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Original article

Validity and reliability of the Thai 3-Minute Diagnostic Interview for CAM-defined Delirium (Thai 3D-CAM)

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Background: Delirium is a common complication of hospitalized patients leading to worse outcomes. Screening tools can improve detection and prompt treatment. The 3-minute Diagnostic Interview for Confusion Assessment Method (CAM)-defined Delirium (3D-CAM) is a practical, valid, and reliable screening tool developed by Dr. Edward R. Marcantonio in 2014. The 3D-CAM was translated into Thai language.

Objective: To demonstrate the validity and reliability of the Thai 3D-CAM compared to psychiatrist diagnosis based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5).

Methods: One hundred and forty-two patients were recruited with consent from the patients or a caregiver from adult inpatients requiring psychiatric consultation. Patients were assessed with the Thai 3D-CAM, the Thai Delirium Rating Scale-Revised-98 (DRS-R-98), followed by a psychiatric interview based on the DSM-5.

Results: Delirium proportion in the study population was 48.6%. The most common motor subtype was mixed delirium (56.5%), followed by hyperactive (23.2%), and hypoactive delirium (20.3%). The sensitivity of the Thai 3D-CAM was 91.3% (95% CI = 84.7 - 98.0), and specificity was 90.4% (95% CI = 83.6 - 97.2). Thai 3D-CAM results correlated with gold standard diagnosis, with χ^2 of 94.763 ($P < 0.001$), and Cohen's kappa of 0.817 (95% CI = 0.723 - 0.911, $P < 0.001$). Internal consistency was demonstrated with Cronbach's alpha = 0.708. Inter-rater reliability showed near perfect agreement (Kappa = 0.818, 95% CI = 0.577 - 1.059, $P < 0.001$).

Conclusion: The Thai 3D-CAM is a valid and reliable screening tool for delirium. Availability of this screening tool could assist in improving detection and early treatment.

Keywords: 3D-CAM, delirium, delirium screening, screening tool, validity and reliability.

Delirium is a common complication of hospitalized patients, with a prevalence ranging from 10.0 - 40.0% in general medicine or surgery wards, to 60.0 - 80.0% in intensive care units. [1] Delirium is related to worse patient outcomes, including increased mortality, longer hospital stay, increased need for nursing home placement, and may accelerate cognitive decline. [1 – 3]

Despite its prevalence, delirium may be unrecognized in up to 60.0% of cases, [4] possibly due to lack of understanding about delirium, the fluctuating nature of delirium, communication barriers, and confusion between delirium and dementia. [5] Delirium screening tools can assist in detection and prompt treatment.

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A variety of screening tools have been developed. Among the most widely used is the Confusion Assessment Method (CAM) devised by S. Inouye in 1990. The CAM is based on 4 core features of delirium: acute onset and fluctuating course, inattention, altered level of consciousness, and disorganized thinking. A diagnosis of delirium was made if features 1 and 2, and either 3 or 4 were present. Due to its limited use in mechanically ventilated patients, the CAM was adapted to create the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) in 2001.[6]

The 3-minute Diagnostic Interview for CAM-defined Delirium (3D-CAM) was derived from the original CAM in 2014 by Marcantonio ER, *et al* for the purpose of creating a more concise, and therefore more clinically applicable, screening method. Sensitivity and specificity of 3D-CAM are 95.0% and 94.0% respectively, with inter-rater agreement of 95.0%. The test performed well even in a subgroup of patients with dementia, resulting in sensitivity of 96.0% and specificity of 86.0%. [7]

In non-intensive care general medicine units, 3D-CAM was found to be more sensitive than CAM-ICU (3D-CAM sensitivity = 95% vs.CAM-ICU sensitivity = 53.0%). [8]

Other assessment tools for delirium have also been developed independently of the CAM, both for screening purposes and for assessment of delirium severity. Screening tools that have been translated into Thai language include the CAM [9], CAM-ICU [10], the Delirium Rating Scale-Revised-98 (DRS-R-98) [11] and the 4A's Test (4AT). [12] The Thai DRS-R-98 can also evaluate delirium severity using the severity sub-score.

The 3D-CAM is a precise, globally accepted screening tool for delirium and easy to use in the clinical setting. Thai availability of such tool could improve standard of care in delirium patients, as well as assist in future research on delirium. The aim of this study was to translate the 3D-CAM according to standard procedures, and investigate the validity, reliability, sensitivity, and specificity of the Thai 3D-CAM.

Materials and methods

Questionnaire development

Permission to translate the 3D-CAM into Thai was requested and granted by Dr. Marcantonio. The researcher translated the questionnaire from English to Thai, and backward translation was completed by the Chulalongkorn University Language Institute. Content validity of the final questionnaire was evaluated by expert opinion consisting of 1 geriatric psychiatrist, 1 general psychiatrist and 1 neurologist. Item-object congruence (IOC) was used to measure validity of each questionnaire item. Items with IOC less than 0.5 were revised according to expert suggestions. Cronbach's alpha was used to assess internal consistency.

Validation process

Inpatients of King Chulalongkorn Memorial Hospital aged above 18 years whose primary physician requested non-urgent psychiatric consultation and were not yet discharged within 24 hours of consultation were included. The list of psychiatric consultations of each data collection day was obtained from the Department of Psychiatry, and all patients in each day were assessed for exclusion criteria. Patients who were intubated, tracheostomized, comatose, mute, severely deaf or blind, could not speak Thai, or too frail to participate were excluded from the study. The patients or surrogate decision makers were approached for consent.

Relevant history and clinical data were obtained from the patient, caregivers or medical record. Severity of underlying diseases was quantified by the Charlson Comorbidity Index. [13] The investigator completed the Thai 3D-CAM in accordance with 3D-CAM training manual for research. [14]

The 3D-CAM is based on the same diagnostic algorithm as the CAM, namely the presence or absence of 4 core features as previously described. Each feature is assessed using 10 interview questions and 10 observer ratings, as well as 2 optional questions to elicit acute change based on history from caregivers, medical staff, medical record, or previous 3D-CAM results. Delirium is considered present if a patient displays characters of feature 1 (acute onset and fluctuating course) and feature 2 (inattention), and either feature 3 (altered consciousness) or feature 4 (disorganized thinking).

As well as the Thai 3D-CAM, The Thai Delirium Severity Score-Revised-98 (DRS-R-98) was also completed to provide information about delirium severity. The reference gold standard for delirium diagnosis was clinical interview by a board-certified psychiatrist (TP) with diagnostic criteria according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5). The psychiatrist was blinded from the Thai 3D-CAM result previously assessed by the investigator. Delirium motor subtype was also classified by the psychiatrist according to obtained nursing data and bedside psychomotor assessment according to DSM-5 specifier criteria. Twenty subjects were randomly selected for a second 3D-CAM rating by an independent psychiatric resident to assess inter-rater reliability. All ratings were completed within 24 hours of the first 3D-CAM rating.

Statistical analysis

Based on expected delirium prevalence of 0.5, 142 subjects were recruited. Twenty subjects were estimated to provide at least 80.0% power for inter-rater reliability (Kappa 0.8, alpha 0.05, prevalence 0.5). Using DSM-5 diagnosis as a reference standard, Chi square test and Kappa agreement were used to investigate concurrent validity, and sensitivity and specificity of the 3D-CAM were also calculated. Pearson correlation and binary logistic regression was used to explore factors associated with delirium or a positive Thai 3D-CAM result. As an additional

investigation of the properties of the 3D-CAM, we investigated whether the total sum of positive items from the Thai 3D-CAM could indicate delirium severity. For this purpose, Pearson correlation between the sum of positive items and the Thai DRS-R-98 score was conducted. The study protocol has been reviewed and approved by the Ethics Committee for Human Research of Chulalongkorn University (IRB no.193/61). All statistical analyses were computed with SPSS for windows version 22. *P*-value < 0.05 was considered statistically significant difference.

Results

Patient characteristics

A total of 142 patients consulted for psychiatric evaluation were included for validation of the Thai 3-Minute Diagnostic Interview for Confusion Assessment Method (Thai 3D-CAM). The demographic and clinical characteristics of the research participants were demonstrated in Table 1.

The majority of patients were male, aged above 60, and had more than 12 years of education. Twenty-four patients (17.0%) had a history of cognitive impairment noticeable by caregivers. The largest proportion of patients were from internal medicine wards, followed by surgical and orthopedic wards.

A final diagnosis of delirium was made in 69 patients by DSM-5 diagnostic interview, resulting in a delirium proportion of 48.6% in our study population. The psychiatric characteristics and motor subtypes are described in Table 2. Delirium was mostly due to multiple etiologies, with 3 cases due to alcohol withdrawal. In patients without delirium at time of assessment, diagnosis was classified according to psychiatrist interview, based on DSM-5. Three patients were diagnosed with resolved delirium. Subsyndromal delirium, noted by the psychiatrist, was classified as negative for delirium. In such cases, other co-occurring conditions were used as the final psychiatric diagnosis.

Table 1. Subjects characteristics.

Characteristics	Frequencies (%)
Mean age ± standard deviation (years)	61.0 ± 19.7
Male	76 (53.5)
Years of education	
0 - 6	45 (31)
7 - 12	38 (26.8)
>13	55 (38.7)
Mean Charlson Comorbidity Index score ± standard deviation	4.3 ± 2.9
Requiring visual aid	29 (20.4)
Requiring hearing aid	14 (9.9)
History of delirium	29 (20.4)
History of cognitive impairment	24 (16.9)
Department	
Medicine	64 (45.1)
Surgery	41 (28.9)
Orthopedics	19 (13.4)
Obstetrics and gynecology	7 (4.9)
Therapeutic radiology	6 (4.2)
Others	5 (3.5)
Final psychiatric diagnosis	
Delirium	69 (48.6)
Resolved delirium	3 (2.1)
Adjustment disorder	26 (18.3)
Depression	22 (15.5)
Substance-related disorders	7 (4.9)
Dementia	4 (2.8)
Pre-transplant evaluation	4 (2.8)
Psychosis	3 (2.1)
Others	4 (2.8)

Table 2. Delirium assessment results.

Characteristic	Frequency (%)
Motor subtype (% of delirium cases)	
Hypoactive	14 (20.3)
Hyperactive	16 (23.2)
Mixed	39 (56.5)
Thai 3D-CAM positive	70 (49.3)
Median DRS-R-98 total score	12 (Interquartile range = 4 - 20)
Median DRS-R-98 severity score	8 (Interquartile range = 2 - 16)

Validity

Expert evaluation of content validity resulted in a total Item-object congruence = 0.98. There was significant association between the Thai 3D-CAM result and psychiatric interview diagnosis with χ^2 of 94.763 ($P < 0.001$), and Kappa agreement was 0.817 (95% CI = 0.723 - 0.911, $P < 0.001$) demonstrating adequate validity of the Thai 3D-CAM. Sensitivity of the 3D-CAM was 91.3% (95% CI = 84.7 - 98.0), and specificity was 90.4% (95% CI = 83.6 - 97.2) Table 3. Positive predictive value was 90.0%, and negative predictive value was 91.7%. Positive likelihood ratio was 9.5.

Reliability

Reliability statistics resulted in a Cronbach's alpha of 0.708 demonstrating acceptable internal consistency. Cronbach's alpha if item were deleted ranged from 0.679 to 0.716 as shown in Table 4. The items most consistent with the questionnaire (lowest Cronbach's alpha if item deleted) were item 21 (acute change based on medical record or history from caregiver), item 1 (ask patient: "Please tell me the year are we in right now"), and item 9 (ask patient: "During the past day did you think that you were not really in the hospital?"). The items least consistent with the questionnaire (highest Cronbach's alpha if item deleted) were item 11A (observation of patient falling asleep during interview), item 8 (ask patient: "During the past day have you felt confused?"), and item 11B (observation of the patient being stuporous or comatose). Inter-rater reliability showed almost perfect agreement between raters (kappa = 0.818, 95% CI = 0.577 - 1.059, $P < 0.001$).

Binary logistic regression was used to examine factors associated with a positive Thai 3D-CAM result. Age, gender, education, Charlson comorbidity index, eyesight difficulties, hearing difficulties (defined by requiring visual or hearing aid), previous history of delirium, history of cognitive impairment, history of head trauma, nicotine use disorder and alcohol use disorder were investigated. It was found that factors significantly associated with a positive Thai 3D-CAM result included age and history of previous delirium while association with alcohol use disorder was nearly significant ($P = 0.05$).

Post-hoc analyses

Post-hoc analyses explored the effect of delirium motor subtypes and delirium severity on the psychometric properties of the Thai 3D-CAM, as shown in Table 5. Accuracy was highest in hyperactive delirium, while lowest in mixed delirium. The F1 score, which is the harmonic mean between sensitivity and positive predictive value, was highest in mixed delirium, while lowest in hypoactive delirium. Cohen's kappa was highest in hyperactive delirium, and lowest in hypoactive delirium.

Table 3. Diagnostic results of the Thai 3D-CAM compared to the gold standard DSM-5 interview.

	Delirium (DSM-5)		Total
3D-CAM	**Present**	**Not present**	
Positive	63	7	70
(% within delirium)	(91.3%)	(9.6%)	
Negative	6	66	72
(% within delirium)	(8.7%)	(90.4%)	
Total	69	73	142

Table 4. Cronbach's alpha if item was deleted.

Item number	Cronbach's alpha if deleted
1	0.724
2	0.732
3	0.734
4	0.732
5	0.748
6	0.727
7	0.741
8	0.747
9	0.725
10	0.740
11	0.753
12	0.748
13	0.747
14	0.733
15	0.748
16	0.737
17	0.734
18	0.746
19	0.739
20	0.726
21	0.746
22	0.720
23	0.708

Table 5. Test characteristics in different delirium motor subtypes.

Motor subtype	Sensitivity (%)	Specificity (%)	Accuracy (%)	F1 score (%)	Kappa
No delirium VS hypoactive delirium	92.9	90.4	90.8	76.5	0.710 ($P < 0.001$)
No delirium VS hyperactive delirium	100	90.4	92.1	82.1	0.772 ($P < 0.001$)
No delirium VS mixed delirium	87.2	90.4	89.3	85.0	0.767 ($P < 0.001$)

Effect of the severity of delirium symptoms as measured by the Thai DRS-R-98 was also investigated, as shown in Table 6. To examine the validity of the Thai 3D-CAM in different severity groups, we divided the patients with delirium into 4 groups according to their Thai DRS-R-98 severity score. Since the first, second, and third quartiles (Q1, Q2, and Q3) of DRS-R-98 severity scores in delirious patients in this study were 10, 15, and 18 respectively, we divided all the patients into 4 groups according to severity score: <10, 10 -14, 15 - 17, and ≥ 18. We then analyzed the properties of the Thai 3D-CAM compared to DSM-5 diagnosis in each group.

Table 6 shows the characteristics of the Thai 3D-CAM in each severity group. The Thai 3D-CAM performed best when the Thai DRS-R-98 severity score was at least 15. When the severity score was 10 - 14, the Thai 3D-CAM was highly sensitive but less specific. The F1 score, which corrects for class imbalance and gives more weight to false positive and negative cases, was high in patients with a severity score of at least 10. In the subgroup of patients with the lowest severity score where delirium was least likely, the Thai 3D-CAM had better value in predicting negative cases (NPV = 91.3%) than detecting positive cases.

Table 6. Test characteristics in different severities.

Thai DRS-R-98 severity score	Sensitivity (%)	Specificity (%)	Accuracy (%)	F1 score (%)	Kappa
< 10	45.5	95.5	88.3	52.6	0.462 ($P < 0.001$)
10 - 14	100.0	40.0	87.0	92.3	0.511 ($P = 0.005$)
15 - 17	100.0	100.0	100.0	100.0	1 ($P < 0.001$)
≥ 18	100.0*	0.0*	95.5	97.7	Not applicable*

*No 3D-CAM negative cases

Another property of the Thai 3D-CAM investigated post-hoc was whether the total sum of positive items could indicate delirium severity. A scatter plot of relationship between the 3D-CAM sum of positive items and DRS-R-98 total and severity scores (Figure 1) shows that patients with a high sum of positive items usually have higher severity according to DRS-R-98 scores. Correlation analyses showed that the sum of positive items correlated with both DRS-R-98 total scores ($r = 0.906$, $P < 0.001$) and severity scores ($r = 0.886$, $P < 0.001$).

The summary of positive 3D-CAM items was explored for its value in predicting delirium diagnosis according to DSM-5. The area under the curve of the receiver operating characteristic (ROC) curve was 0.956 ($P < 0.001$). A cut off score of > 3 was selected for a sensitivity of 97.1% and specificity of 83.6%. Other test characteristics were similar to the original 3D-CAM interpretation (presence of feature 1 and 2 and either 3 or 4), as shown in Table 7.

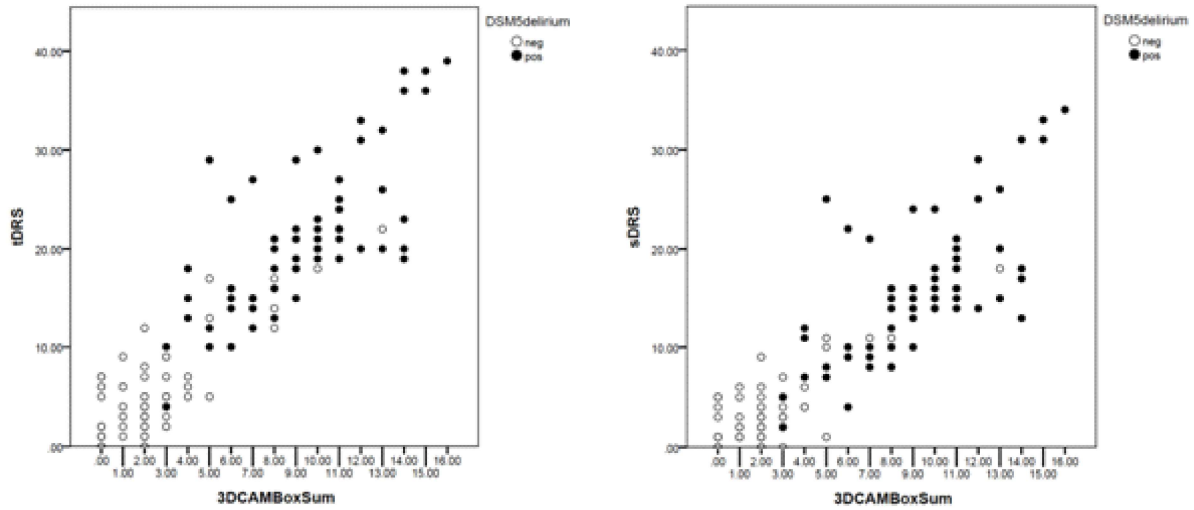

Figure 1. Scatter plot of relationship between the 3D-CAM sum of positive items and DRS- R-98 total and severity scores (3DCAMBoxSum= 3D-CAM sum of positive items; tDRS= Thai DRS-R-98 total score; sDRS= Thai DRS-R-98 severity score).

Table 7. Comparison of 3D-CAM characteristics when interpreted by CAM algorithm (presence of feature 1 and 2 and either 3 or 4) or by number of positive items.

Thai 3D-CAM interpretation	Sensitivity (%)	Specificity (%)	Accuracy (%)	F1 score (%)
Presence of feature 1 and 2 and either 3 or 4	91.3	90.4	90.9	90.7
Sum of positive items > 3	97.1	83.6	90.1	90.5

Discussion

The Thai 3D-CAM demonstrated adequate validity with acceptable sensitivity (91.3%) and specificity (90.4%). It is reliable both in terms of internal consistency, with Cronbach's alpha = 0.708, and inter-rater reliability, with kappa 0.818. These data support comparable validity and reliability of the Thai 3D-CAM to the original English version.

Items that attributed to the most internal consistency included a question eliciting a history of acute change, and questions assessing orientation to time and place. Such questions may have the greatest value in predicting delirium. The items that were least valuable in this study was observation of decreased consciousness. This may be due to a selection bias for patients who were awake enough to participate throughout the interview. Another item that contributed least to internal consistency in this study was asking the patient if he/she felt confused. It is possible that patients with poor insight to their condition do not usually report a subjective feeling of confusion.

Factors significantly associated with a positive Thai 3D-CAM result were age and history of previous delirium, which are known predictors of delirium occurrence.

Post-hoc analyses found that the Thai 3D-CAM performed best in detecting hyperactive delirium but was also useful for other subtypes of delirium. In patients with very low delirium severity scores, or least likely to have delirium, the Thai 3D-CAM was useful in detecting non-delirium cases, but less able to detect such subtle delirium. However, for patients in the second quartile of severity, the sensitivity of the Thai 3D-CAM markedly improved, demonstrating good validity even when delirium severity was less than the median severity of patients in this study. The correlation between DRS-R-98 severity score and clinical outcomes have not been well studied, but it is safe to assume that delirium with low severity scores would be more difficult to detect by untrained healthcare personnel.

The total sum of positive items in the Thai 3D-CAM was found to have a linear relationship with increasing severity as measured by the Thai DRS-R-98. This method of measuring severity is slightly different from previous severity measurements in which it does not quantify the severity of each symptom, but rather converts the number of signs and symptoms elicited by the interview into an expression of severity. Compared to another tool in the CAM family to assess severity, the CAM-S, this may indicate a new way to assess severity without necessarily using an extra questionnaire. However, while the severity of the CAM-S has shown association with clinical outcomes [15], the clinical relevance of the 3D-CAM sum of positive items has yet to be proven.

Compared to the original English 3D-CAM, in which sensitivity was 95.0% and specificity 94.0%, this study yielded lower accuracy, possibly to several factors. In the previous 3D-CAM validation by Marcantonio E., the 3D-CAM assessment and the standard diagnostic interview was completed within a 2-hour time frame. Such temporal proximity could not be achieved in this study due to practical reasons. The 24-hour gap between the 3D-CAM assessment and diagnostic interview could lead to differing clinical symptoms due to the fluctuating nature of delirium. Also, the sample population of this validation study had different characteristics. The English 3D-CAM validation study selected patients at least 75 years old, in contrast to this study which uses a much lower age limit of only 18. This may lead to different neuropsychiatric syndromes due to differences in cognition as well as psychopathology, such as a higher prevalence of mood disorders or substance-related disorders in the younger population.

In comparison to another available Thai language screening tool, the Thai CAM-ICU, sensitivity and specificity of the Thai 3D-CAM were slightly less (Thai CAM-ICU sensitivity = 92.3%, specificity = 94.7%). However, these results may not be directly comparable due to different clinical utility of the 3D-CAM and CAM-ICU. In accordance with intended CAM-ICU use in the intensive care setting, the Thai CAM-ICU was validated in a population of patients in the surgical intensive and subintensive care unit aged over 60. Although delirium severity was not reported, the nature of more severe physical conditions may contribute to greater symptom fluctuation, as well as disruptions in attention and thinking.

Limitations of this study included the large temporal gap between 3D-CAM assessment and the final diagnostic assessment, possibly lowering the overall accuracy. Despite this fact, the psychometric properties of the Thai 3D-CAM are still acceptable for use as a screening tool. A second limitation is that effect of the assessor's clinical experience on performance of the test was not studied. Half of the questionnaire relies on observer ratings, so it is reasonable to assume that the ability to recognize the signs and symptoms of delirium may affect its clinical

utility. As all 3D-CAM assessments in this study were performed by psychiatric residents of Chulalongkorn University, it is unknown how the validity and reliability of the Thai 3D-CAM would be affected if used by other healthcare professionals. Another limitation was that the Thai 3D-CAM was not specifically tested in the geriatric population or in patients with dementia, therefore limiting knowledge about how impaired cognition would impact the test performance. Conversely, this could also be a strength, since it allowed for recruiting of patients from a wide variety of inpatient wards with different psychiatric problems. This may improve the generalizability of study results from the medical geriatric population to a wider range of consultation-liaison psychiatry patients.

Conclusion

The Thai 3D-CAM is a valid and reliable screening tool for delirium across a wide range of consultation-liaison patients. Compared to other available screening tools in Thai, the Thai 3D-CAM is less complicated than the previously translated CAM or DRS-R-98, and may be more appropriate for non-ICU patients than the CAM-ICU. With minimal training, medical personnel other than psychiatrists can also use this tool to assist in detection of delirium, possibly improving detection of delirium cases and so promoting early management.

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Conflict of interest

The authors, hereby, declare no conflict of interest.

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