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Frequency of Acute Changes Found On Head CTs in Critically Ill Patients: A Retrospective Cohort Study

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Abstract

Purpose—The frequency of positive findings on computed tomography (CT) of the head in critically ill patients who develop neurological dysfunction is not known.

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Materials and Methods—Cohort study of head CTs for patients admitted to three Intensive Care Units (ICUs) from 2005–10. We documented the frequency of acute changes for all head CTs, and for the subgroup of patients with altered mental status (AMS). We also examined associations between patient characteristics or medications administered prior to head CT and the odds of an acute change on head CT using multivariate logistic regression.

Results—During 11,338 ICU admissions, there were 901 eligible head CTs on 706 patients (6% of patients). Among head CTs, 155 (17.2%) assessed concern of new focal deficit, 99 (11.0%) concern for a seizure, 635 (70.5%) AMS. Acute changes were found on 109 (12.1%; 95% CI 10.0–14.2%) of all head CTs, and 30% (22.4–36.9%) of patients with focal deficits, 16.2% (8.8–23.5%) of patients with seizures, but only 7.4% (5.4–9.4%) for patients with AMS. A diagnosis of sepsis was associated with a decreased odds of an acute change on head CT for all head CTs (Odds Ratio (OR) 0.61; 95% CI 0.40–0.95, $p=0.028$), but was not significantly associated with a decreased risk among the cohort of head CTs for AMS (OR 0.82; 95% CI 0.41–1.62, $p=0.55$). No other factors were associated with an altered risk of acute change on head CT for all patients in our cohort, or for those with AMS.

Conclusions—Acute changes on head CTs performed for concern regarding new focal neurological deficit or seizures are frequent compared to those performed for AMS with a non-focal exam. No specific patient characteristics or medications were associated with a large change in the likelihood of finding an acute change for patients with AMS.

Keywords

Critical Care; Intensive Care Unit; CT Scan; X-Ray; Radiation; Decision Making

INTRODUCTION

Computed tomography (CT) of the head is often performed in critically ill patients to investigate neurological signs and symptoms that may indicate more serious pathology [1]. Whereas current clinical practice suggests that focal neurological deficits and seizure activity should be further investigated with a head CT [2], the utility of imaging for patients who develop non-specific altered mental status (AMS) is unclear. AMS may indicate a more serious neurological problem, such as an ischemic or hemorrhagic stroke or a central nervous system infection, but may also be caused by transient systemic events, such as sepsis, metabolic derangement, or sedative use [3].

Head CTs can provide very valuable clinical information but are also associated with costs and risks to the patient [4]. The radiation dose of a CT scan is 100 times that of a postero-anterior chest x-ray, increasing the risk of a subsequent malignancy [5]. CT scans in particular represent the greatest contribution to the estimated worldwide collective effective dose from diagnostic imaging [6]. CT scanning also puts critically ill patients at risk for adverse events due to the need for transport to and from the scanner [7]. Additionally, as ICU staff may be required to leave the unit in order to accompany patients for scans [8], care of other critically ill patients could also be compromised, although this is speculative. Finally, concerns over the rising cost of healthcare and the financial expenses of

unnecessary testing add urgency to the need for improved understanding of the utility of a broad ranges of tests and interventions for critically ill patients [9].

Whether or not to send a patient for a head CT is a difficult decision faced by physicians in many fields of clinical care. Studies on head CT use and appropriateness have been conducted in emergency medicine and pediatrics [10, 11], and other studies have focused primarily on head CTs for specific indications such as headache, syncope and traumatic head injury [12, 13]. Currently, few data document the frequency of overall positive findings of head CTs performed in general critical care settings, and no evidence-based clinical guidelines exist to aid physicians in these decisions. We therefore sought to first, provide estimates of the frequency of acute changes on head CTs among critically ill medical and surgical patients, and second, to determine whether any specific risk factors could be identified that might aid clinicians in assessment of the likelihood of finding an acute change on head CT.

METHODS

Study Design

This was a retrospective single-center cohort study based upon chart review of patients who had head CTs while admitted to either the medical or surgical ICUs at Columbia University Medical Center. The study cohort consisted of all patients aged >18 years who were admitted to ICUs and stayed for a minimum of 6 hours (see Figure 1), from January 1, 2005, to December 31, 2010, for surgical ICU patients and between August 2, 2006, and December 31, 2010, for medical ICU patients. The accrual of data for the medical ICU began later because of a transition in location, which made it difficult to identify admissions prior to this date. We extracted data from the electronic medical record, including demographic information, radiological reports for the CTs, documented indications for the scans, comorbidities, hospital admission and discharge dates, ICU admission and discharge dates, and detailed drug administration records for the duration of the ICU admission.

Indications for head CTs

We assessed the indications for head CTs using the radiology report and relevant physician notes. Head CTs were excluded if they were obtained for indications relating to: (1) a cardiac arrest within the same hospitalization, (2) follow-up scans for established ischemic or hemorrhagic stroke, (3) acute or fulminant liver failure, (4) craniofacial diagnoses (such as head and neck tumors requiring follow-up by CT scan), (5) trauma, and (6) cardiac surgery within the same hospitalization. This last group was excluded due to the potential for risk factors for stroke associated with cardiac surgery that are related to intraoperative events. We identified the indications for the remaining scans using chart review as: (1) concern for or documented focal neurological deficit, (2) concern for or documented seizure activity, (3) AMS, or (4) other. A focal neurological deficit was determined during review of patients' medical charts by identifying key phrases indicative of neurological abnormalities, such as facial weakness or unilateral limb weakness or numbness, specifically looking within the documentation of neurological examinations performed by nursing staff, primary care team physicians and neurology consultants. For patients who had more than one

indication for head CT documented, we created a hierarchy, so that a patient who had a focal neurological deficit was coded as such regardless of other reasons. Documented concern for seizure activity was second, and AMS was only coded if neither other reason was documented concurrently.

The primary outcome for this study was a new, acute change on head CT (i.e. not evident on any prior imaging or not documented previously in clinical notes). All CT reports were reviewed independently by two study physicians (RB and HW) to identify mention of any acute changes (defined in Table 1). Each radiology report was assessed independent of any other clinical information; the initial kappa for agreement was 0.78. For the reports where there was disagreement between reviewers regarding presence or absence of an acute change, a neuro-radiologist (AK), blinded to the patient's medical record, examined the primary images and diagnosed acute change using the same list of inclusion criteria.

Potential predictors of an acute change on head CT

Patient characteristics including age, sex and race/ethnicity were assessed as potential predictors of an acute change on head CT. Race/ethnicity was obtained from medical records based on self-classification by patients and/or family members. We identified patient comorbidities by retrieving *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnoses codes and *ICD-9-CM* procedure codes for each hospitalization for the corresponding CT scan. We identified *a priori* two specific diagnoses: atrial fibrillation (427.3x) [14, 15] and carotid stenosis (433.10, 433.11, 433.3) [16] that might be associated with an increased risk of an acute change on head CT in critically ill patients and *post hoc* added malignancy (140–209). However, we found that few people had a diagnosis of carotid stenosis (n=3) so this factor was omitted from analyses.

We also *a priori* identified fifteen medications that are frequently administered in our ICUs that might be associated with the likelihood of an acute change on head CT. These included: anticoagulants (heparin (infusions only), low molecular weight heparin (at therapeutic doses), warfarin (any dose), argatroban (any dose), clopidogrel (any dose)), and sedatives/analgesics that might be associated with a decreased risk due to sedation as the cause of altered mental status (fentanyl, morphine, hydromorphone, methadone, dexmedetomidine, propofol, midazolam, diazepam, haloperidol, quetiapine). We assessed administration of each drug in two ways: any administration during ICU admission prior to head CT, and any administration in the 24 hours preceding the head CT.

Statistical Methods

After appropriate exclusions, we calculated the percentage of all patients admitted to ICUs who had a head CT. We created Kaplan-Meier curves to determine the timing of the first head CT performed on each patient while they were in the ICU, both by time from hospital admission, and time from ICU admission.

For all further primary analyses, each head CT was the primary unit of analysis (i.e. some patients may have had multiple head CTs, and each one was assessed separately). We calculated the percentage of all head CTs that were performed for each reason (focal

neurological deficit, seizure, or AMS) and stratified by type of ICU (surgical versus medical). We then assessed the percentage of head CTs that showed an acute change, for the whole group and similarly stratified by each reason for head CT as well as ICU type. For head CTs that showed an acute change, we also summarized the specific findings on the head CT, stratified by the reason for obtaining the head CT.

We created a multivariate model using variables that were hypothesized to be associated with the outcome. We assessed age using 3 categories (<55, 55–75, >75). We also categorized hospital and ICU length of stay by weeks using less than 1 week as the reference group (<7 days, 7–14 days, and >14 days). We created models using all head CTs as well as those obtained in the subgroup of patients with AMS only. Patients with missing data were omitted from the analysis. Model fit was assessed using the Hosmer-Lemeshow Goodness of Fit test.

Because of the number of potential medications and different exposure periods that might be associated with an increased or decreased likelihood of an acute change on head CT, we did not add them all to the multivariable model. We assessed the data for univariable associations with the outcome of an acute change (Appendix Tables 1). We omitted the data if the event rate was <10 head CTs with an acute change. This meant that we did not further assess medications administered within the 24 hours prior to head CT as all of these had low event rates. For each variable with a high enough event rate, we included it as an additional factor in the multivariable model described above, and assessed whether it changed the model fit using the Wald test, and whether the medication was independently associated with an acute change on head CT. No medications met these criteria and therefore were not included in the final multivariable models presented.

Based on preliminary chart review of 3 months of data, we estimated we would have approximately 1,000 head CTs over the study period. With an estimate of 20% having an acute change on head CT, we would have the power with alpha of 0.05 and beta of 0.80 for a 95% confidence interval around our main estimate of 17.6% to 22.6%. Database management and statistical analyses were performed using Excel (Microsoft, Redmond, WA), and SAS version 9.1 (SAS Institute Inc., Cary, NC) software. This study was reviewed by and received approval from the Columbia University Medical Center Institutional Review Board with a waiver of consent for use of patient data.

RESULTS

During the study period, 1,535 head CTs were performed during 1,211 (10.7%) of the total 11,388 admissions to the surgical and medical ICUs. 634 head CTs were performed for reasons that met the study's exclusion criteria and were therefore omitted from the analyses. After exclusions, there were 901 eligible head CT scans from 706 distinct patients, during 716 hospitalizations, and 771 ICU admissions (Figure 1). The median number of head CTs during the ICU stay was 1 (interquartile range (IQR) 1–2, maximum 7). The mean age of the patients was 62.0 ± 14.5 years and 55.6% were male (Table 2). Median hospital length of stay at the time of the first head CT was 9 days, IQR 4–21 days and median length of stay in

the ICU prior to the first head CT was 3 days, IQR 1–8 days, with no difference for the subgroup of patients who received a head CT for AMS only (Table 2; Figure 2).

Indications for head CTs

Only 17.2% of head CTs were performed for a patient who had a noted neurological deficit; 11.0% of head CTs were done for either documented or concern for seizure activity, and the majority (70.5%) had AMS without another indication. The distribution of reasons for head CTs was similar for the head CTs ordered on medical ICU patients and surgical ICU patients (Table 3).

Frequency of Acute Changes on head CTs

Of the 901 eligible head CTs, 109 (12.1%; 95% CI 10.0–14.2%) had one or more acute changes. In a secondary analysis using patients' first head CT scan ($n=706$), 89 (12.6%; 10.2–15.1%) patients had an acute change. Head CT scans performed due to a focal neurological deficit had the highest percentage of acute changes (30.0%; 22.4–36.9%, Table 4). Of the 635 scans ordered for AMS alone, 49 (7.4%; 5.4–9.4%) had an acute change. There was no difference in the likelihood of an acute change on head CTs performed on MICU patients versus SICU patients (13.3%; 10.5–16.3% versus 10.2%; 7.0–13.4%, $p=0.16$). The most common finding of an acute change on head CT was a new hypodensity (62.4% of all CT scans with an acute change; Table 5). For patients noted to have a focal neurological deficit, 30.4% of head CTs with an acute change had an intraparenchymal hemorrhage.

Factors associated with acute changes on head CTs

Univariate analysis of potential factors associated with acute changes on head CT are shown in Table 6. For the whole cohort, a diagnosis of sepsis was associated with a decreased odds of an acute change on head CT (odds ratio (OR) 0.61; 95% CI 0.40–0.95, $p=0.028$). However, this association did not hold for scans done only for AMS (OR 0.82; 95% CI 0.41–1.62, $p=0.56$). Atrial fibrillation was not associated with acute changes on all head CT (OR 1.05; 95% CI 0.64–1.73, $p=0.86$) or for scans done for AMS (OR 1.17; 95% CI 0.58–2.38, $p=0.66$). No medication examined was found to be significantly associated with the odds of an acute change in univariate analyses (Appendix Table 1), and when added to the final model (Wald test for model difference $p>0.05$ for all medications).

DISCUSSION

Our findings add to the limited data on the frequency of acute changes on head CTs in critically ill patients with robust estimates of the frequency of acute changes on head CTs for all scans, and with specific estimates for scans performed in patients with AMS. In particular, we found that head CTs are performed on approximately one in ten patients in the medical or surgical ICUs of a tertiary care hospital. The majority of these scans were done for AMS without any other indication. Acute changes were very common on head CTs done for patients with focal neurological deficits (one third), but were much less common on scans done for AMS (less than 10%). Although a diagnosis of sepsis was associated with a decreased odds of an acute change on CT scans for all patients, this finding was not also

evident in patients with AMS. Overall, no patient factors were clearly and consistently associated with a large change in the likelihood of an acute change on head CT.

Our estimate of 12.1% overall for acute changes on all head CTs is lower than similar studies carried out in alternative clinical settings as well as our initial estimate prior to the study [17, 18]. These data are important for guiding clinicians regarding their pre-test probability of finding an acute change if a head CT is ordered. We did find that a notable proportion of the scans ordered for focal neurological deficits were positive for acute changes, which indicates clear justification for a low threshold for carrying out head CTs for patients who exhibit such signs. However, it is notable that the majority of scans that showed an acute change were positive for a new hypodensity; as a percentage of scans performed, very few revealed changes (such as an extra-axial collection) that would be easily amenable to treatment.

For patients who developed AMS, the percentage of scans with an acute change was less than 10%, which perhaps highlights a potential area for reducing unnecessary scans, provided we are able to confidently identify a group of patients who are truly at lower risk. Our study results found patient and clinical characteristics to be poorly predictive of acute changes on head CTs. While this lack of statistically significant associations is partially due to the relatively small sample size of our study, it also suggests that no specific clinical characteristics change the magnitude of risk to a degree that they can easily aid in the decision-making regarding the need for head CTs in critically ill patients, including those who develop AMS. Our inability to identify specific risk factors is consistent with two other studies on this topic which were also unable to find any independent predictors [17, 18].

A recent article by Walkey *et al.* demonstrated compelling evidence that atrial fibrillation during a hospitalization was associated with an increased likelihood of stroke, particularly in septic patients [14]. Surprisingly, we found no association between atrial fibrillation and the odds of an acute change on head CT in this general population of critically ill patients. It is possible that the sample size was too small to detect the effect seen at the population-level. Alternatively, the effect found may have been specific for patients with sepsis, whereas we examined all critically ill patients.

Despite the frequency with which clinicians must decide whether or not to send a patient for a head CT, few studies have examined this issue in the ICU setting. The results of our study are supported by two similar studies that assessed head CT use in medical ICU settings using smaller sample sizes. In 2000, Rafanan *et al.* reported new radiological findings in 21.1% of 230 head CTs performed in their medical ICU [19] and in 2008, Salerno *et al.* found new findings in 31% of 123 head CTs [18]. The rates of positive findings were likely higher because of differing exclusion criteria. We chose to be as inclusive as possible, rather than focusing on narrow subgroups. Rafanan and colleagues described a higher incidence of acute changes in head CTs performed to assess focal neurological deficit, which was comparable to our results.

Strengths of this study include the quality of the clinical data; the standardized extraction and examination of data from both medical and radiological records; and the use of a

comprehensive clinical database, which allowed for a wide range of potential variables to assess as predictors. This study was limited in generalizability due to the fact that the study population was drawn from a single site and therefore may not represent nationwide practice patterns. The study was also restricted to the patients who did receive a head CT. Consequently, the sample is biased by inclusion only of patients where a clinical decision was made to obtain a head CT, and we are unable to examine the appropriateness of the clinical decision to obtain the scan. Although our sample size was large (>500 scans), positive findings were relatively infrequent. We were therefore underpowered to detect factors that may only subtly elevate or reduce the risk of an acute change on head CT. We also were unable to use cerebrovascular disease as a potential risk factor for acute changes because we were unable to easily distinguish between pre-existing disease and acute cerebrovascular events such as ischemic or hemorrhagic stroke using ICD-9 codes. Finally, our finding of a high rate of acute changes on head CTs for patients who developed focal neurological deficits highlights the importance of performing accurate clinical neurological examination. Future studies could involve standardization of high quality neurological exams, which ultimately may allow better definition of pretest probability of acute changes being found on head CTs.

Clinical decision rules, which are designed to aid physicians and minimize uncertainty, provide a practical approach to reducing unnecessary scans. For example, significant efforts were directed at developing decision rules for minor head injury, including the Canada head rule [20], and the New Orleans criteria [12], as well as within other specialties, including specific clinical scenarios such as renal colic [21], angiography for pulmonary embolus [22], and ankle fracture [23]. The Ottawa ankle rule is particularly well-known and its success has been attributed to ease of utilization, very high sensitivity and rigorous development process [24]. Further, when clinical scenarios are very common, even moderate specificity in the decision rules can help reduce the number of unwarranted scans. The use of the Ottawa ankle rules have been validated by numerous studies [25, 26], with one notable multicenter study reporting a 26.4% relative reduction of ankle radiography as a direct consequence of implementing the rule [27]. The authors also estimated savings of \$90 (equivalent to \$135 in 2013) per patient who did not need radiography. Evidence to support the use of clinical decision rules for reducing the number of CT scans in the ICU is still currently lacking. However, success in minimizing unnecessary radiography in emergency settings may indicate potential for reducing imaging in ICUs [28].

The current emphasis on cost-containment means a focus on all levels of care, from outpatient prescribing practices to tests ordered in the ICU [29]. Initiatives such as the “Choosing Wisely” campaign of the American Board of Internal Medicine are urging physicians to begin questioning not only what needs to be done for their patients, but also refocusing attention on what *not* to do for patients [9]. A number of the recommendations from across different specialties focus on *not* ordering certain radiological tests in specific circumstances, such as not ordering sinus CTs for acute uncomplicated rhinosinusitis [30]. Care in the ICU represents approximately 15% of hospital costs [31] and is an area where variable costs of care can vary substantially depending on the physician providing care [32], suggesting that reductions in testing and costs of care may be feasible.

Conclusions

Clinical scenarios involving decisions over head CTs in critically ill patients are relatively common. As our study demonstrates, the frequency of acute changes for patients with AMS is relatively low. Therefore, developing high quality clinical decision rules would be of utility. However, identifying specific ways to reduce CT scans presents a considerable challenge, as we were unable to isolate strong predictor variables in these clinical settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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List of Abbreviations Used

AMS	altered mental status
CT	computed tomography
ICU	intensive care unit
IQR	interquartile range
MICU	medical intensive care unit
SICU	surgical intensive care unit

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Fig 1.
Flowchart of exclusions and final analysis sample for ICU patients with head CTs

Fig 2.
Kaplan-Meier curve of ICU length of stay prior to first head CT, for all patients and for patients with altered mental status (AMS) only

Table 1

Radiographic findings on head CT that were considered acute changes (versus subacute/chronic)

Acute	Subacute/Chronic
Cerebral infarction	Cerebral atrophy
Intracerebral hemorrhage	Old infarction
Subarachnoid hemorrhage	Microvascular changes
Extraaxial hemorrhage or Hematoma	Indeterminate age infarction
Cerebral edema	
Posterior reversible Encephalopathy syndrome (PRES)	
Hydrocephalus	
Abscess	

Table 2

Characteristics of patients who received head CTs

Characteristics	Whole Cohort (n=901 CT scans)	AMS only (n=635 CT scans)
Patients, n	706	522
Female, n (%)	400 (44.4)	280 (44.1)
Age, mean (SD)	62.0 (14.5)	62.3 (14.5)
Race, n (%)		
White/ non-Hispanic	309 (34.3)	222 (35.0)
Asian	18 (2.0)	14 (2.2)
Black (non-Hispanic)	135 (15.0)	91 (14.3)
White Hispanic	156 (17.3)	113 (17.8)
Other/unknown	283 (31.4)	195 (30.7)
ICU, n (%)		
MICU	548 (60.8)	378 (59.5)
SICU	353 (39.2)	257 (40.5)
Hospital length of (days) at time of CT scan, median (IQR)	9 (4–21)	10 (4–22)
ICU length of stay (days) at time of CT scan, median (IQR)	3 (1–8)	3 (1–8)
Co morbidities, n (%) ^a		
Atrial fibrillation	219 (24.4)	168 (26.5)
Carotid stenosis	3 (0.3)	1 (0.2)
Malignancy ^b	200 (22.2)	140 (22.1)

AMS = altered mental status; ICU = intensive care unit; MICU = medical intensive care unit; SICU = surgical intensive care unit, SD = standard deviation; CT = computed tomography, IQR = interquartile range

^aDiagnosis data were not available for 3 patients from the whole cohort (1 from the AMS only group)

^bICD-9 codes 140–209

Table 3

Reasons for head CTs among ICU patients, with stratification by type of ICU

	No. of scans (% of total)		
	All	Medical ICU	Surgical ICU
Total, n	901	548	353
Focal Neurological Deficit	155 (17.2)	100 (18.2)	55 (15.6)
Possible Seizure ^a	99 (11.0)	62 (11.3)	37 (10.5)
Altered mental status ^a	635 (70.5)	378 (69.0)	257 (72.8)
Other	12 (1.3)	8 (1.5)	4 (1.1)

^a Patients were classified based on a hierarchy: focal neurological deficit>possible seizure>altered mental status>other. 20 of the CT scans done for a focal neurological deficit also had concern for seizure activity

ICU = intensive care unit

Table 4

Frequency of acute changes on head CTs, stratified by reason for scan and ICU type

	No. of scans with acute changes on head CT (%)					
	Whole cohort		Medical ICU patients		Surgical ICU patients	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Total	109/901	12.1 (10.0–14.2)	73/548	13.3 (10.5–16.3)	36/353	10.2 (7.0–13.4)
Focal Neurological Deficit	46/155	30.0 (22.4–36.9)	30/100	30.0 (20.9–39.2)	16/55	29.1 (16.7–41.5)
Possible Seizure ^a	16/99	16.2 (8.8–23.5)	12/62	20.0 (9.6–30.4)	4/37	10.3 (0.3–20.2)
Altered mental status ^a	47/635	7.4 (5.4–9.4)	31/378	8.2 (5.4–10.9)	16/257	6.3 (3.3–9.3)
Other*	0/12	NA	0/8	NA	0/4	NA

^aPatients were classified based on a hierarchy: focal neurological deficit>possible seizure>altered mental status>other

Table 5

Distribution of Specific Positive Finding Noted on Head CT Stratified by Reason for Head CT*

Specific Acute Change on Head CT	Total Head CTs with an Acute Change N=109	Focal Neurological Deficit N=46	Reason for Head CT	
			Possible Seizure ^a N=16	Altered mental status ^a N=47
Intraparenchymal Hemorrhage	24 (22.1)	14 (30.4)	2 (12.5)	8 (17.0)
Extra-axial Collection	16 (14.7)	8 (17.4)	0	8 (17.0)
Hydrocephalus	8 (7.3)	3 (6.5)	2 (12.5)	3 (6.4)
Mass Effect or Midline Shift	10 (9.2)	6 (13.0)	3 (18.8)	1 (2.1)
Loss of grey-white matter interface	7 (6.4)	4 (8.7)	2 (12.5)	1 (2.1)
Hypodensity	68 (62.4)	27 (58.7)	9 (56.3)	32 (68.1)
Other	1 (1.0)	0	0	1 (2.1)

* Columns do not add up to 100%, as a head CT may have had more than one acute change

Table 6

Multivariate model of associations between patient characteristics and medications and acute changes on head CT

Variable	Acute Change on Head CT (n)	Total I (n)	Whole cohort/ All head CTs	OR (95% CI)	P value	Acute Change on Head CT (n)	Total I (n)	Head CTs for AMS only	P value
Women	51	400	<i>Ref</i>			24	280	<i>Ref</i>	
Men	58	501	0.88 (0.58 – 1.32)	0.53		23	355	0.71 (0.39 – 1.30)	0.27
Age (yrs)									
65	66	523	<i>Ref</i>			26	365	<i>Ref</i>	
> 65	43	378	0.84 (0.53 – 1.31)	0.44		21	270	1.08 (0.56 – 2.08)	0.83
ICU type									
SICU	36	353	<i>Ref</i>			16	255	<i>Ref</i>	
MICU	73	548	1.42 (0.91 – 2.21)	0.13		31	380	1.51 (0.78 – 2.91)	0.22
Hospital length of stay (days) at time of head CT									
0–6	47	338	<i>Ref</i>			16	228	<i>Ref</i>	
7–13	25	219	0.77 (0.43 – 1.38)	0.35		12	155	1.12 (0.48 – 2.61)	0.78
14	37	344	0.75 (0.42 – 1.33)	0.32		19	252	1.23 (0.54 – 2.78)	0.62
ICU length of stay (days) at time of head CT									
0–2	47	411	<i>Ref</i>			17	274	<i>Ref</i>	
3–6	31	222	1.46 (0.88 – 2.43)	0.14		17	161	1.83 (0.88 – 3.80)	0.10
7	31	268	1.40 (0.77 – 2.54)	0.27		13	200	1.04 (0.44 – 2.48)	0.93
Co morbidities n, ^b									
No Atrial Fibrillation	82	679	<i>Ref</i>			33	466	<i>Ref</i>	
Atrial Fibrillation	26	219	1.05 (0.64 – 1.73)	0.86		14	168	1.17 (0.58 – 2.38)	0.66
No Sepsis	41	269	<i>Ref</i>			13	168	<i>Ref</i>	
Sepsis	68	632	0.61 (0.40 – 0.95)	0.028		34	467	0.82 (0.41 – 1.62)	0.56
No Malignancy	82	701	<i>Ref</i>			35	495	<i>Ref</i>	
Malignancy	27	200	1.35 (0.83 – 2.19)	0.23		12	140	1.29 (0.63 – 2.64)	0.49

AMS = altered mental status; ICU = intensive care unit; MICU = medical intensive care unit; SICU = surgical intensive care unit, SD = standard deviation; CT = computed tomography; CI = confidence interval. Hosmer-Lemeshow Goodness of Fit p=0.61 for full cohort; p=0.26 for AMS only

^a variables included in multivariate regression model (P<0.20)

^bDiagnosis data were not available for 3 patients from the whole cohort (1 from the AMS only group) n/a: unable to calculate due to small sample size