

# Potentially inappropriate brain CT-scan requesting in the emergency department: A retrospective study in patients with neurologic complaints

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**Abstract.** *Background:* Potentially inappropriate brain CT scan requesting in the emergency department imposes extra charges to the healthcare system and patients. Besides, the unnecessary radiation exposure may cause irreparable damage to the patient. In this study we investigated the percentage of potentially inappropriately conducted brain CT scan for different chief complaints in non-traumatic patients presented to our emergency department. *Material and methods:* 160 patients aged over 18 years old with chief complaints other than trauma, referred to the emergency department of Imam Hossein Hospital (Tehran, Iran), were enrolled in this study. Data were collected from medical records; the inclusion criteria was patients older than 18 years with chief complaint other than trauma. *Results:* 160 people aged 18 to 100 years old enrolled in this study, 83 (51.87%) were male and 77 (48.13%) were female. There was no statistically significant difference in terms of potentially inappropriate brain CT between different age groups. Percentage of potentially inappropriate CT according to chief complaints were as follows: 4.8% for dysarthria, 0% for right and left hemiplegia, 9.1% for decreased level of consciousness, 30% for nausea and vomiting, 41.7% for generalized weaknesses, 0% for seizures, 55.6% for vertigo, 25% for headache, and 57.7% for other complaints. There was a statistically significant association between chief complaints and potentially inappropriate brain CT scan requests (p-value = 0.001). *Conclusion:* Considering the significant percentage of potentially inappropriate brain CT scan requests for non-traumatic patients in the setting of emergency department, it is critical for healthcare policymakers to propose practical guidelines and supervise their application. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** Brain CT-scan, Emergency, Neurology

## Introduction

Charging patients and healthcare systems with additional costs of unnecessary imaging does not improve the quality of medical care (1, 2). In this setting, unnecessary imaging, on the other hand, may reveal incidental findings that demand further evaluation and procedures. Neurological complaints are commonly encountered in the emergency department (ED). Imaging, particularly brain computed tomography scan (CT-scan), is requested in these patients,

which may not be indicated in the clinical setting. This may arise from absence of practical guidelines and lack of knowledge (3, 4).

Fear of missing significant pathologies which may bring about other consequences such as lawsuits, patient's demand for further evaluation as reassurance, having financial conflict of interest, and self-referral are among the main causes of unnecessary imaging (5, 6).

Brain CT has become the modality of choice for acute neurologic complaints in the emergency

department. There are practical guidelines for ordering brain CT in traumatic brain injury; moreover, in neurology textbooks, other red flags are also proposed such as vertigo, headache, and generalized weakness to choose the patient who needs an instant imaging. As a good case in point, in case of headache, papilledema or a focal neurologic deficit should be pursued by neuroimaging. However, requesting not indicated imaging or rarely missing a patient with an alarming condition may happen. In this retrospective study, we aimed to find out the percentage of brain CT scans among patients with neurologic manifestations in our center that were not indicated based on the Merritt's textbook of neurology (7). This is the first step to encourage local healthcare policy makers to present practical guidelines.

## Material and Methods

160 patients aged over 18 years old with neurological complaints, referred to the emergency department of Imam Hossein Hospital (Tehran, Iran), were enrolled in this retrospective study. All the evaluation and examinations were performed by a single emergency resident. All study protocols were approved by the ethics committee of Shahid Beheshti university of medical sciences.

Patient information, indication of CT scan including clinical symptoms and chief complaints of patients (such as headache, nausea, dizziness, drowsiness, restlessness, hemiparesis, hemiplegia, speech impairment, weakness, seizure), and patient's request were recorded on the checklist. For patients who have more than one chief complaint, each one was reviewed independently. CT scan indications in this study were determined using Merritt's textbook of neurology.

Inclusion criteria were as follows: 1. Patients over 18 years old, and 2. Neurological complaints. Also, exclusion criteria were as follows: 1. Patients less than 18 years, 2. patients presenting with traumatic injuries, and 3. Incomplete medical records.

### Statistical analysis

Data were analyzed using SPSS (version 21.0) software. The significance of not indicated CT scan requested in association with chief complaint of the

patients was analyzed using Chi-square and Fisher exact test.

## Results

160 people aged 18 to 100 years old were enrolled in this study; 83 (51.87%) were male and 77 (48.13%) were female.

Of the patients, 18 (11.2%) aged 18 to 40, 38 (23.7%) aged 41 to 60, 66 (36.7%) aged 61 to 80, and 38 (23.7%) aged 80 to 100 years old.

### Frequency of chief complaints

As shown in table 1, distribution of chief complaints studied were as follows: 21 (13.1%) with dysarthria, 10 (6.2%) with right hemiplegia, 18 (11.2%) with left hemiplegia, 22 patients (13.7%) with decreased level of consciousness, 10 (6.2%) with nausea and vomiting, 24 (15.0%) with generalized weakness, 12 (7.5%) with seizure, 9 (5.6%) with dizziness, 8 (5.0%) with headache, and 26 (16.2%) patients with other complaints.

### Frequency of indicated or not indicated brain CT scan in age groups

Frequency and percentage of indicated and not indicated CT scan in different age groups of the study are illustrated in figure 1. In the group of 18 to 40 years,

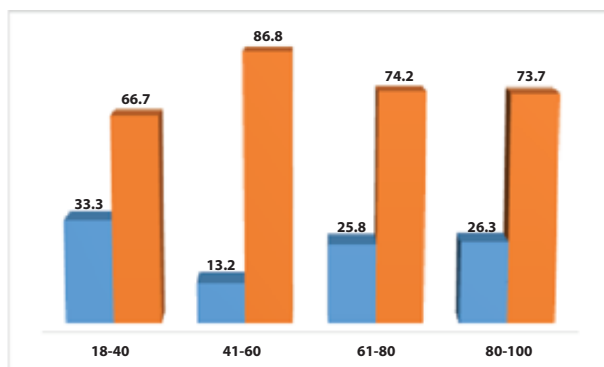
**Table 1.** Frequency and percentage of chief complaints.

Type of symptoms	Frequency	Percentage
Dysarthria	21	13.1
Right hemiplegia	10	6.2
Left hemiplegia	18	11.2
Decreased level of consciousness	22	13.7
Nausea and vomiting	10	6.2
Generalized weakness	24	15.0
Seizure	12	7.5
Dizziness	9	5.6
Headache	8	5.0
Other conditions	26	16.2

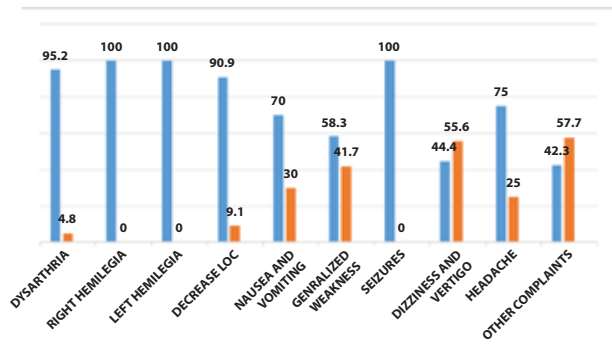
12 (66.6%) indicated and 6 (33.3%) not indicated brain CT scans were conducted. In the age group of 41 to 60 years, 33 (86.8%) were indicated and 5 (13.2%) were not indicated. Also, in the age group of 61 to 80 years, 49 (74.2%) indicated and 17 (25.7%) not indicated, and in the age group of 80 to 100 years, 28 (73.7%) indicated and 10 (26.3%) not indicated decisions were made. There was no statistically significant difference between the studied age groups in terms of potentially inappropriate brain CT scan request ( $p$  value = 0.314) (Figure 1).

#### *Frequency of indicated or not indicated brain CT scan in association with chief complaints*

Frequency and percentage of indicated and not indicated brain CT scan according to the chief complaints is shown in figure 2: dysarthria: 20 (95.2%) indicated and 1 (4.8%) not indicated; for right hemiplegia, 10 (100%) indicated and 0 (0%) not indicated; left hemiplegia, 18 (100%) indicated and 0 (0%) not indicated; decreased level of consciousness, 20 (90.9%) indicated and 2 (9.1%) not indicated, nausea and vomiting 7 (70%) indicated and 3 (30%) not indicated; generalized weaknesses 14 (58.3%) indicated and 10 (41.7%) not indicated, seizures 12 (100%) indicated and 0 (0%) not indicated, vertigo 4 (44.4%) indicated and 5 (55.6%) not indicated, headache 6 (75%) indicated and 2 (25%) not indicated, and in other conditions, 11 (42.3%) indicated and 15 (57.7%) not indicated CT scan were performed. There was statistically significant association between chief complaints



**Figure 1.** Percentage of appropriate and potentially inappropriate CT scan request in different age groups (blue columns shows appropriate and orange columns shows potentially inappropriate decisions).



**Figure 2.** Percentage of appropriate and potentially inappropriate CT scan request in terms of chief complaints. LOC: level of consciousness.

and potentially inappropriate brain CT scan request ( $p$  value = 0.001) (Fig. 2).

#### *Frequency of indicated or not indicated brain CT scan according to gender*

The frequency (percentage) of indicated and not indicated CT scan were 69 (83.1%) and 14 (16.9%) in male patients, respectively, while it was 53 (68.8%) and 24 (31.2%) in female patients, respectively, which was significantly different ( $p$  value = 0.034).

## Discussion

In this study, we demonstrated that there is a high percentage of requesting not indicated brain CT scan in the emergency department for common neurologic complaints.

Performing unnecessary brain imaging leads to extra charges, radiation damage, and excessive burden on the staff. Considering the radiation exposure, there is an estimation that 36,000 lung cancers could be induced associated with CT screening for lung cancer provided that 50% of smokers in the United States underwent testing (8). Brenner and Hall have suggested that 1.5% to 2% of all cancers in the United States may be attributed to CT ionizing radiation (9). Santiago Medina *et al.* in their research mentioned that performing brain CT and MRI for headache evaluation in children with intermediate risk to have brain tumor and normal neurologic examination costs over \$1 million per quality of life adjusted years

gained compared with strategies other than imaging. They also suggested clinical follow up as the strategy of choice in low risk patients and MRI for high risk ones (10). Although the cost of performing a brain CT in our hospital is not high, which itself may have led to the high rate of unnecessary imaging, this is an important issue to be considered.

A previous study by Barzin *et al.* on patients with headache referred to a tertiary center showed that abnormal findings were found in 18.23% of cases, and concluded that the prevalence of important conditions in brain MRI of patients with headache is relatively low (11). A study was conducted in the United States on patients complaining of dizziness and vertigo during a three-year period, evaluating the cost effectiveness of brain CT and MRI. Their analysis showed that performing CT scans for vertigo subjects had only a small prognostic value for significant pathological findings. Although 12.2% of the MRIs detected significant pathologies endorsing wisely selecting the imaging for better management of the patients (12). Consistent with this, Mitsunaga *et al.* have found out that in patients with dizziness, syncope and near syncope, the possibility of finding a significant pathology via brain CT scan was related mainly to three factors including: a focal neurologic deficit, age greater than 60 years, and acute head trauma. Otherwise, patients who were younger and had normal neurologic examination showed lesser involvement (13).

A previous work by Lehnert *et al.* in outpatient setting demonstrated that 26% of elective outpatient imaging examinations did not meet appropriateness criteria and there was a high negativity rate among them, posing the fact that the chance of finding a significant pathology was 3.5 times lesser in not indicated imaging (14). Based on a comprehensive work by Comelli *et al.*, it should be kept in mind that complaints such as nausea/vomiting/dizziness might be the presenting sign of a brain tumor (4.4%) which possibly would be elucidated at earlier stages if brain CT was conducted beyond the indication guidelines (15). Overall, practical tools are needed to help physicians improve the appropriateness of their requests. There are guidelines and protocols all over the world but their practicality and physicians' compliance is under question.

## Conclusion

In conclusion, our findings show a significant percentage of not indicated imaging requests in the emergency departments for neurologic complaints. It is an obligation for healthcare policy makers and authorities to present feasible guidelines and supervise practitioners to stick to these guidelines. There is, however, some evidence that even potentially inappropriate brain CT scanning in the ED could lead to a non-negligible number of diagnoses of brain tumors.

**Conflicts of interest:** Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

## References

1. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 2: health outcomes and satisfaction with care. *Annals of internal medicine.* 2003;138(4):288-98.
2. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care. *Annals of internal medicine.* 2003;138(4):273-87.
3. Childs AW, Hunter ED. Non-medical factors influencing use of diagnostic x-ray by physicians. *Medical Care.* 1972;323-35.
4. Broers MC, Niermeijer J-MF, Kotsopoulos IA, Lingsma HF, Bruinenberg JF, Catsman-Berrevoets CE. Evaluation of management and guideline adherence in children with mild traumatic brain injury. *Brain injury.* 2018;32(8):1028-39.
5. Levin DC, Rao VM. Turf wars in radiology: the overutilization of imaging resulting from self-referral. *Journal of the American College of Radiology.* 2004;1(3):169-72.
6. Hillman BJ, Joseph CA, Mabry MR, Sunshine JH, Kennedy SD, Noether M. Frequency and costs of diagnostic imaging in office practice—a comparison of self-referring and radiologist-referring physicians. *New England Journal of Medicine.* 1990;323(23):1604-8.
7. Lim L. *Merritt's Neurology.* Oxford University Press; 2016.
8. Brenner DJ. Radiation risks potentially associated with low-dose CT screening of adult smokers for lung cancer. *Radiology.* 2004;231(2):440-5.
9. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. *New England Journal of Medicine.* 2007;357(22):2277-84.
10. Medina LS, Kuntz KM, Pomeroy S. Children with headache suspected of having a brain tumor: a cost-effectiveness

- analysis of diagnostic strategies. *Pediatrics*. 2001;108(2):255-63.
11. Barzin M, Alaei A, Gholian Jooibari S. MRI findings in patients with headache referred to Imam Khomeini Hospital, Sari, Iran, from October 2007 to February 2009. *Journal of Mazandaran University of Medical Sciences*. 2010;20(75):65-9.
  12. Ahsan SF, Syamal MN, Yaremchuk K, Peterson E, Seidman M. The costs and utility of imaging in evaluating dizzy patients in the emergency room. *The Laryngoscope*. 2013;123(9):2250-3.
  13. Mitsunaga MM, Yoon H-C. Journal Club: Head CT scans in the emergency department for syncope and dizziness. *American Journal of Roentgenology*. 2015;204(1):24-8.
  14. Lehnert BE, Bree RL. Analysis of appropriateness of outpatient CT and MRI referred from primary care clinics at an academic medical center: how critical is the need for improved decision support? *Journal of the American College of Radiology*. 2010;7(3):192-7.
  15. Comelli I, Lippi G, Campana V, Servadei F, Cervellini G. Clinical presentation and epidemiology of brain tumors firstly diagnosed in adults in the Emergency Department: a 10-year, single center retrospective study. *Annals of translational medicine*. 2017;5(13).
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