

Head CT for non-trauma patients in the emergency department: Yield and clinical Predictors of abnormal findings

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Abstract

Aim: The purpose of this study is to determine the yield of head computed tomography (CT) and from selected subsets of clinical pictures and laboratory tests, what constitutes a predictor of critical, abnormal findings in CT of the head in emergency department (ED) patients, excluding those with a history of trauma.

Materials and Methods: Data were collected from October 1, 2018, through December 31, 2018. Patients included were those presenting to the ED with different clinical pictures. Additional variables were selected, including; age, sex, Glasgow coma scale, vital signs and laboratory results. Patients with a known history of intracranial pathology and those below 18 years were excluded as well. The association of each variable with significant abnormal CT findings was identified utilizing Chi-square test. A P value of less than 0.05 was considered significant.

Results: A total of 636 eligible patients' data were collected, of which 302 (47.5%) were male and 334 (52.5%) were female. Negative head CT was revealed in 82.9% of eligible patients. No evidence of significant association was found for all tested variables except for presenting chief complaint ($p < 0.05$).

Conclusion: The study recognized the ED patient's chief complaint as the sole predictor of positive findings in CT images of the head. Further studies to validate this finding are warranted.

Keywords: Head CT, Emergency department, Positive findings.

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Introduction

Computed tomography (CT) scan takes a series of X-rays from different angles using ionizing radiation to create 2D images or cuts. These cuts can then be used to manufacture (construct) 3D structures to better understand particular anomaly or underlying pathology. Its increasing use reflects how well it has proven its efficacy in diagnosis, therapeutic procedures, and prognosis. Overall, CT use during ED visits increased 330%.¹

Non-contrast head CT scan has gained popularity amongst ED physicians due to its full availability, ease of use and exceptional ability in non-invasively detecting intracranial pathology, such as hemorrhage, structural anomalies, and brain lesions, all which can be dealt with and managed acutely.^{2,3}

The list of people who undergo non-contrast head CT scans in ED includes those who complain of but not limited to dizziness, syncope, headache, seizure, neurological

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deficit, and altered mental status. However, there are speculations that the use of emergency head CT scans has gone overboard, and the images produced are mostly scarce of findings..^{4,5}

Our purpose in this study is to find the yield of head CT in ER at our hospital and determine, retrospectively from selected subsets of clinical pictures and laboratory tests what constitutes a predictor of critical, abnormal findings in head CT in ED patients.

Patients and Methods

The Institutional Review Board approved this retrospective study, and informed consent from the patients was not needed. Data were collected retrospectively for patients who underwent head CT without contrast in The University of Jordan's Hospital, from October 1, 2018 through December 31, 2018, after presenting to the ED with abnormal mental status, dizziness, focal neurological deficit, generalized weakness, headache +/- photophobia, seizure, vertigo, vomiting +/- nausea. Other variables were considered, such as age, sex, Glasgow coma scale, heart rate, blood pressure readings, temperature, hemoglobin, white blood cell and platelet levels, INR value, and other nonspecific symptoms.

Patients younger than 18 years of age or who presented after head trauma (e.g., Road traffic accidents, Quarrel), were excluded from the study. Patients with a known history of intracranial pathology (e.g., intracranial hemorrhage, mass, shunt) were still eligible for inclusion if they had findings not related to primary pathology. A total number of 636 patients were included.

At the patients' day of the visit, ED physicians obtained the clinical picture, and the nurses took the vital signs, whereas board-certified radiologists provided the CT scan reports. The following variables were further subcategorized according to the clinical practice guidelines in the United States of America:⁶

1. Glasgow Coma Scale:

- 3-8: Severe brain injury
 - 9-14: Minor –moderate brain injury
 - 15: Best response
2. Heart Rate:
- Normal: 60-100
 - Tachycardia: more than 100
 - Bradycardia: less than 60
3. Blood Pressure Readings:
- Hypotension: Systolic <90 mmHg
 - Optimal: Systolic 90-120 mmHg and Diastolic <80 mmHg
 - Normal: Systolic 120-129 mmHg and/or Diastolic 80-84 mmHg
 - High normal: Systolic 130-139 mmHg and/or Diastolic 85-89 mmHg
 - Grade 1 hypertension: Systolic 140-159 mmHg and/or Diastolic 90-99 mmHg
 - Grade 2 hypertension: Systolic 160-179 mmHg and/or Diastolic 100-109
 - Grade 3 hypertension: Systolic \geq 180 mmHg and/or Diastolic \geq 110 mmHg
4. Temperature:
- Normal: 36.1- 37.2
 - Hypothermia: less than 36.1
 - Hyperthermia: more than 37.2
5. Hemoglobin level:
- Normal level for men: 13.5-17.5 g/dl
 - Anemia less than 13.5 g/dl
 - Polycythemia more than 17.5 g/dl
 - The normal level for women: 12-15.5 g/dl
 - Anemia less than 12 g/dl
 - Polycythemia more than 15.5 g/dl
6. White blood cells level:
- Normal level: $4 - 11 \times 10^9/L$
 - Leukopenia less than $4 \times 10^9/L$
 - Leukocytosis more than $11 \times 10^9/L$
7. Platelets level:
- Normal level: 150,000 to 450,000 platelets / microliter
 - Thrombocytopenia less than 150,000 platelets/microliter
 - Thrombocytosis more than 450,000 platelets/microliter

8. International normalized ratio (INR) level:
- Normal level: <1.1
 - Elevated: > 1.1

Primary Outcome:

The primary outcome was abnormal findings on a head CT image, defined by one or more of the following: hemorrhage, acute infarction, mass lesion, infarction with hemorrhagic transformation.

Other findings were considered abnormal: Arachnoid cyst, calcified meningioma, calcified meningitis, calcified stroke, cystic lesion, low cerebellar tonsils, and multiple Sclerosis (MS) plaques.

For every abnormal result, we searched for previous records to see if the result was known before. Results with no previous records were considered as an acute insult.

Data Analysis:

For statistical analysis, Statistical Package for Social Sciences (SPSS version 17.0. Chicago: SPSS Inc.) was used. To identify the association between each of the 18 variables that were assessed and the CT scan result, we used Chi-Square test. A *P* value of less than 0.05 was considered significant.

Results

After excluding patients younger than 18 years of age or those presenting to the ER after head trauma, 636 eligible patients' data were collected from October 1, 2018, to December 31, 2018. Slightly more females included in the study (52.2% vs 47.5% males.), (see table 1).

We obtained high percentage of data (parameters values) from our records out of the total number of patients who underwent head CT in ED: chief complaint 601 (94.5%), Glasgow coma scale 636 (100%), heart rate 633 (99.5%), blood pressure 636 (100%), temperature 631 (99.2%), hemoglobin 628 (98.7%), white blood cells 625 (98.3%), platelets 626 (98.4%), INR 294 (46.2%) and CT reports 632 (99.4).

By examining the results of non-contrast CT scans done at the ER for these patients,

almost 83% of these CT scans were negative for acute insults. Only 3% had infarctions, and 1.6% had a brain hemorrhage, as shown in table 1.

As shown in table 2, the most frequent chief complaint encountered at the ER was a focal neurological deficit, with a total of 160 patients (25.2%) of the collected sample presented with this chief complaint. In the second place came headache with or without photophobia, with a total number of 139 patients (21.9%). In the third place came an altered mental status with 100 patients (15.7%). On the other hand, the only variable that showed a statistically significant association with positive CT scan findings was the patients' chief complaint presented to the ER during that period. The principal chief complaints included: abnormal mental status, dizziness, fever, focal neurological deficit, generalized weakness, headache, photophobia, high blood pressure readings, seizure, vertigo, vomiting with or without diarrhea, and others. (*P* value less than 0.05).

Supplementary table 1 data shows the vital signs, including blood pressure, heart rate, temperature, and Glasgow coma scale, some data were missing, but we managed to collect data of around 630 patients. As shown in the table, most patients evaluated at the ED with the Glasgow coma scale showed a score of 15/15 (98.1%), and only 1.9% had a decreased score ranging from 9-14 (1.9%). Regarding heart rate, around 80% of the patients had normal heart rate readings, and the most frequently encountered arrhythmia was tachycardia, with a 16% percent (101 patients).

When looking at blood pressure readings, around half of the selected sample (49%) had elevated blood pressure readings of variable degrees: 23.1% grade 1, 14.6% grade 2, and 11.3% grade three. Regarding temperature, the majority of patients had a normal temperature 86.1% while 7.8% were hypothermic, and 6.2% were hyperthermic.

Regarding hemoglobin, two-thirds (64.6%) of the patients had normal hemoglobin while one-third (33%) were anemic. Around three-

quarters of the patients had normal white blood cell count (74.7%). Only 21.6% showed leukocytosis (increased white cell count). Only 8% showed a low platelet count, and 2.7% showed a high platelet count with the rest (90%) showing normal platelet counts (see supplementary table 2 & 3).

We examined the correlation between the included variables in the study and CT findings. These variables included gender, age, CBC parameters (hemoglobin level, white blood cell and platelet counts), INR and vital signs (including blood pressure readings, temperature and heart rate). All these parameters were shown by the Chi-Square analysis not to be significantly associated with positive CT findings (P value more than 0.05, see table 3).

Discussion:

Overutilization of a brain CT scan in the ED for the non-trauma patient has been increasing in the last decade. This can be attributed to the increase in the number of patients presenting to the emergency department, fear of missing a diagnosis leading to malpractice and lawsuits, and the insufficient awareness of the outcome of radiation exposure.⁴

Doing CT scan is a time-consuming procedure, is of low yield, as most studies have found that the yield of brain CT scan ranges from 0% to 15% only.^{7,8} These findings indicate the need for specific guidelines for the CT scan of the brain in non-trauma patients and those physicians should have a cost-effective use of the tool for diagnosis.^{9,10} In our study, 17.1% of our population showed positive findings which is slightly more than that reported in the literature. This discrepancy may be secondary to different definitions of abnormal findings in different studies.

In this study we have studied multiple variables for the need for CT scan; these factors included Glasgow coma scale, heart rate, blood pressure, temperature, hemoglobin, white blood cells, platelets, INR, and the chief complaints. The only variable that was

significantly associated with positive CT scan findings was the principal chief complaints of the patients presenting to the ED during that period. This finding is consistent with other studies in the literature. For example, Xi Wang, et al. found six clinical factors to be associated with abnormal head CT findings in non-trauma patients presenting to the emergency department and those include: altered mental status, focal neurologic deficit, nausea and/or vomiting, age over 70 years a history of malignancy, and derangements in coagulation profile.⁸

The most widely accepted criteria for CT scan imaging in non-trauma patients were from Rothrock's work.¹¹ In that study, the authors prospectively evaluated multiple factors as a prognosticator for the need for a CT scan of the brain. Of those factors four (age >60 years, altered mental status, focal weakness, and headache with vomiting) were significantly related. The authors combined them in an algorithm with a negative predictive value of 100% and had a 98.8% sensitivity for detecting significant CT scan abnormalities.

Many studies proposed a systematic approach for doing CT scans in non-trauma patients.^{4,12} One study by Bent et al.⁴, showed that patients with a focal neurologic deficit (major risk factor) or ≥ 2 of the five minor risk factors (altered mental status, nausea/vomiting, known malignancy, coagulopathy, and age) should do a CT scan. This method has reduced the need for CT scan by 34% resulting in only a small decrease in sensitivity (98%).

It is widely known that only a small percentage of patients without evidence of trauma and who were admitted to the hospital have a clinically relevant finding on head CT and an even smaller percentage required emergent intervention. These findings emphasize that the need for emergent intervention might be a more useful criterion to use rather than the presence of clinically essential abnormalities on cranial CT when developing a diagnostic tool used to identify which patients should undergo emergent cranial CT as most of the patients with

clinically important findings did not require emergent intervention.¹³ Unfortunately, we did not go further in our study to elaborate more about the need of intervention with respect to the findings.

There are different reports about different clinical presentations and their relation to the indication and yield of head CT in non-trauma patients.^{14,15,16,17} Most of these symptoms are inconclusive and include altered mental status, headache, focal neurologic deficit, syncope, dizziness nausea and/or vomiting. We found that the most common indication to do brain CT is focal neurological deficit followed by headache (table 2). We believe that focal neurological deficit is a hard sign that

encourage emergency physicians to do head CT.

Our study has many limitations, including its retrospective nature, limited period of study and simple statistical analysis. Yet, we believe that we presented a comprehensive study at a single institute with the possibility of future prospective studies.

Conclusion

Indication of head CT in ED should be guided by clinical history and presentation. Abnormal vital signs and abnormal laboratory results could not predict positive CT yield in ED in non-traumatic cases. Further prospective studies with larger sample size are warranted to confirm our findings.

References

- 1- Kocher KE, Meurer WJ, Fazel R, Scott PA, Krumholz HM, Nallamothu BK. National trends in use of computed tomography in the emergency department. *Annals of emergency medicine*. 2011 Nov 1;58(5):452-62.
- 2- Lim HC, Wong EH. Emergent cranial computed tomography in the evaluation of adult non-trauma patients in the emergency department. *Hong Kong Journal of Emergency Medicine*. 2004 Oct;11(4):197-204.
- 3- Pavlović T, Milošević M, Trtica S, Budinčević H. Value of Head CT Scan in the Emergency Department in Patients with Vertigo without Focal Neurological Abnormalities. 2018;6(9): 1664-1667.
- 4- Bent C, Lee PS, Shen PY, Bang H, Bobinski M. Clinical scoring system may improve yield of head CT of non-trauma emergency department patients. *Emergency radiology*. 2015 Oct 1;22(5):511-6.
- 5- Leong LB, Jian KH, Vasu A, Seow E. Identifying risk factors for an abnormal computed tomographic scan of the head among patients with altered mental status in the Emergency Department. *European Journal of Emergency Medicine*. 2010 Aug 1;17(4):219-23.
- 6- Selvarajan SK, Levin DC, Parker L. The increasing use of emergency department imaging in the United States: is it appropriate?. *American Journal of Roentgenology*. 2019 Oct;213(4): W180-4.
- 7- Fischer SAGC, Lipsitz JLBLA, Sands LMK. The yield of head CT in syncope : a pilot study. 2007:46-49. Doi:10.1007/s11739-007-0010-5.
- 8- Wang X, You JJ. Head CT for Nontrauma Patients in the Emergency Department : Clinical Predictors of Abnormal findings 2013;266(3):783-790
- 9- Article O. Clinical predictors of abnormal computed tomography findings in patients with altered mental status. 2009;50(9):885-888.
- 10- Swartzberg K, Chb MB, Sa D, et al. High positive computed tomography yields in the emergency department might not be a positive finding. 2018; 108(3): 230-234. Doi: 10.7196/ SAMJ. 2018. V108i3.12635.
- 11- Rothrock SG, Buchanan C, Green SM, Bullard T, Falk JL, Langen M. Cranial computed tomography in the emergency evaluation of adult patients without a recent history of head trauma: a prospective analysis. *Academic emergency medicine*. 1997 Jul;4(7):654-61.
- 12- Covino M, Gilardi E, Manno A, Simeoni B, Ojetti V, Cordischi C, Forte E, Carbone L, Gaudino S, Franceschi F. A new clinical score for cranial CT in ED non-trauma patients: Definition and first validation. *The American journal of emergency medicine*. 2019 Jul 1;37(7):1279-84.
- 13- Narayanan V, Keniston A, Albert RK. Utility of emergency cranial computed tomography in patients without trauma. *Academic Emergency Medicine*. 2012 Sep;19(9):E1055-60.
- 14- Ozturk K, Soyulu E, Bilgin C, Hakyemez B, Parlak M. Predictor variables of abnormal imaging findings of syncope in the emergency department. *International journal of emergency medicine*. 2018 Dec;11(1):16.
- 15- Patel MM, Tsutaoka BT, Banerji S, Blanc PD, Olson KR. ED utilization of computed tomography in a poisoned population. *The American journal of*

emergency medicine. 2002 May 1;20(3):212-7.
 16- American College of Emergency Physicians. Code of ethics for emergency physicians. Annals of emergency medicine.

2008 Nov;52(5):581.
 17-Fillmore M, Hospital S. Dizziness and yield of emergency head CT scan: Is it cost effective? 2005;12(7). Doi: 10.1136/ emj. 2003. 012765.

Table 1. Demographics and Findings from Head CT Examinations

Age	58.70±16.84
Men:Women (%)	47.5 : 52.5
<i>Findings</i>	Out of 632(reported)
Prevalence of hemorrhage	10 (1.6%)
Infarction with hemorrhagic transformation	1 (0.2%)
Infarction	19(3%)
Prevalence of mass lesion	16 (2.5%)
No acute insult	527 (82.9%)
Other Finding	59(9.3%)

Table 2. Frequency of Clinical Indications for Head CT Examinations

Indication	(n=%) out of 601
Abnormal Mental Status	100(15.7)
Dizziness	76 (11.9)
Fever	7(1.1)
Focal Neurological Deficit	160 (25.2)
Generalized Weakness	30 (4.7)
Headache+/- Photophobia	139(21.9)
SBP>180 or DBP>110	28(4.4)
Seizure	25(3.9)
Vertigo	16(2.5)
Vomiting+/- Nausea	8(1.3)
Other	12(1.9)

Table 3. Correlation between clinical and biochemical factors and positive head CT finding.

PARAMETER	P VALUE
Gender	.678
Age	.456
Chief Complaint	.014
Glascow Coma Scale	.413
Heart Rate	.597
Blood Pressure	.527
Temperature	.961
Hemoglobin	.172
White Blood Cells	.407
Platelets	.550
INR	.656

Supplementary tables:

Table 1: vital signs

Vital signs	Frequency	Valid percent
Temperature		
Hypothermia	49	7.8
Normal	543	86.1
Hyperthermia	39	6.2
Total	631	100.0
Unknown	5	
Total	636	
Blood pressure		
Hypotension	6	0.9
Optimal Blood Pressure	121	19.0
Normal Blood Pressure	80	12.6
High Normal Blood Pressure	117	18.4
Grade 1 Hypertension	147	23.1
Grade 2 Hypertension	93	14.6
Grade 3 Hypertension	72	11.3
Total	636	100.0
Heart rate		
Bradycardia	24	3.8
Normal	508	80.3
Tachycardia	101	16.0
Total	633	100.0
Glasgow coma scale		
9-14	12	1.9
15.00	624	98.1
total	636	100.0

Table 2. Complete blood count data

CBC parameter	Frequencies	Valid percent
Hemoglobin		64.6
Normal	406	33.0
Anemia	207	2.4
Polycythemia	15	100.0
Total	628	
Unknown	8	
Total	636	
WBCs		
Leukopenia	23	3.7
Normal	467	78.4
Leukocytosis	135	100.0
Total	625	
Unknown	11	
Total	636	
platelets		
Thrombocytopenia	51	8.1
Normal	558	89.1
Thrombocytosis	17	2.7
Total	626	100.0
Unknown	10	
Total	636	

Table 3. INR readings

		Frequency	Valid Percent
Valid	Normal	165	56.1
	Elevated	129	43.9
	Total	294	100.0
Missing	Unknown	342	
	Total	636	

الأشعة المقطعية للرأس للمرضى دون حادث في قسم الطوارئ: (العائد والتنبؤات السريرية للنتائج غير طبيعية)

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(2-11). قسم الطوارئ والحوادث، مستشفى الجامعة الأردنية، كلية الطب، الجامعة الأردنية.

الملخص

الهدف: الغرض من هذه الدراسة هو تحديد نتائج المكتسبة من التصوير المقطعي المحوسب للرأس في مرضى قسم الطوارئ، وفي مجموعة مختارة من الحالات السريرية والفحوصات المخبرية تحديد العوامل المتنبئة بالنتائج غير الطبيعية في الصورة الطبقيّة وذلك باستثناء المرضى الذين تعرضوا لإصابة سابقة.

المواد والأساليب: تم جمع البيانات من 1 أكتوبر 2018، حتى 31 ديسمبر 2018، وتضمنت الدراسة المرضى الذين حضروا إلى قسم الطوارئ بحالات سريرية، وتم اختيار متغيرات إضافية بما فيها العمر والجنس ومقياس غلاسكو لفقدان الوعي والعلامات الحيوية والنتائج المخبرية، وتم استثناء المرضى الذين لديهم تاريخ من الأمراض داخل الجمجمة، والذين تقل أعمارهم عن 18 عاماً، وتم تحديد ارتباط كل متغير مع نتائج التصوير المقطعي غير الطبيعية، وذلك باستخدام اختبار الكاي سكوير واعتبرت قيمة P بأقل من 0.05 ذات أهمية إحصائية. **النتائج:** تم جمع ما مجموعه (636) من بيانات المرضى المؤهلين للدراسة منهم 302 (47.5%) من الذكور، و334 (52.5%) من الإناث، وقد كانت الصور المقطعية للرأس طبيعية عند 82.9% من المرضى ولم يعثر على أي دليل على وجود ارتباط للعوامل المختلفة بنتيجة الصورة الطبقيّة للرأس ما عدا الشكوى الرئيسية المقدمة من المريض والتي كانت مهمة إحصائياً ($P < 0.05$) **الخلاصة:** أظهرت هذه الدراسة أن الشكوى الرئيسية للمريض في قسم الطوارئ هي المتنبئ الوحيد بنتيجة الصورة المقطعية ويوصى بعمل المزيد من الدراسات المستقبلية للتحقق من صحة نتيجة الدراسة.

الكلمات الدالة: التصوير المقطعي، قسم الطوارئ، النتائج الإيجابية.