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Role of perfusion CT in differentiating between various cerebral masses using normalized permeability surface area product and cerebral blood volume

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Abstract

Objective: The objective was to assess usefulness of a combined analysis using the perfusion computed tomography parameters permeability surface area product (PS) and cerebral blood volume (CBV) in the differential grouping of various cerebral masses. **Methods:** Thirty patients who had a cerebral mass, confirmed by pathologic verification, were included. We classified PS and CBV results for various cerebral masses by visual as well as semiquantitative assessment. To verify statistically significant differences between the groups, one-way analysis of variance was performed. **Results:** Patients were categorized into five groups with statistically significant differences ($P<.01$). **Conclusions:** PS and CBV were useful in the differential diagnosis of cerebral masses.

Keywords: Perfusion; Computed tomography; Diagnostic techniques; Brain neoplasm

1. Introduction

Conventional magnetic resonance (MR) imaging provides important anatomic information, and contrast enhancement in MR imaging depicts breakdown areas of the blood–brain barrier, which are often associated with high-grade malignant tumors [1]. However, the enhancement may not reflect areas of neovascularity or angiogenesis. Thus, a radiological diagnosis of various cerebral masses with conventional MR imaging is not sufficient in many cases. Various clinically available functional imaging modalities can be used to obtain additional physiological and metabolic information about cerebral masses that may be useful in identifying and guiding treatment. Perfusion imaging is helpful in grading cerebral neoplasms and may afford dependable information on tumor characteristics, such as microvascularity, angiogenesis, micronecrosis, and cellularity. Perfusion computed tomographic (CT) imaging is potentially well suited for studying brain masses, in light of its wider availability, faster scanning times, low cost, and ease of quantification of various perfusion parameters as compared with MR perfusion [2]. Among various perfusion CT parameters, the permeability surface area product (PS) and cerebral blood volume (CBV) have been used for the assessment of intraaxial cerebral tumors and have shown a strong association with glioma grading [3,4]. However, discrepancies in results between PS and CBV have occasionally been seen in other types of cerebral masses. In addition, the combined analysis of PS and CBV in differentiating various cerebral masses has not been systemically studied. Therefore, the purpose of this study was to assess the usefulness of a combined analysis of the perfusion parameters PS and CBV in differentiating between various cerebral masses and to check the specific findings of PS and CBV regarding matched or mismatched results.

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2. Materials and methods

2.1. Patient population

The study was institutional review board approved, and a waiver of consent was obtained for a Health Insurance Portability and Accountability Act-compliant retrospective study. Between March 2007 and June 2010, we retrospectively reviewed the CT perfusion images of 30 patients with cerebral masses, including brain tumors or tumor-mimicking mass lesions, performed at our institution. All patients underwent a surgical biopsy and/or resection. All of the histopathological specimens were examined by one experienced pathologist with over 10 years of experience, and the histopathological diagnosis was based on the World Health Organization (WHO) classification [5]. The gliomas were divided into two groups: low-grade gliomas (WHO category I or II) and high-grade gliomas (WHO category III or IV).

2.2. Perfusion CT technique

Perfusion studies were performed using a 64-slice (VCT; GE Medical Systems, Milwaukee, WI, USA) multidetector row CT scanner for all of the patients. A noncontrast CT head study was done to localize the regions of interest (ROIs) before obtaining a perfusion scan. For the perfusion scan, 50 ml of nonionic contrast (Ultravist 300 mg/ml, Schering, Erlangen, Germany) was injected into the antecubital vein at a rate of 4 ml/s through a 20-gauge intravenous line using an automatic power injector. All perfusion scans were carried out using the VCT protocol at 80 kVp and 200 mA, with 1 s per rotation for a duration of 50 s. Eight 5-mm-thick axial slices were acquired, resulting in a total coverage area of 4 cm. Perfusion maps of PS and CBV were generated on an Advantage Windows workstation using CT perfusion 3.0 software (General Electric Medical Systems, Milwaukee, WI, USA) for all of the patients.

2.3. Perfusion data processing and image analyses

Postacquisition image processing involved the placement of freehand-drawn or automatic ROIs in an input artery and an input vein, followed by the generation of contrast-enhancement curves for these ROIs. The anterior cerebral artery or middle cerebral artery was selected as the input artery, and a large venous structure, such as the torcular herophili, was chosen as the input vein. The software then generated color-coded PS and CBV maps. The colors ranged from blue to red: blue=decreased, green=equal as compared to normal white matter, red=increased. Two neuroradiologists (L.Y.J. and A.K.J., each with 3 years and over 10 years of experience) first classified color-coded images of the PS and CBV results for various cerebral masses by visual inspection into five levels: decreased, equal as compared to normal white matter, mildly increased, moderately increased, markedly increased. Before this study, we underwent a training session and established a baseline consensus about visual assessment. Then, to accurately measure these values, manually drawn ROIs were placed in the greatest visually enhanced region of the tumor (Fig. 1), and the absolute perfusion parameter values were recorded. ROIs varying between 45 and 60 mm² were achieved by repeatedly moving the region into adjacent areas at least five times and recording the average of these values. The PS and CBV values were normalized (nPS, nCBV) by dividing the absolute tumor perfusion parameter values by the values obtained from the normal-appearing white matter of the contralateral cerebral hemisphere as far away from the primary neoplasm as possible. The same procedure was repeated for each slice. For the nonobviously enhanced tumors, we placed the ROI in the solid portion of the tumor, taking care not to include areas of necrosis or areas of cystic degeneration and also to avoid any major cortical vessels in any of the axial CT sections. First, we listed the various cases according to their PS values (Table 1), and then, we made another modified list of cases for the combined analysis of

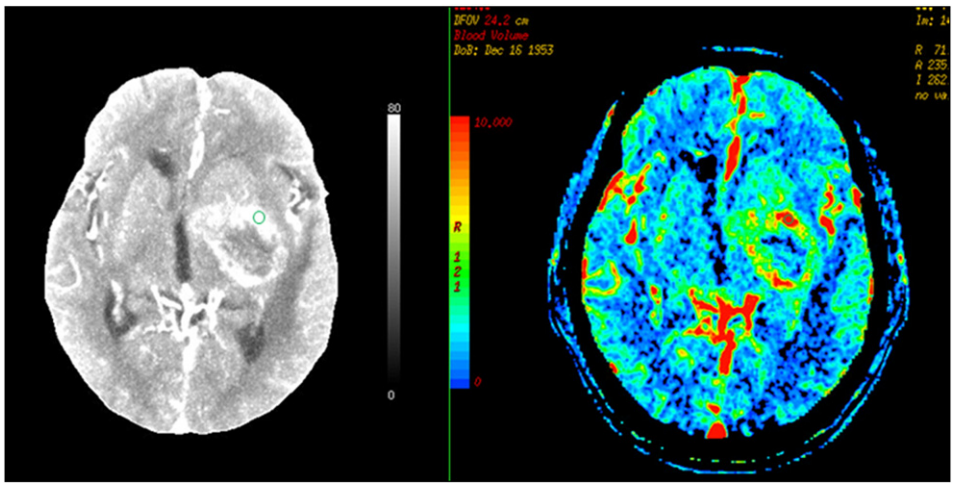

Fig. 1. Regions of interest were manually drawn on the perfusion CT maps to include the greatest visually enhanced region or solid portion of the mass.