ORIGINAL ARTICLE

Clinical Predictors of Abnormal Findings on Urgent CT Brain Scans in Adult Non-trauma Patients at a Tertiary Hospital

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ABSTRACT

Background: Computed tomography (CT) scan of the brain is widely used for assessing various neurological conditions and remains the imaging modality of choice in acute and emergency settings. However, CT brain examinations in non-traumatic patients have been reported to have a diagnostic yield of only approximately 15%. This study aimed to determine the prevalence of abnormal urgent CT brain performed in adult non-trauma patients in our centre and the clinical predictors associated with significant abnormal findings. **Methods:** This is an analytical cross-sectional study of urgent CT brains in patients aged 18 years or older who did not have head trauma or known intracranial pathology in Sultan Ahmad Shah Medical Centre @IIUM (SASMEC) from 1st January 2019 to 31st December 2020. A universal sampling of all urgent CT brain examinations done during the study period were traced from the Radiology Information System (RIS). Exclusion criteria included patients younger than 18 years, patients with a history of head trauma and patients with a known history of any intracranial pathology. **Results:** A total of 771 cases fulfilled the inclusion criteria. The majority of the urgent CT brain examinations for non-trauma adult patients were from the Emergency Department, which contributed to 600 cases (77.8%). Our study showed abnormal CT brain findings in 503 patients (65.2%). Our study showed age (adjusted odds ratio: 1.03; 95% confidence interval: 1.01 – 1.04; p-value: < 0.001), headache (adjusted odds ratio: 1.87; 95% confidence interval: 1.17 – 3.00; p-value: 0.009), focal neurological deficit (adjusted odds ratio 0.387; 95% confidence interval: 0.25 – 0.59; p-value: < 0.001), deranged blood pressure (adjusted odds ratio: 0.71, 95% confidence interval CI: 0.55-0.99; p-value: 0.042) and known malignancy (adjusted odds ratio 2.14; 95% CI: 1.02-4.49, p-value: 0.043) are clinical predictors of abnormal CT brain findings. **Conclusion:** Our study shows positive (abnormal) findings in 65.2% of urgent CT brain examinations among non-trauma adult patients. This suggests appropriate patient selection by clinicians in using urgent CT brain scan for neurological assessment in adult non-trauma patients. Age, headache, focal neurological deficits, deranged blood pressure and known malignancy are the significant clinical predictors for these abnormal CT brains.

INTRODUCTION

CT scan of the brain is a commonly used diagnostic imaging modality in hospitals to evaluate patients with a variety of suspected central nervous system illnesses. There are well-established criteria for the use of CT brain in traumatic patients, but no clinically valid acknowledged guideline is available to assist doctors' decisions to request CT brain for patients with no head injury. Several studies have highlighted concerns regarding the use of CT brain scans in the acute setting of non-trauma patient management due to its low yield (Brenner et al., 2007; Plasencia et al., 2023; Akhtar et al., 2023). The exponential growth of CT brain examinations has increased patient medical radiation exposure, treatment expenses, and the demand for more human resources (Covino et al., 2019; Smith-Bindman et al., 2009). Consequently, there is a rising concern regarding clinical appropriateness for the use of CT brain in urgent non-trauma adult patients. Our study aimed to identify the prevalence of abnormal urgent CT brain performed in adult non-trauma patients in our centre and the clinical predictors associated with significant abnormal findings.

MATERIALS AND METHODS

This was an analytical cross-sectional study of urgent CT brain examinations in patients aged 18 years or older who did not have head trauma or known intracranial pathology in Sultan Ahmad Shah Medical Centre @IIUM (SASMEC) from 1st January 2019 through 31st December 2020. Approval was obtained from the Kulliyyah of Medicine Research Committee, International Islamic University Malaysia (IIUM), IIUM Research Ethics Committee and Department of Education and Research, Sultan Ahmad Shah Medical Centre @IIUM (SASMEC). Informed consent

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was waived because of the retrospective nature of the study.

An urgent CT brain examination was definedas an examination that is performed on the same date of the request and/or if the word 'urgent' is mentioned on the request form. All CT brain scans performed during the study period were traced from the Radiology Information System (RIS). A universal sampling of all urgent CT brain examinations were conducted during the study period. Exclusion criteria include patients younger than 18 years, patients with history of head trauma and patients with known history of any intracranial pathological process.

CT brain examinations were performed with Siemens Somatom Definition AS 128 multi-slice CT scanner. CT brain scans were obtained in an axial plane, contiguous 4-mm axial sections from the skull base to the vertex. Imaging parameters used were 120kVp and320 mA, FOV of 195 mm, 1s/rotation, and table speed of 15mm/rotation.

Specific clinical information: patients' age, sex and clinical presentation, risk factors, medical background history and related laboratory results were retrieved from scanned request forms stored in the departmental RIS (Centricity RIS 5.11.6). The results of the CT brain were obtained from the radiologist report. Patients with an initially negative CT but a positive follow-up CT or MRI were included as positive results. Clinically non-significant CT findings that do not require acute intervention or any change in acute management are considered negative. These include chronic or age-related changes such as old lacunar infarctions, chronic small vessel disease and age-related atrophy.

The data were collected using Microsoft Excel 365. The analysis of the demographic data was performed using IBM SPSS Statistics 2.8.0.0.0 (190). Multivariable logistic regression analysis was used to identify the predictors of clinically important abnormal CT findings. The strength of association of each variable was expressed with clinically important abnormal CT findings as adjusted odds ratio (AOR), 95% confidence interval (CI) and p-value. For the statistical analysis, IBM SPSS Statistics 2.8.0.0.0 (190) was used.

RESULTS

A total of 1502 CT brain examinations were performed from 1st January 2019 until 31st December 2020 retrieved from the radiology information system (RIS). Out of the 1502 examinations, a total of 771 cases fulfilled the inclusion criteria and included into the study. From these 771 cases, 399 patients (51.8%) were males, and 372 patients (48.2%) were females. The mean age was 63.2 years with a minimum age of 18 years old and the maximum age of 98 years old, as shown in Figure 1.

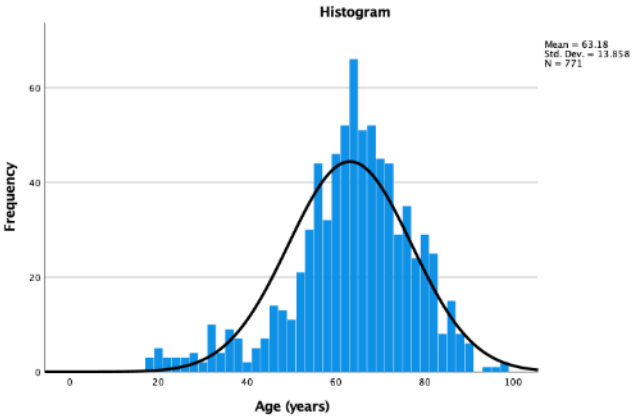

Figure 1: Distribution of patient age

Most of the urgent CT brain examinations for non-trauma adult patients were from the Emergency Department, which contributed to 600 cases (77.8%), followed by the medical wards, accounting for 108 cases (14.0%) and all other departments which contributed less than 3% each. The sources of requests for urgent CT brain scans for non-trauma adult patients are shown in Table 1.

Table 1: Sources of urgent CT brain examination requests

	Frequency (n)	Percentage (%)
Cardiac Care Unit	6	0.8
Emergency Department	600	77.8
General Surgery Wards	21	2.7
Intensive Care Unit	9	1.2
Medical Wards	108	14.0
Medical Clinic	2	0.3
Neurosurgery	2	0.3
O&G Ward	1	0.1
Operation Theatre	1	0.1
Orthopaedic Wards	10	1.3
Infectious Ward	4	0.5
Specialist Centre	6	0.8
Surgical Clinic	1	0.1
Total	771	100.0

The majority of urgent CT brain examinations were plain studies, which were 738 cases (95.7%) and only 33 cases (4.3%) were contrast-enhanced CT brain examinations.

Focal neurological deficit was the most common clinical variable, occurring in 462 cases (59.9%). It is followed by deranged blood pressure, which contributes to 344 cases (44.6%), altered mental status which contributes to 187 cases (24.3%), posterior fossa syndrome which contributes to 130 cases (16.9%), headache which contributes to 111 cases (14.3%) and nausea and/or vomiting with 86 cases (11.2%).The remaining clinical variable each accounted for less than 10% of cases. There was no case with history of drug abuse (including alcohol) in our study. The numbers and percentages of each clinical variable are shown in Table 2 below.

Table 2: Prevalence of clinical variables

Variables	Number (n)	Percentage (%)
Headache	111	14.3
Nausea, vomiting	86	11.2
Altered mental status	187	24.3
Syncope/presyncope	39	5.1
Seizure	56	7.3
Fever	47	6.1
Posterior fossa symptoms	130	16.9
Focal neurological deficit	462	59.9
Lethargy/weak	58	7.5
Deranged blood pressure	344	44.6
Seizure disorder	8	1.0
Known malignancy	35	4.5
Leukocytosis	8	1.0
Deranged coagulation profile	30	3.9

CT scan brain findings were acute cerebral infarctions (56.0%), followed by haemorrhage, and intracranial mass lesion and other intracranial pathologic entities. Other intracranial pathologies found in our study (total n=15) were skull bone lesions (n=5), intracranial arterial aneurysm (n=3), generalised cerebral oedema (n=3), white matter oedema (n=1), intracranial calcification (n=1), subdural effusion (n=1), and communicating hydrocephalus (n=1). Examples of abnormal CT findings images in 2 patients are given in Figure 2 and Figure 3.

Figure 2: Acute intraparenchymal haemorrhage in a 27-year-old male who was unresponsive preceded by severe headache. CT shows hyperdense area (arrow) in left frontoparietal lobe. Subsequent investigation shows a ruptured aneurysm as the cause of the acute bleed.

Figure 3: Acute cerebral infarction in a 63-year-old, presented with worsening dysphagia and right-sided hemiparesis. CT brain shows ill-defined hypodensities in the left corona radiata (arrow) extending to centrum semiovale in keeping with acute infarct.

Age, focal neurological deficit, headache, and derangement of blood pressure (in decreasing order) are the clinical variables with high chi-square values, signifying their association with abnormal CT brain findings. These variables also showed a statistically significant p-value of <0.05: age (p-value: <0.001), headache (p-value: 0.009), deranged blood pressure (p-value: 0.042), known malignancy (p=value: 0.043) and focal neurological deficit (p-value: <0.001). Table 3 shows the association between the clinical variables with CT brain findings.

Table 3: Association between clinical variables and CT brain findings

Variables	CT Brain Findings		Chi square	p-value
	Abnormal n (%)	Normal n (%)		
Age	503 (65.2%)	268 (34.8%)	88.813	<0.001
Gender				
Male	259 (33.6%)	140 (18.2%)	0.039	0.483
Female	244 (31.6%)	128 (16.6%)		
Headache	53 (6.9%)	58 (7.5%)	17.496	0.009
Nausea and/or vomiting	49 (6.4%)	37 (4.8%)	2.915	0.737
Altered mental status	117 (15.2%)	70 (9.1%)	0.778	0.51
Syncope or presyncope	23 (3.0%)	16 (2.1%)	0.711	0.752
Seizure	31 (4.0%)	25 (3.2%)	2.601	0.715
Fever	24 (3.1%)	23 (3.0%)	4.435	0.363
Posterior fossa symptoms	77 (10.0%)	53 (6.9%)	2.49	0.202
Focal neurological deficit	340 (44.1%)	122 (15.8%)	35.468	<0.001
Weakness, lethargy	38 (4.9%)	20 (2.6%)	0.002	0.864
Deranged blood pressure	246 (31.9%)	98 (12.7%)	10.774	0.042
Seizure disorder	3 (0.4%)	5 (0.6%)	2.743	0.863
Known malignancy	15 (1.9%)	20 (2.6%)	8.1	0.043
Leukocytosis	4 (0.5%)	4 (0.5%)	0.828	0.894
Deranged coagulation profile	18 (2.3%)	12 (1.6%)	0.378	0.975

*significant at P<0.05

Using multivariate logistic regression analysis, it was found that increasing age was a significant predictor of abnormal CT brain findings (adjusted odds ratio: 1.025, 95% confidence interval: 1.01 – 1.04, p-value: <0.001) While headache (adjusted odds ratio: 1.87, 95% confidence interval: 1.17 – 3.00, p-value: 0.009) and known malignancy (adjusted odds ratio: 2.14, 95% confidence interval: 1.02 – 4.49, p-value: 0.043) had nearly doubled the odds of abnormal CT brain findings. Meanwhile, focal neurological deficit (adjusted odds ratio: 0.387, 95% confidence interval: 0.25 – 0.59, p-value: <0.001) and derangement of blood pressure (adjusted odds ratio: 0.71, 95% confidence interval: 0.51 – 0.99, p-value: 0.042) decreased the odds for an abnormal CT brain. The multivariate logistic regression analysis is shown in Table 4 below.

Table 4: Significant clinical predictors for abnormal CT brain findings.

Variables	Abnormal CT Brain Findings				
	B	Wald	AOR	95% CI	p-value
Age	0.024	15.5	1.025	1.01 - 1.04	<0.001
Headache	0.626	6.743	1.87	1.17 - 3.00	0.009
Focal neurological deficit	-0.95	19.341	0.387	0.25 - 0.59	<0.001
Deranged blood pressure	-0.344	4.137	0.709	0.51 - 0.99	0.042
Known malignancy	0.763	4.084	2.144	1.02 - 4.49	0.043

DISCUSSION

Our study showed abnormal CT brain findings of 65.2% (n = 503), which were significantly higher than expected. Our result is almost similar to a study by Bener et al. (2008) in Hospital UKM, Malaysia with an overall scan yield of 65.8%. Another study conducted in Pakistan by Nishtar et al. (2019) showed a lower yield of 33.7% (n = 1312). However, the results from previous studies in developed countries showed much lower yield from 10.2% to 27.1% (Wang & You 2013; Bent et al., 2015 and Placencia et al, 2024). We believe that the use of urgent CT brain examinations used in our setting is appropriate, carefully selected and more selective than those reported in some developed countries. A few reasons for this include more widely available CT scanners in their settings and also due to greater medicolegal concerns.

Despite the difference regarding incidence of positive scan, our study shows almost similar patterns of abnormal CT brain findings conducted in developed and developing countries as reported by Wang & You, (2013); Bent et al., (2015), and Nishtar et al., (2019). Acute cerebral infarction shows the highest incidence followed by cerebral haemorrhage and intracranial mass lesion. Table 5 below summarises the comparison.

Table 5: Comparisons of prevalence of abnormal urgent CT brain findings with our study

	Our study	**Wang & You, (2013)**	**Bent et al., (2015)**	**Nishtar et al., (2019)**
Abnormal CT brain	65.2% (n = 503)	13.8% (n=548)	10.2% (n=51)	20.0% (n=778)
Acute infarct	56.0% (n=432)	7.2% (n=275)	6% (n=30)	14.7% (n=309)
Haemorrhage	6.9% (n=53)	4.0% (n=160)	1.6% (n=8)	11.0% (n=232)
Mass lesion	2.9% (n=22)	2.3% (n=91)	1.2% (n=6)	-
Other intracranial entities	1.9% (n=15)	0.1% (n=29)	1.4% (n=7)	-
Total sample (n)	771	3967	500	2108

We identified five independent clinical predictors (p-value < 0.05) for abnormal urgent CT brain findings for non-trauma adult patients, which were age, headache, focal neurological deficit, derangement of blood pressure, and known malignancy. Table 6 demonstrates the clinical predictors of our study compared to other published studies.

Table 6: Comparison of CT brain findings and their clinical predictors with other published studies

Study	**Results of the study**
Our study	Age (adjusted OR: 1.03; 95% CI: 1.01 – 1.04), headache (adjusted OR: 1.87; 95% CI: 1.17 – 3.00), focal neurological deficit (adjusted OR: 0.387; 95% CI: 0.25 – 0.59), deranged blood pressure (adjusted OR: 0.71; 95% CI: 0.55 – 0.59) and known malignancy (adjusted OR: 2.14; 95% CI: 1.02 – 4.49).
Rothrock et al., (1997)	Age ≥ 60 years, focal neurologic deficit, headache with vomiting, or altered mental status, was 100% sensitive (95% CI: 94-100%) and 31% specific (95% CI: 28-33%).
Bent et al., (2015)	Two clinical factors were significant: focal neurologic deficit (adjusted OR 20.7; 95% CI 9.4–45.7) and age >55 (adjusted OR 3.08; CI 1.44–6.56).
Wang & You, (2013)	Six independent clinical predictors of important abnormal findings on head CT were identified: age (adjusted OR per 10-year increase: 1.17; 95% CI: 1.08 -1.28), focal neurologic deficit (adjusted OR: 5.39; 95% CI: 3.90 -7.47), altered mental status (adjusted OR: 2.32; 95% CI: 1.66 - 3.25), history of malignancy (adjusted OR: 4.11; 95% CI: 2.28 - 7.42), nausea and/or vomiting (adjusted OR: 2.22; 95% CI: 1.14 - 4.33), and derangements in coagulation profile (adjusted OR: 1.91; 95% CI: 1.07 - 3.41).

Multiple studies have proved strong association between age with abnormal CT brain findings, which supported our results. Brown et al., 1993 showed that elderly patients presented with signs of atypical stroke and unexplained confusion have a higher yield in CT brain findings compared with younger patients when the same criteria were applied. Segard et al. (2013) Guryildirim et al. (2019) and Alsabri et al. (2025) have also included age as a risk factor for abnormal CT brain findings, particularly intracranial haemorrhage.

Our study showed that headache is a clinical predictor for significant abnormal CT brain findings. We found that most patients with significant CT findings had abnormal physical or neurologic exam or unusual clinical symptoms. Hence, the likelihood of abnormal CT brain findings is increased in the presence of other clinical variables with headache. Guryildirim et al. (2019) and Plasencia et al. (2024) have shown that focal neurological deficit, cluster-type headache, thunderclap headache and worst ever headache increased the likelihood of abnormal CT brain findings.

Our study showed focal neurological deficit as a clinical predictor for abnormal CT brain findings. Previous studies by Brown et al. (1993), Rothrock et al. (1997), Segard et al. (2013), Covino et al. (2019) and Plasencia et al. (2024) also showed similar association between focal neurological deficit with abnormal CT brain findings. While the focal neurological deficit was shown to be the strongest predictor of abnormality of CT brain findings as mentioned by Bent et al. (2015), our findings differed from previous studies with an adjusted odds ratio of only 0.387 with a low CI of less than 1 (0.25 – 0.59), which were suggestive rather than a protective value. In other words, in our study, focal neurological deficit is likely to have an association with normal CT brain findings. This is somehow inconsistent with the assumption that almost all abnormal CT brain scans are associated with focal neurological deficit. Contributing factors for this outcome can be traced at the data collection levels. The retrospective nature of our study made it impossible to ascertain a strict definition of focal neurological deficits.

Our study showed deranged blood pressure was significantly associated with abnormal CT brain findings (p= 0.042). In our study, we grouped patients as having deranged blood pressure based on the following criteria. Derangement of blood pressure (BP) is defined as either hypertension: systolic BP ≥ 140 and/ or diastolic BP ≥ 90 or hypotension: systolic BP ≤ 90 and/ or diastolic BP ≤ 60.

Known malignancy showed a higher adjusted odds ratio of 2.144 with a 95% confidence interval of 1.02 – 4.49, in keeping with a stronger association with abnormal CT brain findings with p-value of 0.043. In the acute setting, CT imaging is used as a screening tool for these patients with acute neurological deficits to rule out neurosurgical emergencies that would require immediate intervention for example presence of mass effect, haemorrhage, and hydrocephalus (Pope et al., 2018).

Derangement of coagulation profile is one of the clinical predictors of abnormal CT brain findings in non-trauma adult patients according to Wang & You (2013) and Ziai & Carhuapoma (2018). However, our study showed a weak association, most likely due to the inclusion of the organic causes of coagulopathy, for example, dengue and sepsis-related.

As expected, nausea and/or vomiting, syncope or presyncope and fever are variables with weak associations with abnormal urgent CT brain findings. These are non-specific symptoms which may be observed in non-neurological related diseases. However, our study also showed that clinical variables i.e. altered mental status and seizure, which are known to be directly associated with neurological diseases, exhibited a weak association to abnormal urgent CT brain findings with low chi-square, low confidence interval and non-significant p-value. Therefore, standardized or more objective methods are required in assessing nausea and/or vomiting, syncope or presyncope and altered mental status to determine patient selection for neuroimaging studies to have the improve diagnostic yield.

CONCLUSION

Our study shows abnormal findings in 65.2% of urgent CT brain examinations among non-trauma adult patients. This suggests good selective criteria by our clinicians in using urgent CT brain scan for neurological assessment in adult non-trauma patients. Age, headache, deranged blood pressure, known malignancy and focal neurological deficits are the significant clinical predictors for abnormal urgent CT brain scans consistent with findings reported in previous studies.

LIMITATIONS

Due to the retrospective nature of our study, patients' assessment and documentation of clinical findings were not standardized. One of the examples is headache. All headaches were grouped into a single category as no reliable distinction could be made between different types of headache based on data available in the patient's record.

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REFERENCES

Aiyagari, V., & Gorelick, P. B. (2009). Management of blood pressure for acute and recurrent stroke. Stroke, 40(6),2251–2256. https://doi.org/10.1161/STROKEAHA.108.531574

Akhtar, H., Chaudhry, S. H., Bortolussi-Courval, É., Hanula, R., Akhtar, A., Nauche, B., & McDonald, E. G. (2023). Diagnostic yield of CT head in delirium and altered mental status-A systematic review and meta-analysis. Journal of the American Geriatrics Society, 71(3),946–958. https://doi.org/10.1111/jgs.18134

Alsabri, M., Ayyad, M., Aziz, M. M., Zaazouee, M. S., Elshanbary, A. A., Shafique, M. A., Sarieddine, L., Qattea, I., Waseem, M., & Gamboa, L. L. (2025). Diagnostic value of CT scans in pediatric patients with acute non-traumatic altered mental status: a systematic review and meta-analysis. European journal of pediatrics, 184(2), 136. https://doi.org/10.1007/s00431-024-05943-3

Bener, A., Ismail, M.S., Fathil, S., Hong, S.B and Azhar, A.A (2008). Emergency head CT scan ordering and yield: A Malaysian experience. Journal of Emergency Medicine, Trauma and Acute Care, 8(3):151-155

Bent, C. Lee, P.S. Shen, P. Y., Bang, H., & Bobinski, M (2015). Clinical scoring system may improve yield of head CT of non-trauma emergency department patients. Emergency Radiology, 22 (5), 511-516

Brenner, D.J., & Hall, E.J. (2007). Computed tomography--an increasing source of radiation exposure. The New England journal of medicine, 357 22, 2277-84

Brown, G., Warren, M., Williams, J. E., Adam, E. J., & Coles, J. A. (1993). Cranial computed tomography of elderly patients: an evaluation of its use in acute neurological presentations. Age and ageing, 22(4), 240–243. https://doi.org/10.1093/ageing/22.4.240

Covino, M., Gilardi, E., Manno, A., Simeoni, B., Ojetti, V., Cordischi, C., Forte, E., et al. (2019). A new clinical score for cranial CT in ED non-trauma patients: Definition and first validation. American Journal of Emergency Medicine, 37(7), 1279–1284

Guryildirim, M., Kontzialis, M., Ozen, M., & Kocak, M. (2019). Acute Headache in the Emergency Setting. Radiographics: a review publication of the Radiological Society of North America, Inc, 39(6), 1739–1759. https://doi.org/10.1148/rg.2019190017

Nishtar, T., Ahmad, T., Noor, N., & Muhammad, F. (2019). Rational use of computed tomography scan head in the emergency department of a high volume tertiary care public sector hospital. Pakistan Journal of Medical Sciences, 35(2), 302–308

Plasencia Martinex J, Oton-Gonzalex E, Sanchez-Canales M, Ortis MayoralH, Cotillo-Ramos et al. (2024). Clinical prediction scale approach derived from a retrospective study to reduce the number of urgent, low-value cranial CT scans. Emergency Radiology, 31 (6): 835-843

Plasencia Martinex J, Sanchez-Canales M, Oton-Gonzalex E, Casado-Alarcon et al. (2023). Inappropriate requests for cranial CT scans in emergency departments increase overuse and reduce test performance. Emergency Radiology, 30 (6), 733-741

Pope W. B. (2018). Brain metastases: neuroimaging. Handbook of clinical neurology, 149, 89–112. https://doi.org/10.1016/B978-0-12-811161-1.00007-4

Rothrock, S. G., Buchanan, C., Green, S. M., Bullard, T., Falk, J. L., & Langen, M. (1997). Cranial computed tomography in the emergency evaluation of adult patients without a recent history of head trauma: A prospective analysis. Acad. Emerg. Med 4(7): 654-661

Segard, J., Montassier, E., Trewick, D., le Conte, P., Guillon, B., & Berrut, G. (2013). Urgent computed tomography brain scan for elderly patients: Can we improve its diagnostic yield? European Journal of Emergency Medicine, 20(1), 51–53.

Smith-Bindman, R., Lipson, J.A., Marcus, R., Kim, K., Mahesh, M., Gould, R.G., Berrington de González, A., & Miglioretti, D.L. (2009). Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. Archives of internal medicine, 169 22, 2078-86

Wang, X., & You, J. J. (2013). Head CT for non-trauma patients in the emergency department: Clinical predictors of abnormal findings. Radiology, 266(3), 783–790

Ziai, W. C., & Carhuapoma, J. R. (2018). Intracerebral Hemorrhage. Continuum (Minneapolis, Minn.) 24(6),1603–1622 https://doi.org/10.1212/CON.0000000000000672