Intraoperative CT Scanner Combined With Image-Guided Neurosurgery

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ABSTRACT: **This article discusses the use of intraoperative computed tomography (CT) during neurosurgery. This intraoperative CT scanner is integrated with an image-guided surgery system. The authors' intent is to present information on how these technologies are implemented in the operating room and to describe the improvements in surgical accuracy. Two case studies demonstrate the workflow during spinal procedures and the advantages for the surgeons and patients. (J Radiol Nurs 2015;34:73-79.)**

KEYWORDS: **Intraoperative computed tomography; Neuronavigation.**

INTRODUCTION

It has been less than 20 years since the routine use of frameless stereotaxy was first introduced into neurosurgical practice. During that time, this technology has been rapidly accepted within the neurosurgical armamentarium, and new systems from different manufacturers have become available (Yavor, 2009). The combination of clinical utility, widespread acceptance, and competitive market forces has led to rapid advances in technology and system software. Optical tracking systems have eliminated the need for a rigid mechanical tracking arm and now allow tracking of most instruments used in surgery. New methods of patient registration have simplified workflow before and during surgical procedures and have improved application accuracy (Bledsoe, Fenton, Fogelson, & Nottmeier, 2009; Metz & Burch, 2008; Mirza et al., 2003). Stereotactic systems have been adapted for use in the spine and other extracranial sites. Software advancements have facilitated the concurrent use of a broad variety of imaging modalities for stereotactic navigation and planning.

As frameless stereotactic systems have been refined and their clinical utility has increased, two well-recognized limitations have been an ongoing concern. The first limitation is that stereotactic navigation systems have relied on preoperative computed tomography (CT) or magnetic resonance imaging (MRI). There has been no easy reliable way to account for changes in anatomy that occur between the time of the scan and various points during the surgical procedure. For example, in spine surgery, the scan is obtained in the supine position and the surgery is often performed in the prone position. This can result in differences in spinal alignment, especially in the cervical spine. The second limitation has been imposed by patient registration techniques that have prevented the use of frameless stereotaxy for minimal access spine surgery. These drawbacks can be mitigated by use of intraoperative imaging and patient re-registration during the surgical procedure.

We describe our early experience with a new neurosurgical suite that combines the use of an intraoperative CT (iCT) scanner (Siemens, Munich, Germany) and built-in frameless stereotactic navigation system for cranial and spinal surgery (BrainSuite iCT; Brainlab AG, Feldkirchen, Germany). This advanced surgical environment with built-in CT scanner has proven its value in a wide variety of neurosurgical cases and is gaining acceptance as community hospitals and academic

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medical centers around the country and around the world are investing in this technology. Our favorable experience with the first of these systems installed in the United States has been made possible by collaboration between surgical and radiologic technologists and nursing staff, the neurosurgeons, and a full-time bioengineer who serves as the clinical specialist providing technical and clinical supports for the built-in data processing, navigation, and image routing functions of the surgical suites. We review the roles of the different members of our clinical team and the adaptations we have made in training, workflow, and patient positioning to permit intraoperative imaging at strategic points in any neurosurgical procedure.

CLINICAL TEAM

The surgery and radiology departments formed a new clinical team to support the iCT scanner and image-guided surgery technology. Since the new operating room (OR) suites first opened, the hospital now offers 24-hr emergency neurosurgical care. This requires that the radiology and surgery departments schedule members of the neuro iCT team at the hospital during normal day and swing shifts as well as an on-call person each night, designated specifically for the neurosurgical team.

The scanner, a Siemens Somatom Sensation 40-Slice scanner (Siemens, Munich, Germany), is the first Siemens CT scanner installed at the hospital and the first sliding-gantry scanner installed by Siemens in the United States. While scanning, the CT gantry moves with respect to the anesthetized immobilized patient who remains stationary in the surgical position. This is contrary to the normal CT workflow, during which a patient on a programmed CT table slides in and out of the stationary gantry. The staff is extensively trained on this state-of-the-art equipment. In addition, each technologist receives training on working within a surgical environment and on the other unique equipment in the rooms, including the BrainLAB systems and radiolucent operating tables. The CT technologist adjusts the operating table and positions the gantry before performing the scan.

The core job functions of the OR circulating nurses and scrub technicians remain; however, they now also have key roles in efficiently executing an iCT scan during the clinical workflow. Both have the added responsibility of implementing new protocols to ensure that sterility and safety are maintained during the CT scanning process. These staff members set up the instrumentation used for image-guided surgery, help place sterile drapes over the patient for the scan, and prepare the surgical field and OR for the scanning process. They also have extensive training on radiation safety and various new surgical tools. Brainlab, Inc. provided 2 weeks of on-site training to all surgeons and staff for the navigation system and the integrated video routing systems. A clinical support engineer from Brainlab is dedicated to the hospital to continue training and provide clinical and technical supports. Depending on the needs of the case, the surgeon may use the CT scanner before the procedure, during the procedure, or immediately after the procedure.

ICT WORKFLOW

The radiologic technologist, circulating nurse, and neurosurgeons collaborate each day to efficiently and safely use the unique tools in the new ORs. Patient positioning and room setup differ from the traditional surgical setting to optimize scan range and image quality, while still providing for patient safety and optimal surgical access. Therefore, before opening the OR suites, the surgeons, staff, and anesthesiologists agree on standardized patient and room setups for various types of cases. For instance, all posterior lumbar and thoracic spine cases with the patient lying prone on the surgical table are scanned feet-first to image the spine without having to tuck the arms (Figure 1). The team also agrees that safety and OR efficiency are maximized if the OR table does not have to be rotated during the surgery for scanning. So, contrary to traditional OR setup that usually includes the patient's head/airway being next to the anesthesiologist, cranial and cervical cases are done with the head rotated away from anesthesia and toward the CT scanner. This not only lowers the possibility of contaminating the sterile field or inadvertently causing patient injury or extubation while moving the OR

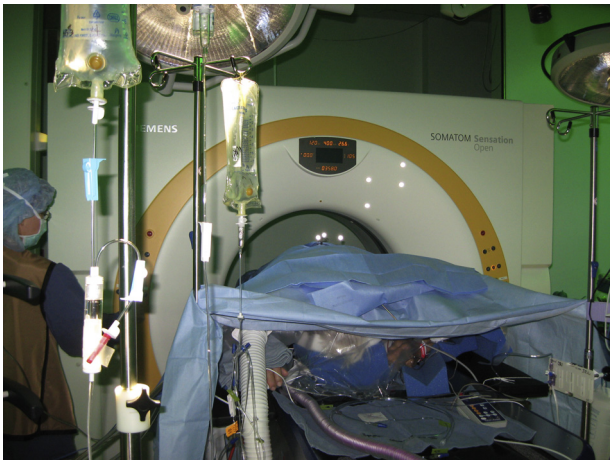

Figure 1. Lumbar patient in CT scanner during procedure. Patient is prone going feet-first into the scanner. The reflective markers attached to the patient and scanner can be seen as they are identified by the infrared tracking system.