimal use of the 3D-CAM, its brevity and algorithmic structure should simplify the process. Clear instructions are available that map specific questions to each CAM feature. The 3D-CAM instrument and training manual (available free of charge at www.hospitalelderlifeprogram.org) explain how to code the presence or absence of each feature on the basis of patient responses. This reduces the amount of judgment required by the assessor and facilitates reproducibility across assessors as evidenced by the extremely high interrater agreement seen in this study. The structured nature of the 3D-CAM also makes it possible to administer through an electronic platform, such as mobile technology. Of note, because only 1 positive item is required to trigger the presence of each feature, the assessment might be shortened further by incorporating skip patterns, which is an approach that we did not test in our validation study. Finally, the 3D-CAM is entirely compatible with the short-form version of the recently published CAM-based scoring system for delirium severity, known as the CAM-S (41). We are developing an algorithm to score the CAM-S using 3D-CAM items that can be presented in future work.

Table 3. **Diagnostic Test Characteristic of the 3D-CAM, Stratified by Baseline Cognitive Function**

Delirium Diagnosis	Reference Standard: Positive	Reference Standard: Negative	3D-CAM Total
Patients with normal baseline cognition or MCI (*n* = 145)			
3D-CAM			
Positive	13	5	18
Negative	1	126	127
Reference standard total	14	131	145
Test characteristic*			
Sensitivity (95% CI), %	93 (66–100)	–	–
Specificity (95% CI), %	–	96 (91–99)	–
Patients with dementia† (*n* = 56)			
3D-CAM			
Positive	27	4	31
Negative	1	24	25
Reference standard total	28	28	56
Test characteristic*			
Sensitivity (95% CI), %	96 (82–100)	–	–
Specificity (95% CI), %	–	86 (67–96)	–

MCI = mild cognitive impairment.
* The sensitivity and specificity result in a positive likelihood ratio of 24.3 (95% CI, 10.2 to 58.2) and a negative likelihood ratio of 0.07 (CI, 0.01 to 0.49) for patients with normal baseline cognition or MCI, and a positive likelihood ratio of 6.8 (CI, 2.7 to 16.8) and a negative likelihood ratio of 0.04 (CI, 0.01 to 0.29) for patients with dementia.
† Includes 1 participant with lifelong, developmental, cognitive limitations.

Our approach has several important strengths. First, the 3D-CAM was created using items rigorously selected through item response theory to be maximally informative for determining the presence or absence of the 4 CAM diagnostic features. These items were further reduced by using model selection techniques in a data set of 4598 delirium assessments. Our prospective validation study enrolled a sample of more than 200 patients with a mean age older than 80 years, substantial comorbid conditions, and a high burden of baseline cognitive impairment, which was a purposeful “challenge population” for 3D-CAM validation. The 3D-CAM may be equally applicable in younger populations with a lower prevalence of dementia and will probably perform better because delirium assessment in these patients is more straightforward. In addition, our study used a clinical reference standard and a design in

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

which all delirium assessments were administered close in time and the results of each test were kept strictly blinded from the other assessors. Finally, we assessed and confirmed excellent interrater agreement for the 3D-CAM ratings and independently validated a subset of reference standard delirium diagnoses.

Our approach has several limitations. First, our prospective validation study enrolled only general medicine patients and was conducted at a single site. Thus, our findings should be confirmed in other non-ICU settings in which delirium is also common, such as surgical wards, palliative care facilities, postacute care facilities, and other types of hospitals. Second, our study assessed patients on a single hospital day only. Additional studies should examine the performance and acceptability of the 3D-CAM when repeated daily for delirium case finding. Third, all of our evaluations were done during the day shift, and performance during evening and night shifts should also be evaluated. Fourth, the 95% CIs for some test characteristics in our stratified analyses are wide and should be interpreted accordingly. Finally, we used a paper-and-pencil, static 3D-CAM assessment, and future studies should examine use of a dynamic assessment using automated skip patterns on an electronic platform, which might further enhance efficiency.

In conclusion, our study of older general medicine patients with a high prevalence of underlying cognitive impairment found the 3D-CAM to be a brief, highly reproducible, and valid method for diagnosing delirium using the CAM algorithm. Given these characteristics, the 3D-CAM could be an important component of future efforts to improve systematic case-finding of delirium in high-risk older adults. Further research will focus on developing the optimal strategies for translating the 3D-CAM into routine care and determining whether improved detection of delirium can result in improved outcomes for vulnerable hospitalized older persons.

From the Beth Israel Deaconess Medical Center, Harvard Medical School, and Hebrew SeniorLife, Boston, Massachusetts; Warren Alpert School of Medicine at Brown University, Providence, Rhode Island; and University of Washington School of Medicine, Seattle, Washington.

Acknowledgment: The authors thank the patients and families at Beth Israel Deaconess Medical Center who participated in this study; clinical assessors Tracee Francis, Leo Waterston, Meghan Collier, and Laura Branford-White; and research assistants Kerry Palihnich, Jacqueline Gallagher, Aleksandra Kuczmarska, Ariel Hodara, Benjamin Helfand, Mary Michaels, and Li-Wen Huang.

Grant Support: By the National Institute of Aging grants R01AG030618 and K24AG035075 (Dr. Marcantonio) and P01AG031720 and K07AG041835 (Dr. Inouye). Dr. Inouye holds the Milton and Shirley F. Levy Family Chair.

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M14-0865.

Reproducible Research Statement: *Study protocol, statistical code, and data set*: Limited availability; please contact the principal investigator, Dr. Marcantonio (e-mail, emarcant@bidmc.harvard.edu).

Requests for Single Reprints: Edward R. Marcantonio, MD, SM, Harvard Medical School, Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, CO-216, Boston, MA 02215; e-mail, emarcant@bidmc.harvard.edu.

Current author addresses and author contributions are available at www.annals.org.

References

1. **Marcantonio ER.** In the clinic. Delirium. Ann Intern Med. 2011;154:ITC6-1-16. [PMID: 21646553] doi:10.7326/0003-4819-154-11-201106070-01006
2. **Marcantonio ER.** Postoperative delirium: a 76-year-old woman with delirium following surgery. JAMA. 2012;308:73-81. [PMID: 22669559] doi:10.1001/jama.2012.6857
3. **Inouye SK, Westendorp RG, Saczynski JS.** Delirium in elderly people. Lancet. 2014;383:911-22. [PMID: 23992774] doi:10.1016/S0140-6736(13)60688-1
4. **Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegal AP, Horwitz RI.** Clarifying confusion: the confusion assessment method. A new method for detection of delirium. Ann Intern Med. 1990;113:941-8. [PMID: 2240918]
5. **Wong CL, Holroyd-Leduc J, Simel DL, Straus SE.** Does this patient have delirium?: value of bedside instruments. JAMA. 2010;304:779-86. [PMID: 20716741] doi:10.1001/jama.2010.1182
6. **Wei LA, Fearing MA, Sternberg EJ, Inouye SK.** The Confusion Assessment Method: a systematic review of current usage. J Am Geriatr Soc. 2008;56:823-30. [PMID: 18384586] doi:10.1111/j.1532-5415.2008.01674.x
7. **Marcantonio ER, Bergmann MA, Kiely DK, Orav EJ, Jones RN.** Randomized trial of a delirium abatement program for postacute skilled nursing facilities. J Am Geriatr Soc. 2010;58:1019-26. [PMID: 20487083] doi:10.1111/j.1532-5415.2010.02871.x
8. **Huang LW, Inouye SK, Jones RN, Fong TG, Rudolph JL, O'Connor MG, et al.** Identifying indicators of important diagnostic features of delirium. J Am Geriatr Soc. 2012;60:1044-50. [PMID: 22690980] doi:10.1111/j.1532-5415.2012.03996.x
9. **Hambleton RK, Swaminathan H, Rogers HJ.** Fundamentals of item response theory. Newbury Park, CA: Sage; 1991.
10. **Yang FM, Jones RN, Inouye SK, Tommet D, Crane PK, Rudolph JL, et al.** Selecting optimal screening items for delirium: an application of item response theory. BMC Med Res Methodol. 2013;13:8. [PMID: 23339752] doi:10.1186/1471-2288-13-8
11. **Simon SE, Bergmann MA, Jones RN, Murphy KM, Orav EJ, Marcantonio ER.** Reliability of a structured assessment for nonclinicians to detect delirium among new admissions to postacute care. J Am Med Dir Assoc. 2006;7:412-5. [PMID: 16979083]
12. **Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al.** The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005;53:695-9. [PMID: 15817019]
13. **Yesavage JA.** Geriatric Depression Scale. Psychopharmacol Bull. 1988;24:709-11. [PMID: 3249773]
14. **Charlson ME, Pompei P, Ales KL, MacKenzie CR.** A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40:373-83. [PMID: 3558716]
15. **Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW.** Studies of illness in the aged. The index of adl: a standardized measure of biological and psychosocial function. JAMA. 1963;185:914-9. [PMID: 14044222]
16. **Lawton MP, Brody EM.** Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9:179-86. [PMID: 5349366]
17. **Galvin JE, Roe CM, Powlishta KK, Coats MA, Muich SJ, Grant E, et al.** The AD8: a brief informant interview to detect dementia. Neurology. 2005;65:559-64. [PMID: 16116116]

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

18. **American Psychiatric Association.** Diagnostic and Statistical Manual of Psychiatric Disorders. 4th ed. Arlington, VA: American Psychiatric Publishing; 1994.

19. **Meagher D, Adamis D, Trzepacz P, Leonard M.** Features of subsyndromal and persistent delirium. Br J Psychiatry. 2012;200:37-44. [PMID: 22075650] doi:10.1192/bjp.bp.111.095273

20. **Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, et al.** The diagnosis of mild cognitive impairment due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimers Dement. 2011;7:270-9. [PMID: 21514249] doi:10.1016/j.jalz.2011.03.008

21. **McKhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR Jr, Kawas CH, et al.** The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimers Dement. 2011;7:263-9. [PMID: 21514250] doi:10.1016/j.jalz.2011.03.005

22. **Fick DM, Agostini JV, Inouye SK.** Delirium superimposed on dementia: a systematic review. J Am Geriatr Soc. 2002;50:1723-32. [PMID: 12366629]

23. **Gustafson Y, Brännström B, Norberg A, Bucht G, Winblad B.** Underdiagnosis and poor documentation of acute confusional states in elderly hip fracture patients. J Am Geriatr Soc. 1991;39:760-5. [PMID: 2071806]

24. **Hustey FM, Meldon SW.** The prevalence and documentation of impaired mental status in elderly emergency department patients. Ann Emerg Med. 2002;39:248-53. [PMID: 11867976]

25. **Kales HC, Kamholz BA, Visnic SG, Blow FC.** Recorded delirium in a national sample of elderly inpatients: potential implications for recognition. J Geriatr Psychiatry Neurol. 2003;16:32-8. [PMID: 12641371]

26. **Lemiengre J, Nelis T, Joosten E, Braes T, Foreman M, Gastmans C, et al.** Detection of delirium by bedside nurses using the confusion assessment method. J Am Geriatr Soc. 2006;54:685-9. [PMID: 16686883]

27. **Milisen K, Foreman MD, Wouters B, Driesen R, Godderis J, Abraham IL, et al.** Documentation of delirium in elderly patients with hip fracture. J Gerontol Nurs. 2002;28:23-9. [PMID: 12465199]

28. **Kiely DK, Jones RN, Bergmann MA, Marcantonio ER.** Association between psychomotor activity delirium subtypes and mortality among newly admitted post-acute facility patients. J Gerontol A Biol Sci Med Sci. 2007;62:174-9. [PMID: 17339642]

29. **Yang FM, Marcantonio ER, Inouye SK, Kiely DK, Rudolph JL, Fearing MA, et al.** Phenomenological subtypes of delirium in older persons: patterns, prevalence, and prognosis. Psychosomatics. 2009;50:248-54. [PMID: 19567764] doi:10.1176/appi.psy.50.3.248

30. **Folstein MF, Folstein SE, McHugh PR.** "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12:189-98. [PMID: 1202204]

31. **Inouye SK, Foreman MD, Mion LC, Katz KH, Cooney LM Jr.** Nurses' recognition of delirium and its symptoms: comparison of nurse and researcher ratings. Arch Intern Med. 2001;161:2467-73. [PMID: 11700159]

32. **Ely EW, Inouye SK, Bernard GR, Gordon S, Francis J, May L, et al.** Delirium in mechanically ventilated patients: validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU). JAMA. 2001;286:2703-10. [PMID: 11730446]

33. **Hart RP, Levenson JL, Sessler CN, Best AM, Schwartz SM, Rutherford LE.** Validation of a cognitive test for delirium in medical ICU patients. Psychosomatics. 1996;37:533-46. [PMID: 8942204]

34. **Brummel NE, Vasilevskis EE, Han JH, Boehm L, Pun BT, Ely EW.** Implementing delirium screening in the ICU: secrets to success. Crit Care Med. 2013;41:2196-208. [PMID: 23896832] doi:10.1097/CCM.0b013e31829a6f1e

35. **McNicoll L, Pisani MA, Ely EW, Gifford D, Inouye SK.** Detection of delirium in the intensive care unit: comparison of confusion assessment method for the intensive care unit with confusion assessment method ratings. J Am Geriatr Soc. 2005;53:495-500. [PMID: 15743296]

36. **Neufeld KJ, Hayat MJ, Coughlin JM, Huberman AL, Leistikow NA, Krumm SK, et al.** Evaluation of two intensive care delirium screening tools for non-critically ill hospitalized patients. Psychosomatics. 2011;52:133-40. [PMID: 21397105] doi:10.1016/j.psym.2010.12.018

37. **Han JH, Wilson A, Graves AJ, Shintani A, Schnelle JF, Dittus RS, et al.** Validation of the Confusion Assessment Method for the Intensive Care Unit in older emergency department patients. Acad Emerg Med. 2014;21:180-7. [PMID: 24673674] doi:10.1111/acem.12309

38. **Han JH, Wilson A, Vasilevskis EE, Shintani A, Schnelle JF, Dittus RS, et al.** Diagnosing delirium in older emergency department patients: validity and reliability of the delirium triage screen and the brief confusion assessment method. Ann Emerg Med. 2013;62:457-65. [PMID: 23916018] doi:10.1016/j.annemergmed.2013.05.003

39. **Ely EW, Truman B, Shintani A, Thomason JW, Wheeler AP, Gordon S, et al.** Monitoring sedation status over time in ICU patients: reliability and validity of the Richmond Agitation-Sedation Scale (RASS). JAMA. 2003;289:2983-91. [PMID: 12799407]

40. **American Psychiatric Association.** Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Arlington, VA: American Psychiatric Publishing; 2013.

41. **Inouye SK, Kosar CM, Tommet D, Schmitt EM, Puelle MR, Saczynski JS, et al.** The CAM-S: development and validation of a new scoring system for delirium severity in 2 cohorts. Ann Intern Med. 2014;160:526-33. [PMID: 24733193] doi:10.7326/M13-1927

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

Current Author Addresses: Drs. Marcantonio and Ngo: Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Boston, MA 02215.
Dr. O'Connor: Department of Neurology, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Boston, MA 02215.
Dr. Jones: Department of Psychiatry and Human Behavior, Warren Alpert School of Medicine at Brown University, Providence, RI 02903.
Dr. Crane: Division of General Internal Medicine, Department of Medicine, University of Washington, Box 35978, 325 Ninth Avenue, Seattle, WA 98104.
Drs. Metzger and Inouye: Aging Brain Center, Institute for Aging Research, Hebrew SeniorLife, 1200 Centre Street, Boston, MA 02131.

Author Contributions: Conception and design: E.R. Marcantonio, L.H. Ngo, R.N. Jones, S.K. Inouye.
Analysis and interpretation of the data: E.R. Marcantonio, L.H. Ngo, M. O'Connor, R.N. Jones, P.K. Crane, E.D. Metzger, S.K. Inouye.
Drafting of the article: E.R. Marcantonio, L.H. Ngo.
Critical revision of the article for important intellectual content: L.H. Ngo, M. O'Connor, R.N. Jones, P.K. Crane, E.D. Metzger, S.K. Inouye.
Final approval of the article: E.R. Marcantonio, L.H. Ngo, M. O'Connor, R.N. Jones, P.K. Crane, E.D. Metzger, S.K. Inouye.
Provision of study materials or patients: E.D. Metzger.
Statistical expertise: L.H. Ngo, R.N. Jones, P.K. Crane.
Obtaining of funding: E.R. Marcantonio.
Administrative, technical, or logistic support: S.K. Inouye.
Collection and assembly of data: E.R. Marcantonio, M. O'Connor, E.D. Metzger.

Appendix Table 1. **List of Most Informative Items for the 4 CAM Diagnostic Features***

Item	Selected for Final 3D-CAM
Feature 1: Acute Change or Fluctuating Course (7 items)	
Direct patient questions	
Have you felt confused today?	X
Did you think you weren't really in the hospital?	X
Did you see things that weren't really there?	X
Were you confused about sounds that you heard?	
Interviewer observations	
Fluctuating level of consciousness	X
Fluctuating attention	X
Fluctuating speech	X
Feature 2: Inattention (13 items)	
Direct patient questions	
Digit span: 3 backward	X
Digit span: 4 backward	X
Days of the week backward	X
Months of the year backward	X
What is the month?	
What type of place are you in?	
What is the year?	
What is the day of the week?	
Interviewer observations	
Trouble keeping track during the interview	X
Fluctuating attention	
Unaware of the environment	
Easily distracted	X
Staring into space	
Feature 3: Disorganized Thinking (10 items)	
Direct patient questions	
What is the month?	
What type of place are you in?	X
What is the year?	X
What is the day of the week?	X
Interview observations	
Unclear, illogical flow of ideas	X
Suddenly change subject	
Rambling conversation	X
Speech limited or sparse	X
Paucity of thoughts	
Speech unusually slow	
Feature 4: Altered Level of Consciousness (6 items)	
Interviewer observations (no patient questions)	
Patient is sleepy, stuporous, or comatose	X
Evidence of disturbance of sleep	
Lethargy and sluggishness	
Restlessness	
Patient is abnormally absorbed by objects (hypervigilance)	X
Grasping or picking	

* Items identified by item response theory.

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

Appendix Table 2. **Additional Test Characteristics of the 3D-CAM***

Sample	Accuracy (95% CI), %	Positive Predictive Value (95% CI), %	Negative Predictive Value (95% CI), %
Entire sample	94 (90–97)	82 (68–91)	99 (95–100)
Baseline cognition			
Normal or MCI	96 (91–98)	72 (47–90)	99 (96–100)
Dementia	91 (80–97)	87 (70–96)	96 (80–100)

MCI = mild cognitive impairment.
* In relation to the reference standard. Most notable is the extremely high negative predictive value seen in the overall sample and both cognitive strata. This shows that the 3D-CAM is extremely effective in ruling out delirium, which is appropriate for a short screening test.

Appendix Table 3. **Interrater Agreement of the 3D-CAM***

Delirium Diagnosis	First 3D-CAM		Second 3D-CAM Total
	Positive	Negative	
Second 3D-CAM assessment			
Positive	21	1	22
Negative	4	74	78
First 3D-CAM total	25	75	100

* A total of 8 raters, representing 18 distinct pairs of raters, participated in the interrater agreement study. Each pair evaluated between 1 to 19 participants. The 2 raters agreed on delirium diagnosis in 95 of 100 participants, with agreement rates among rater pairs ranging from 75% to 100%.

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014

Correction: Derivation and Validation of a 3-Minute Diagnostic Interview for CAM-Defined Delirium

In Figure 1 of a recent article (1), in the "Feature 2: inattention" cell, the "Observed" parameter should read as follows: trouble keeping track of interview or inappropriately distracted.

This has been corrected in the online version.

Reference

1. Marcantonio ER, Ngo LH, O'Connor M, Jones RN, Crane PK, Metzger ED, et al. 3D-CAM: derivation and validation of a 3-minute diagnostic interview for CAM-defined delirium: a cross-sectional diagnostic test study. Ann Intern Med. 2014;161: 554-61.

Downloaded From: http://annals.org/ by Benjamin Littenberg on 10/28/2014