Low-Exposure and High-Speed Scanning of a Pediatric Cancer Patient Using 320-Row Area Detector CT

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received 2010. 5. 3. accsepted 2010. 5. 15.

Abstract

Computed tomography (CT) is a common diagnostic imaging technique. In plastic and reconstructive surgery, preoperative CT is used to identify the positions of vessels accurately, and this is especially useful in supermicrosurgery requiring anastomosis of capillary vessels. However, CT is difficult to perform for pediatric patients due to X-ray exposure and the need for administration of sedative agents. These problems have been partly resolved by shortening of the scanning time with development of multi-detector CT (MDCT) and the introduction of 320-row area detector CT (ADCT) in 2008. In this study, we describe a case of pediatric malignant rhabdoid tumor in which we diagnosed the tumor invasion and planned the anastomosis of vessels using head scanning with ADCT. Using this case as an example, we also discuss the importance of development of ADCT for health professionals and patients.

Keywords Supermicrosurgery, 320-row area detector CT, Low exposure

Introduction

In tissue transplantation, including free flap procedures, identification of blood vessels for anastomosis has commonly been performed based on accumulated knowledge of the vascular anatomy. However, individual variability raises problems since often vessels are not in the expected location. This makes it difficult to plan detailed surgery using anatomical knowledge. This is a particular problem in supermicrosurgery, in which peripheral vessels of 0.1 to 0.3 mm in diameter are treated and the accurate location of the target vessels needs to be identified preoperatively.

CT scanning for identification of micro-vessels

Computed tomography (CT) scanning can be used for identification of microvessels. CT allows visualization of an internal structure of a material by scanning with X rays and subsequent computerized image reconstruction using the scan data. The first CT machine was commercialized in 1973, and thereafter the speed, resolution and breadth of scanning have advanced through development of helical scanning and multi-detector CT (MDCT).

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Problems of CT scanning

Although CT scanning is effective for diagnostic imaging, it also has drawbacks, with the greatest concern being X-ray exposure. In pediatric patients, the risks of malignancy and genetic mutation due to X-rays are a particular concern, and CT scanning is avoided in these patients whenever possible. Pediatric patients also have to take a sedative agent to facilitate broad-range scanning, since they have difficulty keeping still for the required scanning time.

Low-exposure and high-speed scanning using 320-row area detector CT

These problems have roots in the length of the scanning time required for 4- or 16-row MDCT. For example, 16-row MDCT takes approximately 7 s for scanning of a pediatric head (200mm), and patients must remain still and be exposed to X-rays for this time. To shorten the scanning time, increased multi-row MDCT has been developed, and the 320-row area detector CT (ADCT) Aquilion ONE (Toshiba) was introduced in 2008[1]. ADCT allows scanning of a pediatric head in less than 1 s, since its slice thickness is 0.5 mm and the scanning speed is 0.35 s[2]. This broad-range volume scanning also considerably decreases X-ray exposure through avoidance of multiple exposure in overlapping scanning sites, as occurs in helical scanning. In this study, we report a case of pediatric malignant rhabdoid tumor in which we diagnosed the level of cancer invasion and planned anastomosis of the vessels through head scanning using ADCT[3].

Case

The patient was a male child aged one year old. He was 72.8 cm tall, 7.2 kg in weight, and showed normal growth. No neural symptoms were apparent. The patient was born on November 3, 2008 with a birth weight of 3348 g after 39 weeks and 3 days gestation. A tumor mass was found in the left eye at birth and showed a tendency to increase in size.

In January 2009, laser therapy and local injection of steroids were administered at the Department of Plastic Surgery at Gunma Children's Medical Center due to suspected angioma (Figure 1). However, these therapies did not correct the tendency for tumor growth. On February 10, 2009, a biopsy was performed in the Department of Pediatrics at the Center, and this resulted in a diagnosis of rhabdoid tumor and lung metastasis. The tumor was reduced in size and the lung metastasis disappeared after a course of chemotherapy using "high-risk rhabdomyosarcoma protocol 8" (Figure 2). On September 11, 2009, autologous stem cell transplantation and supermass chemotherapy were performed. Follow-up MRI in December 2009 showed no tumor growth or metastasis.

Figure 1.
A huge lobulated tumor was present in the left orbit before chemotherapy.

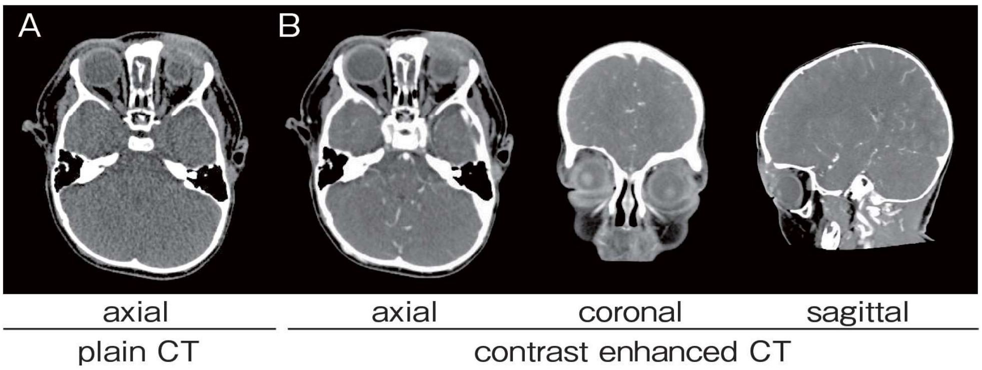

Figure 2.
320-row area detector CT after chemotherapy. The tumor had developed toward the superior wall of the orbit in the anterior part of the left orbit. The tumor was infiltrative with a partially unclear border. After chemotherapy, the tumor size showed a tendency to decrease. No cerebral metastasis was found and there were no significantly enlarged lymph nodes in the range of imaging. The nasal sinuses were developing and pneumatization in bilateral mastoid air cells was good.

A blood examination at the time of admission gave the following data: RBC: 2,890,000 / μl, Hb: 8.3 g/dl, Ht: 25.9%, MCV: 90.9 fL, MCH: 29.1 pg, MCHC: 32.0%, Ret: 10%, WBC: 3,800 / μl (Baso: 0.5%, Eo: 9.0%, Seg: 51.0%, Lym: 22.0%, Mono: 17.5%, Blast: 0.0%, Meta: 0.0%), Plt: 153,000 / μl, APTT: 45.1 s, PT: 11.4 s, Fib: 237 mg/dl, TP: 6.7 g/dl, Alb: 4.2 g/dl, T-bil: 0.3 mg/dl, D-bil: 0.1 mg/dl, AST: 44 IU/l, ALT: 4 IU/l, LDH: 300 IU/l, CK: 146 IU/l, ALP: 632 IU/l, γ GT: 10 IU/l, ChE: 360 IU/l, Na: 136 mEq/l, K: 4.9 mEq/l, Cl: 105 mEq/l, Ca: 9.7 mg/dl, BUN: 12.5 mg/dl, Cre: 0.30 mg/dl, UA: 2.9 mg/dl, CRP: 0.02 mg/dl.

In imaging findings (CT and MRI), a lobulated tumor was apparent along the left orbital rim, superior orbital margin, and medial orbital margin, and the tumor had invaded the upper intraorbital region (Figure 3). The inner part of the tumor was irregular and heterogeneous, which was thought to be due to a mixture of blood, calcification, and adipose tissues.

Discussion

In this study, we performed preoperative diagnostic imaging using 320-row ADCT for surgical removal of a carcinoma and transplantation of a free rectus abdominis muscle in a pediatric patient. We were able to determine the location of the tumor and the microvessels used for anastomosis in the transplantation. This information provided a blueprint that led to a successful operation[4,5].

CT scanning for pediatric patients has generally been avoided because of X-ray exposure and the difficulty of keeping the patient still. However, the development of 320-row ADCT with scans of 160 mm in 0.35 s enables low-exposure and rapid scanning without use of sedatives. This technology has dramatically improved the versatility of CT scanning. In this case, preoperative diagnostic imaging contributed to surgery of low invasiveness for the donor and the recipient. This is also likely to facilitate early rehabilitation of patients and the lowering of medical costs.

Low-exposure, high-speed volume scanning may also have other benefits, including lowering the use of contrast agents required in angiography. The method should also produce high-quality images without errors in imaging processing, since all collected images are scanned in equal time phases. Further improvements of high-speed, high-quality and broad-range CT scanning are likely to be developed based on the ADCT technology.

Conclusion

The high-speed CT scanning by 320-row ADCT described in this study provides huge benefits in the field of pediatric surgery and is also likely to contribute to the development of other medical fields. For example, in supermicrosurgery, identification of supermicrovessels of 0.1-0.3 mm in diameter is quite difficult even with 320-row ADCT, since the spatial resolution is approximately 0.35 mm. Improved acquisition such as a reduction of slice thickness is required to obtain better spatial resolution. High-speed, high-resolution, broad-area and low-exposure CT scanning continues to expand, and the effectiveness of diagnostic imaging by ADCT is likely to be applicable to every medical field.

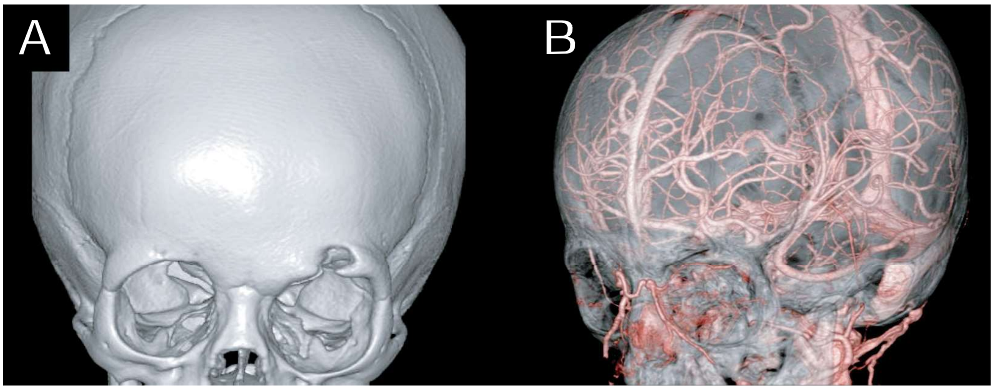

Figure 3.
3D findings for facial bone and blood vessels. Three-dimensional reconstruction of CT images of the skull and blood vessels of the head was performed using a volume-rendering algorithm.

ACSC

Issue 1: Reduction of the risk of cataract

CT scanning of the whole face is a particular risk factor in the pathogenesis of cataract because of direct exposure of the crystal lens to X-rays. Therefore, reduced exposure should be a goal of further advances in CT methodology.

Issue 2: Effects on gonads

X-ray exposure of the gonads can cause genetic changes, although it is difficult to measure the extent of this effect quantitatively. Elucidation of the relationship between dosage and genetic effects is an important issue.

Issue 3: Side effects of contrast agent

Shortening of the scanning time using 320-row ADCT reduces use of contrast agents, but iodinated contrast agents with high risks of side effects are still required. Therefore, development of contrast agents with fewer side effects is important.

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Acknowledgements

This study was supported by grants from the following organizations. The authors would like to thank them all:

- Japan Society for the Promotion of Science (Grants-in-Aid for Young Scientists A)
- Japan Interaction in Science and Technology Forum Foundation
- Leave a nest Co., Ltd. (Leave a nest Grant)
- Foundation for Promotion of Cancer Research
- Children's Cancer Association of Japan
- Fukuoka University, School of Medicine Alumni, Eboshikai
- Mitsui Life Social Welfare Foundation
- National Center for Child Health and Development

- We have no conflict of interest.
- As a policy of ACSC, sales of ACSC are partly contributed to Children's Cancer Association of Japan.