Visible Humans Give Doctors a Stage for Surgical Rehearsals

Watching the computer-generated cross-sectional images of the visible humans appear on a movie screen in rapid succession is akin to an anatomical safari — moving through muscular landscapes, shooting down the cavernous spinal column, and scaling the rib-cage walls. The images are mesmerizing, yet there is a curiosity about who these people were and what the 60 gigabytes of information gathered to make this tour possible will do for oncology.

Donated to Science

The first question is simple: The "visible" man was a 39-year-old executed by lethal injection following his conviction for murder, while the woman was a 59-year-old housewife who died of a heart attack. Both donated their bodies to science, and both were selected for the federally sponsored "Visible Human Project" because they were the most "normal" corpses that were found following a nationwide search.

Revolutionary

The answer to the second question is a little harder. But according to the organizers and attendees of the first users conference of the Visible Human Project, those 60 gigabytes of information may revolutionize the way physicians learn and practice medicine. "The $1.4 million federal investment in the visible male and visible female may turn out to be minuscule in comparison to the health benefits we derive from the project," said Donald Lindberg, M.D., director of the National Library of Medicine. Michael Ackerman, Ph.D., head of the Visible Human Project at the NLM, echoed Lindberg's optimism, asserting that "the virtual human will do for surgery what flight simulators have done for aviation."

In 1986, the NLM took stock of what was happening in medicine and computers and envisioned the day when a digital image database could be as important and useful as the NLM's textual databases. In anticipation of that day, the NLM set out to create an anatomical database that would contain full digital images of a man and woman.

The project's course was charted in 1989 by the NLM's Planning Panel on Electronic Image Libraries, and in 1991 a contract for acquiring the cryosection images, transverse Computerized Axial Tomography (CT) scans and magnetic resonance images (MRI) of a "representative" man and woman was awarded to the University of Colorado Health Sciences Center, Denver.

Widespread Interest

In 1994, the Visible Human Project datasets were made available on the Internet. Any group interested in using the data had only one requirement after signing a licensing agreement with the NLM: They had to keep the library in-

Full body images of the Visible Human Male (left) and Female computed from color cryosections. Images on left side are volume projection images of all data. Images on right show 1-mm-thick coronal slice through the center of the body.
Prostate glands and adjacent structures computed from MRI scans of the Visible Man (top) and two prostate cancer patients (bottom).

Prostate glands and adjacent structures computed from MRI scans of the Visible Man (top) and two prostate cancer patients (bottom).

formed about how the data was used.

The NLM expected only a handful of groups to show interest, but to date 650 licensing agreements have been signed by research and academic groups from 26 countries.

One such group is housed at the Mayo Foundation and Clinic, Rochester, Minn. The biomedical imaging resource team, led by Richard A. Robb, Ph.D., has used the Visible Human Project data to assist in its research on virtual endoscopy and surgical planning and rehearsal. Robb and his team were already engaged in this research when the visible human data were made available, but they immediately tapped into test the imaging software they were developing on real data. "The power of the visible human dataset is that you can test your algorithms [for imaging] on the visible human, then refine them and use them in clinical practice," said Robb.

The Mayo team and many others, including Los Alamos National Laboratories, New Mexico; Cambridge University, England; and the State University of New York, Stonybrook, are using the visible human data for a variety of applications. Robb's team is working on 3-dimensional imaging software that will enable technicians to take CT scan and MRI data, fuse the two sets of data together and create a 3-D rendering of an area of the body with the tumor highlighted.

Prostate Surgery

Once this process is complete, a surgeon can look at the 3-D image and manipulate it to see the relationship of the tumor to the rest of the patient's anatomy prior to surgery. This can be very useful in prostate surgery, Robb said, because the proximity of the prostate gland to surrounding anatomic structures such as the bladder, ureter, and seminal vesicles makes surgery difficult. Furthermore, he feels that rehearsal of an actual surgery can help reduce the high percentage of men — approximately 50% — who have surgery-related complications such as impotence or incontinence.

To date, surgical rehearsal at Mayo has been employed only by a few doctors and used pre-operatively to show neurosurgeons the location of brain activity responsible for epileptic seizures, it was shown that the surgeries were more efficient. In addition, surgical cost was lower, morbidity was reduced, and outcomes of the 15 to 20 patients were good.

Robb and his team are hoping that the same will be true for other high-risk neurosurgery patients for whom surgical rehearsal is now being used. The outlook is good.

The development of surgical rehearsal as a routine clinical practice is progressing more quickly for brain cancer than for prostate cancer, said Robb. He and his team anticipate that this approach might be used routinely for high-risk brain cancer surgeries in the next 2 to 3 years, especially at large cancer centers. Routine use for prostate cancer surgery will lag behind because of an imaging snag. According to Robb, the interconnectedness of the structures in the pelvic region makes it hard to acquire good data for 3-D resolution — these structures are just on the margin in which MRI and software maps were employed pre-operatively to show neurosurgeons the location of brain activity responsible for epileptic seizures, it was shown that the surgeries were more efficient. In addition, surgical cost was lower, morbidity was reduced, and outcomes of the 15 to 20 patients were good.

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Virtual endoscopic view from within the trachea as computed from the Visible Human Female.

Virtual endoscopic view from within the trachea as computed from the Visible Human Female.
of good MRI resolution. "Routine clinical use really won't occur until we solve this imaging problem and are able to consistently collect good data," he said.

Robb and his team also used the visible human datasets to demonstrate the value of virtual endoscopy, another area of research in which his team is engaged. Not only are they working on

PET and MRI images of a brain cancer patient. Red areas suggest regions of abnormal blood distribution.

virtual colonoscopy, (see News, July 20, 1994), but they are also developing virtual esophageal, airway, and stomach endoscopy to make screening for cancer in these areas easier. Robb anticipates that in 1 to 2 years, large centers will be using virtual endoscopy as a means of screening for cancer, thus avoiding the need for an invasive technique and its inherent risks.

"Right now we have all of the [technological] pieces and players together at the table," said Robb. "We are on the threshold of bringing these techniques into clinical use."

— Catherine Law

Cancer Genome Anatomy Project Set for Take-off

Outside the National Archives in Washington, D.C., a large stone statue stares down over Pennsylvania Avenue. On its pedestal, an inscription from Shakespeare reads, "What is past is prologue," a commentary on the dynamic nature of U.S. history.

The same can be said these days for cancer diagnostics. Building on past progress in genetics and biotechnology, the National Cancer Institute now is set to launch an historic project that many predict will lay the foundation for a new era of molecular diagnostics in cancer.

Called the Cancer Genome Anatomy Project (CGAP), the project will compile over the next few years a publicly accessible index of the thousands of genes expressed in common cancers, both in the precancerous and malignant stages.

At the same time, CGAP will make a major push to develop a variety of high-speed technologies that analyze the molecules in a tumor cell. The goal is to create tools able to access hundreds of known genes, proteins, and other telltale biomarkers linked to cancer. With CGAP carving out the scientific foundation, many researchers say NCI should be ready in a few years for followup projects to apply these high-speed tools and biomarkers in the clinic.

Exploiting Advances

Today, cancer often is characterized by two factors: its presumed site of origin, such as the breast or pancreas, and the general appearance of cells biopsied from the tumor.

But some scientists wonder whether looking at tumor cells under a microscope isn't a lot like trying to judge a book by its cover. Without access to the genes and proteins driving the cancerous process, they say it's difficult, if not impossible, to detect precancerous lesions when the number of tumor cells is still small. Nor is it possible to know, once a diagnosis has been made, whether a treatment will be effective in fighting a specific cancer.

"It's hard to do medicine without an accurate diagnosis," said NCI director Richard Klausner, M.D. "Right now, we lump patients together and treat them with the same drugs and then deal with their variable response to treatment.

We're essentially treating different diseases with the same medicine."

When Klausner took the helm of NCI in 1995, he and his advisors let it be known that they wanted to exploit recent advances in molecular analysis. They said there was a real opportunity to do this in cancer diagnostics, where new technologies could be refined to help doctors detect cancer earlier and to begin basing treatment choices on the molecular properties of the tumor cell.

Klausner sent out a call in January 1996 for a panel of experts to begin