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# Development of the Operating Computerized Tomographic Scanner System for Neurosurgery

**H. Okudera, S. Kobayashi, K. Kyoshima, H. Gibo, T. Takemae,** and **K. Sugita**[1]

Department of Neurosurgery, Shinshu University School of Medicine, Matsumoto, and [1] Department of Neurosurgery, Nagoya University School of Medicine, Nagoya, Japan

## Summary

A computerized tomographic (CT) scanner system for intra-operative imaging is presented. The system consists of the following: 1) CT scanner with a mobile gantry, 2) digitally controlled operating table with central processing unit (CPU) and encoder unit; the table can be controlled by the scanner computer as accurately as the scanner bed, and 3) exclusively designed head fixation devices. It allows us to scan the patient on the operating table in the operating room pre-operatively, intra-operatively and immediately after surgery.

*Keywords:* Computerized tomography; neurosurgery; clinical imaging; operating room.

## Introduction

In modern neurosurgical practice, the pre-operative computerized tomographic (CT) scan provides useful information for planning surgery both pre- and intra-operatively. However, especially in the case of a deep-seated lesion, planning an approach only on the basis of topographic measurements taken from the pre-operative CT scan is often inadequate because of the structural shifts of the brain that may occur during surgery. To settle this problem, we installed a CT scanner in the operating room and obtained intra-operative CT images during neurosurgery[6]. Intra-operative images provided useful information about structural changes of the brain intra-operatively[7]. However, we found that intra-operative scanning of the patient requires excessive labour on the part of the staff in the operating room. So, based on these clinical experiences, we have greatly remodelled the CT scanner gantry and operating table and developed the operating CT scanner system for use in the operating room.

## Methods and Material

The prototype of the operating CT scanner system consisted of a whole body type CT scanner system (TCT-300, Toshiba, Tokyo) installed in the operating room, an operating table with a digital connector (MST-7100B, Mizuho, Tokyo) and an exclusively designed head-fixation system[6, 7]. It posed several problems in clinical application, especially the time required to set up the patient for scanning. The major problem stemmed from the fixed gantry at that time.

In order to overcome the problem, the gantry of the operating CT scanner system was mobilized by a gantry carrier[8] (Fig. 1). The scanner gantry can be moved within a range of 10 meters in diameter, this limitation being due to the length of the cable between the gantry and X-ray generator unit, but this range of motion is sufficient for actual use in the operating room. The mobile gantry can move in any direction like an ordinary mobile X-ray unit, thus enabling us to scan the patient in any desired head position. We then designed a digitally controlled operating table[9]. A digital-control motor unit and an encoder system are installed on the operating table so that

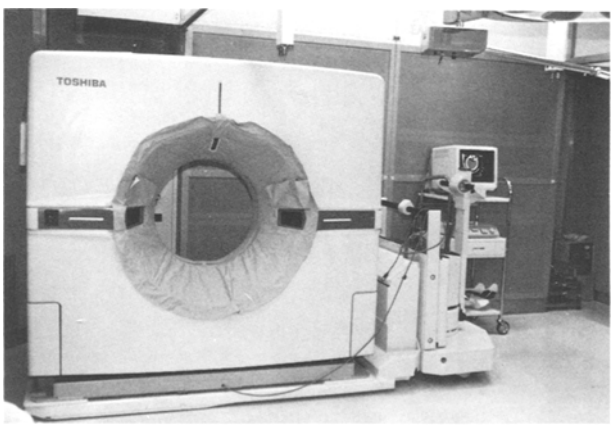


Fig. 1. Mobile scanner gantry with sterile disposable drape for intra-operative scanning

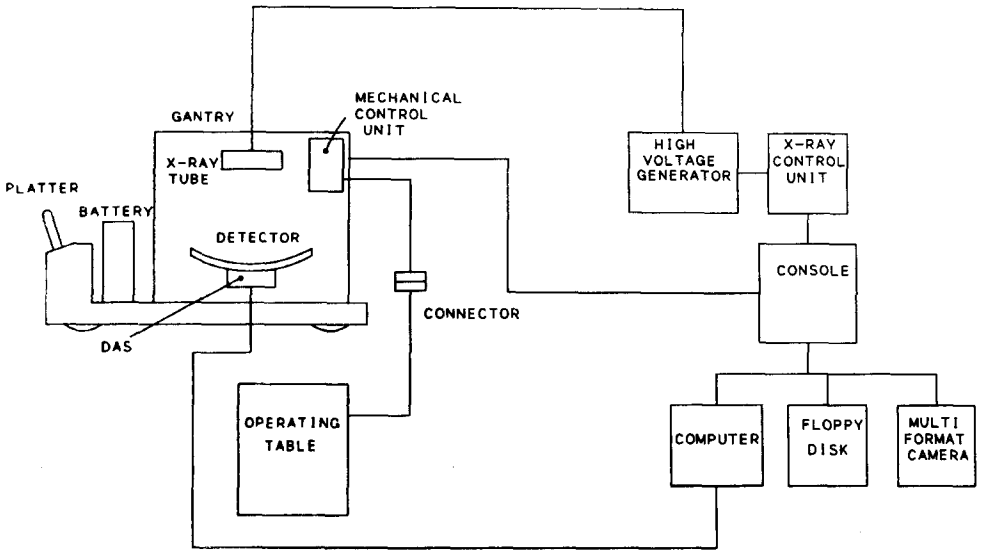


Fig. 2. Block diagram of the operating CT scanner system

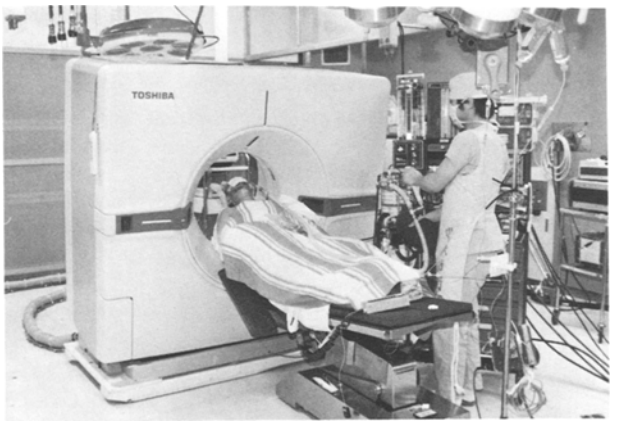


Fig. 3. CT scanning immediately after surgery under general anaesthesia

the table motion can be controlled directly from the computer of the CT. The new operating table provides accurate motion entirely comaparable to an ordinary scanner bed. An accuracy test using the CT scanner with mobile gantry and digitally controlled operating table was performed in the laboratory and yielded a similar degree of error to the ordinary CT scanner with a scanner bed. A block diagram of the operating CT scanner system is shown in Fig. 2.

In June 1988, after 2 years of development and clinical testing, we installed the operating CT scanner system in the Neurosurgical Operating theatre of Shinshu University Hospital (Fig. 3). The operating CT scanner system makes it possible to scan a patient in any head position, pre-operatively, intra-operatively under craniotomy and immediately after surgery, with improved efficiency and precision.

## Discussion

At the operation for an intracranial mass lesion, the neurosurgeon wishes to know the precise three-dimensional structure of the lesion and its topographic relationship to important adjacent structures. Numerous attempts have been made to produce a three-dimensional image from the data obtained from pre-operative CT scan images. More recently, with the development of the computer system, some attempts at realizing a system for stereotactic surgery, simulation of surgery and feedback of CT scan information into the surgical field based on pre-operative CT images[3, 10, 12] have been reported. However, during actual open surgery, the operating CT scanner system revealed anatomical shifts of the brain structures, apparently caused by change in intracranial pressure after craniotomy and dural opening, suction of cerebrospinal fluid, retraction of the brain and gravitational effects due to the patient's position[7]. These findings clearly demonstrate the limitations of pre-operative CT images as an intra-operative surgical guide.

Some authors have reported intra-operative CT scanning[1, 2, 4, 5, 11] and its clinical applications. These attempts are limited to a patient placed on the ordinary scanner bed. Because of the limited movement of the scanner bed for positioning the patient, their systems cannot be applied to neurosurgical procedures which require special positions of the patient, such as the lateral, prone and other positions.

The operating CT scanner system presented in this paper has a scan range of 35 cm in diameter to allow scanning of the patient in any head position together with the head fixation system. The system achieves practical CT imaging of the patient in any situation, either pre-operatively, intra-operatively or immediately after surgery.

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Correspondence and Reprints: Hiroshi Okudera, M.D., Department of Neurosurgery, Shinshu University School of Medicine, 3-1-1 Asahi, Matsumoto 390, Japan.