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Screening and detection of delirium in older ED patients: performance of the modified Confusion Assessment Method for the Emergency Department (mCAM-ED). A two-step tool

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Abstract
Delirium is frequent in older Emergency Department (ED) patients, but detection rates for delirium in the ED are low. To aid in identifying delirium, we developed and implemented a two-step systematic delirium screening and assessment tool in our ED: the modified Confusion Assessment Method for the Emergency Department (mCAM-ED). Components of the mCAM-ED include: (1) screening for inattention, the main feature of delirium, which was performed with the Months Backwards Test (MBT); (2) delirium assessment based on a structured interview with questions from the Mental Status Questionnaire by Kahn et al. and the Comprehension Test by Hart et al. The aims of our study are (1) to investigate the performance criteria of the mCAM-ED tool in a consecutive sample of older ED patients, (2) to evaluate the performance of the mCAM-ED in patients with and without dementia and (3) to test whether this tool is efficient in keeping evaluation time to a minimum and reducing screening and assessment burden on the patient. For this prospective validation study, we recruited a consecutive sample of ED patients aged 65 and older during an 11-day period in November 2015. Trained nurses assessed patients with the mCAM-ED. Results were compared to the reference standard [i.e. the geriatricians' delirium diagnosis based on the criteria of the Text Revision of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)]. Performance criteria were computed. We included 286 consecutive ED patients aged 65 and older. The median age was 80.02 ($Q_1 = 72.15$; $Q_3 = 86.76$), 58.7% of included patients were female, 14.3% had dementia. We found a delirium prevalence of 7.0%. In patients with dementia, specificity and positive likelihood ratio were lower. When compared to the reference standard, delirium assessment with the mCAM-ED has a 0.98 specificity and a 39.9 positive likelihood ratio. In 80.0% of all cases, the first step of the mCAM-ED, i.e. screening for inattention with the MBT, took less than 30 s. On average, the complete mCAM-ED assessment required 3.2 (SD 2.0), 5.6 (SD 3.2), and 6.2 (SD 2.3) minutes in cognitively unimpaired patients, patients with dementia and patients with dementia or delirium, respectively. The mCAM-ED is able to efficiently rule out delirium as well as confirm the diagnosis of delirium in elderly patients with and without dementia and applies minimal screening and assessment burden on the patient.

Keywords Algorithms · Attention · Delirium · Dementia · Prevalence · Performance · Emergency medicine

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Abbreviations

WH	Wolfgang Hasemann
FFG	Florian F. Grossmann
ED	Emergency Department
mCAM-ED	Modified Confusion Assessment method for the Emergency Department
MSQ	Mental Status Questionnaire
mRASS	Modified Richmond Agitation Sedation Scale

Introduction

Delirium is a common neuropsychiatric syndrome with a main feature of inattention. It displays a fluctuating course of acute disturbance in consciousness and decline in cognition [1]. Delirium is frequent in Emergency Department (ED) patients, and it occurs primarily in older patients. About 10% of patients presenting to the ED aged 65 and older are delirious [2–4]. ED patients with delirium are at increased risk of mortality, prolonged hospitalization and in-hospital complications [5, 6]. However, detection rates for delirium in the ED are low. Up to 83% of cases are missed [7–10]. While informal delirium screening appears to be insufficient, systematic delirium screening has been shown to improve delirium detection [4, 11]. Early and accurate recognition of delirium in older patients in the ED might facilitate treatment, and potentially lead to beneficial outcomes. Even more challenging is detecting delirium superimposed on dementia (DSD), as symptoms might be falsely attributed to dementia alone [12].

We previously introduced a systematic delirium screening and assessment by developing and implementing the modified Confusion Assessment Method for the Emergency Department (mCAM-ED) to improve early detection. It proved to be a feasible screening and assessment tool for the ED setting [4].

First, we aim to investigate performance criteria of the mCAM-ED compared with diagnosis based on the reference standard criteria (i.e. geriatricians' delirium diagnostic criteria according DSM-IV-TR) in a consecutive sample of ED patients aged 65 and older. Second, we investigate whether the mCAM-ED's ability to detect delirium differs between older ED patients with and without dementia. Third, we test whether this tool is efficient in keeping evaluation time to a minimum and reducing screening and assessment burden on the patient.

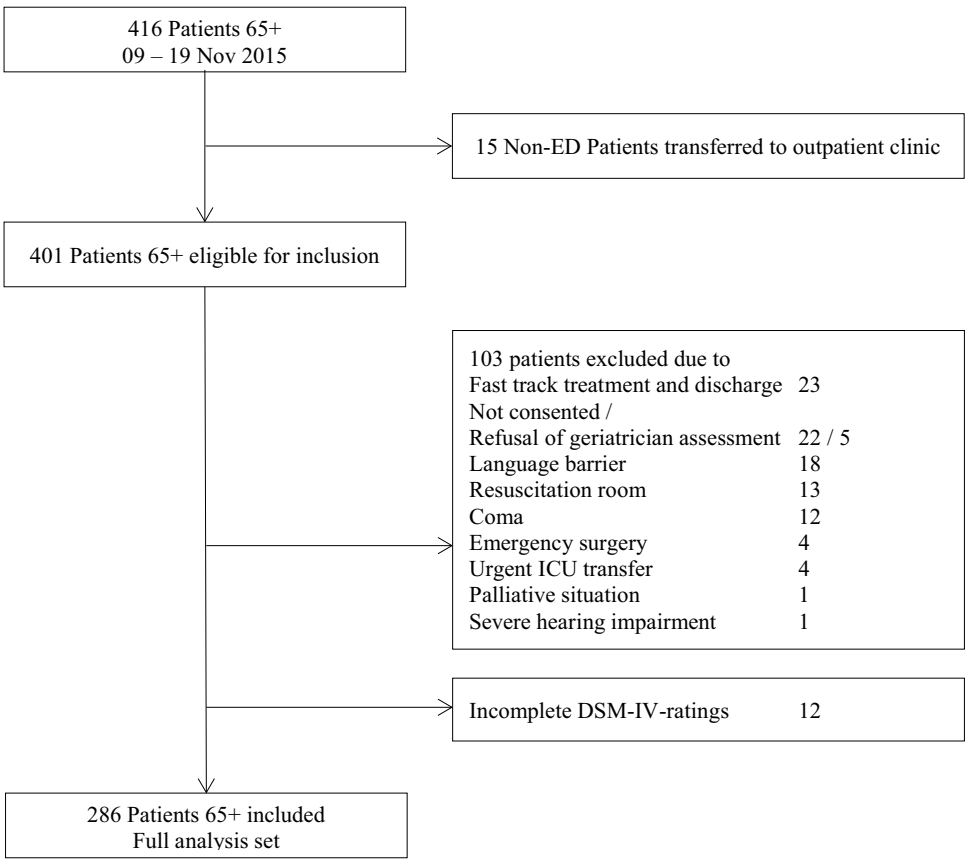

Fig. 1 Flow of participants

Methods

Study design, setting and population

This single center prospective validation study comprised a consecutive sample of ED patients aged 65 or older. It was conducted in the ED of the University Hospital Basel, a tertiary care hospital in Northwestern Switzerland serving a population of about 730,000 inhabitants whose ED census is approximately 50,000 adult patients per year.

In November 2015, we consecutively collected data 24 h a day over a 11-day period. We excluded patients who were treated in the resuscitation bay, transferred immediately to the intensive care unit, underwent emergency surgery, or had restrictions in communication ability (e.g. language barrier, severe hearing impairment, coma) (see Fig. 1 for inclusion procedure).

Variables and measurement

The mCAM-ED two-step screening and assessment tool

The mCAM-ED algorithm was developed and implemented in our ED in 2012 as part of routine care in patients aged 65 and older, and is usually administered by ED nurses [4].

To achieve the goals of feasibility and minimal assessment burden on the patient, the tool follows a two-step approach: (1) screening for inattention and (2) an assessment of patients with a positive screening result. The mCAM-ED uses the Months Backwards Test (MBT) to detect inattention [13]. According to the framework of Stillman et al., inattention is present if a patient scores three or more points either by making at least three errors or by making at least two errors and needing more than 30 s [14]. In clinical practice, the second step is initiated only if the screening indicates inattention. For formal cognitive assessment to confirm delirium, the mCAM-ED uses the Mental Status Questionnaire (MSQ) by Kahn et al. [15] to detect changes in cognition. The MSQ is a 10-item questionnaire testing orientation to time, place and person and memory. When more than two errors are made the patient is regarded as having an altered cognition. The Comprehension Test by Hart et al. [16] is used to detect disorganized thinking by asking questions such as "Will a stone float on water?" and "Can you use a hammer to pound nails?". When more than two errors out of four questions are made, the patient is regarded as having disorganized thinking. Fluctuating course of cognition, perception or speech and altered level of consciousness such as drowsiness or being hyper-alert are rated based on patient observation during the interview or collateral information. Altered level of consciousness is operationalized as any change from being awake (other than 0) in the modified Richmond Agitation Sedation Scale (mRASS) [17, 18]. Similar to the original Confusion Assessment Method (CAM) algorithm [4, 19], possible or probable delirium is rated when patients show (1) acute changes in cognition (MSQ, collateral history if available), or fluctuating symptoms (observation) and (2) inattention (MBT from step one) and (3) disorganized thinking (Comprehension Test) or (4) an altered level of consciousness (mRASS) [20].

For this validation study both steps of screening and assessment (i.e. the complete mCAM-ED) were conducted on all included consecutive patients, irrespective of their screening result. The mCAM-ED has validated content and its sub-items were previously identified as valid measures of inattention [13, 21, 22], cognitive impairment [15], disorganized thinking [16] and arousal [17, 23]. The CAM algorithm, which was used to obtain the diagnosis, is well validated and the most accepted delirium scale in scientific literature [19, 24, 25].

Geriatricians' reference standard diagnosis

Reference standard diagnosis was conducted by geriatricians using DSM-IV-TR criteria.

According to DSM-IV-TR, delirium is present when (A) there is a disturbance of consciousness with inattention, (B) an acute change in cognition is present, (C) symptoms develop over a short period of time with fluctuation of severity over time and (D) evidence suggests that the disturbance is caused by the direct physiological consequences of a general medical condition [1].

Demographic and efficiency outcome variables

Demographic data included age, gender, time and date of patient presentation, and triage level as measured by the Emergency Severity Index [26]. Additional variables included chief complaint stratified into specific and non-specific symptoms, and trauma according to the framework of Nemec et al. [27]; comorbidities were classified according to the Charlson Comorbidity Index [28]. A dementia diagnosis was considered if it was acknowledged in the electronic health record. The time when the mCAM-ED assessment started and ended, and the time when the reference standard diagnosis started and ended were recorded.

Data collection

Trained nurses (TNs) conducted the complete mCAM-ED screening and assessment on all patients who met inclusion criteria. If patients consented orally, they were included in the study, and an attending geriatrician conducted the reference standard delirium assessment within 1 h of the TN's

assessment. TNs and geriatricians documented the exact time frame, i.e. begin and end of the complete formal assessments. The duration of the screening with the MBT was recorded dichotomously as either shorter or longer than 30 s. Geriatricians and TNs were blinded to each other's results.

TNs were specially trained. They were advanced practice nurses with a certified education in geriatric care (WH, FFG) or bachelor-level nurses with special training in delirium care. This training consisted of an 8-h session about delirium assessment in theory, role playing and discussion of videotapes of real patients. In addition, they were supervised by an expert for 5 days performing delirium assessments at the bedside.

ED nurses were not involved in this study to minimize bias due to potential qualification differences. The training of ED nurses consists of an 8 h theoretical and practical session about delirium prevention, recognition and management including 2 h teaching on the mCAM-ED.

All geriatricians were attending physicians, and had no other clinical duties during the study. All staff were instructed about the procedure of data collection prior to the study.

Data analysis

Demographic data are presented using frequencies and measures of central tendency; i.e., mean scores with standard deviations (SD), and median with first (Q_1) and third quartile (Q_3). The sensitivity, specificity, positive and negative likelihood ratios, as well as the two-sided 95% confidence intervals (CI) of the MBT and the mCAM-ED were computed according to the method of Agresti and Coull [29] and Zhou et al. [30], respectively. The performance criteria of the mCAM-ED were calculated for the full analysis set and the two subsamples of patients with or without dementia. A professional statistician analyzed the data with R version 3.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

The sample size estimation was based on the assumption of a delirium prevalence of 9.5% [4], a sensitivity of about 94% and a two-sided 95% CI with a width of 6% for the mCAM-ED. By applying the sample size approximation of Flahault et al. as adapted by Zhou et al., a sample size of $n = 492$ patients resulted [30, 31].

Ethical considerations

The study was approved by the local ethics committee (identifier EKNZ-2015-123), and registered with ClinicalTrials.gov (identifier NCT02782143). Oral informed consent was obtained from the patient or an authorized proxy. Due to the minimal risk and burden on the patient as well as the potential negative consequences for the patient if a diagnosis were to be missed, the ethics committee allowed patients to be assessed even if obtained consent, either through the patient or by proxy, was not possible.

Table 1 Patients' characteristics ($n = 286$), stratified for patients with and without delirium

	Delirium		No delirium	
	N	%	*N*	%
	20	7.0	266	93.0
Age				
median (Q_1; Q_3)	86.05*	81.32, 90.53	79.32	71.74, 86.44
Gender				
Female	16	80.0	152	57.1
Male	4	20.0	114	42.9
Dementia	11	55.0	30	11.3
No dementia	9*	45.0	236	88.7
CCI				
Mean (SD)	2.70	2.75	2.46	2.87
Symptoms				
Nonspecific	5	25.0	46	17.3
Specific	10	50.0	143	53.8
Trauma	4	20.0	69	25.9
Not classified	1	5.0	8	3.0
ESI level				
1	0	0.0	1	0.4
2	9	45.0	67	25.2
3	11	55.0	150	56.4
4	0	0.0	47	17.7
Not classified	0	0.0	1	0.4

Patients' presenting complaints, stratified into nonspecific, specific, trauma according the framework of Nemec et al.

CCI Charlson Comorbidity Index, *ESI* Emergency Severity Index, Q_1; Q_3 first and third quartile, *SD* standard deviation

*$p < 0.001$

Results

Out of 401 patients aged 65 and older who were eligible for inclusion, 103 were excluded due to the exclusion criteria, and 12 were excluded due to incomplete DSM ratings, resulting in 286 patients being included in the full analysis set (Fig. 1). Included patients had a median age of 80.02 ($Q_1 = 72.15$; $Q_3 = 86.76$), were 58.7% female, 14.3% had dementia documented in their electronic medical record, and 56.3% of the patients were triaged as ESI-level 3 (Table 1). We find a delirium prevalence of 7.0% according to the reference standard during the observation period. The variables of gender and Charlson Comorbidity Index are

Table 2 Performance of the screening step of the mCAM-ED (Month of the Years Backwards Test) versus DSM-IV diagnosis for the total sample and for the subsamples of patients with and without dementia

	Total sample ($n = 286$)		Dementia ($n = 41$)		No dementia ($n = 245$)	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Sensitivity	0.95	0.76; 0.99	1.00	0.74; 1.00	0.89	0.57; 0.98
Specificity	0.86	0.81; 0.90	0.63	0.46; 0.78	0.89	0.84; 0.92
Positive predictive value	0.34	0.23; 0.47	0.50	0.31; 0.69	0.24	0.12; 0.40
Negative predictive value	1.00	0.98; 1.00	1.00	0.83; 1.00	1.00	0.97; 1.00
Positive likelihood ratio	6.83	4.98; 9.36	2.73	1.70; 4.36	8.07	5.25; 12.40
Negative likelihood ratio	0.06	0.01; 0.39	0.00	0.00; NaN	0.12	0.02; 0.79

NaN not a number, *CI* confidence interval

Table 3 Performance of the mCAM-ED versus DSM-IV diagnosis for the total sample and for the subsamples of patients with and without dementia

	Total sample ($n = 286$)		Dementia ($n = 41$)		No dementia ($n = 245$)	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Sensitivity	0.90[a]	0.70; 0.97	0.91	0.62; 0.98	0.89	0.57; 0.98
Specificity	0.98	0.95; 0.99	0.87	0.70; 0.95	0.99	0.97; 1.00*
Positive predictive value	0.75	0.55; 0.88	0.71	0.45; 0.88	0.80	0.49; 0.94
Negative predictive value	0.99	0.97; 1.00	0.96	0.82; 0.99	1.00	0.98; 1.00
Positive likelihood ratio	39.90	17.85; 89.20	6.82	2.69; 17.30	104.89	25.89; 425.01
Negative likelihood ratio	0.10[a]	0.03; 0.38	0.10	0.02; 0.68	0.11	0.02; 0.71

CI confidence interval

*$p = 0.002$

[a]The sensitivity of the rule out procedure with the MBT was 0.95 (CI 0.76; 0.99) for DSM-IV-TR and the negative likelihood ratio was 0.06 (CI 0.01; 0.39)

Table 4 Cross-tabulation of mCAM-ED results by DSM-IV-TR delirium diagnosis ($n = 286$)

mCAM-ED	DSM-IV-TR	
	Delirium	No delirium
Delirium	18	6
No delirium	2	260

DSM-IV-TR Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition Text Revision, *mCAM-ED* modified Confusion Assessment Method for the Emergency Department

similar in patients with and without delirium, but patients with delirium are significantly older, and significantly more had dementia.

The screening for inattention with the MBT, i.e. the first step of the algorithm, is sensitive at 0.95 (CI 0.76; 0.99), has a lower specificity at 0.86 (CI 0.81; 0.90). The positive predictive value is 0.34 (CI 0.23; 0.47) and the negative predictive value 1.00 (CI 0.98; 1.00). The positive likelihood ratio is 6.83 (CI 4.98; 9.36) and the negative likelihood ratio is 0.06 (CI 0.01; 0.39). Specificity of the MBT is higher in patients without dementia 0.89 (CI 0.84; 0.92) and lower in patients with dementia 0.63 (CI 0.46; 0.78) (Table 2).

Performance criteria of the mCAM-ED assessment are as follows: sensitivity is 0.90 (CI 0.70; 0.97) and specificity is 0.98 (CI 0.95; 0.99). The positive predictive value is 0.75 (CI 0.55; 0.88) and the negative predictive value 0.99 (CI 0.97; 1.00). The positive likelihood ratio is 39.9 (CI 17.85; 89.20) and the negative likelihood ratio is 0.10 (CI 0.03; 0.38) (Tables 3, 4).

While sensitivity does not differ significantly between patients with and without dementia ($p = 1.000$), differences are significant for specificity ($p = 0.002$). The positive likelihood ratio is 6.82 (CI 2.69; 17.30) in the dementia subsample in contrast to 104.89 (CI 25.89; 425.01) in patients without dementia.

The mCAM-ED was applied on average 94.1 (SD 63.7) min after patient arrival. In 228 (80.0%) cases, the screening for inattention with the MBT took less than 30 s. Of the remaining 58 patients needing more than 30 s to go through the MBT, 27 (46.6%) had no known cognitive impairment, 11 (19.0%) had dementia and 20 (34.5%) had delirium. The complete mCAM-ED (screening and assessment) took on average 3.2 min (SD 2.0) in patients without dementia or delirium. In patients with dementia or delirium, however, screening and assessment took on average 5.6 (SD 3.2) min, and 6.2 (SD 2.3) min, respectively.

Discussion

Our study confirms good performance criteria for the mCAM-ED (i.e. good sensitivity and specificity), acceptable positive predictive value, high negative predictive value, and good positive and negative likelihood ratios. Furthermore, we demonstrate that the mCAM-ED identifies delirium efficiently with a minimum screening and assessment burden on the patient.

Sensitivity is similar when the performance of the MBT is compared in the subsamples (i.e. patients with and without dementia). However, specificity is significantly lower in the subsample of patients with dementia. Thus, a second step (i.e. delirium assessment) appears to be necessary to rule out delirium due to false positive screening results for inattention. A two-step approach is suggested in other studies as well [32–35]. As the application of the screening part of the mCAM-ED required less than 30 s in 80% of the patients, the mCAM-ED can be considered a quick assessment tool, and is ideally suited for the ED environment.

Today, there are 60 delirium tools, all of which were developed over the past few decades [36]. Even recent developments such as the 3D-CAM or the 4AT [21, 37, 38] use a single-step approach.

To our knowledge, only one other scale, the Delirium Triage Screening (DTS)/brief Confusion Assessment Method (bCAM) by Han et al. [39], was developed and validated for the ED setting as a two-step tool. The DTS is used as a first step to rule out delirium or to initiate the brief confusion assessment method (bCAM) assessment [39]. The DTS consists of the Richmond Agitation Sedation Scale (RASS) to measure the level of consciousness and a screening for inattention (spelling the word "lunch" backwards). As desired from a screening tool, the sensitivity of the DTS is excellent. In our study on the mCAM-ED, sensitivity of screening with the MBT is comparable but specificity is higher. This difference may result in fewer false positives when using the MBT, potentially leading to fewer required assessments.

The second step in the approach used by Han et al. consists of a delirium assessment (bCAM), which is similar to the second step (assessment) of the mCAM-ED [39]. Overall, the performance of the tools appears to be comparable. Interestingly, when the bCAM was tested in a study beyond the ED setting (i.e. in a geriatric assessment unit), sensitivity and specificity are lower at 70.3 and 91.4%, respectively. However, in that study the screening with the DTS was not analyzed separately [32].

Among the traditional scales tested in the ED, the CAM-ICU (originally designed for the ICU setting) has modest sensitivity, but excellent specificity when compared with a psychiatrist's DSM-IV-TR delirium assessment [40]. In a second ED study, sensitivity and specificity of the CAM-ICU are 100 and 98%, respectively. However, validation was performed by a nurse practitioner as reference standard in a relatively small subsample of 53 patients only. Furthermore, patients with severe dementia were excluded [11].

In a very recent study, the 4AT and the 6-Item Cognitive Impairment Test (6-CIT) are shown to be able to accurately exclude both delirium and dementia in emergency patients [38]. However, the 6-CIT generates more false-positives when used for delirium detection. Interestingly, both tools contain the MBT, which is the first screening step of the mCAM-ED [4, 38].

The mCAM-ED does not require any manual tasks. This is in contrast to the CAM's original validation with the Mini-Mental State Examination [19, 41]. Additionally, no proxy information is needed for the MBT. Therefore, potentially more patients can be evaluated with the mCAM-ED. Furthermore, the mCAM-ED has the advantage that it reduces patients' assessment burden by 79%, as it only assesses patients with a positive screening result (true positive and false positive). However, the specificity of the mCAM-ED in patients with dementia is only moderate. Very recently, it has been suggested that the combination of a different arousal and attention test might be more specific in identifying delirium in patients with dementia in a non-ED setting [42].

In summary, the mCAM-ED is able to efficiently rule out delirium as well as diagnose delirium with a low assessment burden on the patient.

Limitations

This is a monocentric study from Northwestern Switzerland. The mCAM-ED might perform differently in other settings. However, the components of the screening and assessment tool were evaluated in other studies and perform well. A strength of our study is the consecutive sampling procedure that minimized potential selection bias inherent in long-term data collection periods [39].

The reference standard delirium diagnosis was established on DSM-IV-TR based assessments, which were conducted by attending geriatricians. We were unable to test interrater reliability (i.e. with two geriatricians assessing the same patient). However, the geriatricians did not have other duties during the study, and were allowed sufficient time to thoroughly evaluate the patients.

There is paucity of evidence when to perform delirium screening during the ED stay [43]. We, therefore, decided to assess all patients as early as possible during the ED stay, with the geriatricians' assessment occurring no later than 1 h afterwards. This might explain the unexpectedly low delirium prevalence in our study.

During the study period, fewer patients than expected were treated in our ED leading to a lower sample size than anticipated. The sensitivity and positive predictive value could not be estimated with great precision due to the small number of cases of delirium in the sample. However, the calculations could be conducted with acceptable Cis, which are also comparable with other studies [39].

Because of time constraints, in the absence of a proxy, we did not call to obtain more precise information about pre-hospital cognition. This is in contrast to Han`s study [39]. As a consequence, the geriatricians in our study had incomplete information for a DSM-IV-TR delirium diagnosis in 12 cases. These cases were excluded from the analysis. Some delirious patients may have been missed in the 27 (6.7%) eligible patients who did not consent. However, the consent rate was high enough to minimize consent bias [44].

Because we focused on the validity of the mCAM-ED in this study, investigations on reliability and reproducibility in different EDs are still required [45]. Furthermore, we cannot extrapolate our findings to ED nurses performing the mCAM-ED in everyday practice, as TNs performed the assessments for the validation study.

Conclusions

The mCAM-ED is able to rule out delirium as well as to identify delirium quickly. Its application is efficient even in patients with dementia and may lead to lower screening and assessment burden for the patient. Validation studies in other ED settings are needed.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest with this study.

Statement of human rights The study was approved by the cantonal ethics committee (identifier EKNZ-2015-123) and registered with ClinicalTrials.gov (identifier NCT02782143). All procedures performed in this study involving human participants were in accordance with the ethical standards of the local/national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent If possible, oral informed consent was obtained directly from the patient or an authorized proxy. Due to the minimal risk, little burden and potential benefit to the patient, the ethics committee allowed patients to be assessed even if there was no chance to obtain informed patient consent due to the nature of delirium or availability of a proxy.

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