

RADIOLOGY RESIDENTS EXPERIENCE WITH CT BRAIN PERFUSION: REGIONAL CROSS-SECTIONAL STUDY IN SAUDI ARABIA



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ABSTRACT

Background:

CT brain perfusion (CTP) is the gold standard for ischemic penumbra detection. Residents should be confident to report CTP by the end of their training. Our informal observation led us to question whether residents are encountering enough cases to become confident in reporting them.

Objectives:

To determine the level of confidence of radiology residents in a regional study and to identify the factors affecting their confidence.

Materials and methods:

Direct communication with radiology residents at the western region of Saudi Arabia to complete an online survey describing their experience with CTP and their level of confidence in reporting these cases.

Results:

One hundred and nine out of 224 residents participated in the study within the study period. 49 (45%) residents did not encounter CTP during their neuroradiology rotation (45%) nor their on-calls (53%). Sixty (55%) residents encountered at least one CTP during their neuroradiology rotation (55%) and during on-calls (47%), only half of them (55%) reported the cases while the rest only observed. Overall, 60% of residents were not confident in reporting CTP independently and majority (93%) believe they would benefit from a dedicated teaching on stroke imaging. Confidence to independently report CTP during on-calls was significantly higher among residents who received their primary training in Jeddah (51.4%) compared to other regions. This self-reported confidence increased significantly with the increased average number of CTPs reported per one rotation and per on-call.

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Conclusion:

Half of the residents do not feel confident reporting CTPs when less than 10 CTPs are encountered during their neuroradiology rotation or on-calls.

1. INTRODUCTION:

Computed Tomography (CT) brain perfusion is a CT technique that enables quick qualitative and quantitative evaluation of cerebral perfusion such as cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT). The primary use of CTP is to identify the ischemic penumbra amenable to reperfusion treatment [1]. It is considered the gold standard for penumbra detection due to its minimal patient risk and prompt ability for acquiring data either quantitatively (numerical values) or qualitatively [2].

Previous studies have measured the interval for radiology residents in CTP processing and interpretation [3]. However, no previous studies have evaluated the confidence level among radiology residents either globally or locally in interpreting CTP. Therefore, the aim of this study is to determine the confidence level of CTP interpretation by the radiology residents in the Western region of the radiology residency program at Saudi Arabia.

2. MATERIALS AND METHODS:

2.1 Study design and settings:

This cross-sectional study was conducted at King Abdulaziz University Hospital (KAUH) in Jeddah, Saudi Arabia, from August to September 2022. The study obtained approval by the Institutional Review Board (IRB) of KAUH (reference number 393-22).

2.2 Subjects and data collection:

A web-based electronic survey, using Google Forms (Appendix 1), was created and validated then sent via emails and direct text messages to all radiology residents at the western region on August 17, 2022. The survey remained open for 2 weeks, until August 31, 2022. The online survey platform was designed to only allow one response per participant, in order to maximize survey integrity. Consent was implied.

Data received from residents outside the Western region and those who completed the electronic survey after the timeframe were excluded.

The data collected include demographics (such as age and gender), residency year, range of encountered number of cases during one neuroradiology rotation and during on-calls, range of number of cases reported or observed, confidence in reporting, and awareness of pitfalls and limitations of CTP.

2.3 Statistical Analysis:

Statistical analysis was carried out using RStudio (R version 4.1.1). Categorical data was expressed as frequencies or percentages. The internal consistency of different domains was investigated using the Cronbach's alpha test. Factors associated with confidence to report CT brain perfusing and the variation in confidence based on the training center were explored using a Pearson's Chi-squared test or a Fisher's exact test, whenever applicable. The significantly associated variables from the association analysis were used as independent variables in a multivariate logistic regression model to assess the independent associations. The outcomes were expressed as odds ratio (OR) and 95% confidence intervals (95% CIs).

3. RESULTS:

3.1 Demographic and occupational characteristics

At the time of the study, out of all 224 radiology residents in the Western radiology residency program, we received 109 responses. Approximately a half of them were females (51.4%) and aged 30 to 34 years (48.6%). About two thirds of the residents were in their second and fourth year of training (33.9% and 32.1%, respectively). The primary centers of training were primarily located in Jeddah (64.2%, [Table 1](#)), and these included King Abdulaziz University Hospital (14.7%), King Abdulaziz Medical City for National Guard (11.9%) and King Fahad General Hospital (11.0%, [Figure 1](#)). Notably, 1 to 3 full-time neuroradiology consultants were working at the primary centers as indicated by 61.5% of the participants. The majority of residents (89.9%) had a SCHS-credited neuroradiology rotation at the primary center ([Table 1](#)).

3.2 Reliability analysis

We assessed the internal consistency of two domains, including residents' practices and experiences of CTP (four items) and participants' awareness of CTP limitations and confidence in independently reporting CTPs during the on-calls (two items). Results indicated that both the domains were reliable (Cronbach's alpha = 0.890 and 0.743, respectively).

Table 1 Demographic and occupational characteristics.

Parameter	Category	N (%)
Gender	Male	53 (48.6%)
	Female	56 (51.4%)
Age	24 to 26	27 (24.8%)
	27 to 30	29 (26.6%)
	30 to 34	53 (48.6%)
Year of residency	First year	25 (22.9%)
	Second year	37 (33.9%)
	Third year	35 (32.1%)
	Fourth year	12 (11.0%)
City	Jeddah	70 (64.2%)
	Madinah	11 (10.1%)
	Makkah	20 (18.3%)
	Taif	8 (7.3%)
	None	5 (4.6%)
Number of full-time neuroradiology consultants	None	5 (4.6%)
	1 to 3	67 (61.5%)
	4 to 6	34 (31.2%)
	7 or more	3 (2.8%)
Have a SCHS-accredited neuroradiology rotation at the primary center	Yes	98 (89.9%)

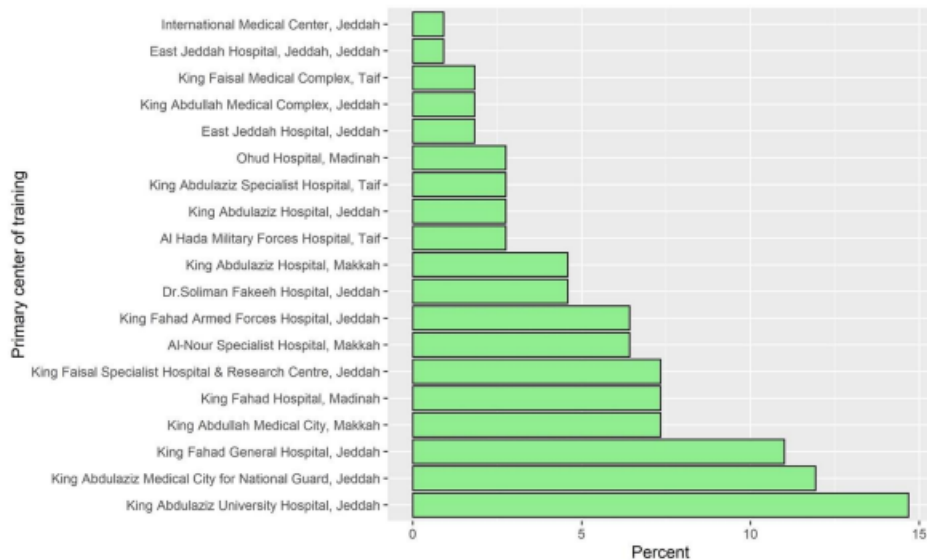


Figure 1 The percentages of primary centers of training.

3.3 Practices and experiences of CT brain perfusion

About half of the residents did not encounter CT brain perfusions in their neuroradiology rotation (45.0%) nor during the on-call (53.3%) (Table 2).

Table 2 Practices and experiences of CT brain perfusion

Parameter	Category	N (%)
Average number of the encountered CT brain perfusions in a neuroradiology rotation (number per one rotation)	None	49 (45.0%)
	1 to 5	25 (22.9%)
	6 to 10	16 (14.7%)
	>10	19 (17.4%)
Average number of the encountered CT brain perfusions during the on-call (number per one on-call)*	None	49 (53.3%)
	1 to 5	38 (41.3%)
	6 to 10	1 (1.1%)
	>10	4 (4.3%)
The number of observed cases*	None	53 (48.6%)
	1 to 5	28 (25.7%)
	6 to 10	6 (5.5%)
	>10	22 (20.2%)
The number of reported cases*	None	49 (45.0%)
	1 to 5	29 (26.6%)
	6 to 10	8 (7.3%)
	>10	23 (21.1%)

*the variable had 17 missing records.

3.4 Awareness of limitations and confidence in reporting

Awareness of CTP pitfalls and limitations was apparent among 49 residents (45.0%, Figure 2A). Additionally, only 43 of the residents (39.5%) were confident to report CT brain perfusion independently during the on-call (Figure 2B). The majority of residents (92.7%) believe they will benefit from a dedicated teaching module for stroke imaging including CT brain perfusion interpretation (Figure 2C).

3.5 Difference in awareness and confidence based on encountering CT brain perfusions

Results of the association analysis showed that residents who encountered CTP during their rotations or on-calls were significantly aware of its limitation and more confident to report them compared to those who did not (68.1% vs 27.4%, respectively, $p < 0.001$ for the awareness of limitations and 68.1% vs 17.7%, respectively, $p < 0.001$ for confidence to report independently during on-calls, Table 3).

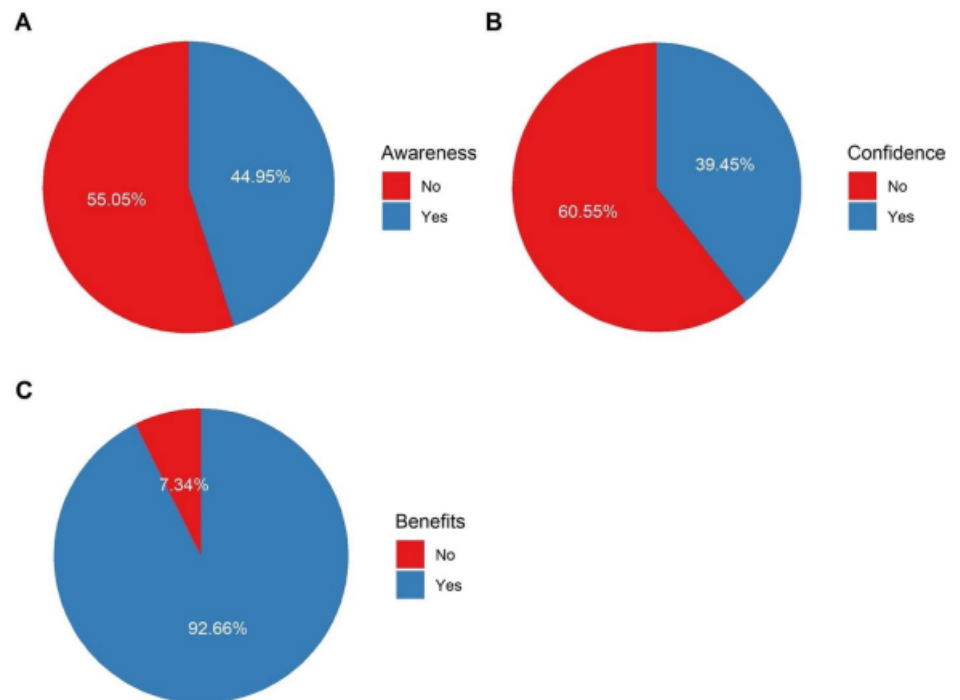


Figure 2 The proportions of residents' awareness of CTP limitations (A), confidence in independent reporting (B) and those who would benefits from a dedicated teaching module for stroke imaging.

3.6 Factors associated with confidence to report CT brain perfusion during the on-call

Confidence to independently report CTP during on-calls was significantly higher among residents who received their primary training in Jeddah (51.4%) compared to other regions, including Madinah (27.3%), Makkah (15.0%) and Taif (12.5%, $p = 0.005$). Furthermore, this self-reported confidence increased significantly with the increased average number of CTPs reported per one rotation (14.3% for no reported CTPs, 48.0% for 1 to 5 reported CTPs, 56.2% for 6 to 10 reported CTPs and 78.9% for > 10 reported CTPs, $p < 0.001$) and per one on-call (12.2% for no reported CTPs, 55.3% for 1 to 5 perfusions, 100.0% for 6 to 10 reported CTPs and 50.0% for > 10 reported CTPs, $p < 0.001$). Unsurprisingly, residents' confidence in reporting CTPs independently also increased consistently with more observed and reported cases (Tables 3 and 4).

Table 3 Factors associated with confidence to report CT brain perfusion during the on-call.

Parameter	Category	Confidence		p-value
		No, N = 66	Yes, N = 43	
Gender	Male	31 (58.5%)	22 (41.5%)	0.669
	Female	35 (62.5%)	21 (37.5%)	
Age	24 to 26	17 (63.0%)	10 (37.0%)	0.278
	27 to 30	14 (48.3%)	15 (51.7%)	
	30 to 34	35 (66.0%)	18 (34.0%)	
Year of residency	First year	15 (60.0%)	10 (40.0%)	0.221
	Second year	25 (67.6%)	12 (32.4%)	
	Third year	22 (62.9%)	13 (37.1%)	
	Fourth year	4 (33.3%)	8 (66.7%)	
City	Jeddah	34 (48.6%)	36 (51.4%)	0.005
	Madinah	8 (72.7%)	3 (27.3%)	
	Makkah	17 (85.0%)	3 (15.0%)	
	Taif	7 (87.5%)	1 (12.5%)	
Number of full-time neuroradiology consultants	None	5 (100.0%)	0 (0.0%)	0.321
	1 to 3	40 (59.7%)	27 (40.3%)	
	4 to 6	19 (55.9%)	15 (44.1%)	
	7 or more	2 (66.7%)	1 (33.3%)	
	Have a SCHS-accredited neuroradiology rotation at the primary center	Yes	58 (59.2%)	
Average number of CT brain perfusions per one rotation	None	42 (85.7%)	7 (14.3%)	<0.001
	1 to 5	13 (52.0%)	12 (48.0%)	
	6 to 10	7 (43.8%)	9 (56.2%)	
	>10	4 (21.1%)	15 (78.9%)	
Average number of CT brain perfusions per one on-call	None	43 (87.8%)	6 (12.2%)	<0.001
	1 to 5	17 (44.7%)	21 (55.3%)	
	6 to 10	0 (0.0%)	1 (100.0%)	
	>10	2 (50.0%)	2 (50.0%)	
Number of observed cases	None	46 (86.8%)	7 (13.2%)	<0.001
	1 to 5	15 (53.6%)	13 (46.4%)	
	6 to 10	2 (33.3%)	4 (66.7%)	
	>10	3 (13.6%)	19 (86.4%)	
	Number of reported cases	None	45 (91.8%)	
1 to 5	15 (51.7%)	14 (48.3%)		
6 to 10	2 (25.0%)	6 (75.0%)		
>10	4 (17.4%)	19 (82.6%)		

Table 4 Location-based differences in the occupational characteristics of residents.

Parameter	Category	Training center in Jeddah		p-value
		No, N = 39	Yes, N = 70	
Number of full-time neuroradiology consultants	None	4 (10.3%)	1 (1.4%)	0.091
	1 to 3	23 (59.0%)	44 (62.9%)	
	4 to 6	10 (25.6%)	24 (34.3%)	
	7 or more	2 (5.1%)	1 (1.4%)	
Have a SCHS-credited neuroradiology rotation at the primary center	Yes	33 (84.6%)	65 (92.9%)	0.196
Average number of CT brain perfusions per one rotation	None	31 (79.5%)	18 (25.7%)	<0.001
	1 to 10	4 (10.3%)	37 (52.9%)	
	>10	4 (10.3%)	15 (21.4%)	
Average number of CT brain perfusions per one on-call	None	32 (82.1%)	17 (24.3%)	<0.001
	1 to 10	5 (12.8%)	34 (48.6%)	
	>10	2 (5.1%)	2 (2.9%)	

4. DISCUSSION:

Stroke is the second most common cause of mortality and the third leading cause of morbidity worldwide [4]. Ischemic strokes account for about 90% of all stroke cases [5]. In the Kingdom of Saudi Arabia (KSA), prevalence of stroke is estimated to be 43.8 per 100,000 [6]. Stroke mortality and dependency showed to be 19% and 48% respectively; establishing a burden to the patient, patient's family, and the healthcare facilities [7]. The latest 2018 American Heart Association (AHA) stroke guidelines recommends CT perfusion (CTP) or MR perfusion imaging 6-24 hours after the onset of stroke symptoms [1] as early detection of patients who present with hyperacute stroke may benefit from early intravenous (IV) and/or intra-arterial thrombolytic treatment such as recombinant tissue plasminogen activator (rtPA) [8].

CTP enables quick qualitative and quantitative evaluation of cerebral perfusion such as cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT). It has the ability to distinguish between permanently injured brain tissue from reversibly compromised brain tissue (penumbra) [9]. The primary use of CTP is to identify the ischemic penumbra amenable to reperfusion treatment [1].

CTP for the past several years has been gaining increasing recognition in the clinical settings for evaluating patients with cerebrovascular diseases (CVD), especially due to its widespread availability in the radiology departments compared to other imaging modalities such as MRI [9]. In addition, CTP is the gold standard for penumbra detection is

CTP due to its minimal patient risk and prompt ability for acquiescing data either quantitatively (numerical values) or qualitatively [2]. Nonetheless, CTP demonstrate several disadvantages, most notably the use of ionizing radiation and iodinated contrast material, which is contraindicated in patients who had a previous allergic reaction and impaired renal function [1, 2, 10].

Confidence level in reporting radiological studies was previously explored in previous studies. Bedayat, et al. looked into the confidence level of reporting acute pulmonary embolism on CT pulmonary angiogram (CTPE) by assessing the final reports of these studies and clinical outcome. They found overall low percentage (10%) of uncertainty in CTPE reports and the reports with low confidence did not have significant impact on clinical course or outcome [11]. Carney et al. studied the level of confidence of radiologist in reporting sets of screening mammograms in relation to time spent in interpretation and accuracy. They found that the level of confidence increased with more time spent on the study, however, it is also associated with higher false positive reporting [12]. Limited data available on the level of confidence of radiology residents in reporting or performing radiological studies during their training. Bateni et al. assessed the level of confidence of radiology residents in pediatric intussusception reduction procedure in relation to number of encountered cases during their training across multiple centers and identified lack of confidence due to limited opportunity to encounter such cases and suggested a computer simulation model to address this issue [13].

The radiology residency training program in Saudi Arabia is a four-year training program comprised of 13 blocks of rotations. One of the core rotations is neuroradiology rotation. Residents are required to have their neuroradiology rotation in centers where these rotations are accredited by the Saudi Commission for Health Specialties (SCFHS).

Our findings showed that there is clear difference in the number of accredited training centers in Jeddah compared to other cities which also reflects on the number of encountered CTPs during the rotation and on-calls. Notably, those trained in Jeddah were more confident in reporting CTPs during on-calls which again can be explained by the significant difference in number of cases encountered during the rotation and on-call (Table 4). However, the confidence in reporting CTPs independently is low overall for all trainees with almost half of the residents do not feel confident when less than 10 CTPs are encountered in one rotation or during on-calls. This low number of encountered CTPs should be explored in future investigations.

No significant difference in confidence level found between trainees in relation to their level of training. However, the number of responses from fourth year trainees was only 11% (Table 1). This response rate can be explained by them being busy preparing for their board exam at the time of the survey. The decision to distribute the surveys at the end of

the academic year is based on the suggestion made by previous study [12].

Several limitations noted in our study. The total number of residents at the time of conducting the study was 224 residents. We assumed that 50% of residents would be confident to report CTPs. Considering a confidence interval of 95%, a margin of error at 5%, the sample size was estimated at 142 residents. Sample size calculation was performed using the online Raosoft calculator. Therefore, our sample size was under representative due to poor response or limited reach to residents. One way to improve this is to have incentives for the residents to participate. The answers in the survey are subjective and self-reported. Assessment of residents with higher self-reported confidence in reporting CTPs would have more reliable data to drive future improvements. However, this would need larger coordination between multiple centers in planning and financial support. There is clear discrepancy in the data collected from residents training in Jeddah compared to other cities, this is likely due to the majority of training accredited centers are located in Jeddah therefore more responses are expected from there. This would also contribute to the differences that were clearly illustrated in (Table 4).

5. CONCLUSION:

The study showed that the significantly higher number of CTPs encountered during the rotation and on-calls accounts for the higher self-reported confidence in reporting them. However, half of the residents do not feel confident reporting CTPs when less than 10 CTPs are encountered during their neuroradiology rotation or on-calls. One way to mitigate this deficiency is to have a well curated teaching module on stroke imaging followed by objective assessment. More collaborative work is needed in this regard to have a representative sample for future research.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

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Non

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