American Journal of Emergency Medicine 37 (2019) 1279–1284

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

A new clinical score for cranial CT in ED non-trauma patients: Definition and first validation

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ARTICLE INFO

Article history:
Received 22 May 2018
Received in revised form 15 August 2018
Accepted 19 September 2018

Keywords:
Computed tomography
Cranial
Emergency department
Clinical score

ABSTRACT

Introduction: Well recognized guidelines are available for the use of cranial computed tomography (CCT) in traumatic patients, while no definitely accepted standards exists to for CCT in patients without history of head injury. The aim of this study is to propose an easy clinical score to stratify the need of CCT in emergency department (ED) patients with suspect non-traumatic intracranial pathology.
Methods: We retrospectively evaluated patients presenting to the ED for neurological deficit, postural instability, acute headache, altered mental status, seizures, confusion, dizziness, vertigo, syncope, and pre-syncope. We build a score for positive CCT prediction by using a logistic regression model on clinical factors significant at univariate analysis. The score was validated on a population of prospectively observed patients.
Results: We reviewed clinical data of 1156 patients; positivity of CCT was 15.2%. Persistent neurological deficit, new onset acute headache, seizures and/or altered state of consciousness, and transient neurological disorders were independent predictors of positive CCT. We observed 508 patients in a validation prospective cohort; CCT was positive in 11.3%. Our score performed well in validation population with a ROC AUC of 0.787 (CI 95% 0.748–0.822). Avoiding CT in score 0 patients would have saved 82 (16.2%) exams. No patients with score 0 had a positive CCT findings; score sensitivity was 100.0 (CI 95% 93.7–100.0).
Conclusions: A score for risk stratification of patients with suspect of intra-cranial pathology could reduce CT request in ED, avoiding a significant number of CCT while minimizing the risk of missing positive results.

1. Introduction

Cranial computed tomography (CCT) is a diagnostic tool frequently used in the emergency department (ED) setting, to evaluate patients with a wide range of suspected central nervous system disorders [1]. Although CCT is considered essential in the diagnosis of acute and sometimes life-threatening illness, a dramatic increase in the ED utilization of this diagnostic tool was evidenced in the last decades [2,3]. This phenomenon is partly explained by the increasing number of patients attending the ED but, more likely, by other factors such as growing availability, increased efficiency of the procedure, augmented patients' expectation, and providers' fear of medicolegal repercussions [4]. The exponential increase of CCT in the emergency setting caused growing concern about costs and medical radiation exposure [5,6], leading to introduce the question of clinical appropriateness criteria for the use of advanced imaging in the “Top Five” policy agenda within the emergency medicine literature [7]. Although well recognized guidelines are available for the use of CCT in traumatic patients [8-12], not clinically reliable accepted guidelines exists to support emergency physicians' decision to order CCT for patients without history of head injury [13-16]. Most of the previous studies published with this aim have examined mixed trauma and non-trauma patients [17,18], or a narrow range of suspected disorders or considered retrospective chart reviews [19-24].

In our ED about 60% of non-contrast head CT are performed in non-trauma patients. These patients present to ED with several clinical conditions, including acute neurological deficit (both transient and persistent), headache, seizures, altered state of consciousness, confusion, dizziness, vertigo, and syncope. Some previous studies [13-16] both retrospective and prospective, seemed to suggest that CCT scans are of low diagnostic yield in these non-trauma patients and current criteria for ordering this test may be too liberal. These studies proposed the use of different scoring algorithms to predict abnormal head CT findings, thus identifying patients at low risk that would not require CCT in the ED. Most of the algorithms and rules proposed had a very high sensitivity

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https://doi.org/10.1016/j.ajem.2018.09.032

and could reduce CCT utilization up to 30% [13-16]. However conclusive data that identify independent predictors of abnormal CCT findings, and external validation of proposed scores are still lacking.

Aim of this study is to identify in a large cohort of retrospective patients an easy to use clinical score to decide if a patient with suspect acute non-traumatic neurological syndrome should undergo a CCT in the ED. Furthermore we evaluated prospectively the proposed score in a cohort of consecutive ED patients for an initial validation of our findings and an independent evaluation of previously proposed algorithms.

2. Methods

The study was conducted in accordance with the Declaration of Helsinki and approved by the local revision committee. None of the patients or authors received any honorary or economic benefits for the participation in this study. This study did not receive any funding or grant from private or public institution.

2.1. Study design

This study was conducted in a teaching, urban hospital with annual attendance at the ED of about 80.000 patients, >87% adults. It was divided into two sections.

The first part was a retrospective population study. We included consecutive patients that presented to our ED in a three-month period from August 1st 2016 to October 31st 2016 and were submitted to CCT for focal neurological deficit (transient or persistent), postural instability, acute headache, altered mental status, seizures, confusion, dizziness, vertigo, syncope, and pre-syncope. We considered as headache any type of new onset headache, in patient with no recurrent headache history, and pain different from usual in patients with history of recurrent headache. Clinical records were reviewed to assess clinical history data including, atrial fibrillation history, coagulopathy, hypertension, dyslipidemia, diabetes, chronic kidney disease, oral anticoagulant therapy, aspirin/clopidogrel therapy, and oral estroprogestinic therapy.

We excluded patients with history of head trauma in the previous month to ED presentation, known cerebral tumor (primitive or metastatic), known hydrocephalous with ventricular shunt, recent intracranial hemorrhage or ischemia, and age <18 years old. Clinical and demographic data (age, sex) were collected from the hospital computerized clinical record (GIPSE®).

We evaluate the association of the study variables to positive CCT at univariate analysis and multivariate analysis to identify independent predictors of positive CCT findings. Independent factors were used to create a score, Emergency CT Head Score (ECHS) to stratify the risk of detecting pathological findings at CCT in these patients.

In the second part of the study we observed a cohort of consecutive patients evaluated in our ED in a month period (from January 1st to 31st 2017), submitted to CCT for the same clinical conditions as those of the retrospective series, with the aim to perform prospective observational validation of ECHS, and to compare our score to previously proposed algorithms.

2.2. Radiologic requests

Decision-making to perform CCT was always taken by a board-certified emergency physician. Axial CT images were acquired at 2.5 mm slices on a 64 slide CT scan (Revolution CT, GE Healthcare). Cranial computed tomography scan interpretations were performed in all cases by experienced neuro-radiologists and considered positive if one of the following intracranial pathologies was detected: acute ischemic lesion, intra-axial or extra-axial hemorrhage, intracranial mass, abscess, hydrocephalous, cerebral edema. Results of the CT scans were obtained from radiologists' reports.

2.3. Sample size, statistical analysis and score's elaboration

Based on results of prior studies [12-16], we estimated that approximately 10% of CT scans would have positive results in our population. Since 10 variables were entered into the logistic regression model, a total of 1000 patients would have been required with the expectation of at least 100 positive scans. On the validation population, since 4 independent variables were comprised in our score, a total of at least 400 patients should be comprised into the study samples with the expectation of at least 40 positive scans.

All variables evaluated into the study were statistically correlated to evidence of positive CCT findings at univariate analysis by Chi-square test. All factors evaluated were dichotomous apart from age that was dichotomized using 55 years as cut-off value, to even out our score to previously proposed one [15,16]. Significant variables at univariate analysis were entered into a logistic regression model to identify independent predictors of positive CCT scan. To reduce variables redundancy in the logistic regression model, some variables were combined during analysis. Goodness of fit of our model was assessed by Hosmer-Lemeshow test. Four variables were identified as independently associated to positive CCT finding. Each variable was given a +1 value to build a score (ECHS) ranging from 0 to 4 for each patient.

In the second part of the paper we present initial validation of our score in a prospective cohort of consecutive patients. Score performance for association with positive CT was evaluated by receiver operating characteristic (ROC) analysis. We also compared our score performance with formerly proposed criteria [13-16] by ROC curve comparison.

Categorical variable were presented as numbers and percentages, and continuous variables are presented as mean $\pm$ standard deviation. Association of factors to positive CCT is presented at univariate and multivariate analysis as odds ratio (OR) (95% confidence interval). Sensitivity, specificity and ROC area under curve (AUC) are presented as value (95% confidence interval). A two-sided p value of 0.05 or less was considered significant. All data were analyzed by SPSS v25® (IBM, NY, USA).

3. Results

Between August 1st 2016 to October 31st 2016, 1573 consecutive non-trauma patients ≥18 years presented to our ED and underwent head CT scan. Three hundred sixty eight patients were excluded for history of trauma in the previous month, known cerebral tumor or intracranial pathology. Forty nine more patients were excluded because of insufficient clinical data in medical reports, thus we identify a retrospective study cohort of 1156 patients. Most of patients included presented to our ED for transient (40.1%) or persistent neurological disorders (36.0%), new onset acute headache (37.3%), altered state of consciousness (25.9%), and dizziness or vertigo (21.7%). Other clinical symptoms of presentation are detailed in Table 1. We found 175 (15.1%) positive CCT in our cohort. Main findings included acute or non-acute ischemia (68 pts. – 38.8%), subdural or parenchymal hemorrhage (62 pts. – 35.4%), malignancies (37 pts. – 21.1%). Other findings (8 pts. – 4.7%) included obstructive hydrocephalus, cerebral abscess, and nonspecific lesions.

At univariate analysis we identified several variables statistically associated to a CCT positive scan: age > 55 years OR 2.5 (1.8–3.7); transient focal motor disorders OR 5.0 (3.5–7.1); transient focal sensitive disorders OR 2.2 (1.5–3.2); transient speech or visual disorder OR 2.6 (1.8–3.6); any transient neurological deficit (combined) OR 3.3 (2.3–4.6); focal motor deficit 9.7 (6.8–13.8); focal sensitive deficit 5.4 (3.6–8.1); focal speech or visual deficit 7.8 (5.4–11.5); presence of any neurological deficit at physical examination (combined) OR 11.1 (7.4–16.6); new onset acute headache OR 1.7 (1.2–2.3); postural instability and/or gait disorders OR 4.5 (3.1–6.5); new onset seizures OR 3.2 (1.8–5.8); altered state of consciousness OR 2.8 (2.0–4.0); seizures and/or altered state of consciousness OR 4.0 (2.9–5.6); confusion OR 5.4

Table 1
Demographic, symptoms and sign at ED presentation, and clinical history data of patients included in study. The two populations were mainly comparable. Percentage of patients presenting each factors considered in the study.

Variable	Retrospective cohort (1156 pts.)	Prospective cohort (508 pts.)
Age (mean ± sd)	58.9 ± 19.8	61.1 ± 19.9
Age > 55 years	685 (59.3%)	314 (61.8%)
Sex (M)	523 (45.2%)	243 (47.8%)
Clinical signs/simphtoms		
Acute headache	431 (37.3%)	170 (33.5%)
Transient focal motor disorders	210 (18.2%)	109 (21.5%)
Transient focal sensitive disorders	182 (15.7%)	56 (11.0%)
Transient speech or visual disorders	306 (26.5%)	122 (24.0%)
Focal motor deficit	229 (19.8%)	102 (20.1%)
Focal sensitive deficit	123 (10.6%)	28 (5.5%)
Persistent speech or visual deficit	215 (18.6%)	88 (17.3%)
New onset seizures	52 (4.5%)	16 (3.4%)
Altered state of *consciousness*	299 (25.9%)	121 (23.9%)
Nuchal stiffness	13 (1.1%)	2 (0.4%)
Confusion	162 (14.0%)	52 (10.3%)
Postural instability e/o gait disorder	175 (15.1%)	42 (8.3%)
Dizziness/vertigo	251 (21.7%)	110 (21.7%)
Sincope/presincope	192 (16.6%)	77 (15.2%)
Vomit	180 (15.6%)	98 (19.3%)
Combined: any transient neurological disorders	463 (40.1%)	210 (41.3%)
Combined: any neurological deficit at physical examination	416 (36.0%)	175 (34.4%)
Combined: new onset seizures and altered state of consciousness	345 (30.2%)	130 (25.6%)
Clinical history data		
Hypertension	559 (48.5%)	242 (47.6%)
History of malignancies	174 (15.1%)	73 (14.4%)
Dyslipidemia	129 (11.2%)	71 (14.0%)
Atrial fibrillation history	82 (7.1%)	54 (10.6%)
Diabetes	145 (12.6%)	56 (11.1%)
Chronic kidney disease on dyalisis	31 (2.7%)	19 (3.8%)
Coagulopathy history	11 (1.0%)	18 (3.5%)
Oral anticoagulant therapy	70 (6.1%)	49 (9.6%)
Aspirin/clopidogrel therapy	233 (20.2%)	99 (19.5%)
Oral estroprogestinic therapy	30 (2.6%)	8 (1.6%)

Table 2
Odds ratio and 95% confidence interval for each factor evaluated with respect to positive cranial CT findings. Total positive CT scans were 175/1156 (15.1%).

Variable	Odds ratio (95% confidence interval) for each clinical condition (1156 patients)	χ^2 *p* value
Age > 55 years	2.5 (1.7–3.7)	0.000
Sex (male)	0.7 (0.5–0.9)	0.030
Clinical signs/simphtoms		
Acute headache	1.7 (1.2–2.4)	0.001
Transient focal motor disorders	5.0 (3.5–7.1)	0.000
Transient focal sensitive disorders	2.2 (1.5–3.2)	0.000
Transient speech or visual disorders	2.6 (1.8–3.6)	0.000
Focal motor deficit	9.7 (6.8–13.8)	0.000
Focal sensitive deficit	5.4 (3.6–8.1)	0.000
Persistent speech or visual deficit	7.8 (5.4–11.5)	0.000
New onset seizures	3.2 (1.8–5.8)	0.000
Altered state of *consciousness*	2.8 (2.0–4.0)	0.000
Nuchal stiffness	13.2 (4.0–43.5)	0.000
Confusion	5.4 (3.7–7.8)	0.000
Postural instability e/o gait disorder	4.5 (3.1–6.5)	0.000
Dizziness/vertigo	0.3 (0.1–0.5)	0.000
Sincope/presincope	0.3 (0.2–0.6)	0.000
Vomit	0.8 (0.5–1.3)	0.462
Combined: any transient neurological disorders	3.3 (2.3–4.6)	0.000
Combined: any neurological deficit at physical examination	11.1 (7.4–16.6)	0.000
Combined: new onset seizures and altered state of consciousness	4.0 (2.9–5.6)	0.000
Clinical history data		
Hypertension	1.7 (1.2–2.4)	0.001
History of malignancies	1.9 (1.2–3.1).	0.009
Dyslipidemia	0.9 (0.5–1.5)	0.699
Atrial fibrillation history	1.2 (0.6–2.1)	0.612
Diabetes	0.9 (0.6–1.5)	0.844
Chronic kidney disease on dyalisis	1.1 (0.4–2.8)	0.870
Coagulopathy history	3.2 (0.9–11.2)	0.051
Oral anticoagulant therapy	1.7 (0.9–3.1)	0.061
Aspirin/clopidogrel therapy	1.0 (0.7–1.5)	0.859
Oral estroprogestinic therapy	0.8 (0.3–2.5)	0.780

(3.7–7.8); nuchal stiffness OR 13.2 (4.0–43.5); hypertension OR 1.7 (1.2–2.4); history of malignancies OR 1.9 (1.2–3.1). The rate of positive CCT among patients with syncope or dizziness/vertigo was significantly low: syncope OR 0.3 (0.2–0.6); dizziness/vertigo OR 0.3 (0.1–0.5) (Table 2).

When entered into a logistic regression model, several variables showed redundancy at our analysis. To reduce redundancy and improve goodness of fit of the model we combined some variable. Accordingly to our analysis we combined together presence of any transient neurological disorder in a single variable; similarly we combined any focal neurological deficit at physical examination in a single variable, and new onset seizures and altered state of consciousness in a single factor for the analysis. At our best fitted logistic regression model we identified 4 variables to be independent predictors of positive CCT scan finding: any neurological deficit at physical examination OR 10.4 (5.9–18.3), new onset acute headache OR 6.8 (4.2–10.0), combined new onset seizures and altered state of consciousness OR 3.6 (2.1–6.2), any transient neurological disorder OR 1.8 (1.1–3.1) (Table 3).

Each of the four independent predictor of positive CCT scan was given a +1 value. Thus our 4 points score (ECHS) divided population in 5 subgroups. When applied to retrospective cohort we found that higher ECHS was associated to a larger percentage of positive CCT. No positive CCT scan were found in the 209 ECHS 0 patients; 24 positive CCT were found in the 466 ECHS 1 patients (5.2%); 49 positive CCT were found in the 271 ECHS 2 patients (18.1%); 90 positive CCT scan were found in the 193 ECHS 3 patients (46.6%) and 12 positive CCT were found in the 17 ECHS 4 patients (70.6%). ECHS >0 sensitivity was 100% (CI 95% 97.9–100) and specificity was 21.3% (CI 95% 18.8–24.0). Area under ROC of ECHS in this cohort was 0.831 (CI 95% 0.808–0.852).

To validate our score we prospectively observed, in a month period from January 1st to 31st 2017, 526 consecutive non-trauma patients presented to our ED for the same clinical condition of retrospective cohort. Eighteen patients were excluded because they refused CCT, thus we included in the prospective study cohort 508 patients. Patients included presented at our ED for new onset acute headache (33.5%), persistent neurological disorders (34.4%), transient neurological disorders (24.0%), altered state of consciousness (25.6%), and dizziness or vertigo (21.7%). Clinical symptoms of presentation of this prospective cohort are detailed in Table 1. We had 58 (11.3%) positive CCT scan in these patients. Main findings included acute or non-acute ischemia (22 pts. – 37.9%), subdural or parenchymal hemorrhage (20 pts. – 34.5%), malignancies (12 pts. – 20.7%). Other findings (4 pts. – 6.9%) including obstructive hydrocephalus, nonspecific lesions, and atheromatous disease with basilar artery augmented density in absence of acute ischemia.

Demographic and clinical data of this validation prospective population were quite similar to retrospective one. However when comparing the two populations we found a significant higher number of patients older than 55 years in the prospective group (45% in retrospective cohort vs 52.5% in prospective one, $p = 0.047$), and the two study populations also differed in history of atrial fibrillation (6.1% in the retrospective group vs 9.6% in the prospective group; $p = 0.016$) and

Table 3
Significant variables for positive CCT at univariate analysis were entered into a logistic regression model. Some variable were combined to increase goodness of fit of the model. Final logistic regression model had an overall predictive value of 88%; Model χ^2 was 297.5 ($p < 0.001$); −2 log likelihood was 677.4. Goodnees of fit (Hosmer-Lemeshow) χ^2 was 8.7 ($p = 0.365$). Constant was included into the model. Only focal neurological deficit at physical examination, new onset acute headache, combined new onset seizures and altered state of consciousness, and transient neurological disorder were independent predictors of positive CT scan in our population.

Variable	*p* value	β	SE β	Odds ratio (CI 95%)
Any neurological deficit at physical examination	0.000	2.35	0.28	10.4 (5.9–18.3)
New onset acute headache	0.000	1.92	0.25	6.8 (4.2–1.0)
New onset seizures and/or altered state of consciounsness	0.000	1.28	0.27	3.6 (2.1–6.2)
Any transient neurological disorder	0.020	0.62	0.26	1.8 (1.1–3.1)
Age > 55 years	0.051	0.40	0.28	1.5 (0.9–2.0)
Sex	0.235	0.28	0.24	1.3 (0.8–2.1)
Nuchal stiffness	0.334	0.65	0.67	1.9 (0.5–7.1)
Postural instability and/or gait disorder	0.990	0.01	0.25	1.0 (0.5–1.5)
Confusion	0.155	0.42	0.29	1.5 (0.8–2.7)
Hypertension	0.758	0.07	0.23	1.1 (0.7–1.7)
Constant	0.000	−5.27	0.36	

oral anticoagulation therapy consumption (7.1% in the retrospective group vs 10.6% in the prospective group; $p = 0.010$).

When applied to validation population we found that our score performed well. No positive CCT scan were found in the 82 ECHS 0 patients; 9 positive CCT were found in the 226 ECHS 1 patients (4.0%); 31 positive CCT were found in the 147 ECHS 2 patients (21.1%); 12 positive CCT scan were found in the 47 ECHS 3 patients (25.5%); 5 positive CCT were found in the 6 ECHS 4 patients (83.3%) (Table 3). In this population ECHS >0 sensitivity was 100% (CI 95% 93.7–100) and specificity was 18.2% (CI 95% 14.7–22.1). Area under curve (AUC) ROC was 0.787 (CI 95% 0.748–0.822) (Table 4).

When compared to previously proposed criteria, ECHS performed better than Harris and Rothrock criteria: ROC AUC ECHS 0.787 (0.748–0.822); vs. Harris criteria 0.633 (0.590–0.675), $p < 0.001$; vs. Rothrock criteria ROC AUC 0.574 (0.530–0.618), $p < 0.001$ (Fig. 1). Our score showed a ROC AUC similar to Bent score ROC AUC 0.782 (0.744–0.817), $p = 0.910$, and Wang score ROC AUC 0. 745 (0.705–0.782), $p = 0.332$ (Fig. 1). However while ECHS sensitivity for positive CT scan was 100%, same as Bent score, both Harris and Wang score showed a lower sensitivity, respectively 98.2 (90.6–99.7) and 94.7 (85.4–98.8).

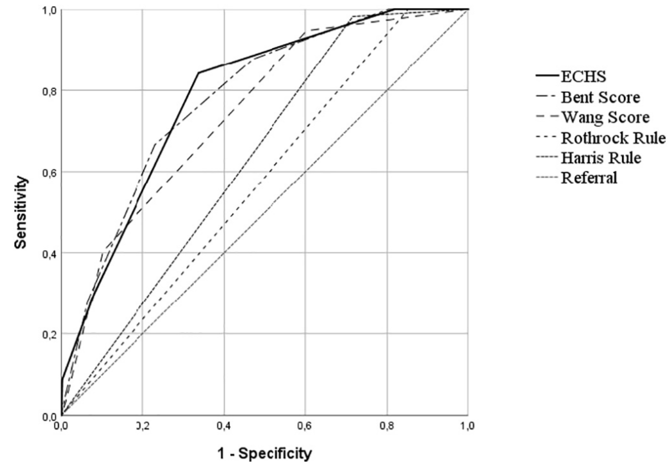

Fig. 1. Receiver operating characteristic area under curve (ROC AUC) comparison between ECHS and previously proposed criteria by Bent [15], Wang [16], Rothrock [13], and Harris [14]. ROC AUC ECHS 0.787 (0.748–0.822); vs. Harris rule ROC AUC 0.633 (0.590–0.675), $p < 0.001$; vs. Rothrock rule ROC AUC 0.574 (0.530–0.618), $p < 0.001$; vs. Bent score ROC AUC 0.782 (0.744–0.817), $p = 0.910$; vs. Wang score ROC AUC 0.745 (0.705–0.782), p = 0.332.

4. Discussion

The question of the appropriate indications to CCT in the ED setting is still object of debate. A wide range of clinical conditions and signs persuade emergency physicians to order CCT, even in scarcely symptomatic patients. As a result of such an uncertainty, and of the increased availability, the use of CCT has increased exponentially in the last years [25]. Most of the previous studies published with the aim to suggest reliable guidelines to support emergency physicians' decision to order CCT examined mixed trauma and non-trauma patients [17,18] or included patients presenting only with a specific neurological disorder, such as headache [22,23], seizures [24], or syncope and dizziness [19,20]. In our experience patients presenting to ED often complain several symptoms at the same time and have heterogeneous clinical condition. Therefore clinical decision rules for CCT request based on “pure” clinical presentation are of reduced clinical effectiveness in the ED setting. To the best of our knowledge, only few studies have been published till now with the aim to identify clinical criteria for ordering CCT in the general non-trauma ED population [13-16]. These studies suggest that a risk stratification of patients with suspect of intra-cranial pathology could reduce CT request up to 30% with a minimal loss of positive results. There are obvious advantages to defining a single set of parameters to

Table 4
ECHS and previously proposed algorithm performance if applied to our validation population. Percentage of positive CT scan for each score group. Positive CT scans were 57 on 508 patients (11.2%).

	ECHS	Bent score	Wang corrected	Rothrock rule	Harris rule
Score value 0 positive scan	0%	0%	1.6%	0%	0.8%
Score value 1 positive scan	4%	4.5%	12.1%	12.9%	14.8%
Score value 2 positive scan	21.1%	10%	33.9%	/	/
Score value 3 positive scan	25.5%	22.7%	28.6%	/	/
Score value 4 positive scan	83.3%	35.0%	/	/	/
ROC AUC	0.787 (0.748–0.822)	0.782 (0.744–0.817)	0.745 (0.706–0.782)	0.574 (0.530–0.618)	0.633 (0.590–0.675)
Possibly saved CT scan	82 (16%)	89 (17%)	182 (36%)	67 (13%)	129 (25%)
Sensitivity for score > 0	100.0 (93.7–100.0)	100 (93.7–100)	94.7 (85.4–98.8)	100.0 (93.7–100.0)	98.2 (90.6–99.7)
Specificity for score > 0	18.2 (14.7–22.1)	19.7 (16.2–23.7)	39.7 (35.1–44.4)	14.9 (11.7–18.5)	28.4 (24.3–32.8)

ECHS: +1 for each of the following: transient neurological deficit; focal neurological deficit at physical examination, new onset acute headache; new onset seizures and/or altered state of consciousness.
Bent score: +2 for focal neurological deficit; +1 for each: altered mental status; nausea and/or vomiting; coagulopathy; history of malignancies; age > 55 [15].
Wang *corrected*: +1 for each: focal neurological deficit; altered mental status; nausea and/or vomiting; coagulopathy; history of malignancies; age > 55 [16].
Rothrock rule: any of the following: age > 60 years, focal neurologic deficit, headache with vomiting, or altered mental status [13].
Harris rule: any of the following: focal neurologic deficit, headache with vomiting, Glasgow coma score < 14 [14].

help identify high or low risk patients for radiology requests. These advantages include improved clinical utility, as well as memorization and ready implementation into everyday clinical practice [13]. This is especially true in small first aid services, where there is no possibility of performing CCT, and patients have to be transferred to a referring center to make the procedure, or in an overcrowding situation, so common in any ED of referring teaching hospitals, where stratifying patient's risk is mandatory to establish the priority in the execution of CCT. Moreover, the stratification of the risk could allow avoiding a large number of CCT and consequent concerns about medical radiation exposure and increasing costs [2,3]. Nevertheless it is evident that the score should be enough specific to reduce at maximum the number of missed results.

On the base of preceding experiences, the first goal we tried to achieve in our study was to build an effective score to identify patients that surely need CCT in ED. We tried also to keep sensitivity at maximum to avoid missed diagnosis, even at the cost of some extra negative CT scan. In our retrospective cohort we found that 175 patients (15.2%) had a positive CCT finding, a result similar to what evidenced in previous series [13-16]. At multivariate analysis we found that acute headache, transient neurological disorders, presence of any neurological deficit at physical examination and combined seizures and altered consciousness, resulted independently predictive of positive CCT scan in our population. We created a score (ECHS), varying from 0 to 4, giving to each independent variable at multivariate analysis a +1 value if present, with the aim to give to the emergency physician of a simple tool to predict the risk of detecting pathological findings at CCT for each patient. Differently from other proposed algorithms, our score include only clinical signs and does not take in account clinical history data and age. We think that this kind of score fits better to emergency physicians that often are lacking of anamnestic data in their first approach to patients.

On the validation population of 508 patients our score performed well (Table 4). Avoiding CT in ECHS 0 patients would have saved 16% of CCT without any loss in term of sensitivity in this cohort. Although ECHS had a very good performance, and no positive CCT were found in ECHS 0 group, the number of positive CCT rapidly increase from score 1 to 4, ranging from 4% in ECHS group 1 to 83% of ECHS 4 (Table 4). These data suggests that while in ECHS 0 group CCT could be avoided, ECHS group 1 or higher should be considered only for risk stratification and patients triage to radiology.

Our score perform quite similar to other clinical decision rules proposed for head trauma patients, although these findings are yet to be validated in larger cohort [10-12]. In non-trauma populations, our data confirm that, as previously reported, CT scan is of poor utility in the investigation of syncope, dizziness and vertigo, in absence of focal neurological deficit [19,20]. Other data derived from a cohort of patients presenting with delirium, confirmed that main predictor of head CT findings are new neurological deficits and deterioration of consciousness [21]. The routine use of CCT in ED for patients presenting with seizures is still debated [24]. However most of these patients are at high risk of intracranial pathologic findings. Our data confirms that both seizures and altered consciousness patients should undergo a head radiological examination.

The question of head CCT scan in patients presenting to the ED with headache requests further discussion. There is large consensus that patients presenting to ED with headache and new onset neurological findings should undergo CCT [22,23]. However it is well known that up to half of subarachnoid hemorrhage patients could show no neurological signs at time of presentation [26-28]. There is some evidence that time from onset to peak of headache could predict presence of subarachnoid acute hemorrhage in these patients [26]. However further data are needed to better stratify the risk in headache patients. At this time our data support the use of CCT scan on adult patients presenting to ED with new onset acute headache even in absence of new onset other neurological signs.

Comparing the performance of ECHS to previously proposed criteria we found that the number of possibly avoided CT is similar to what could be obtained applying Bent score [15] or Rothrock rule [13] that would reduce scan respectively by 17.5% and 13.2%. Both these algorithms would not have missed any positive scan, such as ECHS. Applying more restrictive criteria such as Harris rule [14] or Wang score [16], the number of CT scan avoided could have been much greater, respectively 25.4% and 35.9%. However both these algorithms would miss some positive scan (respectively 0.8% and 1.6%), that on annual basis could led to up 30 missed positive scan in a high volume ED such ours, that is obviously hardly acceptable.

The identification of a simple tool to support emergency physicians' decision to request CCT in non-trauma patients is highly desirable. The range of the potential intracranial disorders that can be defined by CCT is wide, it is probable that a single set of criteria will not ever be 100% sensitive in the detection of clinically significant pathology [13]. Not missing any positive CCT is extremely difficult and this is hardly acceptable in our opinion. Although this objective limitation, the goal of reducing the high number of CCT requested in the ED seems easily achievable making risk stratification analysis using sets of clinical criteria or a simple clinical score as the one proposed by the authors.

Our data confirm that risk stratification could reasonably reduce CT utilization in the emergency department patients, keeping high standard of sensitivity. As expected, and suggest by most of preceding experiences, presence of focal neurological deficit is the key element for risk stratification [14-18,29]. Adult patients presenting with new onset acute headache remain a great challenge for the emergency physician, but the wisest choice at this point could be obtaining a head CT scan in all cases. To propose a guide line to CCT scan's request in ED based on ECHS, we could suggest that in ECHS 0 patients CCT should be avoided, ECHS 1 patients could be considered for further clinical observation, while a CCT should be recommended to ECHS 2–4 patients. We believe that the ECHS is a very simple, reliable and useful tool for the emergency physician in order to consistently save CCT scan requests in the ED setting.

Limitation of this study includes the single center design, and the reduced sample observed. An independent validation of the score is obviously necessary, possibly by prospective controlled trials, prior to consider it in common clinical practice.

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