Three-Dimensional Images by Helical CT Scan with Intra-Arterial Injection of Diluted Contrast Medium

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INTRODUCTION

Three-dimensional (3-D) computed tomography (CT) is a newly developed diagnostic technique which enables the spatial location of a lesion and is useful for surgical simulation in a neurosurgical field (1). We present a technique for angiographic 3-D CT in which a helical CT is carried out during cerebral angiography, and we introduce a method to produce virtual 3-D images using this technique.

MATERIAL AND METHOD

Eighty-seven patients with primary or metastatic brain tumors who were admitted to the National Cancer Center Hospital since April 1996, underwent a helical CT scan during cerebral angiography using the IVR-CT system (Toshiba Medical Systems, Tokyo, Japan), which comprised a digital subtraction angiography system (KXO-80C/DFP-2000A) and a helical CT scanner (X-Vision, Toshiba Medical Systems, Tokyo, Japan) (2). An angiographic catheter was introduced into the carotid or vertebral artery, the main feeding artery of the tumor, and 100 ml of a 1:5 diluted contrast medium was injected at a rate of 2 ml/s. The couchtop of the CT scanner was shifted at a speed of 2 mm/s during injection. Axial images obtained from helical CT were reconstructed to produce 3-D images on a shaded surface display using accessory software of the helical CT scanner (3,4). In order to distinguish the vessels from the tumor, red color was applied to the vessels and orange color to the tumors, according to their CT attenuation numbers. Most of the malignant brain tumors were enhanced with the contrast medium and could be outlined on the display to create clearer images. Two of these 3-D images which were horizontally rotated by 7° from each other were placed side by side to yield a virtual 3-D image by staring at the left image with the right eye and the right image with the left eye.

RESULTS

The main feeding arteries and contrast enhancing tumors were well visualized on 3-D CT, especially when red and orange colors were applied to the blood vessels and the tumors, respectively. The images could be rotated to any direction on the display and two images which were horizontally rotated by 7° from each other were placed side by side. When looking at the images with convergence, staring at the left image with the right eye and the right image with the left eye, a virtual 3-D image can be obtained. Figure 1 shows 3-D images of a sphenoid ridge meningioma with intra-carotid injection of a 1:5 diluted contrast medium. The blood vessels and the tumor are well visualized on each 3-D CT image, and virtual 3-D images can be observed by staring with convergence. Spatial relationships of the vessels and the tumor can be seen more clearly on this image. Each image revealed the branches of the middle cerebral artery penetrating the medial surface of the tumor, yet they were more clearly seen on a virtual image. No allergic reaction or subacute side effects were observed by using diluted contrast media.

DISCUSSION

Helical CT images can be created on the shaded surface display by continuous movement of the couchtop of a CT scanner during scanning. They are so-called 3-D CT images, but are feigned ones created by shadowing the two-dimensional images. When these two images are rotated horizontally a few degrees from each other, placed side by side and observed simultaneously with convergence, virtual 3-D images are obtained. The resolution of these images is much higher than that of each one and the spatial location of anatomical structures can be clearly seen. It is useful to know how much normal structures deviate and how normal and abnormal tissues are related in surgical simulation, especially of a neurosurgical field. With this technique, images from any direction can be made and surgical simulation can be performed by creating images similar to the surgical approach. Moreover, the information from the hidden side of the tumor can also be obtained. Typical 3-D CTs have been carried out with intravenous bolus injection of non-diluted contrast media. More than 100 ml of non-diluted contrast medium is injected rapidly to make
Figure 1. Three-dimensional images of the left sphenoid ridge meningioma created by helical CT. An angiographic catheter was introduced into the left internal carotid artery and a 1:5 diluted contrast medium was injected during scanning. The right anterior and middle cerebral arteries were demonstrated by cross circulation through the anterior communicating artery. Cerebral veins and sinuses were also visualized as well as the tumor. Virtual 3-D images can be obtained by staring at these images with convergence. Spatial relationships of the tumor and vessels are clearly demonstrated.

images with good contrast. Patients often experience flashes, nausea or somewhat uncomfortable feeling during injection of non-diluted contrast media. However, we have shown that a 1:5 diluted contrast medium is sufficient to create well contrasted images, when 3-D CT is performed during cerebral angiography, without acute or subacute side effects. Tumors such as meningiomas and glioblastomas, which were intensely enhanced by the contrast media, were well visualized without any artificial maneuvering. In order to create better images, their margins were outlined on each slice. Therefore, virtual 3-D images using helical CT scan can be extremely useful in the diagnosis of intracranial lesions as well as in the surgical simulation.

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References