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COMPUTED TOMOGRAPHY UTILIZATION IN THE EMERGENCY DEPARTMENT OF KING FAHAD SPECIALIST HOSPITAL, BURAYDAH, QASSIM, SAUDI ARABIA

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ABSTRACT

Background: Despite the numerous benefits of computed tomography (CT), there are also some risks to the patient, including high radiation exposure that may increase the risk of tumor development, kidney function impairment, and allergic reactions associated with contrast CTs. In the United States, the use of CT in the emergency department (ED) has been increasing since 1993, with a few periods of minor reductions in its use. We aimed to determine the most commonly requested CT scans according to the type and region of the scan, identify the most common complaints associated with the requests and their relations with age, sex, time, and date, and determine the associations of CT scan types with age, sex, date, and time.

Objectives: We aimed to determine the comprehensive characteristics of CT scan requests in the ED of King Fahad Specialist Hospital (KFSH), Buraydah, Qassim, Saudi Arabia. Our specific objectives included determining (i) the most common types of CT scan requests in the ED, (ii) the most common complaints associated with these requests, (iii) the age group for the highest CT scan request rate for each anatomical region, (iv) the associations between CT scan types and sex, age, date, and time of the scan, and (v) the associations between patients' complaints and sex, age, date, and time of the scan.

Methodology: A retrospective electronic record review was conducted among the patients who underwent CT scans in the ED of King Fahad Specialist Hospital (KFSH) in Buraydah, Qassim, Saudi Arabia. The study included adult patients older than 18 years who visited the ED from January 1 to December 31, 2019, and underwent CT scans.

Results: This single-center retrospective study included 6858 patients, 42.4% of whom were women and 57.6% were men. The majority of the patients ranged between 18 and 61 years of age; 36.9% were aged 18–39 years and 34.5% were aged 40–61 years, and the mean age was 49.3±19.9

years. The anatomical region with the highest demand for CT was the head and neck region (56.8%), and brain CT was the most common type (52.7%). Significant associations were found between the type of CT scan and sex, age, time, and date. In our study, only 1628 CT requests had written complaints, of which 1254 were single complaints. The most common complaints among the patients with single complaints were loin pain and decreased levels of consciousness, constituting 9.3% each. The most common complaints among the patients with multiple complaints were dizziness/vertigo (32.1%), headache (25.9%), and vomiting (23.3%).

Conclusion: 6858 patients who underwent CT scans in the ED of KFSH were included. The region with the highest demand for CT was the head and neck; additionally, there were significant associations between the type of CT scan and sex, age, time, and date. An association between complaints, age, sex, and the date was found.

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INTRODUCTION

Computed tomography (CT) is a common imaging procedure that directs ionizing radiation with a series of x-rays from different angles on different organs within the human body, which are then processed by a computer to generate a constructed image [1]. It can be used in several cases, such as head trauma, subarachnoid hemorrhage, sinusitis, pulmonary embolism, blood vessel aneurysms, acute appendicitis, urolithiasis, as well as in the diagnosis and staging of some tumors, such as in colon and lung cancers [1-3].

Along with its numerous benefits, it carries some risks to the patient, including high radiation exposure that may increase the risk of tumor development, impairment of kidney function and allergic reactions associated with contrast CTs, and acute radiation syndrome, which is a rare complication that usually occurs when the patient's whole body is exposed to radiation [3,4].

In the United States (US), the use of CT in the emergency department (ED) has been increasing since 1993, with a few periods of minor reductions in its use. Yet, there were no significant changes in the diagnoses of life-threatening conditions [5-7]. Another study conducted in a trauma center in the US noted that the use of CT in the ED is decreasing, possibly due to increased adherence to the guidelines [8]. The highest increases in CT requests in the ED were in the following anatomical regions: cervical spine, chest, abdomen, and head, in descending order. The cervical spine and chest region CT requests were for the younger individuals, whereas the abdomen and head region CT requests were for older populations [9].

In the ED, the leading chief complaint most commonly associated with CT imaging was headache in 2001; however, in 2007, abdominal pain was the leading chief complaint, followed by headache, chest pain, flank pain, and head injury [10]. A study showed that of 426 pre-CT diagnoses of abdominal pain, only 133 were confirmed, and the CT examinations had offered new or alternate diagnoses in 90 patients [11].

A majority of the studies concerned with CT utilization in the ED are from the US, and a

minority are from other countries; however, we were not able to find a national or a regional study in the Middle East; additionally, the Kingdom of Saudi Arabia lacks a survey with similar concerns.

MATERIALS & METHODS

A retrospective electronic record review was conducted among the patients who underwent CT scans in the ED of KFSH in Buraydah, Qassim, Saudi Arabia. The study included adult patients older than 18 years who visited the ED from January 1 to December 31, 2019, and underwent CT scans. Patients younger than 18 years and those who underwent imaging modalities other than CT scans were excluded. The collected data were entered into an Excel database and then transferred to IBM SPSS Statistics for Windows, version 26.0 (SPSS Inc. Chicago, IL, USA) and then statistically analyzed. P-values <0.05 were considered significant.

Statistical Analysis

Descriptive analyses were performed, followed by association analyses using the Chi-square test, where P-values < 0.05 were considered statistically significant. Single complaints and multiple complaints were categorized as "others" if presented by ≤50 patients and ≤20 patients, respectively. The dates were coded and categorized as Q1–Q4, where Q1 included January–March; Q2, April–June; Q3, July–September; and, Q4, October–December.

Ethical Consideration

Data collection was initiated after obtaining IRB approval from the regional research ethics committee, approval number:1441-1383497. Patient confidentiality was maintained. No identification or personal information was collected or stored, including the participant's name, identity document, and other information.

RESULTS

This single-center retrospective study was conducted in the ED of KFSH, Buraydah, Qassim, Saudi Arabia, in 6858 patients, of which 42.4% and 57.6% were women and men, respectively. The majority of the patients were aged between 18 and 61 years; 36.9% were aged between 18 and 39 years, and 34.5% were aged between 40 and 61 years, with a mean age of 49.3±19.9 years. The anatomical region with the highest demand for CT was the head and neck region (56.8%). Brain CT was the most common type of CT (52.7%), followed by kidney, uterus, and bladder (KUB) CT (17.4%) and abdominal CT (12.4%). CT of the abdomen and pelvis comprised 32.6% without contrast and with contrast comprised 60.8% and 37.1%, respectively; and both in 2.1%. Only 9.5% had undergone chest CT, 56.3% of which was without contrast; 35.5%, with contrast; and 8.2%, with and without contrast (Table 1).

The association between the demand for different types of CT and sex was found to be statistically significant (P = 0.000). Greater percentages of women underwent angiography (51.1%), chest (61.5%), and "neck, chest, abdomen, and pelvis" CTs (52.5%). In addition, a significant association was found between age and CT type (P = 0.000), with the mean age ranging between 35 and 55 years (Table 2). A significant

Parameter			Frequency	Percent
Sex	Women		2906	42.4%
	Men		3952	57.6%
Age	18–39 years		2531	36.9%
	40–61 years		2364	34.5%
	62–83 years		1590	23.2%
	84–106 years		373	5.4%
	Mean ± SD		49.3±19.9	
CT Region	Abdomen and pelvis	Total	2239	32.6%
		Without contrast (N=2239)	1361	60.8
		With contrast (N=2239)	830	37.1
		Both with and without (N=2239)	48	2.1
	Chest	Total	650	9.5%
		Without contrast (N=650)	366	56.3
		With contrast (N=650)	231	35.5
		Both with and without (N=650)	53	8.2
	Head and neck		3893	56.8%
	Miscellaneous		76	1.1%
CT Type	Abdomen		848	12.4%
	Angiography		137	2.0%
	Brain		3613	52.7%
	Cardiac coronaries		72	1.0%
	Chest		234	3.4%
	Chest, abdomen, and pelvis		57	0.8%
	Neck, chest, abdomen, and pelvis		40	0.6%
	Dental		8	0.1%
	HR chest		227	3.3%
	Kidney, uterus, and bladder (KUB)		1192	17.4%
	Lower limb(s)		13	0.2%
	Maxillofacial		90	1.3%
	Neck		34	0.5%
	Pelvis		36	0.5%
	Cervical spine		144	2.1%
	Lumbar spine		54	0.8%
	Thoracic spine		27	0.4%
	Trauma		12	0.2%
	Upper limb(s)		20	0.3%

CT = computed tomography, SD = standard deviation; HR chest = high-resolution CT of the chest

Table 1: Sex, age, CT region, and CT type (N=6858)

association was also found between the CT region and the time it was conducted (P = 0.000). The percentages of CTs conducted were higher between 6 AM and 12 AM than that in the time between 12 AM and 6 AM (Table 3). Furthermore, a significant association was found between the CT region and the date in months (P = 0.004).

Parameter		Sex		P-value	Age		P-value
		Female	Male		Mean	SD	
CT Type	Abdomen	48.5%	51.5%	0.000*	42	19	0.000**
	Angiography	51.1%	48.9%		53	20	
	Brain	43.0%	57.0%		53	20	
	Cardiac coronaries	26.4%	73.6%		50	12	
	Chest	61.5%	38.5%		55	20	
	Chest, abdomen, and pelvis	29.8%	70.2%		55	18	
	Neck, chest, abdomen, and pelvis	52.5%	47.5%		53	17	
	Dental	25.0%	75.0%		35	16	
	HR Chest	47.6%	52.4%		58	21	
	Kidney, uterus, bladder (KUB)	36.7%	63.3%		43	16	
	Lower limb(s)	30.8%	69.2%		49	19	
	Maxillofacial	36.7%	63.3%		39	16	
	Neck	32.4%	67.6%		44	20	
	Pelvis	38.9%	61.1%		52	18	
	Cervical Spine	22.2%	77.8%		40	19	
	Lumbar Spine	33.3%	66.7%		50	21	
	Thoracic Spine	22.2%	77.8%		49	21	
	Trauma	16.7%	83.3%		37	21	
	Upper limb(s)	15.0%	85.0%		46	20	

CT = computed tomography, HR Chest = High-resolution CT of the chest
*Chi-square test was used
**One-way analysis of variance was used

Parameter			Time of CT				P-value
			12-6 am	6am -12pm	12-6pm	6pm-12am	
CT Region	Abdomen and pelvis	Total	18.5%	25.9%	28.6%	27.0%	0.000*
		Without contrast (N=2239)	16.5%	27.9%	28.5%	27.0%	
		With contrast (N=2239)	21.7%	22.5%	28.7%	27.1%	
		Both with and without (N=2239)	18.8%	29.2%	29.2%	22.9%	
	Chest	Total	16.3%	26.0%	31.7%	26.0%	
		Without contrast (N=650)	12.6%	32.2%	33.6%	21.6%	
		With contrast (N=650)	19.9%	18.2%	30.3%	31.6%	
		Both with and without (N=650)	26.4%	17.0%	24.5%	32.1%	
	Head and neck		18.3%	21.3%	29.6%	30.8%	
	Miscellaneous		11.8%	19.7%	34.2%	34.2%	

CT = computed tomography
*Chi-square test was used

Table 3: Association of CT region with time (N=6858)

Abdominal and pelvic CTs and chest CTs were more commonly requested during July–December and October–March, respectively; head and neck CTs were almost equally distributed throughout the year, and other miscellaneous types of CTs were focused during July–December (Table 4).

Table 5 shows the frequencies of single complaints due to which patients visited the ED and were advised CT scans. The most

frequent complaints were loin pain (9.3%), decreased levels of consciousness (9.3%), abdominal pain (9.1%), and road traffic accidents (RTA) (8.8%). The chi-square test revealed a significant association with the sex of the patient, as the majority of the patients presenting with loin pain, flank pain, and RTA were men (70.9%, 73.7%, and 81.8%, respectively). A one-way analysis of variance revealed a significant association with age; patients presenting with decreased levels of consciousness tended to be older (mean age ± standard deviation = 64 ± 21), whereas the patients who met with RTAs were younger (mean age ± standard deviation = 35 ± 16).

Table 6 illustrates the cases with multiple complaints rather than single complaints. The most frequent complaints were dizziness/vertigo (32.1%), headache (25.9%), vomiting (23.3%), and abdominal pain (12.6%). Sex and age were significantly associated with the presentation of multiple complaints (P = 0.002 and 0.000, respectively).

A higher number of men presented with decreased levels of consciousness (69.4%), limb weakness (79.4%), trauma (79.3%), and RTAs (80.8%), and the older patients presented with dizziness/vertigo and limb weakness.

Tables 7 and 8 illustrate the times and dates of CT in association with single and multiple complaints, respectively. The date of CT was significantly associated with single complaints (P = 0.007). RTA and flank pain were more common in Q2 (35.5%) and Q1 (44.7%), respectively. Interestingly, in single complaints, loin pain was more frequently seen from 12–6 AM compared to other complaints (22.2%), followed by seizures/convulsions (21.8%).

DISCUSSION

In this study, we aimed to examine the frequency of CT scans for patients visiting the ED, the most frequently ordered types of CT, the most common complaints, and the age group with the highest number of CTs.

The percentage of patients older than 65 years for whom CT was requested in our study was found to be relatively high (28.6%) as compared to that in other countries. This percentage was even higher than that reported in previous studies conducted in Saudi Arabia, where the percentage of geriatric patients' visits to the ED comprised approximately 19.14% of the total adults' visits to the ED [12], and the percentage (20%) in the US as reported in a study conducted from 2014 to 2017 [13]. However, the percentage of geriatric patients in our study was lower than that of younger patients. The results of another study conducted in the US that assessed the trends in CT use in the ED from 1995 to 2007 showed a compound annual growth rate of 16% in CT-involving ED visits. The CT use was greater in older patients (aged ≥65 years), with no significant difference between men and women except in the first year of the study [10].

In Turkey, a study conducted in an urban hospital to analyze visits made by older patients to the ED found that they constituted only 11.9% of all emergency department visits [14]. In Saudi Arabia, a study that was conducted on 300 patients visiting the ED in three different hospitals found that the older patients (aged >60 years) comprised only

Parameter			Date of CT				P-value
			Q1	Q2	Q3	Q4	
CT Region	Abdomen and pelvis	Total	23.2%	23.8%	25.6%	27.3%	0.004*
		Without contrast (N=1361)	23.1%	24.1%	26.1%	26.7%	
		With contrast (N=1361)	23.1%	24.1%	24.9%	27.8%	
		Both with and without (N=1361)	29.2%	12.5%	22.9%	35.4%	
	Chest	Total	27.2%	20.9%	23.7%	28.2%	
		Without contrast (N=650)	28.1%	21.9%	24.3%	25.7%	
		With contrast (N=650)	23.4%	19.0%	22.9%	34.6%	
		Both with and without (N=650)	37.7%	22.6%	22.6%	17.0%	
	Head and neck		25.8%	25.8%	23.7%	24.7%	
	Miscellaneous		17.1%	19.7%	30.3%	32.9%	

CT = computed tomography
*Chi-square test was use

Table 4: Association of CT region with date (months) (N=6858)

7.3% of the total visits made to the ED in comparison with the percentage (46%) of the patients aged between 24 and 60 years [15]. The difference in the number of older patients visiting the ED is surprising considering the differences in the population composition between Saudi Arabia and other countries. According to a survey conducted in 2017, the older adults (aged ≥60 years) constituted 5.2% of the Saudi population [16] in comparison to 16% in the United States [17]. In our study, the anatomical region with the most frequent demand for CT was the head and neck region (56.8%). Brain CT was the most common type of CT (52.7%), followed by KUB CT (17.4%) and abdominal CT (12.4%). This is comparable with the findings of another study conducted between 2003 and 2012 at an academic tertiary-care center that found that head CT and abdominal and pelvic CT were the most common CTs [18]. Furthermore, in another study conducted in Taiwan, the head (44.74%) and abdomen (37.94%) were found to be the most commonly requested sites [19]. However, this contrasts with the results of another study conducted between 2000 and 2010 wherein abdominal CT was the most common and accounted for more than 50% of the CT requests [20].

The prevalence of head CT may be attributed to its evident diagnostic value [21], or it could indicate a misuse of CT. A study conducted in Pakistan found that head CT was the most commonly requested type (90.8%); however, 66.29% of these scans revealed normal

Complaint	Frequency	Percentage	Sex		Age	
			Female	Male	Mean	SD
Loin pain	117	9.3%	29.1%	70.9%	40	13
Decreased level of consciousness	117	9.3%	44.4%	55.6%	64	21
Abdominal pain	114	9.1%	42.1%	57.9%	41	18
Road traffic accidents (RTA)	110	8.8%	18.2%	81.8%	35	16
Seizures/convulsions	101	8.1%	39.6%	60.4%	39	19
Dizziness/vertigo	101	8.1%	34.7%	65.3%	59	15
Headache	87	6.9%	44.8%	55.2%	45	18
Flank pain	76	6.1%	26.3%	73.7%	41	13
Trauma (any trauma except RTA)	70	5.6%	35.7%	64.3%	42	19
Shortness of breath	59	4.7%	57.6%	42.4%	61	18
Others (complaints found in less than 50 patients)	302	24.1%	36.4%	63.6%	54	19
P-value			0.000*		0.000**	

CT= computed tomography, RTA = road traffic accidents
*Chi-square test was used
**One-way analysis of variance was used

Table 5: Single complaints leading to CT scans, and their associations with patient sex and age (N=1254)

Complaint	Frequency	Percentage	Sex		Age	
			Female	Male	Mean	SD
Dizziness/vertigo	120	32.1%	44.2%	55.8%	53	18
Headache	97	25.9%	47.4%	52.6%	44	19
Vomiting	87	23.3%	43.7%	56.3%	46	19
Abdominal pain	47	12.6%	55.3%	44.7%	42	19
Decreased level of consciousness	36	9.6%	30.6%	69.4%	51	24
Limb weakness	34	9.1%	20.6%	79.4%	53	16
Loin pain	32	8.6%	50.0%	50.0%	43	12
Trauma (any trauma except RTA)	29	7.8%	20.7%	79.3%	42	19
RTA	26	7.0%	19.2%	80.8%	30	11
Nausea	22	5.9%	36.4%	63.6%	46	15
Dysuria, oliguria	21	5.6%	57.1%	42.9%	45	15
Others (complaints found in less than 20 patients)	218	58.3%	43.1%	56.9%	49	19
P-value			0.002*		0.000**	

CT = computed tomography RTA= road traffic accidents
*Chi-square test was used
**One-way analysis of variance test was used

Table 6: Multiple complaints leading to CT scans, and their associations with patient sex and age (N=374)

results, and only 33.7% had positive findings [22]. In a study conducted in India, including the CT scans of 2498 patients, the samples were classified into groups A and B; group A had a headache as the only complaint, and group B had a headache in addition to other neurological symptoms. In group A, 82% of the patients had normal results on their CT scans compared to 74.5% in group B. This indicates that a proper pre-CT clinical

evaluation can be beneficial in minimizing head CT performance rate [23].

Furthermore, CT without contrast was requested more frequently than CT with contrast; 60.8% of abdomen and pelvis CTs and 56.3% of the chest CTs were not contrast-enhanced. This suggests that a minimal number of cases required contrast-enhanced CT, such as acute appendicitis, cancer staging, pancreatitis, diverticulitis, suspected complications of inflammatory bowel disease, and pulmonary embolism [24].

Most of the ED visits were made between 6 and 12 AM rather than at late night to early morning, i.e., from 12 AM to 6 AM, with 55.6% between 12 PM and 12 AM. This corresponds with the findings of a study conducted in the Eastern region of Saudi Arabia, where 57.5% of ED visits were made between 3 and 11 PM [25]. Another study conducted in the US found that the arrival rate in the ED increased sharply starting from late morning, after which it peaked at midday and then remained high until 10 PM [26]. A study was carried out in Korea to assess the emergency department visit volume variability. The study came up with a bimodal representation of the hourly visit volume, with peaks at 10:00 to 11:00 and 20:00 to 21:00. The visits were minimal between 2 AM and 8 AM [27].

In our study, the most common complaints among patients with single complaints were loin pain and decreased levels of consciousness, constituting 9.3% each in the total number of single complaints. This is in contrast with the findings of Bellolio et al., where headache and abdominal pain were the most common causes of the demand for a CT scan [18]. This, however, is comparable with the most common complaints among the patients with multiple complaints in our study: dizziness/vertigo (32.1%), headache (25.9%), and vomiting (23.3%). Hess et al. reported the most common diagnostic categories to be lower respiratory disease, abdominal pain, and headache [20]. Similarly, the top three common complaints reported by Larson et al. were abdominal pain, headache, and chest pain [10].

Our study found significant associations between sex, age, single complaints, and multiple complaints. Women were more likely to present with shortness of breath alone, whereas men were more likely to present with all the other categories, most prominently, loin pain, RTA, flank pain, trauma, and seizures.

Regarding patients presenting with multiple complaints, a greater number of women presented with abdominal pain and dysuria/oliguria than did males. Moreover, our study found a significant association between the date of CT and single complaints; flank pain and RTA were mostly presented in Q1 (44.7%) and Q2 (35.5%), respectively.

Our study faced the common limitations of retrospective studies, including a recording bias. In addition, there is a lack of literature on the subject within the Kingdom. Furthermore, our study lacks data on the nationalities and socioeconomic characteristics of the target population, which could contribute to the study's overall results. In our research, not all the patients (1628/6858) presented with written causes of request for CT. Moreover, our results were limited to the department from which the data

were collected and can hardly be generalized. Thus, we encourage further studies in the Kingdom to obtain more generalizable results and significant data.

CONCLUSIONS

Our study included 6858 patients who underwent CT scan in the ED of KFSH. The Head and neck regions were found to be the highest anatomical region requested, and brain CT was the most common type required. Significant associations were found between CT type and sex, age, time and date. Only 1628 CT requests had a written cause, of which 1254 were single complaints, 374 were multiple complaints. Significant associations were observed between complaints, age, sex, and date of CT request in patients with single complaints.

Better documentation with the cause of request specification and more significant researches conduction at a national level is required for accurate assessment and to ensure the best utilization of CT and avoidance of overutilization and its associated risks.

FUNDING

None.

CONFLICT OF INTEREST

No conflict of interest to declare.

ETHICAL APPROVAL

Regional Research Ethics Committee - Qassim region, approval number:1441-1383497, date 02/03/2020.

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