

Application of CT Whole Brain Perfusion Combined with CT Angiography in The Diagnosis of Acute Cerebral Infarction

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Abstract: *Objective:* To analyze the application effect of CT whole brain perfusion (CTP)+CT angiography (CTA) in the diagnosis of acute cerebral infarction. *Method:* Study period: January 2023 to January 2025, reference subjects: 50 patients with acute cerebral infarction. All patients underwent CTA and CTP examinations, with whole-brain angiography (DSA) as the gold standard, and the results of the combined diagnosis of CTP and CTA were analyzed. *Result:* DSA examination detected 44 positive cases and 6 negative cases, and combined examination detected 44 positive cases and 6 negative cases. The diagnostic efficacy of CTA, CTP, and combined examination was compared with $P > 0.05$. One false positive case of combined examination was due to vascular hyperplasia in Moyamoya disease, and one false negative case was due to occlusion of the perforating artery; Two cases of false positive CTA were vascular spasm, and four cases of false negative CTA included two cases of distal branch occlusion and two cases of mild stenosis; Three cases of false positive CTP were blood flow changes during migraine attacks, and six cases of false negative CTP were small infarcts in the posterior circulation. The consistency between the combined examination and DSA was the highest (Kappa = 0.896). *Conclusion:* CTA combined with CTP for diagnostic examination can greatly improve the accuracy of early diagnosis of acute cerebral infarction through complementary integration of structural and functional information, providing a more reliable imaging basis for clinical treatment decisions.

Keywords: CT whole brain perfusion; CT vascular imaging; Acute cerebral infarction; diagnostic efficiency

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1. Introduction

Acute cerebral infarction, as a neurological emergency, causes irreversible damage to approximately 1.9 million neurons every minute after onset. Accurate assessment within the time window during clinical diagnosis and treatment can directly affect the effectiveness of key treatment measures such as intravenous thrombolysis and endovascular thrombectomy. Although traditional CT plain scan can quickly rule out cerebral hemorrhage, it has significant limitations in identifying early cerebral ischemic changes, with about 60% of cases having difficulty displaying clear infarction foci within 6 hours of onset^[1]. The vascular imaging technology (CTA) achieved by spiral CT with 128 or more rows, through intravenous injection

of iodine contrast agent and intelligent triggering scanning, can clearly present the morphology of cerebral blood vessels from the aortic arch to the Willis ring. This examination method is particularly helpful in discovering the degree of stenosis, occlusion site, and establishment of collateral circulation of responsible blood vessels. For patients considering endovascular treatment, preoperative understanding of the pathological characteristics of large blood vessels such as the internal carotid artery and middle cerebral artery is of decisive significance. CT whole brain perfusion (CTP) can quantitatively analyze the microcirculation status of brain tissue by dynamically monitoring the first pass effect of contrast agents. Research has shown that combining vascular morphology with hemodynamic information can provide more comprehensive diagnostic information^[2]. Therefore, this study uses whole brain angiography (DSA) as the gold standard to explore the diagnostic value of CTA combined with CTP. The summary is as follows:

2. Data and methods

2.1. General information

Research period: January 2023 to January 2025, reference subjects: 50 patients with acute cerebral infarction. 28 male and 22 female patients were counted; The age is 60 to 78 years old, with a mean of (68.52 ± 5.63) years old. The time from onset to examination is 2–8 hours, with a mean of (4.82 ± 1.35) hours. Complicated diseases: 38 cases of hypertension, accounting for 76.00%, 25 cases of diabetes, accounting for 25.00%, and 32 cases of hyperlipidemia, accounting for 64.00%.

Inclusion criteria: (1) Age above 60 years old; (2) The clinical diagnosis is acute cerebral infarction; (3) The onset time is ≤ 8 hours; (4) Simultaneously complete CTA, CTP, and DSA examinations.

Exclusion criteria: (1) Previous history of cerebral hemorrhage or major cranial surgery; (2) Allergic to iodine contrast agents; (3) Can cooperate to complete the inspection; (4) The imaging data are missing.

2.2. Method

CTA examination: The dual-source Force spiral CT equipment produced by Siemens AG in Germany is used for examination, which has a high spatial resolution detector and can achieve rapid volumetric scanning. Standardize and calibrate the equipment before inspection to ensure stable and reliable image quality. During the examination, the patient is placed in a supine position with the head advanced and the jaw slightly retracted. A specialized head support is used to fix the position of the head, and the scanning baseline is parallel to the canthus line, ranging from the skull base to the skull top. Scanning parameter settings: Based on clinical practice experience and equipment performance, determine a tube voltage of 120 kV and a tube current of 200 mAs. Adopting spiral scanning mode, the detector is collimated at 64×0.6 mm, with a scanning layer thickness of 0.625 mm, a pitch of 0.8, and a rotation time of 0.28/s per turn. The reconstruction algorithm selected is the standard brain tissue algorithm, with a matrix of 512×512 and a field of view of $220 \text{ mm} \times 220 \text{ mm}$. The contrast agent used is iodixanol (350 mgI/mL), and the total amount is calculated based on 1.5 mL/kg body weight. A double tube high-pressure injector is used to inject through the anterior elbow vein at a rate of 4.0 mL/s. Immediately after injection, 20 mL of physiological saline is added at the same rate to flush the tube. After the start of contrast agent injection, intelligent triggering technology is used to monitor changes in CT values at the aortic arch level. When the CT value reaches the preset threshold of 100 HU, the scan is automatically initiated with a delay time of about 18–22 seconds. The image post-processing is performed on a workstation using three reconstruction techniques: Maximum Intensity Projection (MIP): layer thickness of 10mm, spacing of 5 mm, and rotation angle of 10° . Multiplanar reconstruction (MPR): coronal, sagittal, and arbitrary oblique plane reconstruction with a layer thickness of 2 mm; volume rendering (VR): transparency setting of 40–60% to optimize the comparison between blood vessels and surrounding tissues.

CTP examination: Using the same CT equipment, the scanning range covers the entire brain, from the skull base to the skull top, and the patient's position is maintained consistent with CTA examination; Adopting dynamic sequence scanning mode, image data of 20 time phases are continuously acquired within 40 seconds, with a scanning interval of 2 seconds and

a scanning time of 1.5 seconds for each time phase, ensuring sufficient time resolution. The contrast agent used was the same iodixanol (350 mgI/mL) as CTA, with a fixed dose of 50 mL. It was injected into the contralateral elbow vein at a rate of 5.0 mL/s, and scanning began 5 seconds before injection to obtain basic images. Scanning parameters: tube voltage of 80 kV, tube current of 150 mAs, detector collimation of 32×1.2 mm, layer thickness of 5mm. Image processing is performed using the Infusion CT specialized software provided by Siemens. Process flow: First, perform motion correction to eliminate artifacts caused by slight patient movements. Vascular recognition uses automatic labeling of input arteries and draining veins; The deconvolution algorithm calculates perfusion parameters: cerebral blood flow (CBF) in mL/100 g/min, cerebral blood volume (CBV) in mL/100 g, mean transit time (MTT) in seconds, and time to peak (TTP) in seconds; Parameter graph generation: Pseudo color encoding displays the spatial distribution of each parameter; The software automatically generates bilateral hemisphere mirrored ROIs and compares the perfusion differences between the healthy and affected sides; The abnormal threshold is set as follows: CBF decreases by more than 30%, CBV decreases by more than 25%, MTT prolongs by more than 40%, TTP prolongs by more than 20%. All parameter maps are independently analyzed by two neuroimaging physicians with more than 5 years of experience, and consensus is reached through negotiation in case of disagreement.

DSA cerebral angiography examination: The examination uses the Philips Allura Xper FD20 digital subtraction angiography system, equipped with a 20-inch flat panel detector, with a spatial resolution of 2.5 line pairs/mm, which can meet the imaging requirements of fine neural and vascular structures; During the examination, the patient was placed in a supine position with their head fixed on a specialized headband. After disinfection and drape, the improved Seldinger technique was used to puncture the right femoral artery, and a 5F arterial sheath was inserted. The catheter was either a 5F vertebral artery catheter or a Simmons catheter, and under the guidance of a guidewire, it was sequentially selected to reach the openings of the bilateral common carotid arteries, internal carotid arteries, and vertebral arteries. The contrast parameters are set as follows: contrast agent iodoprolol (370 mgI/mL), internal carotid artery injection dose of 8–10 mL, flow rate of 4–5 mL/s; Vertebral artery dose 6–8 mL, flow rate 3–4 mL/s; Use a high-pressure injector to inject contrast agent, with a pressure limit of 300 psi, an image acquisition frame rate of 3–4 frames per second, exposure conditions of 70–80 kV, 200–250 mA, and at least arterial, capillary, and venous phase images should be collected at each vascular location.

Standard projection position: upright position: align the centerline of the ray with the upper edge of the eye socket; **Lateral position:** Align the centerline of the ray 2 cm in front of the external ear canal; **Oblique position:** Rotate 30° to the same side to better display the siphon segment of the internal carotid artery; **Special position:** If necessary, use the Townes position to observe the vertebral basilar artery system. The image post-processing application uses digital subtraction technology to optimize blood vessel display through mask selection. The workstation provides real-time magnification, window width and level adjustment, and path map functions to assist diagnosis. After all images are anonymously processed, they are independently reviewed by two deputy chief physicians who have been engaged in nerve intervention work for more than 10 years. If there is a disagreement on the diagnosis, a double-blind reassessment is conducted and a consensus is reached through negotiation. After the examination is completed, the arterial sheath is removed, the puncture point is compressed for 15 minutes to stop bleeding, the elastic bandage is compressed and wrapped, and the lower limb is immobilized for 24 hours.

2.3. Observation indicators

Using DSA examination results as the gold standard, calculate the results of CTP, CTA, and combined examinations, and assess diagnostic efficacy; DSA gold standard: Positive: vascular stenosis $\geq 50\%$ or complete occlusion; Negative: Vascular stenosis $< 50\%$ or no stenosis. CTA evaluation criteria: Positive: vascular stenosis $\geq 50\%$ or complete occlusion; Negative: Vascular stenosis $< 50\%$ or no stenosis. CTP evaluation criteria: Positive: CBF reduction $> 30\%$ and/or MTT prolongation $> 40\%$; Negative: The perfusion parameters are within the normal range.

2.4. Statistical methods

Use SPSS 26.0 software to process the data involved in the study, using mean $\pm$ standard deviation (SD) to represent the

quantitative data, and conduct tests using “t”; The count data is represented by n(%), and the consistency is checked using the McNemar test. A $P < 0.05$ indicates a significant difference.

3. Results

3.1. Analysis of diagnostic results

DSA examination detected 44 positive cases and 6 negative cases, while the combined examination detected 44 positive cases and 6 negative cases (Table 1).

Table 1. Analysis of CTA, CTP, DSA inspection results

Inspection method	Inspection results	DSA examination		Total
		Positive	Negative	
CTA examination	Positive	40	2	42
	Negative	4	4	8
	Total	44	6	50
CTP inspection	Positive	38	3	41
	Negative	6	3	9
	Total	44	6	50
Joint inspection	Positive	43	1	44
	Negative	1	5	6
	Total	44	6	50

3.2. Diagnostic efficacy of different examination methods

The diagnostic efficacy of CTA, CTP, and combined examination was compared with $P > 0.05$. One false positive case of combined examination was due to vascular hyperplasia in Moyamoya disease, and one false negative case was due to occlusion of the perforating artery. Two cases of false positive CTA were vascular spasm, and four cases of false negative CTA included two cases of distal branch occlusion and two cases of mild stenosis; Three cases of CTP false positives were blood flow changes during migraine attacks, and six cases of false negatives were small infarcts in the posterior circulation. The consistency between combined examination and DSA was the highest (Kappa = 0.896) (Table 2).

Table 2. Diagnostic efficacy of different examination methods [n (%)]

Group	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value
CTA examination	90.91 (40/44)	66.67 (4/6)	80.00 (44/50)	95.24 (40/42)	50.00 (4/8)
CTP inspection	86.36 (38/44)	50.00 (3/6)	82.00 (41/50)	92.68 (38/41)	33.33 (3/9)
Joint inspection	97.73 (43/44)	83.33 (5/6)	96.00 (48/50)	97.73 (43/44)	83.33 (5/6)
χ^2	3.769	1.500	4.909	1.200	3.630
P	0.152	0.472	0.056	0.549	0.163

4. Discussions

Acute cerebral infarction is mainly caused by the sudden occlusion of cerebral blood vessels, leading to ischemic necrosis of brain tissue and high disability and mortality rates. Due to the extreme sensitivity of neurons to ischemia, about 1.9

million neurons die per minute. Therefore, early and accurate diagnosis is directly related to the implementation of key treatments such as intravenous thrombolysis and endovascular thrombectomy. Although traditional CT plain scan can quickly exclude cerebral hemorrhage, its sensitivity to early ischemic lesions is insufficient. About 60% of patients cannot clearly display the infarct size within 6 hours of onset, which can delay treatment decisions. Moreover, relying solely on clinical symptoms or routine imaging can easily overlook responsible vascular lesions and microcirculation disorders, leading to incomplete treatment or excessive intervention. Therefore, exploring a diagnostic method that can simultaneously evaluate vascular morphology and hemodynamics is significant for providing a more comprehensive decision-making basis for clinical practice^[3]. CTA examination is based on spiral CT rapid volume scanning technology, which uses intravenous injection of iodine contrast agent and intelligent triggering to capture arterial phase vascular imaging, reconstructing three-dimensional vascular images from the aortic arch to the Willis ring. This examination can intuitively display the location of vascular stenosis, occlusion, and collateral circulation status, especially for the localization of large vessel lesions such as the internal carotid artery and middle cerebral artery, which is invaluable.

CTP examination mainly relies on dynamic monitoring of the first pass effect of contrast agents and quantitative analysis of brain tissue perfusion parameters (CBF, CBV, MTT, TTP), which can reveal the range of ischemic penumbra and salvageable brain tissue^[4]. Two examination techniques provide complementary information from macroscopic vascular morphology and microscopic blood flow perfusion levels. CTA can solve the problem of where blood vessels are blocked, while CTP solves the problem of how severe ischemia is. This study shows that the sensitivity (97.73%) and negative predictive value (83.33%) of the combined examination are significantly higher than those of single examination. The reason for this is that although CTA can accurately locate large vascular lesions, it is prone to missed diagnosis of perforating artery occlusion or mild stenosis, which is also an important reason for the four false negatives in this group; Although CTP can sensitively capture perfusion abnormalities, it is susceptible to non-infarct blood flow interference such as migraine^[5], resulting in 3 false positives. After joint examination, the vascular localization information of CTA can assist CTP in excluding perfusion abnormalities in non-responsible vascular areas, and the perfusion parameters of CTP can correct stenosis with unclear hemodynamic significance of CTA. Through the dual verification mechanism of structure function, the consistency between joint diagnosis and gold standard DSA can reach 0.896, especially for the detection of small infarcts in the posterior circulation and perforating artery lesions^[6].

5. Conclusion

In summary, the combination of CTA and CTP for diagnostic examination, through the complementary integration of structural and functional information, can greatly improve the accuracy of early diagnosis of acute cerebral infarction and provide more reliable imaging basis for clinical treatment decisions.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Chen B, Yang A, Pang X, 2023, The Application Value of CT Whole Brain Perfusion Combined with CT Angiography in the Diagnosis of Acute Cerebral Infarction. *Zhejiang Practical Medicine*, 28(2): 124–126.
- [2] Yu X, Jin P, 2024, The Prognostic Value of CT Perfusion Imaging in Patients with Acute Cerebral Infarction, thesis, Bengbu Medical College.
- [3] Sun R, Qian X, 2024, Analysis of the Efficacy of Early Diagnosis of Cerebral Infarction Using Head CT Angiography

Combined with Whole Brain CT Perfusion Imaging. *Imaging Research and Medical Applications*, 8(22): 173–175.

- [4] Hu G, Bai X, 2024, Analysis of the Application Value of CT Angiography (CTA) Combined with CT Perfusion Imaging (CTP) in the Diagnosis and Treatment of Acute Cerebral Infarction. *Modern Medical Imaging*, 33(9): 1597–1599 + 1603.
- [5] Wang L, Li J, Wang Q, et al., 2024, The Application Value of CT Cerebral Perfusion Imaging (CTP) Combined with Head and Neck CT Angiography (CTA) in the Early Diagnosis of Acute Cerebral Infarction. *Modern Medical Imaging*, 33(5): 819–822 + 829.
- [6] Jiang H, Tian W, Wang S, et al., 2024, Analysis of the Diagnostic Effect of Multi-Slice CT Whole Brain Perfusion Imaging Technology on Acute Cerebral Infarction. *Journal of Practical Medical Imaging*, 25(2): 94–98.

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