

Nationwide Children's Physicians and Researchers Use Simulation Training to Improve Patient Care

Gregory J. Wiet, MD, FACS, FAAP, Surgeon, Department of Pediatric Otolaryngology, Nationwide Children's Hospital



Simulation training can be defined as the “replacement of one dangerous activity by the enactment of a similar activity in a non-dangerous environment” (Satava, 08). The most clearly recognized area of simulation training is used in the aviation industry. Aviation simulation training originated with the use of the Link Simulator for training pilots during World War II. Today, sophisticated, multi-million dollar computer based systems are in use in modern military and civilian training facilities. The most important attribute of these simulation trainers and of simulation training in

general, is that the trainee has the opportunity to explore and to repeat practice in an environment that allows failure without consequence. In this environment, the trainee is able to learn to predict failure and either control it or avoid it altogether. This article defines the use of simulation and virtual reality models at Nationwide Children's Hospital and outlines the advantages the implementation of these new technological advancements offer.

Researchers Using Virtual Technology

Kathleen K. Nicol, MD, Anatomic and Clinical Pathologist, Department of Laboratory Medicine, Nationwide Children's Hospital
Tom Barr, Imaging Manager, Biopathology Center, The Research Institute at Nationwide Children's Hospital



Training Surgeons Using Simulation Models

Simulation training has been used in the surgical field with the use of cadavers and animals but these opportunities are often limited due to availability and cost. Because of this, most surgical training has been performed in the apprentice model of "see one, do one, teach one." This "on the job training" using real patients has rightfully become less attractive recently with the recognition by the general public of medical and surgical misadventure and the cost to individuals and society. Secondly, there is less time for teaching of surgical trainees. This has been driven by financial pressures to see

more patients in less time and the institution of the 80-hour work-week. These two elements have brought pressure on the current training system to develop new paradigms for technical skills training.

Simulation training holds the promise to substantially impact technical skills training by providing ready and cost effective access with less risk to both trainee and patient. An additional benefit is that simulation training allows the trainee exposure to infinite anatomical variations as digital data repositories are

accumulated and preserved for repeated use. Trainees can access these data anywhere at anytime. Lastly, simulation can provide a platform for objective measurement of technical skills performance. Objective measurement can be undertaken with control of variability among study subjects, conditions and testing material, as well as means to objectively measure such "in process" metrics as fluidity of movement, pressure on tissues, completeness of volume resections, as well as end product analysis. Results can be standardized and compared to experts doing the same procedure on the same specimen.

With the advent of the video gaming industry, there has been incredible advancement in the science of computer visualization and simulation technology. Shored up by the millions of dollars spent on development of faster graphics hardware and complex algorithm development, "virtual reality" or simulation has come to the desktop as Moore's Law would predict. Simulation environments that once cost millions of dollars to develop and maintain are currently being replicated using "commodity off the shelf" (COTS) computing. COTS refers to use of computer hardware that is widely available to the general public.

Early development of simulation environments was performed on graphic supercomputers costing hundreds of thousands of dollars. Currently, better performance systems are now available at a fraction of the cost. In our own experience, initial hardware platforms capable of providing processing power sufficient to allow rudimentary simulation cost between \$100 and \$500 thousand dollars. Today, the platform that the temporal bone simulator runs on costs approximately \$6,500 dollars.

Simulation technology has greatly advanced due to developments driven by the gaming industry. These developments have allowed the application of simulation technology to technical skills training in medical and surgical fields. Simulation training holds the promise to offer a paradigm shift in technical skills training in medicine and surgery. The American Council for Graduate Medical Education has recognized this and emphasized simulation training as a key component in curriculums for surgical training. The American College of Surgeons has developed a program of Accreditation of Educational Institutes of simulation training to help develop, disseminate and assure high quality in the application of simulation technology for surgical education (Cooke et al, 2008). The challenge going forward is to continue to develop and implement systems that truly translate into improved training for our future physicians, researchers and surgeons to ultimately improve patient outcomes.



Above: Dr. Wiet stands in front of flat screen monitors that show the images from the virtual scalpel.

The Development of the Virtual Scalpel

In the early 90s, Don Stredney, a Research Scientist at the Ohio Supercomputer Center, and Gregory Wiet, MD developed a collaboration centering around the application of high performance computing to Otolaryngology. Don, although a medical illustrator by training, emphasized computer graphics in his implementation of anatomical representation. As a pioneer in the medical application of computer visualization, Don was exploring potential applications with several clinical departments. A collaboration was developed with others across The Ohio State University, which resulted in funding from the Department of Defense, Department of Energy, and the National Institutes of Health.

The nature of simulation work emphasizes the necessity of multidisciplinary research in that each of our co-investigators possesses unique expertise that, when brought together, provides synergistic progress. Our group has worked on projects related to skull base tumors using three dimensional visualization in the early 90s (before this was readily available on PACS workstations), simulation of sinus surgery, epidural anesthesia delivery, and currently, temporal bone surgery.

The temporal bone project began under an R21 two-year grant from the NIH/NIDCD in the late 90s. This project culminated with a demonstration of our system at the American Academy of Otolaryngology Annual Meeting in September of 2001. At that time, our system was well received by the otolaryngology community (Wiet et al 2001; 2002). In particular, international training programs that had limited access to cadaveric material and expert training were interested in acquiring the technology immediately. Subsequently, RO1 funding from NIH/NIDCD enabled further development of the system. An interdisciplinary group consisting of members of the Departments of Radiology, Computer and Information Science, Biomedical Engineering, Otolaryngology and the Ohio Supercomputer Center are currently involved in the research effort that addresses the issues surrounding simulation in otologic surgery. Key components of the project include data acquisition, improvement in dissemination of the system, realism and most importantly – validation of the system as a training tool.

Data Acquisition

The importance of data acquisition could not be overstated in that the entire simulation depends upon the accuracy of the data whereby both the visual and haptic (sense of touch) displays are calculated. Various imaging technologies, including clinical CT, clinical MRI, microCT (30um resolution voxels) and high field strength (up to 8T) as sources for data for the simulator (Figures 1A and 1B) have been explored. The end result was to develop an image acquisition protocol that could be disseminated to different sites across the country allowing capture of temporal bone data sets from various specimens and patients.

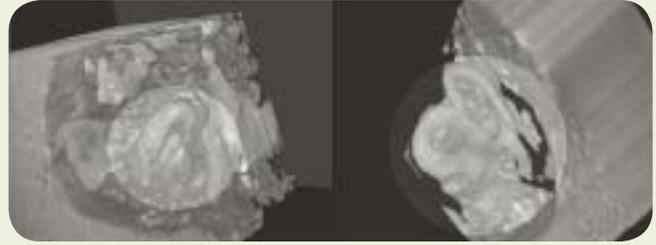


Figure 1A: High Field Strength MRI

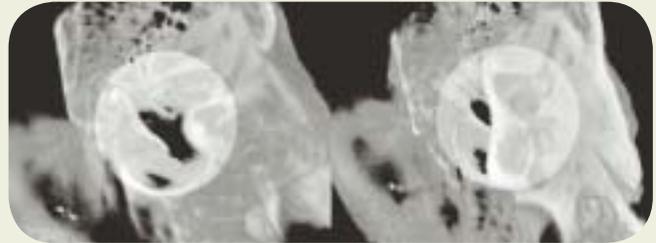


Figure 1B: MicroCT



Figure 2A: 2001 Visual Display

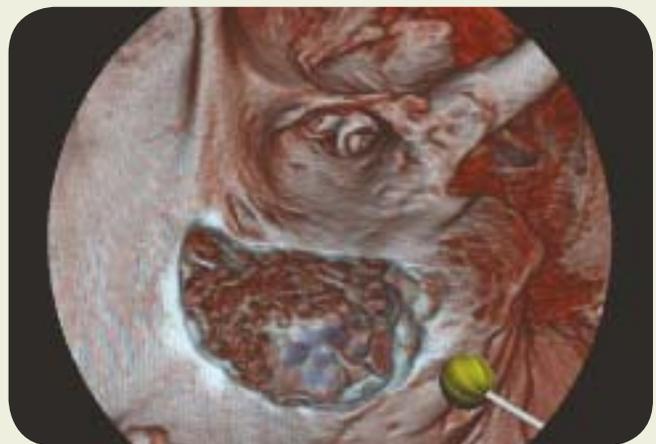


Figure 2B: 2008 Visual Display

CONTINUED FROM PAGE 5

Realism

A second area of emphasis was in improvement of realism. Although dependent upon the image data obtained, this component involves visualization algorithm development and makes use of the advancement in graphics processing hardware (GPU) for the video gaming industry. Early on, using the best graphics hardware available to keep interactivity in real time, the visual representation of data did not allow for a very realistic display. As GPU capability advanced, we have been able to leverage this technology to provide more realistic visual, haptic and auditory display (Figure 2A and 2B compare 01 to 08 views).

Validation with Improvement in Proficiency

Lastly, through collaboration with Otolaryngology training programs throughout the country, we have been able to improve the system to the point that we hypothesize it will actually improve temporal bone surgical skills for trainees. We are in the midst of a multi-center (Table 1 – trial sites) trial where residents in Otolaryngology are being randomized under IRB approved protocols to either training in traditional fashion in the cadaveric laboratory or training in the simulator. After training, study subjects are given an objective test to determine proficiency (Figure 3 schematic of protocol).

Figure 3: Testing Protocol for Validation Studies

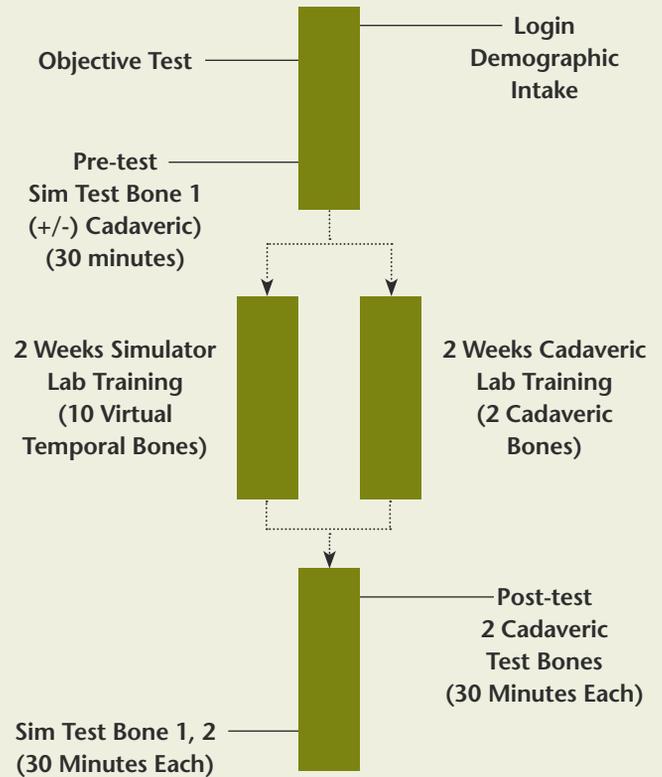


Table 1: Testing Sites for Temporal Bone Project

Institution	Status	Number of Subjects
Duke University	Completed	6
Massachusetts Eye and Ear Infirmary, Harvard Medical School	In Process	TBA
University of Texas, Southwestern	Completed	10
University of Iowa	Completed	15
Baylor College of Medicine	In Process	TBA
University of Mississippi	In Process	TBA
Wayne State University, Henry Ford Hospital System	In Process	TBA
Eastern Virginia College of Medicine	In Process	TBA
Albert Einstein College of Medicine, Montefiore Medical Center	In Process	TBA
University of Cincinnati	In Process	TBA
Virginia Commonwealth University	In Process	TBA

*TBA = To Be Announced



Virtual Microscopy for Education and Sharing Data

Virtual microscopy as an educational tool, much like simulation training for surgeons or pilots, provides a favorable learning experience to medical students, residents, pathologists and other medical laboratory professionals. By working with multiple pathologists, The Biomedical Imaging Team (BIT), located in the Biopathology Center at The Research Institute at Nationwide Children's Hospital is establishing a clinically well-annotated image archive of high-quality, whole-slide images for education and research. Further integration of data systems such as electronic medical records, laboratory information systems, cardiology and radiology PACS systems, and cytogenetics systems is still necessary to provide a true digital pathology environment. The addition of image analysis algorithms, developed in partnership with pathologists, to detect and measure cancerous features will provide a more efficient workflow and will benefit patient care and the education of laboratory professionals.

Improved Diagnosis – Improved Outcomes

Performing as diagnosticians, pathologists are the physicians specializing in medical diagnosis through autopsies and the inspection of organs, tissues and body fluids. Much of this diagnostic evaluation is performed by the assessment of stained tissues and body fluids microscopically. Pathology is often referred to as a visual science because pattern recognition is used to identify and quantify specific arrangements associated with cancer and other diseases. This pattern recognition is very complex, requiring years of training. Laboratory professionals, like surgeons and other healthcare professionals, are challenged with staffing shortages and workload demands which further challenge both the training required and the time available for

such education. This challenge may be more evident in pathology subspecialties, for example, where community hospitals are less likely to see rare pediatric diagnoses such as neuroblastoma or Wilm's tumor.

Virtual Microscopy

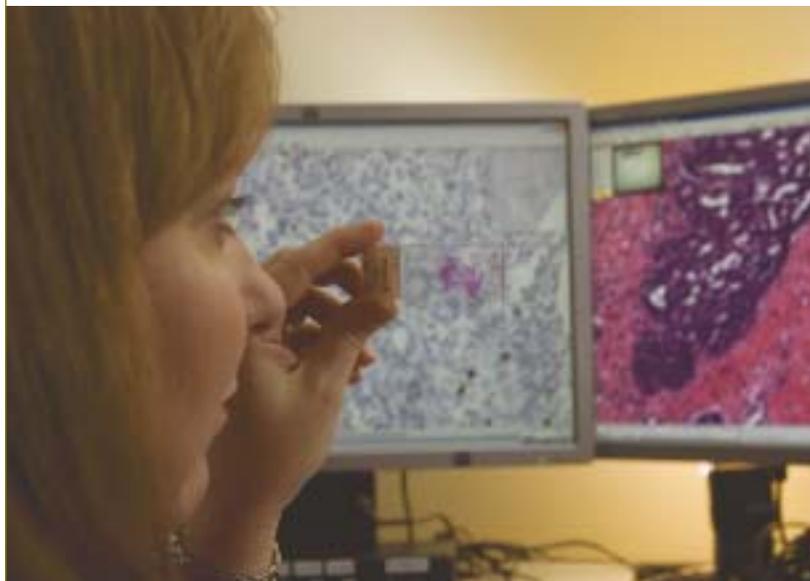
With the emergence of virtual microscopy, the field of pathology is embracing technology to facilitate many processes including consensus reviews, quality assurance¹, tissue microarray production, education and proficiency testing. Imaging robots are now available which can be batch-loaded with several hundred glass slides and quickly provide whole-slide images with superior image quality.

The use of whole-slide images provides several advantages over traditional glass slides including:

- Real-time pathology consults
- Digital archive of material
- Digital annotations by one or many users
- Ability to share the same image with multiple users in multiple locations at the same time
- Integration of images into laboratory information systems or electronic medical records
- Introduction of sophisticated image processing and analytical tools

VIPER

The Virtual Imaging for Pathology, Education & Research application (VIPER, see Table 1) is a web-based automated pathology review system initially designed to expedite



Above: Stephanie Weaver, biomedical imaging team technician, uses virtual microscopy to convert hundreds of glass slides each day into high-quality, whole slide images that can be viewed on computer screens by colleagues across the country during pathology consults.

pathology review for clinical trials and for tissue quality control purposes by providing expert pathologists from multiple cooperative cancer groups with high-quality, whole-slide images, pathology reports and review forms. After quickly realizing the educational benefits of virtual microscopy, several teaching sets have been added to the image archive (primarily rare pediatric and gynecologic tumors).

The VIPER application integrates with other software applications to enhance the training and professional consult experience with tools such as digital slide conferencing (DSC) which is provided by Aperio Technologies, Inc. The DSC software makes it possible for several pathologists to view the same digital slide from multiple remote locations and allows for real-time annotation sharing. The Virtual Microscope to Molecule (VM2M, see Table 2) application, developed by the Research Informatics Core and the Ohio Supercomputer Center, further integrates VIPER and virtual microscopy with

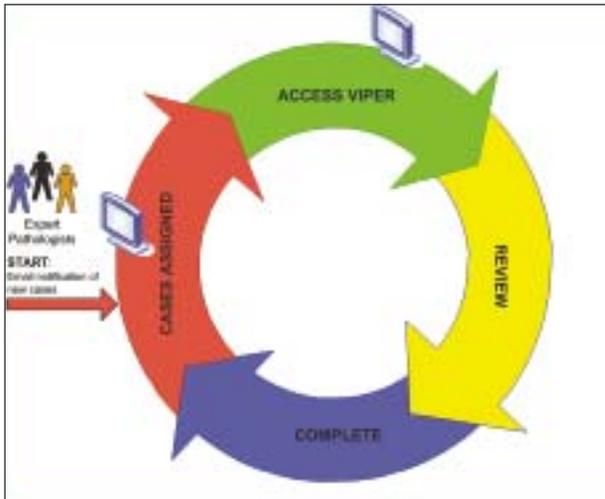


Table 1: Virtual Imaging for Pathology, Education & Research (VIPER) application

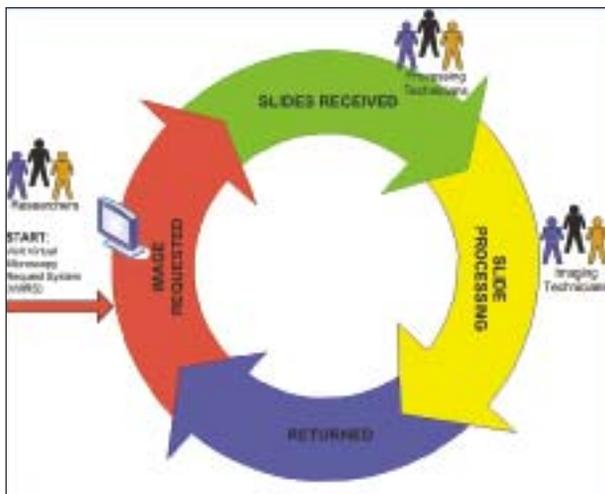


Table 2: Virtual Microscopy Request System

genetic expression data by providing a web-based multi-modal view of cancer biopsies that show pathologies of cancer cells alongside their genetic information. 

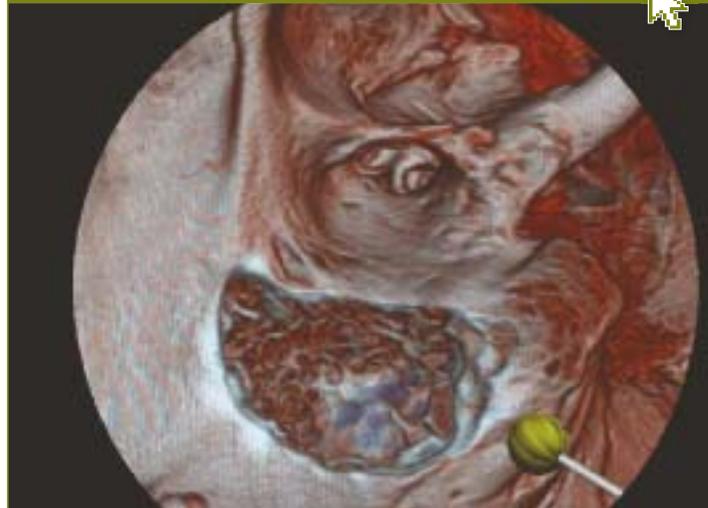
Nicole/Barr References:

1. Utilizing virtual microscopy for quality control review. Ramirez NC, Barr TJ, Billiter DM. *Dis Markers*. 2007;23(5-6):459-66. No abstract available. PMID: 18057529 [PubMed - indexed for MEDLINE]

Wiet References:

- Satava, Richard. Historical Review of Surgical Simulation-A personal perspective. *World J Surg* (2008) 32:141-148.
- Wiet, GJ, Stredney D, Sessanna and J Bryan. "Volume-based Temporal Bone Dissection Simulator," AAO-HNSF/ARO Research Forum, Annual Meeting of the American Academy of Otolaryngology-Head and Neck Surgery Foundation, Denver, Colorado, September 9-12, 2001.
- Wiet GJ, Stredney D, Sessanna D, Bryan J, Welling DB and P Schmalbrock. "Virtual temporal bone dissection: An interactive surgical simulator", *Otolaryngology-H&NS*, July (2002) 79-83.
- Cooke, DT; Jamshidi, R; Guitron, J; Karamichalis, J. The Virtual Surgeon: Using medical simulation to train the modern surgical resident. *Bul of the Am Col of Surg*. (2008) 93(7): 26-31.

Web Exclusive



To view videos demonstrating the Temporal Bone Project and for additional VIPER imaging information visit NationwideChildrens.org and search keyword: **Virtual Technology**

A Tribute: Dr. Qualman and the Creation of VIPER



Stephen J. Qualman, MD initiated the VIPER system, which was initially the Virtual Imaging Pilot Endeavor, in January 2005. As a pilot project it was created to evaluate an automated pathology review process of both normal and diseased tissues for quality control purposes. The Biopathology Center located at The Research Institute currently

acts as the biospecimen bank for the Children's Oncology Group (COG) and the Gynecologic Oncology Group (GOG). The Biopathology Center receives and processes specimens from over 500 institutions in multiple countries and distributes specimens to approved investigators.

As described in this article, VIPER has now evolved into the Virtual Imaging for Pathology, Education & Research application to introduce imaging to other areas of emphasis at the Biopathology Center.

Virtual Imaging

By utilizing two Aperio XT Scanners the VIPER Team is able to generate high quality virtual slides and make these images available via the VIPER application over the Internet. These "virtual" slides have virtually the same image quality and resolution as the same slide viewed through an optical microscope. Once the digital slide is available on VIPER a common personal computer becomes the microscope. To facilitate the long-term storage and viewing of digital images, the VIPER Team has partnered with the Ohio Supercomputer Center (OSC). As a leader in computing and networking, the OSC provides a reliable high performance computing and communications infrastructure and has allocated 10 terabytes of storage capacity for VIPER.

Pathology

The VIPER Team currently works with over twenty pathologists representing the Children's Oncology Group, Gynecologic Oncology Group, and Nationwide Children's Hospital on multiple projects related to both pediatric and gynecologic cancers as well as non-cancerous diseases.

Education

Many teaching sets are now available digitally via VIPER. Many of these teaching sets are focused on rare pediatric and adult tumors and have been generated at the request of leading cancer researchers in both the COG and GOG.

Research

The Biopathology Center receives and processes over 25,000 specimens annually. Many of these specimens are processed into glass slides and evaluated digitally for quality control purposes.

An outstanding pathologist, Dr. Qualman dedicated his life to improving the lives of patients diagnosed with cancer through research. In addition to initiating the VIPER system, he was a world leader in biopathology of pediatric sarcoma. Dr. Qualman established the Biopathology Center (BPC) at Nationwide Children's 24 years ago, making the program facility a prototype upon which other national biorepositories have been built.

Dr. Qualman's academic pursuits focused on pediatric cancers, especially rhabdomyosarcoma and other soft tissue sarcomas. He was awarded the Lotte Strauss Prize from the Society of Pediatric Pathology in 1993 for an outstanding research paper (Qualman SJ, O'Dorisio MS, Fleshman D, Shimada H, O'Dorisio TM. Neuroblastoma: correlation of neuropeptide contents in tumor tissue with other prognostic factors. *Cancer*, 70:2005-2012, 1992). He was the first pediatric pathology liaison for the Cancer Committee of the College of American Pathology. In 2004, Dr. Qualman was named Director of the Center for Childhood Cancer at The Research Institute at Nationwide Children's Hospital and the Richard M. and M. Elizabeth Ross Endowed Chair in Pediatric Research. He was also co-director of the emerging Pediatric Oncology Program in the Comprehensive Cancer Center and showed great passion and leadership throughout its development.

Ironically, the very disease that Dr. Qualman devoted his life to defeating to improve the quality of life for others, took his life on August 30, 2008. After a 13-month battle with pancreatic cancer Dr. Qualman, director of the Center for Childhood Cancer at Nationwide Children's Hospital passed away. He retired in 2007, his honors included: elected an American Association for the Advancement of Science (AAAS) Fellow in October of 2007; elected member in the Johns Hopkins Society of Scholars in February of 2008; Society for Pediatric Pathology President Award (2008); and received the American Cancer Society Hero of Hope award (Ohio Chapter) in August 2008.