Neurologic Applications of Whole-Brain Volumetric Multidetector Computed Tomography

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KEYWORDS

• 320-detector row CT scanner • CT perfusion • 4D-CTA • Carotid occlusion
• Cerebrovascular reserve

KEY POINTS

- Imaging with 320-slice volumetric multimodal computed tomography (CT) is able to visualize dynamic changes in the blood flow of the entire brain because of its 16-cm z-axis coverage.
- Whole-brain perfusion allows direct visualization of the posterior circulation (brainstem, cerebellum) as well as anatomic areas close to the vertex (distal anterior cerebral artery territories).
- Dynamic four-dimensional CT angiography combines whole-brain CT perfusion with time-resolved three-dimensional angiography and can differentiate between anterograde flow in cases with a partially occluded artery versus retrograde collateral flow.
- Dynamic CT angiography can assist in differentiating between extracranial chronic internal carotid occlusion versus acute pseudo-occlusion.
- Combining CT perfusion with acetazolamide challenge provides a powerful insight into the brain's hemodynamic status by evaluating its cerebrovascular reserve.

INTRODUCTION

The introduction of computed tomography (CT) scanning in 1973 as a clinical tool revolutionized the way in which neurologists and neurosurgeons could diagnose

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and treat ischemic stroke, hemorrhagic stroke, and other causes of stroke syndrome. However, early scanners were slow, requiring several minutes for a single tomographic slice, were associated with a high radiation dose, and had prominent susceptibility to metallic artifacts. Several methods to reduce radiation dose were developed and are listed in **Table 1** and shown graphically in **Fig. 1**. Metal artifact can be reduced by several means, as listed in **Table 2**. This suppression of metallic artifact is particularly helpful in visualizing flow within vessels previously treated with metallic stents and coil material. Several technological advances have significantly reduced scan time and are listed in **Table 3**. Key developments in this regard include slip ring gantry and multidetector technology. A recently developed 320-slice (detector) CT scanner acquires a thin-slice volumetric study of the whole brain in less than a second. The introduction of whole-brain volumetric multimodal CT scanners has given clinicians a powerful tool to visualize dynamic changes in hemodynamic parameters of the brain and its vasculature. This information can be used to manage patients with acute ischemic stroke caused by large vessel arterial occlusion and assess hemodynamic reserve, and it plays an important role in the evaluation of patients with other neurologic conditions, such as moyamoya disease, venous sinus thrombosis, or arteriovenous malformations. This new CT technology fundamentally changes the way treatment options for certain cerebrovascular disorders can be conceptualized. This article presents case examples of how volumetric multimodal CT data is used in diagnosing and managing these various cerebrovascular conditions.

Table 1
CT dose reduction techniques

	Dose Reduction Technique	How It Helps
1	Optimize technique with lower input current	Trade SNR and penetration for dose
2	Detector material	Less technique required for same detector light output
3	Filtering	Noise removal via postprocessing
4	4 slice	Fewer rotations required, therefore less radiation overlap
5	Tube modulation	Technique adapts to requirements at each axial level
6	16 slice	Fewer rotations required, therefore less radiation overlap
7	64 slice, ECG modulation	Fewer rotations, full dose applied only during image acquisition (eg, during diastole)
8	Filtering	Improvements in postprocessing
9	Dynamic sampling methods	For perfusion or dynamic CT angiography, full dose is not required for all temporal samples; reduced temporal sampling during steady state periods (eg, washout phase)
10	Volume acquisition	Single rotation, no overlapping radiation, dynamic scans require no table movement
11	Active collimation	Radiation profile optimized
12	Reconstruction processing	Improved cone beam processing and noise filtering
13	Iterative reconstruction	Statistical processing that uses information about system noise characteristics to maximize SNR

Abbreviations: ECG, electrocardiogram; SNR, signal/noise ratio.