Symbia: a Merger of Two Equals

Does the future for all SPECT systems include CT – or vice versa? The brilliant design of Symbia and TruePoint SPECT·CT will transform the delivery of diagnostic imaging as we know it.

THANKS TO SYMBIA'S entertainment features, patients can watch movies during the examination.

"If you had a CT engineer design a nuclear medicine system or had a nuclear medicine person design a CT system, you wouldn't be happy with the result," says John Pawlak, senior project leader and system architect at Siemens' Nuclear Medicine division in Hoffman Estates, Illinois. How, then, did the company manage to design the new Symbia® TruePoint™ SPECT·CT system without making everyone unhappy? By forming a highly qualified international team of both nuclear medicine and CT specialists who would work closely together, facilitated by countless phone calls, e-mails, and long flights between Hoffman Estates where Siemens Medical Solutions' Nuclear Medicine coordinated the development of the system, and Forchheim, Germany, where the CT group is based.

The design process began with surveys and focus groups to determine the needs and desires of customers for such a system. "Of course, asking customers what they want in a hybrid system with which they have no experience was not always an easy process," according to Keith Andress, director of software engineering at the Nuclear Medicine division. At that time, PET/CT systems were recently introduced, and customers and engineers alike were already beginning to imagine the possibilities of SPECT and CT together. The preliminary customer surveys lead to an initial concept involving basic CT capabilities added to the powerful SPECT capabilities of the e.cam® Signature Series. The early design concept was aimed at providing accurate attenuation maps to allow for attenuation correction during the SPECT reconstruction, but the success of PET/CT systems involving high-end CT technology and the explosive growth in multi-slice CT studies ultimately led the company to design the current lineup of Symbia scanners, the T, T2, and T6 systems, involving single-, dual-, or six-slice CT technology drawn directly from the company's CT group.

This Symbia lineup would also incorporate Siemens' state-of-the-art SPECT technology, found in the e.cam. Having already designed the best in SPECT, the design team gave Symbia everything the e.cam has to offer, including HD detectors, and unparalleled image quality and speed in nuclear imaging.

The team decided early on to avoid what Pawlak calls the "washer-dryer" approach of simply coupling two existing systems with a common patient bed, in favor of a more tightly integrated design, all while using as many existing components as possible.

The goal was to achieve a 200-cm scan range through both systems' fields of view without requiring an impractically long patient motion range. An excessively long patient motion

THE OPEN AND INVITING integrated design of Symbia offers increased patient comfort and ease of operation.

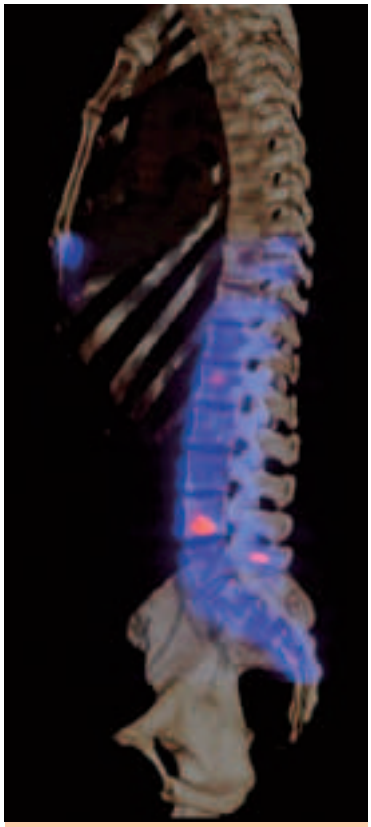
range would have made it difficult to site the system in standard nuclear medicine and radiology rooms.

Minimizing the patient motion range meant minimizing the distance between the CT and SPECT fields of view. One possible solution, of course, would have been to mount the CT and SPECT components on the same rotation gantry so that they shared a field of view. However, the team rejected this design because the weight of the SPECT heads would have severely limited the gantry rotation speed and thus the imaging speed achievable by the CT components. If high-end CT components were to be used, the system needed to be capable of the sub-second gantry rotation speeds expected in modern CT scanners. So the team opted for maintaining distinct but closely spaced subsystems.

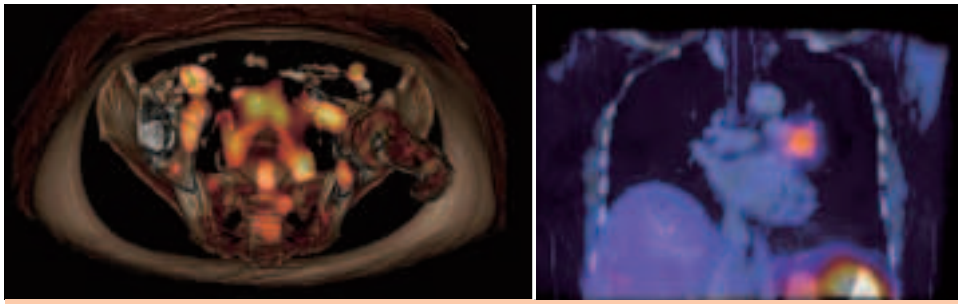
A Complex System in Compact Form

Fusing the two technologies was not simply a matter of shoehorning the components of two existing systems into a slightly larger housing. "The system is highly integrated, mechanically and electronically," says Pawlak. While striving to make use of existing components wherever possible, the team often had to reconfigure and redesign components from each technology in the interest of meeting their compactness goals. The SPECT drive system was pushed to the outside, which allowed the CT components to be brought closer to the SPECT heads. The CT gantry was essentially redesigned, allowing the components to be as close as possible.

With the SPECT and CT components tightly integrated, the resulting system offers many possible modes of operation. "The challenge from an industrial design standpoint is to make all of this usable," says Ansgar Graw, principal industrial designer for Siemens Nuclear Medicine. In researching design options, the team visited numerous hospitals to observe clinical workflow with the company's e.cam SPECT systems, as well as competitive products. This inspired the incorporation of a wide range of new features into the Symbia system, such as the inclusion of a patient entertainment system. Incorporating the best features from other systems, such as the e.cam SPECT, the patient entertainment system idea origi-



THIS BONE SCAN reveals multiple skeletal metastasis. (Data courtesy of University Hospital Erlangen-Nuremberg)



IMAGES OF A prostate cancer (left) and an Acth-producing tumor (right) acquired with the TruePoint SPECT·CT components. (Data courtesy of University Hospitals Cleveland and Erlangen-Nuremberg)

nated from observing a technologist who played fairy tales on a portable tape player to distract and calm pediatric patients.

Symbia's design is not simply the industrial design of the outward appearance of an imaging modality, its hardware, software, technology and mechanics, but a design that incorporates the experience of Symbia through the eyes of the customer and patient. In addition to the fact that Symbia TruePoint SPECT·CT is technologically advanced, includes the power and speed of a Siemens e.cam, diagnostic quality CT imaging, and is visually welcoming to both user and patient, it is designed to be efficiently operated by its technicians.

The design team incorporated elements such as a large, easily visible progress bar on the front of the unit, so that operators and patients alike would be able to see the progress of their scan. This is a key feature for technicians scanning multiple patients simultaneously. Designers also incorporated other features that facilitate ease of use.

As far as the particular difficulties posed by a hybrid system, Graw says that the principal goal was "to make the system seem open and friendly for the patient." A number of innovations were implemented towards increased patient friendliness; for example, the SPECT heads were designed to dock under the patient table during the CT scan, so as not to loom over patients as they are translated through the CT field of view.

The push for tight integration extended to the software as well as the hardware. According to Andress, who was also in charge of the software development, "It was really my goal to make sure things would move smoothly between the CT and SPECT systems." The team aimed at keeping the individual user interfaces the same as those employed in the component systems. They modeled the three orthogonal screen views and their correlated cursor-image fusion displays on the company's PET/CT interface.

Taking Accuracy and Clarity to the Next Level

At the heart of the software lies the Flash 3D SPECT image reconstruction software, based on an iterative maximum-likelihood algorithm that allows for modeling and correction of data degradations such as attenuation, collimator blurring, and scatter. Obviously, the CT images can be used to estimate the attenuation experienced by the SPECT photons, but not directly. Gamma ray sources produce photons with a broad range of energies, typically centered around 70 keV, while SPECT radionuclides most commonly emit photons of 140 keV. To convert a CT image into a SPECT attenuation map, says research lead Hans Vija, senior principal research scientist at Siemens Medical Solutions' Nuclear Medicine division, it is necessary first to determine the effective average energy of the photons contributing to the CT image, and then to apply appropriate conversion factors to each pixel. The conversion has to be accurate for all isotopes and SPECT acquisition parameters. Moreover, the great difference in resolution between CT and SPECT images must be bridged in order for the CT images to be registered with SPECT

THE SYMBIA SYSTEM is both visually welcoming to the patient and designed to be efficiently operated.

for attenuation correction. These technical challenges had been addressed and incorporated into previous versions of the Siemens e.soft™ package installed on the company's stand-alone e.cam SPECT systems. However, notes Vija, that software package was designed with an eye toward the ultimate development of the Symbia TruePoint SPECT·CT system, where performing the CT scan immediately after the SPECT scan makes accurate registration of the two data sets more likely than if the patient needs to be moved to a different scanner.

Transforming Diagnosis and Treatment

According to Symbia's marketing manager Reinout Vogt, the most compelling applications of the TruePoint SPECT·CT system are in oncology, where the addition of the CT modality for anatomical localization can be essential, and in cardiology, where the accurate attenuation correction provided by the CT is most important. The hybrid SPECT·CT system will no doubt impact the future of molecular imaging. The anatomical information provided by CT will become even more significant as increasingly specific molecular imaging agents are developed. SPECT studies using such biomarkers might produce little more than isolated hot spots, with very little background activity to provide even a crude anatomical roadmap, says Vogt, "The more specific the SPECT marker, the higher the need for anatomical information."

Tumor detection, disease management and staging of cancer treatment are significantly enhanced by this dual modality system. Because of earlier and more accurate diagnosis of prostate cancer, for example, physicians will be able to plan treatment more effectively and provide feedback on treatment efficacy, as well as avoid unnecessary invasive surgery and reduce the risks of necessary surgery.

According to Homer A. Macapinlac, M.D., deputy chairman, department of nuclear medicine, MD Anderson Cancer Center in Houston, Texas, "MD Anderson Cancer Center's goal is to eliminate cancer... TruePoint SPECT·CT is going to help us significantly in the diagnostic interpretation of clinical exams. Ultimately, the person who benefits from this new technology is the patient." MD Anderson Cancer Center plans to install five Siemens Symbia systems, incorporating TruePoint SPECT·CT technology, in early 2005. "That a world-renowned institution such as MD Anderson Cancer Center is making such a significant investment in our Symbia systems confirms that this technology is at the leading edge of cancer diagnosis and patient care," says Michael Reitermann, president of Siemens Medical Solutions' Nuclear Medicine division.

Siemens expects the Symbia system to appeal to a number of different medical specialists, including radiologists, cardiologists and, of course, nuclear medicine specialists. Fittingly for a system born of cooperation and integration, it may actually realize its full potential when used in concert across departmental lines, with interpretation of the diagnostic-quality CT scans and SPECT data ultimately improving patient care.

THE SOMATOM SPIRIT is a dual-slice system for the ambitious entry into the fascinating world of CT.