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Clinical Predictors of Abnormal Head CT Findings for Non Trauma Patients at the Eric Williams Medical Sciences Complex (EWMSC) Emergency Department

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ABSTRACT

Background: The utilization of Computed tomography (CT) has exponentially increased since its inception, providing faster and more reliable results. However, there are several downsides which include: increased radiation exposure to patient, increased health care cost and increased output times at a radiology department. In the acute setting for example, the Emergency Department (ED), the increase use of this modality therefore has widespread ramifications. Therefore, more selective use of CT in the ED can reduce the number of unnecessary scans done, resulting in a reduction in healthcare cost. Clinical decision guidelines to assist physicians in ordering head CT for these patients are therefore needed. The objective of this study was to determine the clinical predictors of abnormal imaging findings among those patients in the ED with non-traumatic history who underwent head CT at the EWMSC. Currently, such data does not exist locally and this study can serve as a foundation for creation of protocols and guidelines. The results can also be compared to international findings.

Method: Ethical approval was obtained and a retrospective analysis of the non-contrast head CT examinations done for patients who presented to the ED from June 1st to August 31st, 2016, analyzed. The patients were adult patients with non-traumatic history or no known intracranial pathology. A multivariable logistic regression was performed with correlation of each of the variables with predicting abnormal findings expressed as an adjusted odd ratio (OR) and confidence interval of 95% (CI).

Results: Of 2090 unenhanced Head CT images done at the EWMSC between June 1st to August 31st, 2016, 701 were eligible for this study. Only 153 (21.8%) revealed any abnormalities. Five predictors of abnormal findings were identified and they included age (adjusted OR 1.18; 95% CI: 1.09, 1.29), elevated blood pressure (OR: 2.23: 95% CI 1.15, 4.34), posterior fossa symptoms (OR: 4.12; 95% CI: 2.29, 7.43) focal neurologic deficit (OR: 5.40; 95% CI: 3.91, 7.48) and altered mental status (OR: 2.33; 95% CI: 1.67, 3.26).

Conclusion: Five variables were independent predictors of abnormal findings among ED patients who were referred for head CT for non-trauma related indications: age>65, elevated blood pressure, altered mental status, posterior fossa symptoms and focal neurological deficits.

Levels of evidence: III

Study type: Retrospective study, economic and value based evaluation.

Keywords: Non-contrast head CT, Emergency department

INTRODUCTION

Since the development of the first generation CT in 1972, the use of CT has demonstrated an exponential increase. It was been estimated that in the United States of America about 70 million CT examinations are done annually [1,2]. Research has shown a six fold increase in CT utilization was demonstrated from the period 1995 to 2007 [3]. It has been postulated that this is due by increased frequency of CT scanning with a smaller fraction being attributable to increased patient load [3]. Faster and more accurate diagnosis with an increased awareness of malpractice

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litigation has are some factors accountable for this trend [4-8].

CT scans are non-invasive and can proved faster and more accurate results and can be protective in cases of medicolegal litigation [9-11]. However, there are several downsides such as the exposure to radiation, increased output times leading to an increase cost and burden to an already limited health care system. In the acute setting, the increase use of this modality therefore has widespread ramifications.

Around 60-70% of all CT requests from our Radiology Department are from the Emergency Department. In 2005, it was estimated that the average cost of a non-enhancement Head CT to the institution (EWMSC) was $1,200 TTD (equivalent to $176 USD) in comparison to a typical hospital in the United States which ranges from $400-$800 USD [12,13].

A recent study performed at the EWMSC by Rampersad et al., analyzed Head CT studies in patients with head trauma. However, there has been no study to analyze the referral patterns and outcomes of CT Brain in patients without trauma.

Few studies have postulated scans in patients with no trauma are of low diagnostic yield; however it was limited to the characteristics [14-22]. It was seen that, almost all non-trauma patients with abnormal findings demonstrated a positive neurologic examinations and most of who were over the age of 65 [20-22]. More robust data in identifying clinical predictors of finding an abnormality in head CT findings is therefore lacking.

The creation of guidelines to aid the Emergency doctors to more efficiently and accurately refers patients for CT scanning and therefore has the potential to reduce the burden and reduce the cost of health care.

There are several decision aids that exist which provide guidelines to reduce the utilization of radiation in low-risk patients and include the National Emergency X-Radiography Utilization Study, the Canadian Cervical Spine Rule and the Ottawa Foot and Ankle Rules [23-25]. There are even less aids for the use of CT, one example of which is the Canadian Head CT Rule [12]. The importance of more selective importance in today's medical practice where the threshold for the use of CT has decreased and often it is increasingly used among healthy individuals in whom the potential harmful effects and cost/burden to health care resources may outweigh the benefits of the study.

The main objective of our research was to pin point those symptoms that are mostly like to predict an abnormality in an unenhanced CT Brain among those patients without trauma who presented to the EWMSC.

Local data regarding these referral patterns does not exist in the literature and this study provides a starting ground for further revision of protocols and comparison across other radiology departments both locally and regionally.

METHODS

Study population

Data was collected after approval from the ethics board and was done at the EWMSC Radiology Department, a tertiary health care facility and subspecialty referral center.

The department also provided the advantage of a picture archiving and communications system and Radiology information system that made data collection more efficient. Consecutive Head CT examinations performed on patients from the Emergency Department from June 1st to August 31st, 2016 were collected.

Patients that were excluded from this study include those who:

- were not referred by the EWMSC ED
- were less than 18 years old
- had an history of trauma
- had known current intracranial pathology
- had a known history of brain tumor/lesion- either primary or metastatic in nature

Those requisitions that did not state any of the clinical predictors of interest were also excluded.

The CT studies were interpreted by radiology residents and certified by local board-certified radiologists.

Data collection

Data was categorized based on demographic and clinical symptoms into the following variables:

- Age
- Sex- Male/Female
- Presence of headache or signs of meningism
- Vomiting and/or nausea
- Altered mental status
- Focal neurologic deficits
- Posterior fossa symptoms
- Seizures
- Presence of seizure disorder such as epilepsy
- Presence of a malignancy
- Illicit drug use, including alcohol
- Fever or elevated leukocytes
- Altered blood pressure

- Altered coagulation profile
- Weakness and/or fatigue

Primary outcome

The main outcome was abnormal finding on an unenhanced head CT image and includes the following:

- Acute intra or extra cranial hemorrhage
- Ischemic infarction, either acute or sub-acute
- Mass lesion

Information was obtained using the official reports on head CT examinations accessed on the PACS.

Sample size determination

About 10 outcomes were required for each of the variable used in logistic regression model in order to avoid over-fitting [26,27].

We aimed to examine 15 candidate independent variables with abnormal findings on head CT scans. Therefore, at least 150 CT findings with abnormal findings were required.

DATA ANALYSIS

The total data set was collected between June 1st to August 31st, 2016. August 31st, 2016, was chosen as a cut-off date because this provided a data set that had the minimum requirement of 150 head CT images showing an abnormality.

Standard descriptive and multivariate logistic regression analyses were performed using the 15 candidate variables. The strength of each association of each variable with the primary outcome was expressed as an adjusted odds ratio and 95% confidence interval. A P value of 0.05 suggested statistical significance. SPSS version 23.0 (IBM, San Jose, Calif) was used in analysis.

RESULTS

From June 1st and August 31st, 2016, 2090 CT examinations were identified on our PACS. Of these, 599 (28.7%) were not from the ED and 103 were pediatric patients (4.9%). Patients who had insufficient data or incomplete request forms amounted to 108 patients or 5.2%. 470 patients (22.4%) had a history of trauma and 109 patients (5.2%) had a known intracranial pathology. Only 701 CT (33.5%) of the total met our eligibility criteria **(Figure 1 and Table 1)**.

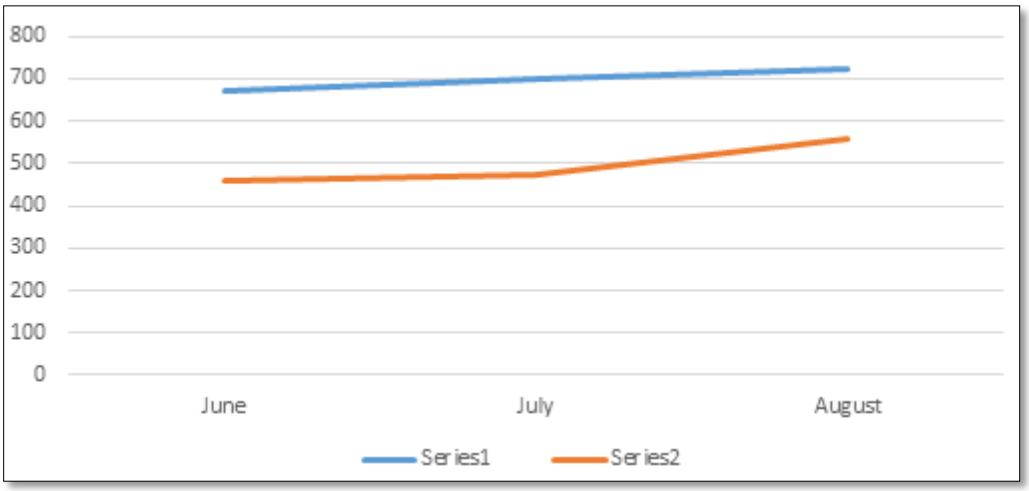

Figure 1: Number of head CT performed at EWMSC from June 1st to August 31st, 2016.

Table 1. Analysis of the findings of the head CT reports.

Mean age (y)	63.8 +/- 11.8
Male:Female (%)	50.7:49.3
Abnormal Head CT	153 (21.8%)
Acute intra or extracranial hemorrhage	28 (4.0%)
Prevalence of acute ischemia- Acute or sub-acute	100 (14.3%)
Other pathologic entities*	11 (1.6%)

* *Arteriovenous malformation, hydrocephalus, mass lesion, cerebral toxoplasmosis*

Apart from age 9 (over 18) and gender/sex, 13 variables were assessed in our study population **(Figures 2-5 and Table 2)**.

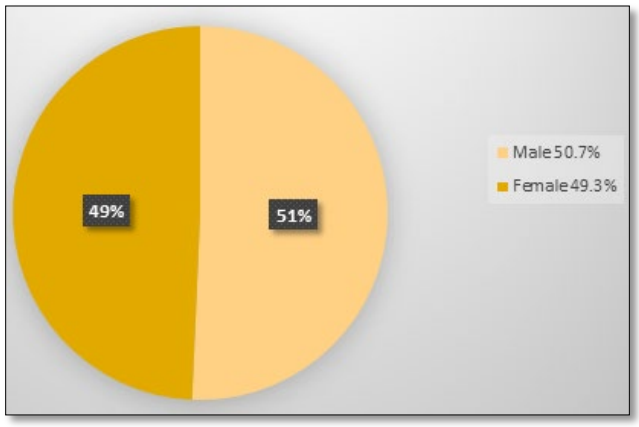

Figure 2. Gender distribution of sampled patients (701).

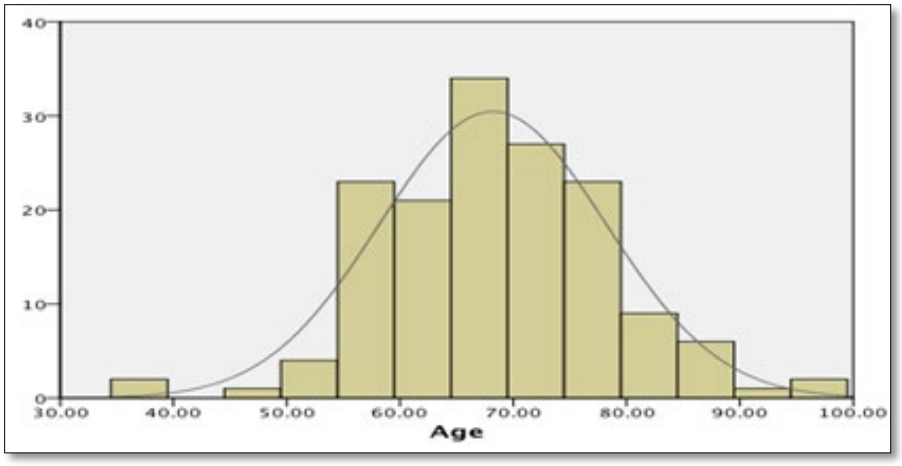

Figure 3. Age patients with abnormal head CT findings.

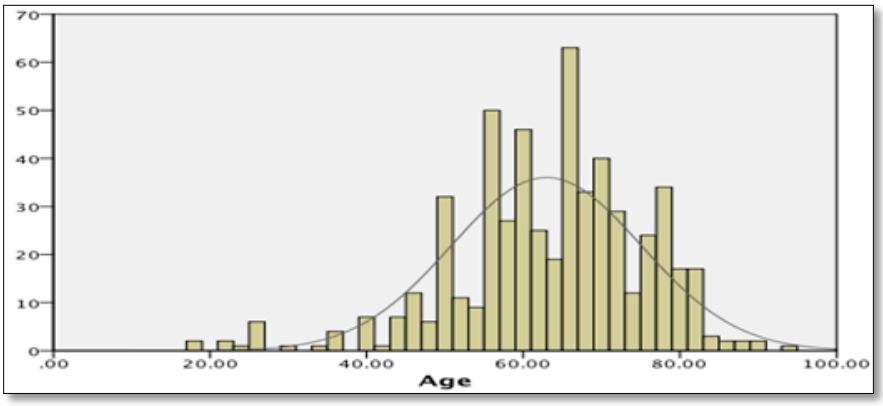

Figure 4. Age of patients with normal head CT findings.

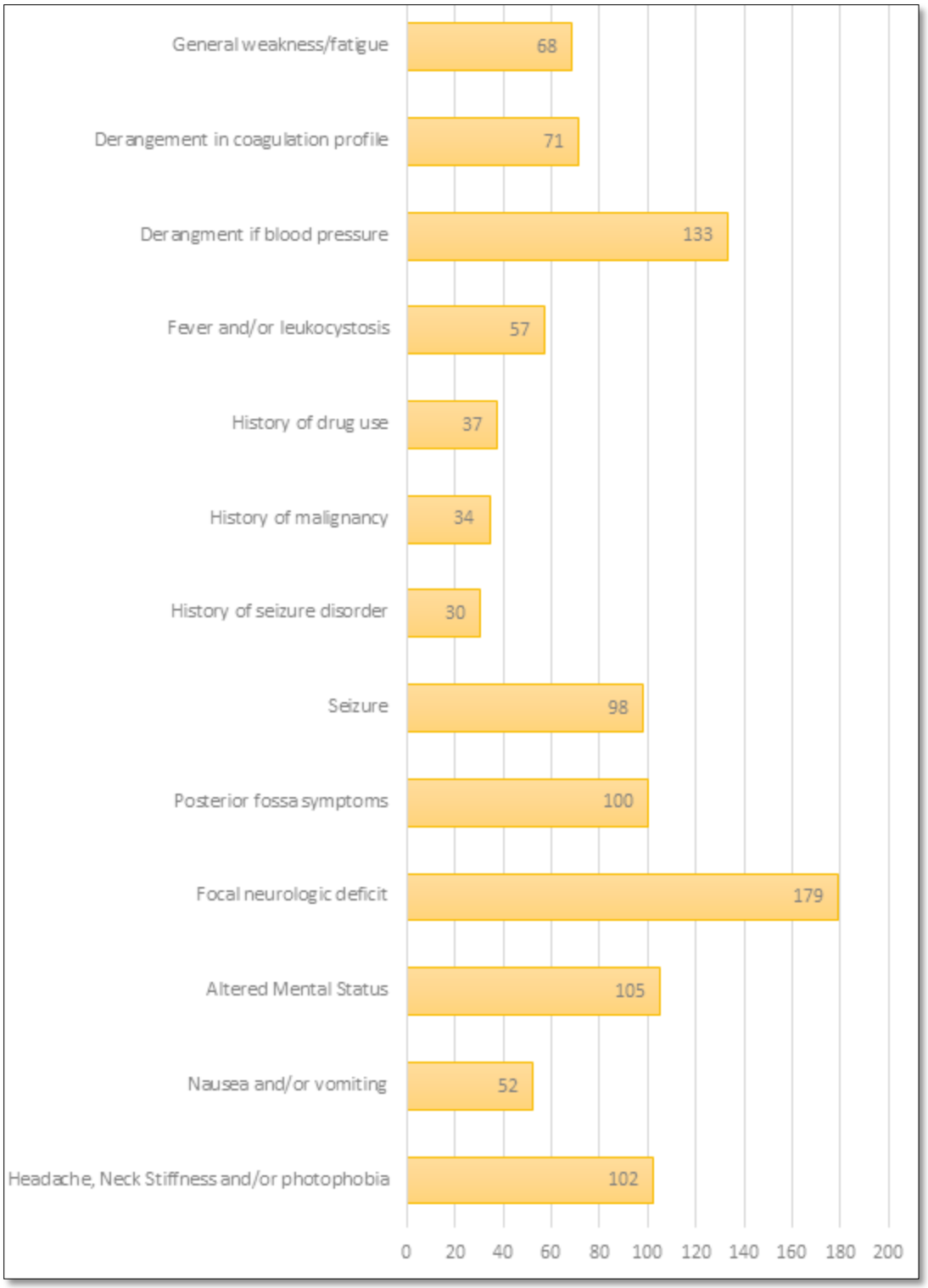

Figure 5. Frequency of clinical indications for head CT.

Table 2. Frequency of Indications as per patient's requisition.

Headache and/or signs of meningism	102	14.6%
Nausea and/or vomiting	52	7.4%
Altered mental status	105	15.0%
Focal neurologic deficit	179	25.5%
Posterior fossa symptoms	100	14.3%
Seizure	98	14.0%
Presence of seizure disorder	30	4.3%
Presence of malignancy	34	4.9%
Illicit drug use and/or alcohol	37	5.3%
Fever and/or elevated white blood cells	57	8.1%
Altered blood pressure	133	19.0%
Altered coagulation	71	10.1%
Weakness and/or fatigue	68	9.7%

Note: Cohort was patients from the ED who had an unenhanced CT brain and no history of trauma

The following 5 variables were identified as independent variables **(Tables 3 and 4)**:

Table 3. Independent clinical predictors of abnormal head CT findings.

Predictor variable	Adjusted Odds Ratio
Age	1.18 (1.09, 1.29)*
Elevated blood pressure	2.23 (1.15, 4.34)
Altered mental status	2.33 (1.67, 3.26)
Posterior fossa symptoms	4.12 (2.29, 7.43)
Focal neurological deficit	5.40 (3.91, 7.48)

Note: Numbers are from 701 patients with 95% confidence intervals
**The odds ratio was adjusted per 10 year increase in age*

Table 4. Predictor variables for abnormal head CT findings.

Parameter	Sensitivity	Patients who would be Scanned
One or more of five predictors*	144 of 153 (94.1)	490 of 701 (69.7)
One or more of five predictors and age>70 years	147 of 153 (96)	556 of 701 (79.3)

Abnormal findings were less apparent (8 of 98 [8.1%]) in patients who presented with a seizure (145 of 603 [24%]). Furthermore, there were no abnormal findings in those who had a known seizure disorder such as epilepsy.

If patients had been scanned only if they had one or more of the five independent clinical predictors regardless of age a sensitivity of 94.2% (144 of 153 images with positive findings). The number of examinations to would be reduced by 69.9% o (490 of 701). A small increase in sensitivity to 96.0% (147 of 275) would have been achieved if patients over the age of 70 were scanned.

DISCUSSION

In our research, the following independent clinical predictors of abnormal CT findings were found after analyzing the images and reports of 701 patients: age older than 65 years, altered/elevated blood pressure at presentation, focal neurologic deficit, altered mental status and the presence of posterior fossa symptoms.

To determine to true effect of this prediction rule there will be a prospectively study will be needed; however this preliminary analysis suggested that the number of CT examinations performed could have been reduced by almost 20% of the original number.

These results are comparable to the Canadian Assessment of Tomography for Childhood Head injury (CATCH) [28]. It also compares favorably with the Canadian CT head rule developed by Papa et al. [29].

This study does not did not provide any correlation between an abnormal Head CT finding with the following variables as the only presenting symptom: headaches, fever and/or elevated white blood cells, nausea or vomiting, vertigo, dizziness, seizure, seizure disorder, drug use and/or alcohol use, history of malignancy or generalized constitutional symptoms in patients under the age of 65 years.

In the literature, there are few studies examine that examine non-trauma patients. These studies are typically smaller but demonstrate that head CT examinations in this population are of low diagnostic yield. Moreover, nearly all patients with abnormal CT findings also had abnormal neurologic examination findings. Naughton et al. [17] determined that only 15% had positive findings on CT.

Another study of 200 patients who presented with acute dizziness or vertigo found no findings that could be the primary cause [18].

Lai et al. [30] examined 300 elderly patients with delirium and concluded that new neurologic deficits, deterioration in consciousness, and recent history of a fall predicted abnormal CT. Several other studies mirrored similar predictor variables (14-19, 31-32).

In our study population, several patients who presented with headache would not have met the criteria for a Head CT. However, one of these patients did have a non-aneurysmal subarachnoid hemorrhage (SAH). The remainder of patients with SAH had either one or more of the 5 predictor variables and would have qualified for a head CT. Due to the retrospective nature of our study, all headaches were grouped into a single category as no distinction could be made between sudden onset headaches versus those that had been present for several days or has been increasing in severity.

Time for a headache to peak is one feature that has echoed few studies and could be a preliminary predictor of SAH [33]. The American College of Emergency Physicians recommends that patients with headache and demonstrable neurological deficit and those who present with new sudden-onset severe headache should undergo urgent unenhanced head CT [34]. Such policies present a challenge. Currently Perry et al. [35] are conducting a prospective study regarding the referral of patients with new sudden-onset severe headache.

There was no preliminary evidence from our study to routinely refer patients who presents solely with seizure or seizure disorder. It was deduced in several reviews that patients who have seizures will also have other symptoms or variable which greatly increases the likelihood of an abnormal CT finding [36,37].

The Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology is responsible for developing clinical practice guidelines for the use of diagnostic test various presentations such as seizures and aims to employ improved methodology [38]. In their assessment in 1999, the authors investigated the probability that imaging would lead to an acute or urgent change in management

Our work can add to this field locally because, to our knowledge, it is the first study locally and regionally to examine a comprehensive set of clinical features that are associated with abnormal head CT in our patient population.

LIMITATIONS

There were several limitations in our research. Firstly, there were no standardization in assessment and documentation due to the retrospective nature of the study. There were some limitations as the CT request form or requisition did not clearly state the presence or absence of the clinical variables that were investigated. It was assumed that a feature was not present if there were no mention of it. Furthermore, there were no communication between the referring physician so there was no understanding of the day to day functioning and justification of the requisition.

There was also no standard terminology within the CT requisitions. An example of this was seen in those referral forms that stated “LOC” which made it unclear whether it meant “loss of consciousness” or “altered consciousness.” To avoid such limitations categorized the requisition under broad definitions for some predictors, such as “altered mental status” (which could include loss of consciousness, dizziness, syncope, delirium and amnesia). However, this had likely lowered the specificity.

Finally, our results are from a busy tertiary academic level hospital which provides services to a large fraction of the population and the results of our study might not be appropriate in another clinical setting such as local health centers or non-academic urban centers.

CONCLUSION

Five variables were independent predictors of abnormal findings among ED patients who were referred for head CT for non-trauma-related indications: age over 65, elevated blood pressure, altered mental status, posterior fossa symptoms and focal neurological deficits.

FURTHER RECOMMENDATIONS

To further validate our findings, a prospective research or validation in our population is warranted and can reduce the number of referrals to radiology departments which can lead to a more efficient and optimized service and potentially reduce the burden on our limited health care resources.

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