



# Head computed tomography for elderly patients with acute altered mental status in the emergency setting: value for decision-making and predictors of abnormal findings

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**Objective** This study evaluated the impact of head computed tomography (CT) on clinical decision-making about older adults with acute altered mental status (AMS) in the emergency department in terms of CT's diagnostic yield, emergency department length of stay, and changes in medical strategy. It also attempted to find predictors of an acute imaging abnormality.

**Methods** This was a 1-year, retrospective, single-center observational study of patients aged  $\geq 75$  years who underwent noncontrast head CT because of an isolated episode of AMS. The acute positive CT findings were ischemic strokes, hemorrhages, tumors, demyelinating lesions, hydrocephalus, and intracranial infections.

**Results** A total of 594 CTs were performed, of which 38 (6.4%) were positive. The main etiology of AMS was sepsis (29.1%). Changes in medical strategy were more common in patients with a positive CT, and the major changes were ordering additional neuro exams (odds ratio [OR], 95.3; 95% confidence interval [CI], 38.4–233.8;  $P < 0.001$ ), adjusting treatments (OR, 12.2; 95% CI, 5.0–29.5;  $P < 0.001$ ), and referral to a neurologic unit (OR, 7.3; 95% CI, 3.0–17.5;  $P < 0.01$ ). Three factors were significantly associated with a positive outcome: Glasgow Coma Scale  $< 13$  (OR, 8.5; 95% CI, 2.3–28.9;  $P < 0.001$ ), head wound (OR, 3.1; 95% CI, 1.1–8.2;  $P = 0.025$ ), and dehydration (OR, 0.3; 95% CI, 0.1–0.4;  $P = 0.021$ ). For elderly patients with a Glasgow Coma Scale  $\geq 13$  and no head wound or clinical dehydration, the probability of a positive CT was 0.02 (95% CI, 0.01–0.04). Considering only those patients, the diagnostic yield fell to 1.7%.

**Conclusion** In elderly patients, the causes of AMS are primarily extracerebral. Randomized clinical trials are needed to validate a clinical pathway for selecting patients who require emergent neuroimaging.

**Keywords** Emergency medicine; Confusion; Serial computed tomography; Diagnostic imaging; Resource allocation

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## Capsule Summary

### What is already known

*Previous studies have evaluated the relevance of emergent head computed tomography (CT) in nonselected cohorts. They recommended that neuroimaging be ordered for confused patients with new focal neurological signs or suspected traumatic brain injury without an age criterion. However, when treating the increasing number of elderly patients in emergency departments, isolated acute mental status changes are still a challenging reason for using emergent head CT.*

### What is new in the current study

*In an elderly population, the diagnostic yield of head CT for isolated altered mental status was very low. Although ordering a head CT significantly affected the emergency department length of stay, changes in the initial medical strategy based on the CT scan results were rare. CT scans could be deemed unnecessary, in patients with a Glasgow Coma Scale  $\geq 13$ , the absence of a head wound, and the presence of clinical dehydration.*

## INTRODUCTION

Acute altered mental status (AMS) is a common presentation for elderly people in an emergency department (ED) and describes "any changes in a patient's baseline status," including "variable time courses and degrees of severity" such as confusion, altered behavior, disorientation, alertness, delirium, or coma.<sup>1,2</sup> AMS accounts for 4% to 10% of all ED admissions<sup>1,3,4</sup> and approximately 40% of ED admissions among elderly patients.<sup>4-7</sup> AMS should be considered as an acute brain failure that highlights the brain's vulnerability and decreased cognitive reserve precipitated by an underlying medical illness.<sup>8</sup> It increases both the long-term risk of dementia and 1-year mortality.<sup>9-11</sup> Because EDs are the leading hospital point of entry for an increasing number of elderly patients, emergency physicians (EPs) should be able to identify triggering factors and initiate early treatments adapted to many underlying conditions. The etiologies of AMS are mainly extracerebral, including infections, hydroelectrolytic disorders, and medications.<sup>3,8,12</sup> However, ED neuroimaging is increasingly used<sup>13-15</sup> to evaluate confused elderly patients, as often as in 14% to 21% of cases.<sup>16</sup> Some researchers have expressed concern about how that increase in neuroimaging is improving patient outcomes.<sup>14,17</sup> For EPs, the challenge is to quickly differentiate confused elderly patients who need an emergent head computed tomography (CT) scan from those who have an extracerebral cause of AMS.

Our aim in this study was to determine how emergent head CT in elderly patients with isolated, acute AMS affected EP decision-making in terms of three critical criteria: diagnostic yield, ED length of stay related to CT use, and changes in the initial medical strategy. We also sought predictors of acute cerebral lesions for which imaging could be useful.

## METHODS

### Ethical statements

This study was approved by the Institutional Ethics Committee of the Hospital Paris Saint-Joseph (No. IRB00012157) and registered at ClinicalTrials.gov (No. NCT 04929704). French research regulation states that written consent from the patients is not mandatory, but investigators are required to give each patient an informational leaflet explaining the purpose of the research. Those informational documents were addressed to all eligible patients (Official Journal of the French Republic, 0160; July 13, 2018; paragraph 110, MR-004). For patients with legal protection, the informational documents were addressed to the patient's legal guardian (guardianship or curatorship). After a period of 1 month, if the patient or guardian had not contacted the investigator, it was established that the patient did not oppose the use of his or her data. The patients' information and nonopposition to the use of their data for research was also collected in accordance with European regulations (General Data Protection Regulation). All data were extracted from our computerized medical record system (Dx-Care ver. 12.2.0.1.0; Medasys, Le Plessis-Robinson, France). The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper, and its final contents. The authors vouch for the accuracy and completeness of the data and analyses and for the fidelity of the study to the protocol.

### Design and settings

This was an investigator-initiated, retrospective, and observational cohort study evaluating the effects of head CT and the predictors of acute anomalies in elderly patients presenting with isolated AMS at their admission to a single ED. The cohort included patients seen from January 1, 2019 to December 31, 2019 in the

ED of Hospital Paris Saint-Joseph, in Paris, France, a tertiary urban hospital with approximately 700 beds and 59,350 annual ED encounters. Data from 2020 were not used because of potential bias related to the COVID-19 pandemic.

### Cohort definition

The cohort was drawn from consecutive patients aged  $\geq 75$  years who underwent a noncontrast helical head CT scan in the ED. That age criterion was chosen because it is the age requirement for geriatric units in France.<sup>18</sup> Head CT scans were performed on a Revolution Frontier CT scanner (GE Healthcare, Chicago, IL, USA) with a total dose length product of 755.44 mGy.cm, a volume CT dose index of 45.09 mGy, a slice thickness of 0.6 mm, and a pitch value of 0.5. The decision to perform a CT was made by the attending EP. The suspected disease to confirm or rule-out using CT was evaluated retrospectively by two independent EPs who examined each medical record and the CT referral forms. The interpretation of the CTs was done by a senior radiologist through an official written report, in accordance with the current practice in our hospital. The inclusion criteria for this study were the presence of an acute AMS, defined as new onset behavioral and cognitive change associated with a Glasgow Coma Scale (GCS)  $< 15$  with or without disorientation, loss of memory, altered consciousness, hallucination, agitation, or persecution delirium within the past 1 month. The AMS analysis considered only the past month because it has already been shown that patients who have AMS for more than 1 month very rarely have potentially treatable intracranial lesions.<sup>19</sup> Also, AMS for more than 1 month is included in the diagnostic framework for dementia.<sup>3</sup> Patients with an unequivocal reason to order neuroimaging were excluded: concomitant localizing neurological signs (abnormalities of the cranial nerves, meningeal syndrome, cerebellar syndrome, aphasia, vestibular syndrome, sensory, or motor deficit); head trauma on anticoagulant or antiplatelet treatment; major head trauma, such as a traffic accident, except falls from height; unusual headache; and coma, defined as GCS  $\leq 8$ . A patient who visited the ED with nonrelated episodes of AMS could be included more than once in this study.

### Variables and outcomes

The primary endpoint was the rate of positive head CTs in the cohort, defined as an imaged finding of a recent intracranial lesion that explained the AMS. The following conditions were considered positive findings: acute ischemic strokes, acute hemorrhages, recent cerebral tumors, recent demyelinating lesions, acute hydrocephalus, and intracranial infections. Imaging lesions of primary dementia (cerebral atrophy, leukoaraiosis, periventricular le-

sions, arterial calcifications, microbleeds, or dilatation of Virchow-Robin spaces) or secondary dementia (chronic hydrocephalus, meningioma or hygroma, neurosurgery stigmas, or chronic vascular lesions) were classified as negative findings even if they were a predisposing condition for AMS. All other abnormalities were considered to be negative findings.

The secondary endpoints were the following. First, the rate of 48-hour changes in medical strategy based on the head CT outcomes (positive or negative). The following were considered to be changes in medical strategy: changes in diagnostic approach (use of additional neuro exams, such as brain magnetic resonance imaging [MRI], electroencephalogram, head CT monitoring, or an incidental finding that changed the care approach), changes in the therapeutic approach (withdrawal or initiation of antiplatelet, anticoagulant, or antiepileptic agents or endovascular or neurosurgical treatments), and changes in referral decisions (admission to a stroke unit or the neurology or neurosurgery department). Second, the ED length of stay related to head CT use (i.e., time between head CT order and interpretation by a senior radiologist through a written official report). Lastly, the factors (historical, clinical, and biological) that predict a positive head CT. Clinical dehydration was defined using tachycardia ( $> 100$  beats/min), low systolic blood pressure ( $< 100$  mmHg), dry mucous membrane, dry axilla, poor skin turgor, sunken eyes, delayed capillary refill time ( $> 2$  seconds), urine color, and saliva flow rate.<sup>20</sup>

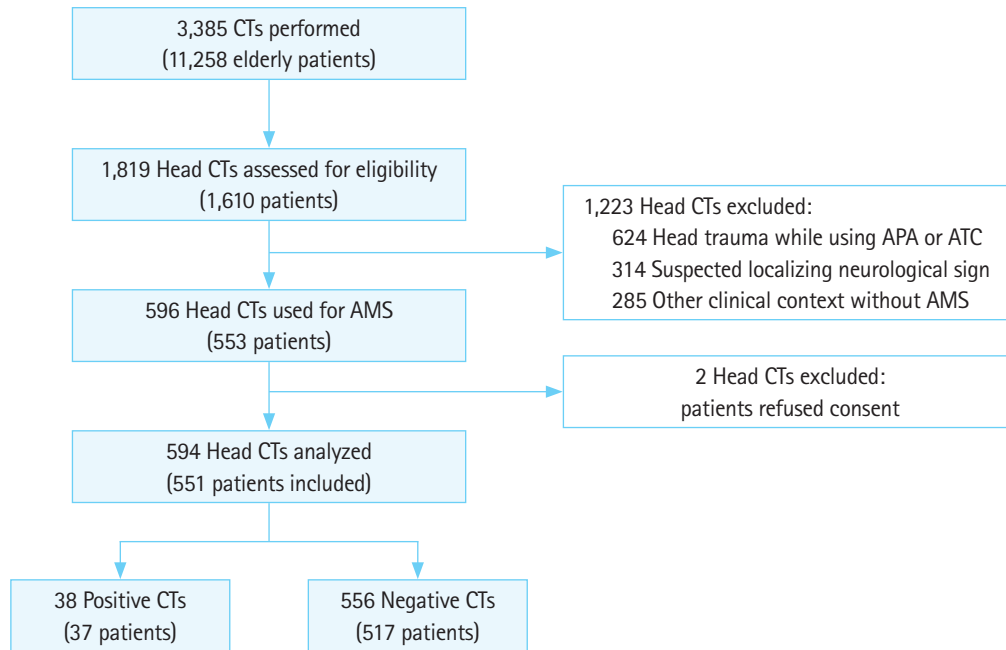
### Data collection

Key clinical features, radiological and biological parameters, and organizational data were collected retrospectively from computerized medical records. The primary endpoint was determined by the CT interpretation. Changes in the attending EP's medical strategy related to the CT result and the final etiology of AMS were assessed by two EPs.

### Statistical analysis

This study followed the standards for reporting observational studies in the epidemiology guidelines. Continuous variables are reported as means with standard deviations or medians with interquartile ranges. The Shapiro-Wilk test was used to test the assumption of a normal distribution in each group. Student t-test was used to compare normally distributed continuous variables, and the Wilcoxon test was used otherwise. Qualitative variables are reported as numbers with percentages and were compared with the chi-square test or Fisher exact test, as appropriate.

To determine the association between patient characteristics and the occurrence of the primary outcome, we first performed a



**Fig. 1.** Study flowchart. Head computed tomography (CT) performed per patient: one, 514 patients; two, 68 patients; and three, four patients. APA, anti-platelet agent; ATC, anticoagulant; AMS, altered mental status.

univariable analysis of all variables. Then, to adjust those associations for possible confounding factors, we tested a multivariable logistic model with all variables except those with insufficient data. The results are reported as odds ratios (ORs) with their 95% confidence intervals (CIs). The goodness of fit of the logistic regression analysis was ascertained using the Nagelkerke pseudo- $R^2$ . Using that equation, we predicted the risk of having a positive CT. The CI of the prediction was obtained using its standard error, which we calculated as  $\sqrt{C' \times \text{covariance matrix} \times C}$ , where  $C$  is the linear combination of estimates, and  $C'$  is its transposition.

All statistical tests were two-tailed at the 0.05 level of significance. All data analysis was completed with R ver. 4.0.4 (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Characteristics of the cohort

In 2019, 5.3 head CTs were performed per 100 elderly patients to search for an acute cerebral etiology for an isolated incident of AMS (Fig. 1). Those CTs affected 18.9% of elderly patients who visited the ED and accounted for 17.6% of all CTs and 32.7% of head CTs ordered for elderly patients. This corresponded to a total of 596 head CTs for 553 patients. Two of those patients refused to consent to this study. Of the 594 CTs analyzed, the mean patient age was  $87.3 \pm 6.4$  years, and the 1-year mortality rate was 8.4%. Among the study population, 249 patients (41.9%) had de-

mentia, 83 (13.9%) had a history of stroke, and 38 (6.4%) had ever had a brain hemorrhage. The medical history of the enrolled patients is summarized in Table 1. The key clinical features and diagnostic work-ups of the attending EPs are reported in Table 2.

### Main results

Of the 594 head CT scans completed, 38 found a lesion that explained the symptoms, for a diagnostic yield of 6.4% (Table 1). The main cerebral etiology was acute brain hemorrhage (60.5%), including 16 cerebral or subarachnoid hemorrhages (42.1%), and seven acute-on-chronic subdural hematomas (18.4%), i.e., visualization of extra-axial fluid layers of varying densities separated by internal membranes (Table 3). Of the 38 positive head CTs, 29 (76.3%) led to changes in the prescan management plan, mainly in the form of orders for additional neuro exams (65.8%) rather than by adjusting treatments (42.1%) or referrals to a neurological unit (34.2%). Eleven patients underwent an additional MRI within the first 48 hours (six after a positive CT and five after a negative CT) (Table 3). Two acute ischemic strokes that involved the temporal area were diagnosed on the additional MRI despite a normal CT result (Table 4). Imaging showed significantly more predisposing conditions of AMS, i.e., anomalies of primary dementia, in patients with a negative head CT than a positive head CT (44.7% vs. 77.9%), with an OR of 0.23 (95% CI, 0.12–0.45;  $P < 0.001$ ) (Table 3). The rates of anomalies indicating secondary dementia were similar regardless of the outcome (29.0% vs. 34.0%,

**Table 1.** Baseline characteristics of the cohort according to the head CT outcome

Characteristic	Overall (n = 594)	Positive CT (n = 38)	Negative CT (n = 556)	OR (95% CI)	P-value
Age (yr)	87.3 ± 6.4	86.9 ± 5.9	87.2 ± 6.5	-	0.767
Male sex	380 (64.0)	19 (50.0)	361 (64.9)	1.85 (0.96–3.58)	0.064
Underlying condition					
Dementia <sup>a)</sup>	249 (41.9)	14 (36.8)	235 (42.3)	0.80 (0.40–1.57)	0.512
Psychiatric disorder	96 (16.2)	6 (15.8)	90 (16.2)	0.97 (0.39–2.39)	0.949
Parkinson	37 (6.2)	1 (2.6)	36 (6.5)	0.39 (0.05–2.93)	0.501
Epilepsia	39 (6.6)	1 (2.6)	38 (6.8)	0.37 (0.05–2.76)	0.501
Ischemic stroke or TIA history	83 (14.0)	2 (5.3)	81 (14.6)	0.33 (0.08–1.38)	0.109
Brain hemorrhage history	38 (6.4)	2 (5.3)	36 (6.5)	0.80 (0.19–3.47)	>0.999
Cancer history	68 (11.4)	4 (10.5)	64 (11.5)	0.90 (0.31–2.63)	>0.999
Chronic kidney disease <sup>b)</sup>	51 (8.6)	5 (13.2)	46 (8.3)	1.67 (0.62–4.49)	0.362
Medication <sup>c)</sup>					
Anticoagulant	111 (20.6)	3 (7.9)	108 (19.4)	0.36 (0.11–1.18)	0.078
Antiplatelet	137 (25.4)	7 (18.4)	130 (23.4)	0.74 (0.32–1.72)	0.483
Benzodiazepine	138 (25.6)	7 (18.4)	131 (23.6)	0.71 (0.30–1.67)	0.436
Neuroleptic	49 (9.1)	0 (0)	49 (8.8)	-	0.062
Opioid	16 (3.0)	2 (5.7)	14 (2.5)	2.13 (0.46–9.75)	0.278
Anticholinergic	179 (33.1)	7 (18.4)	172 (30.9)	0.48 (0.21–1.13)	0.088
Diuretic	92 (17.0)	4 (11.4)	88 (15.8)	0.61 (0.21–1.78)	0.361
Context					
Fall	294 (49.5)	25 (65.8)	269 (48.4)	2.05 (1.03–4.09)	0.038
Head trauma	121 (20.4)	14 (36.8)	107 (19.2)	2.45 (1.23–4.89)	0.009
Infection < 1 mo	67 (11.3)	3 (7.9)	64 (11.5)	0.66 (0.20–2.20)	0.789
Alcohol use	8 (1.3)	0 (0)	8 (1.4)	-	>0.999
Epileptic seizure	12 (2.0)	1 (2.6)	11 (2.0)	1.34 (0.17–0.65)	0.551
Outcome					
Hospitalization	486 (81.8)	35 (92.1)	451 (81.1)	2.72 (0.82–9.00)	0.089
Death in the year	50 (8.4)	4 (10.5)	46 (8.3)	1.30 (0.44–3.84)	0.550

Values are presented as mean ± standard deviation or number (%). No OR for continuous variables and neuroleptic treatment (headcount, 0).

CT, computed tomography; OR, odds ratio; CI, confidence interval; TIA, transient ischemic attack.

<sup>a)</sup>Alzheimer, Lewy, and Korsakoff diseases, normal pressure hydrocephalus, vascular dementia, and unspecified dementia. <sup>b)</sup>592 Overall (37 positive CT and 555 negative CT).

<sup>c)</sup>540 Overall (35 positive CT and 505 negative CT).

P=0.524), except for the rate of chronic hematoma, which was higher in the positive CT group than in the negative CT group (13.2% vs. 1.6%), with an OR of 9.21 (95% CI, 2.92–29.03; P<0.001) (Table 3). Among the 23 patients with hemorrhages, one patient was included twice for incidents of AMS within the previous 24 hours after head traumas with wounds. His two CTs, taken 8 weeks apart showed, acute-on-chronic subdural hematomas.

Among the 556 negative CTs, the main cause of AMS was sepsis (29.1%), especially from urinary tract infections (15.3%), followed by dementia with no other associated etiology (21.6%) (Table 4). Overall, there was no statistical difference between the median times needed to request, perform, and interpret CT scans, regardless of the outcome (P-values of 0.626, 0.865, and 0.818, respectively). The median time for CT interpretation was 104 minutes and accounted for 22.0% of the ED length of stay, regardless of the outcome (P=0.614) (Table 3). In an additional query of our database of

elderly ED patients during the study period, we found that our cohort's ED length of stay was higher than that of the 3,385 older patients who received any type of CT (median, 560 minutes vs. 372 minutes) and higher than that of the 7,873 who did not receive a CT (median, 560 minutes vs. 210 minutes) (Table 3 and Fig. 1).

### Prediction of a positive CT scan

Table 5 shows the results of the logistic regression analysis of demographic, clinical, and biological parameters that could predict a positive CT result. Two variables were significantly predictive of a positive CT finding: a GCS < 13, with an OR of 8.50 (95% CI, 2.30–28.87; P<0.001), and a head wound, with an OR of 3.06 (95% CI, 1.14–8.21; P=0.025). One variable tended to exclude a positive CT finding: clinical dehydration, with an OR of 0.29 (95% CI, 0.09–0.77; P=0.021).

Fig. 2 shows the predictive values of the three clinical presen-

**Table 2.** Emergency physician diagnostic work-up of altered mental status according to the head CT outcome

Variable	Overall (n = 594)	Positive CT (n = 38)	Negative CT (n = 556)	OR (95% CI)	P-value
<b>Vital sign</b>					
GCS (9–15)	14.2 ± 0.8	13.7 ± 1.0	14.2 ± 0.8	-	< 0.001
GCS ≥ 13	573 (96.5)	33 (86.8)	540 (97.1)	0.20 (0.07–0.57)	0.008
Heart rate (beats/min)	81.6 ± 18.2	77.8 ± 14.7	81.8 ± 18.4	-	0.184
Systolic blood pressure (mmHg)	141.9 ± 25.7	138.4 ± 24.1	142.1 ± 25.8	-	0.388
Body temperature (°C)	36.8 ± 0.6	36.8 ± 0.4	36.8 ± 0.6	-	0.851
<b>Altered mental status</b>					
Onset (day)					0.966
< 1	303 (51.1)	20 (52.6)	283 (50.9)	1.00	
1–7	87 (14.6)	5 (13.2)	82 (14.7)	0.87 (0.32–2.40)	
> 7	204 (34.3)	13 (34.2)	191 (34.4)	0.96 (0.47–1.98)	
Hallucination or agitation or delirium	144 (24.2)	7 (18.4)	137 (24.6)	0.69 (0.30–1.60)	0.387
Acute disorientation	512 (86.2)	31 (81.6)	481 (86.5)	0.69 (0.29–1.62)	0.394
Acute loss of memory	463 (77.9)	25 (65.8)	438 (78.8)	0.52 (0.26–1.04)	0.062
Alertness	311 (52.4)	17 (44.7)	294 (52.9)	0.72 (0.37–1.40)	0.331
<b>Clinical feature</b>					
Head wound	93 (15.7)	14 (36.8)	79 (14.2)	3.52 (1.75–7.10)	< 0.001
Dehydration <sup>a)</sup>	204 (34.3)	5 (13.2)	199 (35.8)	0.27 (0.10–0.71)	0.005
Oxygen requirement	95 (16.0)	3 (7.9)	92 (16.5)	0.43 (0.13–1.44)	0.159
Urinary retention	60 (10.1)	2 (5.3)	58 (10.4)	0.48 (0.11–2.03)	0.412
Rectal exam performed	183 (30.8)	8 (21.1)	175 (31.5)	0.58 (0.26–1.29)	0.178
Fecaloma	43 (7.2)	1 (2.6)	42 (7.6)	0.33 (0.04–2.47)	0.511
Infectious trigger	228 (38.4)	4 (10.5)	224 (40.3)	0.17 (0.06–0.50)	< 0.001
<b>Additional exam</b>					
Electrocardiogram	373 (62.8)	25 (65.8)	348 (62.6)	1.15 (0.58–2.30)	0.693
Chest X-ray	318 (53.5)	15 (39.5)	303 (54.5)	0.54 (0.28–1.07)	0.072
Urine dipstick	360 (60.6)	20 (52.6)	340 (61.2)	0.71 (0.37–1.36)	0.298
Cytobacterial urinary	229 (38.6)	12 (31.6)	217 (39.0)	0.72 (0.36–1.46)	0.361
<b>Biological parameter</b>					
Glucose (mmol/L)	6.9 ± 3.1	7.6 ± 5.5	6.9 ± 2.9	-	0.611
Sodium (mmol/L) <sup>b)</sup>	139.9 ± 5.3	140.53 ± 4.1	139.82 ± 5.4	-	0.409
Calcium (mmol/L) <sup>c)</sup>	2.4 ± 0.1	2.4 ± 0.1	2.4 ± 0.2	-	0.628
Creatinine (μmol/L) <sup>b)</sup>	81.0 (63.0–110.0)	81.5 (70.5–105.7)	80.0 (62.0–110.0)	-	0.407
Proteins (g/L) <sup>d)</sup>	71.0 ± 6.3	70.6 ± 4.5	71.1 ± 6.4	-	0.987
C-reactive protein (mg/L)	24.5 (8.6–59.7)	18.8 (7.3–47.6)	24.6 (8.8–59.9)	-	0.443

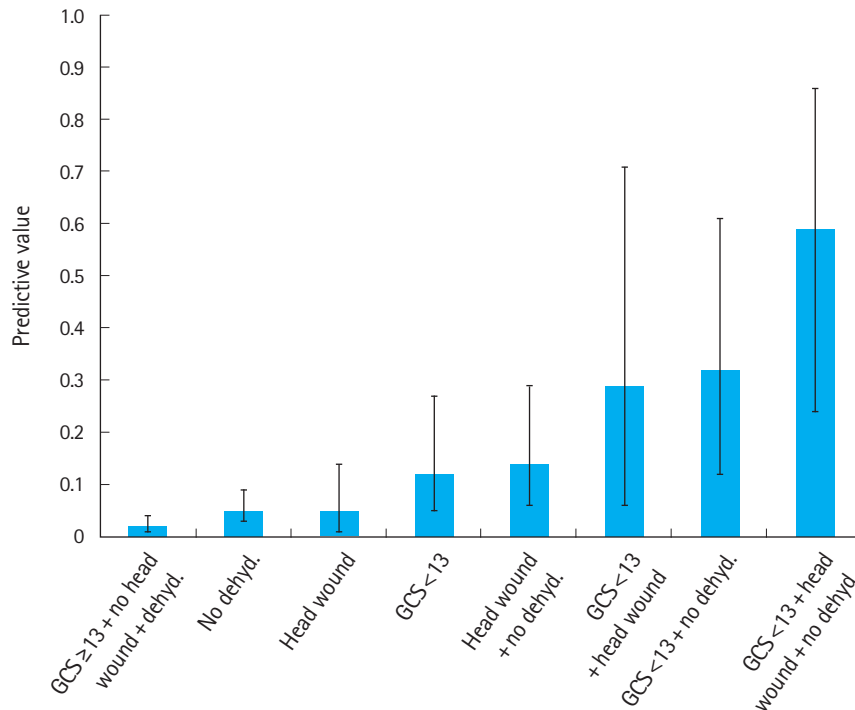
Values are presented as mean ± standard deviation, number (%), or median (interquartile range). No OR for continuous variables.

CT, computed tomography; OR, odds ratio; CI, confidence interval; GCS, Glasgow Coma Scale.

<sup>a)</sup>Clinical dehydration was diagnosed using tachycardia (> 100 beats/min), low systolic blood pressure (< 100 mmHg), dry mucous membrane, dry axilla, poor skin turgor, sunken eyes, delayed capillary refill time (> 2 seconds), urine color, and saliva flow rate. <sup>b)</sup>592 Overall (38 positive CT and 554 negative CT). <sup>c)</sup>270 Overall (15 positive CT and 255 negative CT). <sup>d)</sup>592 Overall (38 positive CT and 554 negative CT).

tations associated with a positive CT finding, both alone and together. In the absence of any risk factor (GCS ≥ 13, no head wound, and presence of clinical dehydration), the probability of a positive CT finding was 2.0%. Thus, three of the 181 concerned patients (1.7%) had a positive CT finding: two had acute hydrocephalus that did not require a change in their medical strategy, and one had a cerebral tumor and was referred to neurosurgery. By contrast, in the presence of a GCS < 13, a head wound, and no dehydration, the risk of a positive CT finding was 32.0%. Thus, five of the 13 concerned patients (38.4%) had a positive CT find-

ing: two subarachnoid hemorrhages, one ischemic stroke (temporal area), one acute-on-chronic subdural hematoma, and one discovery of a cerebral tumor. One of those patients died during the 1-year follow-up. For patients with a GCS ≥ 13 and no head wound who were not clinically dehydrated, the risk of a positive CT finding was 4.6%. Thus, of the 481 patients concerned, 20 had a positive CT: five acute hydrocephalus, four acute-on-chronic subdural hematomas, four brain hemorrhages (i.e., parenchymal or subarachnoid), four tumors, and three ischemic strokes. Those findings led to a change in the initial medical strategy for 15 pa-



**Fig. 2.** Predictive values of clinical variables for a positive head computed tomography. Error bars indicate 95% confidence interval. GCS, Glasgow Coma Scale; dehydr., dehydration.

tients, mainly the prescription of additional neuro exams ( $n = 12$ ) or treatment adjustments ( $n = 10$ ), rather than referrals to specialists ( $n = 8$ ).

Of the 556 patients with negative CT results, five underwent an additional MRI during their hospitalization (Table 3). All of them had a GCS of 14 and CT findings of secondary dementia with vascular lesions (i.e., old infarcts). Among them, two patients who had a GCS of 14, no head wound, and were not clinically dehydrated were diagnosed with a temporal ischemic stroke on an additional brain MRI (Table 4). One patient had a head wound with no dehydration and a normal brain MRI. One patient was clinically dehydrated, had a GCS of 14, and no head wound and had a normal brain MRI.

## DISCUSSION

Given the increasing number of elderly patients being seen in EDs, deciding whether an emergent head CT is indicated for acute AMS is a growing diagnostic challenge.<sup>14,16</sup> Despite current guidelines,<sup>21,22</sup> a third of 1,819 head CTs were ordered to investigate a potential cerebral etiology for an isolated AMS, and positive findings were rare (6.4%) in a busy, urban ED. Our findings are consistent with a previous retrospective study showing that delirium or disorders of consciousness were among the main reasons for

requesting head CTs in a similar emergency setting (21.0% and 14.0%, respectively).<sup>16</sup> This concern for misdiagnosing a cerebral lesion can be explained by common, vaguely related histories in confused patients.<sup>23</sup> The large number of diagnostic resources used per patient and overall long ED stays clearly reflect the diagnostic complexity of this clinical setting. Almost all patients had a blood exam, and more than 50% underwent an electrocardiogram, a urine dipstick, and a chest X-ray, as recommended in the guidelines.<sup>22</sup> Most of these elderly patients (82%) were hospitalized after their ED visit, regardless of their head CT scan results ( $P = 0.09$ ).

One multicenter Chinese study in a younger ED cohort stated that CT use might not delay patient outcomes.<sup>24</sup> However, we found that the ED length of stay was higher in this cohort (560 minutes) than in the overall ED population of patients aged  $\geq 75$  years, both for those who had another type of CT and those who did not have CT (372 and 210 minutes, respectively). When the overall time between the order for a CT scan and its interpretation affects the time spent in the ED by 22.0%, we cannot ignore the association between the ED length of stay and the occurrence of adverse events among elderly patients, as demonstrated by Considine et al.<sup>25</sup> Furthermore, an ED admission and long length of stay are themselves precipitating factors of AMS, with attendant complications of wandering and falls, agitation, chemical

Table 3. Primary and secondary outcomes

Head CT outcome	Overall (n = 594)	Positive CT (n = 38)	Negative CT (n = 556)	OR (95% CI)	P-value
Positive finding					
Acute hemorrhages <sup>a)</sup>	16 (2.7)	16 (42.1)			
Acute-on-chronic subdural hematomas	7 (1.2)	7 (18.4)			
Brain tumor	6 (1.0)	6 (15.8)			
Acute hydrocephalus	5 (0.8)	5 (13.2)			
Acute ischemic strokes	4 (0.7)	4 (10.5)			
Chronic anomaly					
Lesions of primary dementia <sup>b)</sup>	450 (75.8)	17 (44.7)	433 (77.9)	0.23 (0.12–0.45)	<0.001
Lesions of secondary dementia	200 (33.7)	11 (28.9)	189 (34.0)	0.79 (0.38–1.63)	0.524
Vascular lesions <sup>c)</sup>	116 (19.5)	5 (13.2)	111 (20.0)	0.61 (0.23–1.59)	0.306
Chronic subdural hematoma	14 (2.4)	5 (13.2)	9 (1.6)	9.21 (2.92–29.03)	<0.001
Meningioma or hygroma	17 (2.9)	0 (0)	17 (3.1)	-	0.617
Chronic hydrocephalus	10 (1.7)	2 (5.3)	8 (1.4)	3.81 (0.78–18.58)	0.130
Neurosurgery stigmas	8 (1.3)	0 (0)	8 (1.4)	-	0.457
48-Hour change					
Diagnostic management <sup>d)</sup>	51 (8.6)	29 (76.3)	22 (4.0)	78.21 (33.07–184.99)	<0.001
Therapeutic adjustment <sup>e)</sup>	36 (6.1)	25 (65.8)	11 (2.0)	95.28 (38.84–233.75)	<0.001
Referral decision <sup>f)</sup>	27 (4.5)	16 (42.1)	11 (2.0)	12.17 (5.02–29.50)	<0.001
Referral decision <sup>g)</sup>	26 (4.4)	13 (34.2)	13 (2.3)	7.28 (3.03–17.47)	<0.001
Operational influence					
Head CT order <sup>h)</sup> (min)	85.5 (45.3–158.0)	86.0 (46.0–158.3)	76.5 (43.5–137.0)		0.626
Head CT performance <sup>h)</sup> (min)	54.5 (26.0–106.0)	53.0 (26.0–107.8)	61.5 (28.3–96.3)		0.865
Head CT interpretation <sup>h)</sup> (min)	104.0 (70.0–172.3)	102.5 (68.0–172.8)	104.5 (70.0–170.8)		0.818
ED length of stay <sup>i)</sup> (min)	560.5 ± 260.5	598.4 ± 236.2	557.9 ± 262.1		0.355
Head CT interpretation/ED length of stay	0.2 (0.14–0.34)	0.2 (0.14–0.34)	0.2 (0.14–0.34)		0.614

Values are presented as the number (%), median (interquartile range), or mean ± standard deviation. No OR for continuous variables.

CT, computed tomography; OR, odds ratio; CI, confidence interval; ED, emergency department.

<sup>a)</sup>Parenchymal or subarachnoid. <sup>b)</sup>Cerebral atrophy, leukoaraiosis, periventricular lesions, arterial calcifications, microbleeds, or dilatation of Virchow–Robin spaces. <sup>c)</sup>Chronic ischemia and lacunar infarctions. <sup>d)</sup>Additional neurological exams: 11 brain magnetic resonance imaging (six after positive CTs and five after negative CTs), five electroencephalograms, 16 second CTs. <sup>e)</sup>Withdrawal or initiation of antiplatelet, anticoagulant, or antiepileptic agents or endovascular or neurosurgical treatments. <sup>f)</sup>Hospitalization in stroke unit or neurology or neurosurgery departments. <sup>g)</sup>From the first medical evaluation to the order of CT. <sup>h)</sup>From the order to the CT performance. <sup>i)</sup>From the order to the interpretation via written report by the radiologist. <sup>j)</sup>ED length of stay in the overall population of patients aged ≥ 75 years during the study period: 3,385 any type of CT, 210 minutes (range, 336–466 minutes); 7,873 no CT, 372 minutes (range, 479–625 minutes).

and mechanical restraint, inappropriate use of benzodiazepines and neuroleptics, and increased time spent in a noisy and stressful environment.<sup>26</sup> Whether or not head CT helps in the management of patients in the ED remains controversial in patients with no focal neurological signs and no major head injury.<sup>17</sup> In this clinical setting, our results also address whether ordering emergency neuroimaging in elderly patients with AMS alone leads to effective diagnostic, therapeutic, or referral intervention.

With the increasing use of CT imaging in EDs, our analysis suggests a scope for future intervention studies to evaluate the accuracy of clinical prediction rules for identifying intracranial lesions in elderly patient with isolated AMS. Previously, the utility of head CT for evaluating AMS in emergency medicine has mainly been studied through reviews of nonselected cohorts, including patients who have a high risk of cerebral lesions because of neurological signs,<sup>27–32</sup> traumatic brain injuries,<sup>33,34</sup> unusual headaches,<sup>35</sup> or the use of antiplatelet or anticoagulant treatments.<sup>32,36</sup>

Few studies have specifically examined elderly patients undergoing head CT in EDs for isolated AMS, but that situation accounted for 14% to 30% of head CT requests.<sup>16,37</sup> Comparison with other emergency settings is limited by the inclusion of younger patients (means ranging from 66 to 73 years vs. 87 years in our cohort)<sup>27,31</sup> and the presence of focal neurological signs (33% to 60%),<sup>16,27,31</sup> which was an exclusion criterion for our analysis. The diagnostic yields in those previous studies were higher than those in our selected population by 10% to 40%.<sup>27,31,38</sup> Our low diagnostic yield also differs from that of a retrospective study of 170 patients referred to a geriatric unit for confusion.<sup>19</sup> That previous study considered confusion, decreased alertness, and seizure, and its diagnostic yield was higher than in our setting: about 18.0% of their 68 patients had an intracranial cause of confusion.<sup>19</sup> That difference might be explained by the high prevalence of cerebral tumors (16%) related to the inclusion of patients with confusion lasting for less than 1 year.<sup>19</sup> Most of all, it probably reflects the



**Table 4.** Main etiology of altered mental status in patients with a negative head computed tomography

Etiology	Negative CT (n = 556)
Sepsis	162 (29.1)
Urinary tract infection	84 (15.1)
Respiratory tract infection	48 (8.6)
Other infections <sup>a)</sup>	29 (5.2)
Dementia	120 (21.6)
Central nervous system disease	66 (11.9)
Postconcussion syndrome	35 (6.3)
Postictal confusion	22 (4.0)
Transient global amnesia	5 (0.9)
Other central diseases <sup>b)</sup>	5 (0.9)
Rhabdomyolysis	64 (11.5)
Metabolic encephalopathies	39 (7.0)
Sodium disorder	31 (5.6)
Hypoglycemia	4 (0.7)
Uremic encephalopathy	3 (0.5)
Hepatic encephalopathy	1 (0.2)
Urinary retention and/or fecaloma	33 (5.9)
Cardiac disorder	29 (5.2)
Medication	18 (3.2)
Psychiatric disorder	12 (2.2)
Acute alcohol intoxication	7 (1.3)
Joint pain	5 (0.9)
Undetermined	1 (0.2)

<sup>a)</sup>Sixteen cutaneous, nine gastrointestinal, four articular. <sup>b)</sup>One previous cerebral tumor, two acute ischemic strokes involving the temporal area (diagnosed on magnetic resonance imaging during hospitalization), one meningitis, and one migraine.

increasing use of head CT during the 2000s without significant changes in imaging indications.<sup>14,39</sup> That suggests that other factors have become important explanations for the increased prescription of head CT for current geriatric patients.<sup>14</sup> Head CT is commonly available 24/7 in the radiology departments adjoining urban EDs.<sup>15</sup> Beyond operational factors, Broder and Warshauer<sup>14</sup> suggested that "the tolerance for diagnostic uncertainty" is falling among EPs, their consulting specialists (neurologists, geriatricians), and their patients. Presently, geriatric teams commonly want an extensive diagnostic work-up before they accept an admission.<sup>14</sup> A recent retrospective ED study over 4 years found a high diagnostic yield (9.8%) for head CT performed for AMS, but that rate decreased to 5.3% when considering a disorder of consciousness alone.<sup>38</sup>

A recent review of 294 ED patients recommended that neuroimaging be ordered for confused patients with new focal signs, suspected traumatic brain injury, suspected encephalitis, or no identifiable cause for delirium.<sup>27</sup> When their analysis was confined to 280 cases of acute isolated AMS, the diagnostic yield of CT was even lower (3%) than in our setting.<sup>27</sup> We suggest that

**Table 5.** Multivariable analysis of factors predictive of positive head computed tomography

Variable	OR (95% CI)	P-value <sup>a)</sup>
Age	0.99 (0.93–1.05)	0.656
Male sex	1.65 (0.78–3.49)	0.190
Dementia, psychiatric disorder, or Parkinson	0.59 (0.28–1.22)	0.157
Anticoagulant or antiplatelet use	0.76 (0.30–1.86)	0.547
Fall	1.80 (0.72–4.46)	0.204
Head trauma	0.92 (0.31–2.79)	0.886
Infectious trigger	0.80 (0.17–2.75)	0.752
Glasgow Coma Scale < 13	8.50 (2.30–28.87)	<0.001
Systolic blood pressure	0.99 (0.98–1.01)	0.227
Body temperature	0.90 (0.49–1.94)	0.775
Onset of AMS (day)		
> 7 vs. < 1	1.26 (0.38–3.60)	0.677
1–7 vs. < 1	1.56 (0.67–3.53)	0.292
Acute loss of memory	0.51 (0.24–1.13)	0.090
Glucose level	1.07 (0.97–1.16)	0.138
Sodium level	1.03 (0.96–1.09)	0.436
Creatinine level	1.00 (0.99–1.01)	0.953
Head wound	3.06 (1.14–8.21)	0.025
Dehydration	0.29 (0.09–0.77)	0.021

OR, odds ratio; CI, confidence interval; AMS, altered mental status.

<sup>a)</sup>Nagelkerke pseudo-R<sup>2</sup> = 0.18.

that small difference occurred because complex structured examinations are often difficult in confused elderly patients. Indeed, some localized neurological signs might have been missed by the EPs. The main causes of isolated AMS in the previous study were the same as in our cohort: dementia (28%) in combination with medical or pharmacological conditions; medical conditions (11%) such as sepsis, dehydration, and metabolic disorders; dementia alone (8%); and multiple causes (8%).<sup>27</sup>

This study shows that ordering noncontrast head CTs for patients having an isolated AMS only when the three clinical variables are present at ED arrival could help to improve the diagnostic yield of cerebral lesions and prioritize appropriate medical strategies. A GCS < 13 is an important threshold for prioritizing patients who require a CT, with a high OR of 8.50 (95% CI, 2.30–28.87; P < 0.001).<sup>16</sup> This cutoff has been chosen to differentiate patients who present with only confused verbal responses (verbal score, 3 of 5) from those presenting with drowsiness that alters both the verbal score and the eye-opening score. It was also grounded on findings from a previous trial.<sup>16</sup> Although the GCS was originally designed to evaluate patients with a brain injury, it is now systematically recorded at ED admission for patients with acute brain injury or other conditions. It is easy to use and facilitates communication among emergency staff to detect neurological changes.<sup>40</sup>

In addition, we found that a history of minor head trauma,

falls, and antiplatelet or anticoagulant use did not individually result in positive CT findings among patients having only an acute AMS (ORs, 0.92, 1.80, and 0.76, respectively). On the other hand, the 3.06 OR value for a head wound is meaningful (95% CI, 1.14–8.21;  $P=0.025$ ) because it can be difficult for EPs to understand the timing, triggers, and effects of falling by elderly patients who appear to be only confused. This finding reinforces results from previous nonselected cohorts that recommended that emergent neuroimaging be reserved for patients suspected to have a brain injury or a fall.<sup>16,27,32</sup> It also confirmed a prior study showing that minor head traumas were not predictive of a positive CT.<sup>35</sup>

Based on the clinical variables available upon ED arrival, our results from a large emergency setting suggest a pathway that can avoid the use of unnecessary head CT in EDs and delay it until after initial diagnostic management in geriatric units or outpatient imaging centers. The very low adjusted OR of 0.29 (95% CI, 0.09–0.77;  $P=0.021$ ) for clinical dehydration combined with the predictive values of a GCS  $\geq 13$  and the absence of a head wound strongly suggest that emergent head CT not be used for those elderly patients. Of the 181 patients concerned (30.5%), only one CT result affected the initial medical strategy through the diagnosis of a cerebral tumor. This recommendation should not be applied to patients who are not clinically dehydrated because the risk of miss rate was about 5% (95% CI, 0.03–0.09). Our findings differ slightly from another ED study of 178 patients without an age criterion.<sup>27</sup> In that study, AMS without focal signs and with evidence for clinical dehydration or fever did not require neuroimaging.<sup>27</sup> In our cohort, neither the infectious context nor body temperature were predictive of a positive CT.

Our study has several limitations. First, it is a single-center study conducted in an urban ED with a high rate of elderly encounters (19%). This allowed us to provide a larger cohort of consecutive elderly patients than prior studies.<sup>27,29–31,35,41,42</sup> Second, our observations certainly require external validation because of our very low rate of positive CT findings, which makes the predictions of our model imprecise. Indeed, the quality of our data is not perfect, which is a limitation of any retrospective study, but we tried to limit potential bias by checking each head CT and medical record twice. Our analysis provides a reasonable cohort for a future randomized clinical trial to determine the actual effects of early ED imaging prioritization on medical management, ED length of stay, and miss rates. Third, we did not analyze elderly patients who presented with acute isolated AMS and did not receive head CT. They might have had an acute cerebral disease missed by the attending EP. That analysis would have required an additional review and follow-up of medical observa-

tions for all 11,258 elderly patients during the study period. In emergency settings with younger patients, prior studies reported that 40% to 60% of acute episodes of AMS were investigated through emergent neuroimaging (CT or MRI).<sup>27,42</sup> Because only a few patients received an additional MRI during follow-up, some small ischemic strokes might have been missed in patients with no etiology to explain their AMS except incipient dementia.

In summary, the yield of head CT in this elderly patient population remained lower than in the general population. In this retrospective cohort study, we have identified three clinical variables that can help improve resource allocation, limit unnecessary radiation exposure, and shorten the ED length of stay in the growing elderly population of emergency departments. These findings suggest that a prospective comparative study should be undertaken to design and validate specific clinical tools to limit the use of head CT in elderly patients at low risk of having a curable cerebral disease.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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## AUTHOR CONTRIBUTIONS

Conceptualization: all authors; Data curation: CG, MF, AF, GC; Formal analysis: CG, MF, AF, GC; Visualization: CG; Writing—original draft: all authors; Writing—review & editing: all authors. All authors read and approved the final manuscript.

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