A year ago, surgeons at Massachusetts General Hospital, guided by digital x-rays transmitted from the South Pole, helped a physician at the Amundsen-Scott South Pole Station surgically repair the damaged knee of a meteorologist overwintering in Antarctica. Teleradiology plays a leading role in such long-distance medical dramas. Three other Antarctic research stations are now wired to transfer DICOM images directly to the University of Texas Medical Branch at Galveston (UTMB).

Although research stations are staffed by emergency physicians and physician assistants, onsite specialty care is limited. UTMB's role is to provide specialty opinion in difficult cases. Providing polar teleradiology presents unique challenges, however. The South Pole is 17 hours ahead of Central Standard Time, and satellite line-of-sight variability makes communications acceptable for irregular periods only.

"Some days they may have a large-bandwidth pipe over which to communicate, and other times it's minimal at best," said Jake Angelo, director of technology at UTMB's Center for Telehealth and Distance Education. "In order to hit a satellite you have to shoot over the equator, and the Earth gets in the way if you're on the South Pole."

The Antarctic incident is an example of how contemporay radiology is being recast to meet changing radiology demands. Reshaped by digital technologies, demand for remote medical services, and personnel shortages, today's radiology department is no longer a medical monolith confined to the hospital basement. Patients may still find imaging modalities at the end of locator lines painted on hospital corridor walls, but the reading radiologists themselves may now often found across town or even on the other side of the world. It is not unusual for the midnight scans of a car accident victim in Minnesota to be read within three minutes by a radiologist in Bangalore, India.

Broadly defined, teleradiology is a means of electronically transmitting radiographic patient images and consultative text from one location to another. Image transmission depends primarily on high-speed electronic communication pipelines such as ATM (asynchronous transfer mode) or gigabit networks that enable rapid transmission of digital images without loss of content or resolution. Advances in computer technology, telecommunications, and digital medicine have served mostly to widen the digital divide between the developed and the developing worlds. Those who need technology the most have the least. In sub-Saharan Africa, 14 entire countries do not have a single radiologist. But teleradiology is adept at closing economic and technological gaps. Critical infrastructure necessary to support double-reads or electronic consultations in emergency or special cases is slowly threading its way into the Third World. High-speed data links to the African continent are coming online via an undersea cable launched last year, signaling good news for patients in areas with few medical services.

The $650 million cable backbone, built by a consortium of 36 telecommunication companies led by Telkom, stretches from Portugal, down the west coast of Africa, around the Cape of Good Hope, and on to India and Malaysia, delivering up to 130 Gbps. All countries along Africa's Atlantic coast have immediate access. Links to landlocked nations will follow as necessary.

Global teleradiology services are, in fact, popping up all around the world:

· Colombia: The Centro de Telemedicina network connects two islands in the Caribbean, Leticia and Centro Providencia in the Amazon, and an aboriginal community between the Apaporis and Miriti rivers to a central server and diagnostic workstations in Bogotá.

· Tomsk, Russia: The Telemedicine Center at Siberian State Medical University is gearing up to support 12 medical disciplines at university clinics, including teleradiology. "We are ready to transmit radiological images in order to create faster diagnosis," said Khasanshin Yuri, chief of information technology.

· South Africa: The Eastern Cape TeleHealth Programme supports diagnostic services in rural hospitals in Eastern Cape province. Candidate teleradiology images for consult are sent to the Basel...
University iPath server.

- Nigeria: The Jajuwa Foundation supports a store-and-forward teleradiology service, using a digital camera to snap x-ray films to forward by e-mail.
- Greece: The Network of Integrated Vertical Medical Services, based on a powerful multimedia health record with the ability to manage data and images, hopes to create a European-wide telemedicine network connecting central health organizations with remote locations and ships at sea.
- Punjab, India: The Development of Telemedicine Technology links three major North India hospitals practicing teleradiology, telecardiology, and telepathology.
- Islamabad, Pakistan: The philanthropic TelMedPak project is trying to improve quality health services for rural residents and reduce the isolation of rural practitioners through the use of telemedicine technologies, including teleradiology. Images are transferred initially using simple e-mail store/forward.
- Tokelau: On this isolated Pacific atoll with limited medical resources, the Tokelau Health Telemedical Program provides access to specialist resources in New Zealand, including the ability to transmit images from a digital camera, scans of x-rays and electrocardiograms, and captured images from the ultrasound scanner.

Telemedicine in the form of satellite-operated telecenters housed in recycled 20-foot metal ISO shipping containers (called LINCOS, for "little intelligent communities") has begun to address connectivity needs in areas of Togo, Uganda, Tanzania, and Kenya, as well as parts of the Philippines, Vietnam, Russia, and Brazil.

LONG-DISTANCE REMEDY

Teleradiology in the West, while more mature in Scandanavia and the U.S., is just finding its legs elsewhere, propelled by the same interests and demands for remote medical services as in the Third World.

In Europe, several pilot teleradiology programs have been conducted, mostly within hospital groups or academia to test technical, organizational, legal, and economic issues in digitization and networking in specific areas, said Dr. Erik Ranschaert, a radiologist at Jeroen Bosch Ziekenhuis, locatie Carolus Hospital in 's-Hertogenbosch, the Netherlands.

One example is the Rhineland-Palatinate project in Germany, which makes use of the CHILI network. Another example in Germany is a project in Saxony, called SaxTeleMed, a government initiative covering seven regional projects and 39 hospitals.

In Italy, a RIS/PACS implementation being carried out at a provincial level includes four heterogeneous hospitals and two healthcare centers, representing approximately 290,000 procedures annually. Also in Italy, the Island Project consists of a cardiological and radiological telemedicine videoteleconsulting network, connecting the islands of Procida and Ischia off the Naples coast to mainland hospitals of Pozzuoli and Giugliano.

Networking and teleradiology between hospitals is most advanced in Scandinavia, where many hospitals already have PACS, a necessary component. The Pax Vobiscum project in Sweden built one virtual filmless radiology department through the total digitalization and integration of five independent radiology departments within Örebro County. This virtual department performs approximately 180,000 procedures a year, one of the largest PACS installations in Europe, with 48 radiology rooms forming a functional unit.

"In most other EU countries, PACS is still relatively scarce, and therefore teleradiology is simply not possible," Ranschaert said.

In the Netherlands, however, digitization has flourished. Ranschaert estimates that most hospitals there will have PACS by the end of 2005.

Still, the only functioning commercial teleradiology company in Europe is Ranschaert's Eurad Consult, a group based in Mechelen, Belgium, that provides primary and subspecialty reads and expert opinion to customers located primarily in the Netherlands.

Eurad is well placed to take advantage of current political and economic climates. The Netherlands is dealing with a radiologist shortage, and many hospitals have waiting lists for imaging studies. The political trend in some areas toward privatization of medical services also invites teleradiology expansion.

"Our long-term goal is to provide worldwide 24/7 services," Ranschaert said.

Once all licensing issues are resolved, whether by complementary training and examinations for EU radiologists or international political agreements and collaboration, it will be possible to provide around-the-clock radiology services throughout the entire world, simply by following the sun.

LOCAL ANSWERS TO GLOBAL CHALLENGES
Experts agree that today's radiologist shortage will only get worse?the workforce is aging and fewer new radiologists are joining its ranks. Teleradiology offers a likely solution. In some cases, teleradiology is not only bringing medicine to the underserved, it is relieving rural hospitals of the burden of attracting their own radiologists, which is becoming more and more difficult.

"Without radiology services, rural hospitals will tell you they cannot keep their doors open," said Steven Mecklenburg, telehealth coordinator at Poudre Valley Health System, Fort Collins, CO.

Poudre Valley's telehealth system began in 1998. It provides diagnostic-quality digital teleradiology to several outlying hospitals in the High Plains region of Colorado and Nebraska, including Haxtun Hospital District in Haxtun, CO; Memorial Health Center in Sidney, NE; Kimball Community Hospital in Kimball, NE; and Morrill County Hospital, in Bridgeport, NE.

Teleradiology projects abound throughout the U.S.: The Children's Memorial Medical Center telemedicine service in Chicago includes clinical consultations and interpretations in cardiology and radiology, connecting institutional and physician sites in the U.S. and several international sites. In Minnesota, the Allina Health System/Rural Health Alliance Telemedicine Network links rural locations to urban radiology subspecialists for emergency coverage. The Upper Peninsula Telehealth Network provides teleradiology coverage throughout northern Michigan.

In Puerto Rico, the Telemedicine Pilot Study installed a system between the municipality of Vieques and the Tertiary Centro Medico Emergency and Radiology Department in San Juan that allows patients to have imaging studies performed and diagnosed from Vieques. This saves them the expense of traveling to the main island.

While the U.S. may have the richest concentration of teleradiology programs, it also has a full complement of challenges. Among the hazards of providing state-to-state teleradiology is malpractice insurance, which is not only expensive but difficult to obtain in large part because teleradiology-focused insurance companies are new and the risks are unclear. The idea of radiologists interpreting images at 3 a.m. from their bedrooms sends shudders down the backbone of insurance company decision-makers.

A 2002 Diagnostic Imaging Intelligent Report from the Institute of Management and Administration in New York, found that one recent quote was $225,000 per year for covering 90,000 reads, an amount equal to approximately $50,000 per full-time radiologist, assuming each FTE did 20,000 reads per year. The rates are high, DIIR said, because malpractice lawyers can pick the most plaintiff-friendly states in which to sue. They can file suit in the state where the teleradiology firm is based, the state where the patient is located, or even in another state where the teleradiology firm happens to do business.

It's possible to negotiate lower rates ($30,000 to $40,000 per radiologist) if the practice agrees not to read studies from high-liability areas such as Manhattan and parts of Florida. Licensing is another hurdle. Most states require a full medical license to practice teleradiology, and this can run as high as $10,000 per state per radiologist, including fees, time, and other costs.

The 20% shortage of U.S. radiologists is also a trip wire for nighthawk teleradiology services that exploit global time zone variations for domestic radiology groups.

"The U.S. shortage of radiologists is driving practices to find creative staffing solutions, including teleradiology, to meet demand for their services," said Dr. David Hirschorn, a clinical fellow in radiology informatics/MRI at Massachusetts General Hospital and Harvard Medical School.

By stationing or enlisting radiologists in a different time zone to cover nighttime hours in the U.S., a practice can avoid having any local radiologist take night call, an attractive inducement when recruiting. Overnight demand for radiologists follows the dramatic increase in emergency department volumes. Taking call most night in most areas has become untenable.

"Ten years ago I could sleep through the night on call," said Dr. James Sayre, director of diagnostic radiology at Valley Medical Center in Renton, Washington. "Now, they wake us at least once an hour."

PACS, DSL, cable modems, and virtual private networks are enabling technologies that allow real-time interpretations of nighttime studies by qualified?and alert?radiologists located thousands of miles away.

NIGHT MOVES

Two basic nighthawk models have emerged: Radiology groups station one or two of their members at a time overseas for short periods, or they contract with radiology services already there. In the Middle East, for instance, two U.S.-trained and board-certified radiologists living in Israel provide real-time interpretation services during the wee hours in the U.S. for three hospitals in the Crozer-Keystone Health System in Delaware County, PA. Both radiologists are licensed in Pennsylvania and credentialed at the hospitals they serve.
Between 10 and 30 CTs are transmitted to Israel every night, along with an assortment of ultrasound and nuclear medicine exams. Head CTs take about two minutes to transmit, and abdominopelvic CTs four to 10 minutes, using compression settings optimized to increase transmission speed while maintaining diagnostic quality. Network connections are provided over the Internet by a VPN running over 1.5-Mbps DSL in Israel and a T1 line in the U.S. Workstations are installed in the radiologists' homes in Israel.

"We take over for the U.S. radiologists between 11 p.m. and 8 a.m.," said Dr. Jonathan Schlakman of Remote Radiology International. "Head CTs are turned around within five to 10 minutes, and abdominopelvic CTs between 10 and 20 minutes."

Emergency physicians prefer the nighthawk service to the previous night call system, since they now receive service at night on par with daytime coverage. The hospitals' attitude is so positive they actually advertise it, touting higher quality radiology service because scans are being read by radiologists who are already awake, not by someone who's just been disturbed.

While international nighthawk arrangements benefit the practice, the radiologist, the emergency department, and the patient, controversial issues remain. Reimbursement is one.

"Medicare prevents offshore final reads from being reimbursed," said Dr. Arjun Kalyanpur, CEO and chief radiologist at Teleradiology Solutions in Bangalore, India.

Short of sorting all cases immediately based on payer, nighthawks find it simpler to provide preliminary reports, which the in-house radiology group can scrutinize the next morning before issuing the final report. Next-day review, while inherently unproductive, is not all bad. It allows the group to perform quality assurance and have the final word on any report, which is in the best interest of patient care.

Licensing and credentialing can also be issues. In order to provide international nighthawk services, the interpreting radiologist must be certified by the American Board of Radiology, licensed in the state in which the image originates, and have malpractice insurance to cover practice within the U.S.

"Some states now offer specific telemedicine licenses that are adequate for teleradiology coverage and somewhat easier to obtain than the regular state license," Kalyanpur said.

Once the radiologist is licensed in the state in which the group is located, the only delay is related to credentialing, which can be tedious. A new online physician credentialing service (www.caqh.org) could help. The service, developed by a group of health plans and run by the not-for-profit Council for Affordable Quality Healthcare, allows physicians to complete a single contract form, which is accepted by all member health plans.

A YANK RADIOLOGIST IN CAMBRIDGE

Sayre's group decided against contracting for nighthawk coverage, choosing instead to rotate one of its own staff eight hours east of Washington State to a Cambridge, U.K., cottage for several months at a time to provide overnight reads. Sayre himself was there for six months last year and is returning soon for a two-year stint.

"Unlike other groups that contract out the service, we recognized that if we signed up with a group that would merely offer preliminary reads, that would allow us to sleep at night but all that over-reading was still to be done the next morning," he said.

The group, which started its Cambridge teleradiology operation in early 2001, is believed to be the first private group to do so. Because there's not enough overnight work to keep the Cambridge radiologist occupied full time, the group was taking an economic hit: In addition to the cost of teleradiology, it was paying full salary for part-time work. The solution was to take late afternoon early evening outpatient work in Renton and shift it to England.

This accomplished two things: It keeps the Cambridge radiologist busy all day, and it decreases report turnaround because afternoon-evening outpatient studies usually weren't read until late the next morning. Now those cases are already read and transcribed by 8 a.m.

"That radiologist, who used only read 12 cases, now reads 45," Sayre said. "You've just paid for your European radiologist."

Sayre surveyed several venues, including Amsterdam and Israel, before selecting Cambridge. Israel was rejected primarily due to political instability.

"We decided on Cambridge for all the reasons that Amsterdam wouldn't work," he said. "When you tell somebody you're going to Amsterdam, they think it's a junket. In Cambridge, the language barrier is effectively nonexistent, which is not to be underestimated when you're going to Europe."

Some experts caution those considering nighthawk services to resist the temptation to dismiss developing nations based on fears of technological inferiority.

"The decision to go with a particular nighthawk provider should be determined by performance as certified by current users and by the credentials of the interpreting radiologists, and not on racial
biases or popular conceptions of what may or may not constitute a high-technology region geographically," Kalyanpur said.

At present, he is the only Indian radiologist providing nighthawk service to the U.S. He receives an average of 25 emergency scans per day from several U.S. hospitals, including Yale-New Haven Hospital and the University of Minnesota Clinical Center.

The Cambridge setup is not yet bulletproof. For one thing, weekend coverage is nonexistent. The radiologist there works 9.5-hour days, from 6 a.m. to 3:30 p.m., Monday through Friday, covering Sunday night through Thursday night back in Renton. Remedies include a possible contract with a local U.K. group for weekend support.

"Right now, we still have to take call on weekends, reminding everybody how bad call is," Sayre said. Some question whether the nighthawk arrangement is actually generating additional income. Sayre explains it in terms of hiring, which for most private practice groups is the most expensive thing they do.

"If you can delay a hiring by one or two years, that's where the real cost savings come," he said. One other benefit is better patient care. It goes without saying that an awake radiologist will do a better job than a sleepy one. Another benefit that wasn't expected was the response from the emergency department, which was expected to reject the service.

"They love it," Sayre said. "They went from skepticism to willingness to being our biggest advocate. What's fascinating is they now believe they get better coverage at night than they do on days."

Previously, emergency physicians would hesitate to wake up the radiologist at 3 a.m. Now, EP's dial a four-digit number on campus and the phone rings in Cambridge.

"They call much more in England than they do when we're on call here," Sayre said. "They know they're going to get somebody who's wide awake and happy to talk to them.

YEN FOR TELERADIOLOGY

In Japan, the radiologist shortage is mandated by local medical law, which allows any physician to practice radiology. Under Japanese policies, hospitals are equipped with imaging modalities but are not staffed with radiologists to interpret the studies. Teleradiology has therefore enjoyed a necessary popularity since 1993.

"Teleradiology offers the possibility to run imaging centers in local communities without radiologists," said Dr. Mutsumasa Takahashi, chair of radiology at Kumamoto University School of Medicine.

As elsewhere, Japanese teleradiology has expanded for other reasons. Information technology has enabled the transmission of high-quality images within an acceptably short time period. And the introduction of PACS has promoted an acceptance of filmless radiology.

"Teleradiology has made significant contributions to Japanese medicine," Takahashi said. "High-quality reports are available to clinicians quickly for patient management."

Japanese hospitals send imaging exams to one of about 10 radiology groups. Takahashi directs the largest group, with about 300 hospitals under contract.

"When images are sent to us, we interpret them within 24 hours, then send the reports to the referring physicians," he said. "We get 600 to 700 studies every day."

Takahashi's group includes 75 to 80 radiologists. It does not currently provide nighthawk services to the U.S., Europe, or elsewhere in the Pacific, although in the future this is likely.

"The issue is licensing," Takahashi said. "Some countries require medical licensure in those countries, so it can be rather difficult to establish a teleradiology relationship at present."

Reimbursement is an open issue in Japan as well. Under present Japanese health insurance, fees for MRI interpretation have been set at ¥3000 (about US$25) and ¥2000 (about $16.68) for CT reads. "This is not adequate for the management of teleradiology services," Takahashi said.

SEA CHANGE

The reach of teleradiology extends to the high seas, although most experts agree that the maritime teleradiology is still limited. It does allow the transmission of radiographs from a ship anywhere in the world via satellite and Internet links for immediate expert radiological opinion and advice. Among the major cruise lines, only Princess Cruises offers a teleradiology service. Five ships in the Princess fleet beam radiographs to Southampton University Hospital in the U.K.

"A number of maritime operators have been offered teleradiology and telemedicine in one form or another," said Dr. Vincent Batty, director of nuclear medicine at Southampton. "The biggest stumbling block is cost, particularly since Sept. 11."

Cruise lines are enduring faltering tourism, first because of terrorism fears and then because of SARS and the Iraq War.

"They're looking to trim expenses. But Princess finds that teleradiology is still worth the expense,"
Batty said. Teleradiology enables cruise lines to minimize the risk of litigation in the event of medical complications, and at the same time it allows repudiation of frivolous claims. Maintenance of radiographic equipment aboard ship is another headache cruise lines don't want.

"If you have something aboard that breaks, you can't just pull into Turks and Caicos and expect a GE or Philips technician to be there to fix it," said Dr. Philip Brewer, an assistant professor of surgery and emergency medicine at Yale University and a consultant to Vanter Cruise Health Services, the provider of shipboard medical care for Disney Cruise Line. "Also, when equipment is moved on or off ship, there are customs issues."

In the absence of teleradiology, cruise doctors take high-resolution pictures of x-ray with digital cameras, then e-mail the image to the shoreside consultant. Batty’s operation looks at about 20 images a month from each of the five Princess vessels, mostly plain radiography of chest and extremities.

An American College of Emergency Physician report says that 5% of passengers, most of them elderly, report serious illness during their cruise. There were 60 deaths on ships sailing out of Miami between 1996 and 1999, according to a 1999 New York Times investigation of cruise ship medicine. The report also found radical variation in onboard medical standards, including physician competence. Most cruise ships are registered in countries such as Panama, Liberia, and the Bahamas, which have far less stringent regulations for physicians than the U.S.

"There is a widely held, naive assumption that medical facilities on a cruise ship are equivalent to those of a small hospital," Batty said. "This is not the case. A cruise ship may be a floating town, but it is certainly not a floating hospital."

Batty runs a crew training course to make sure ships’ medical personnel are able to use the imaging equipment properly.

"It's no good just putting the modalities on the ship and asking them to press a button and send the film over," Batty said. "They've got to be able to send something of good diagnostic value."

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