by Madan M. Rehani

Smart Protection

An electronic "Smart Card" could serve as a digital medical record of radiation exposure for patients who want one.

Up until a decade ago, radiation protection programmes in healthcare were largely dominated by actions that concerned protection of the staff at the medical facility. Patient protection was felt to be not as important, as it was assumed that a patient undergoes examination with ionizing radiation once or only a few times in his or her lifetime.

When I entered the medical radiological profession in 1972, I was informed that my protection, as a member of staff, was more important than protection of the patient. Most countries of the world had adopted a system whereby it was mandatory to monitor radiation dose to the staff and keep lifetime records of it, while annual dose limits for staff as well as for members of the public were set. It was always felt that the concept of "dose limit" should not apply to patients, because of the associated medical benefits of exposure to radiation.

Further, if you asked the representative of a manufacturer of imaging equipment about the radiation dose to the patient, he would hardly have a clue as no buyer would normally ask such a thing. The image quality and the speed of the examination were the main focus of buyers rather than the radiation dose for patients. Take the example of computed tomography (CT). Every year the manufacturers of CT scanners would announce an improvement in scanning time from the previous year while there would be no mention of radiation dose. Faster scanners are what users want. In fact, most professionals would still instinctively associate lower radiation dose with a quicker scan.

The early emphasis on staff protection did pay rich dividends in terms of making staff safer. Currently, most (nearly 98%) of those who work with ionizing radiation in any area of medical practice receive a radiation dose that is lower than what they get from natural radiation sources — the so-called background radiation, e.g., cosmic radiation, radon, radiation from building material, earth, food, etc. Background radiation depends on the place you live, but typically is 1 mSv to 3 mSv per year, although in some places can be up to 10 mSv. The dose limit for staff currently recommended by the International Commission on Radiological Protection (ICRP), and adopted by the IAEA and most countries with few exceptions, is 20 mSv/year, expressed as 100mSv over a period of five years. Such has been the success of occupational radiation protection programmes that not even 0.5% of staff members who work in medical facilities (or in any nuclear facility) reach or exceed the dose limit.

Since there are no dose limits for patients, many may incorrectly assume that there are no controls on patient exposure. The 1996 International Basic Safety Standards (BSS), developed by the IAEA in cooperation with Food and Agriculture Organization (FAO), International Labour Organization (ILO), Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA), Pan American Health Organization (PAHO) and World Health Organization (WHO), clearly

Radiation Record Card: this image is only a representation of what such a card might look like if developed.

stipulates requirements on patient protection that involve the need to justify and optimize radiation doses. Although no dose limits are propagated, the concept of diagnostic reference levels or guidance levels (DRL or GL) has been proposed. This concept has been included in the European Safety Standards and in most national regulations. Thus there are requirements to keep radiation dose for the patient as low as possible without hampering the diagnostic or intended clinical purpose.

Many countries have estimated DRLs based on large scale surveys and have used these to demonstrate a reduction in patient doses with time, say over 10 years. But such reductions have been observed only for simple radiographic examinations such as chest X-rays or X-rays of other parts of the body. The effective dose to the patient from any of these radiographic examinations is typically in the range of 0.02mSv to 2mSv. During the last 100 years, improvements in technology have resulted in dose reduction for single radiographic examinations by a factor of a few tens.

However, these are low dose examinations, whereas a single CT scan can impart a dose of 5 mSv to 20 mSv to a patient. On average, a CT scan with 10 mSv effective dose is equivalent to 500 chest X-rays, each with 0.02 mSv. Yet, patients nowadays are not getting lower doses compared to two decades ago. While technology has improved substantially, making it possible to obtain a CT scan with a lower radiation dose than in the past, the usage pattern has been changing. Much better clinical information is obtained, but generally there is no reduction in dose per examination.

This apparent paradox could be better understood by comparing CT scans to personal computers (PCs) and the evolution they have gone through. The price of PCs has changed relatively little over the years, but their performance has improved many fold. Similarly, the diagnostic benefits of CT scans have been increasing over time, as has patient friendliness thanks to shorter scanning times, making it very convenient for patients — unlike MRI scans, which still remain relatively unfriendly for the patient. For a CT scan, you just hold your breath for a few seconds and your whole chest is scanned with CT, or your whole body (head to pelvis) is scanned in about a minute. As for MRI, the patient has to lie in an inconvenient tunnel with the unpleasant noise of gradient coils for almost 40 minutes for each scan. The convenience of CT with the added advantage of increased information has resulted in increased usage to the point that there are instances of patients getting tens of CT scans in a year, which may not be justified, or getting CT scans when it is not indicated. An increasing number of infants and children are also getting CT scans.

A Growing Problem

It is the alarming increase in use of high radiation dose examinations such as CT that is creating a need for cumulative records of patient dose, somewhat similar to the practice adopted for medical staff all these years. Of course, this would be a voluntary system for patient dose records rather than a mandatory system.

It may be argued that in no other practice in the world is a human being exposed to so much radiation as in medical examinations. According to the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), there are over 4 billion medical radiation imaging procedures done annually. Other than natural background radiation, medical uses constitute the next largest source of ionizing radiation to the world's population.

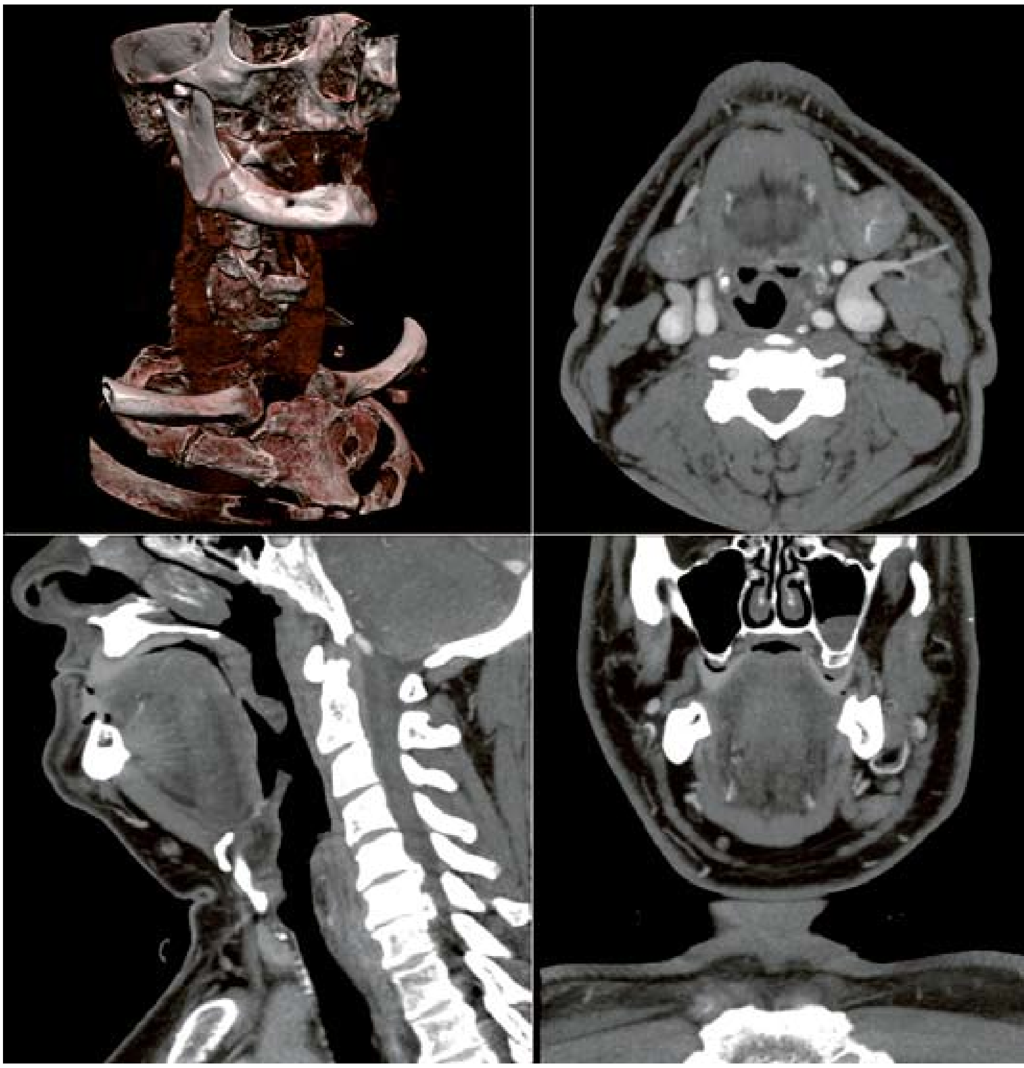
There has been an increased use of X-rays to guide interventions so as to replace surgical procedures. A typical example is angioplasty, which has reduced the need for coronary bypass surgery in many situations. But the patient exposure to radiation is quite large (no less than CT) and there have been a number of reports of radiation-induced skin injuries to patients.

In the early part of twentieth century, when radiation protection measures were not yet established, skin injuries to the hands of those working with X-rays were often observed. Then, for almost 70 years (from the 1920s to 1980s) such injuries largely disappeared. It was in the 1990s that a number of skin injuries in patients undergoing interventional procedures started to be observed. Thus we are now in an era when patient exposure has increased tremendously, is increasing and will continue to increase. Overall, this may not be a bad thing as the medical benefits still outweigh the harm. But there is growing concern about increased cumulative doses to patients. For example, an estimate based on UNSCEAR data indicates that the average lifetime dose to the patient is almost 200 times higher than the average lifetime dose to the staff. This means that the conventional dictum that staff protection is more important than patient protection is no longer valid. This calls for action and thinking about the future.

The IAEA is the first UN organization to take a lead in this area, in a clear sign of its commitment to the radiation protection of patients. In fact the IAEA was the first organization to create a separate unit dedicated to the "radiological protection of patients" in 2001.

An international action plan on radiation protection of patients has been developed involving a number of international organizations such as WHO, PAHO, UNSCEAR, ICRP, European Commission (EC), International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) and professional societies in the field of radiology (ISR), medical physics (IOMP), nuclear medicine (WFNMB), radiographers (ISRRT) and radiation oncology (ESTRO).

The risk of cancer from radiation doses imparted through a number of CT scans is not insignificant. Most other radiation effects (such as skin injury, just to name one) can be avoided rather effectively, but this is not true for the risk of cancer. There are estimates of few million excess cancers in the USA over the next two to three decades from about 60 million CT scans done annually.



A Smart Plan

So, what needs to be done? The situation demands records of patient doses such that there is a lifetime record of how much radiation an individual has received. This is a highly ambitious plan full of ifs and buts, but developments in information technology in health care show promise.

One idea is to have a 'smart card' that contains a patient's information including radiation dose data. This is something that is already in sight in several countries, at least for medical records, and if works starts right now it is possible to imagine that it will be possible to add radiation dose information to the smart card. However, more important than that is the electronic health record systems that many countries are aiming at. Imagine a situation where the health records of a patient in a European country (say A) are available on a server in his country. He goes to another doctor in another country (say B) and gives permission for this doctor to access his records. Thus doctor B does not need to repeat many radiological examinations that were already done. Again, this will result in avoidance of additional radiation exposure to millions and millions of patients. This is something that is not a distant dream but could fast become reality.

The IAEA has launched a smart card project that covers both of the above options. The first meeting dedicated to the smart card project was held in Vienna on 27-29 April 2009. Much of the framework will be decided and partially implemented within three to five years. The manufacturers of the imaging equipment and those dealing with issues of standards for inter-connectivity and inter-operability will also be involved. After all, it has taken decades to develop occupational dosimetry and still its outreach is far from 100%.

It is hoped that despite increasing use of radiation which is for the benefit of patients, it will be possible to keep radiation risks to a level that are acceptable.

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A lifetime record of how much radiation a patient has received is a highly ambitious plan. But developments in information technology in health care show promise.

(Photo: wikimedia commons)

africa's nightmare

by Sasha Henriques

The Struggle to Protect Medical Workers in Radiological Services

Africa is sharing the benefits of advances in medical imaging technology that makes it possible for doctors to more quickly diagnose and treat serious illnesses. But the stunning new machines have brought along some problems of unknown magnitude in the absence of adequate monitoring of staff for radiation exposure. Overexposure of medical staff to ionizing radiation is one concern.

As the complement of lifesaving machines grows in African countries, so has this problem. Practitioners say it stems from a number of causes — lack of oversight, insufficient staff, poor equipment, inadequate dosimetry, medical personnel who aren't properly trained, and a lack of guidelines.

The situation affects thousands of workers across the continent, and highlights the need for more training and support.

Over the past six years, the IAEA has trained 107 radiographers and radiologists from 26 African countries in radiation protection. It has also helped 35 of the continent's governments draft radiation protection legislation, and provided detailed guides to States for the application of the IAEA's International Basic Safety Standards on radiation protection.

The work is ongoing. Zambia and Kenya, two African countries where officials say more support is needed to control radiation exposures, are receiving help from the IAEA.

Beatrice Mwape, a medical imaging specialist in Zambia's Ministry of Health describes the situation in her country" "We have a CT (Computed Tomography) scanner, we are planning to buy an MRI (Magnetic Resonance Imaging) machine. We have ultrasound services and we have a radiotherapy centre. Some of these use radiation. There are also some hospitals with obsolete equipment, which need to be checked almost every month to ensure that the right dosage of radiation is going to the patient as well as to the radiographer. And that is a major problem for us."

There are 150 workers in radiation-related jobs in Zambia's civil service. But officials have no idea how many are in the private sector. These persons remain off the radar and are never monitored for radiation exposure. For those within the Health Ministry's sphere of influence, the IAEA provided Zambia with a Thermoluminescent Dosimeter (TLD) reader in March 2006, and has offered to procure another for the country's health service under a cost-sharing scheme in 2011.

Kenya also struggles to monitor its 5,000 workers in radiation-related jobs at 600 medical facilities. Only about a quarter of these nurses, patient assistants, dentists, radiographers, and radiologists are monitored for exposure.

The IAEA is working with the Kenya Bureau of Standards to standardise radiation measurements. Specialists helped design the country's secondary standards laboratory, which last year began offering calibration of machines involved in radiation monitoring. The IAEA also provided basic equipment, trained essential staff and provided expert advice to the Kenyan authorities.

Problems Grow Alongside Demand

Dosimeter badges measure the radiation dose to which an individual has been exposed. Not all of Zambia's 150 radiographers in the country's 94 public hospitals have these badges. Even those who do aren't being monitored because of the Radiation Protection Authority's acute personnel shortage.

The Authority is charged with monitoring workers, but its three officers have no proper transport in a country that covers more than 290,000 sq miles. They find the task virtually impossible. "So my radiographers are never monitored," says Ms. Mwape. "And that is a major problem."

Estimates suggest that there are more than 7,000 new cases of cancer in Zambia a year, and 3,600 new cases in Kenya annually. As cancer cases increase, so has the demand for radiation therapy.

In 2003 the Zambian government and the government of the Netherlands provided 25 million Euros to equip 71 hospitals with new X-ray equipment and ultrasound machines. There are plans to purchase more medical imaging equipment, all of which use radiation.

Ms. Mwape says, "We would like radiographers in the provinces to be trained to do inspections, so they can assist the Radiation Protection Board. But more importantly, we need more radiation protection officers. So far, our current crop consists of only diploma holders. There's nobody with advanced training."

The IAEA does offer training, but the majority of Zambian workers aren't qualified to take advantage of it, since the minimum requirement is an undergraduate science degree. Over the past six years, only two workers have qualified for the IAEA's advanced training course.

In Kenya, Dr. Jeska Wambani, Chairman of the Radiation Protection Board, says, "There is no academic institution in our country that offers medical physics as an area of study. The five medical physicists we have were trained abroad." She wants to see a centre set up that would cater to the needs of the East and Central Africa region and train professionals in nuclear and radiation safety.

To date, Kenya has benefited from the IAEA's biannual regional post-graduate educational course on radiation protection and safety of ionizing radiation sources. So far, five officers from the Kenya Bureau of Standards, the Radiation Protection Board and Kenyatta National Hospital have been trained.

To the Heart of the Matter

Using poorly calibrated radiotherapy and medical imaging machines has resulted in radiographers and patients in both countries being exposed to unknown amounts of unnecessary ionizing radiation. Both Ms. Mwape and Dr. Wambani agree that more research is essential to determine the true scale of the problem.

Beatrice Mwape, a medical imaging specialist in Zambia's Ministry of Health, spoke about her country's plight during the IAEA's General Conference in September 2008.

(Photo: D.Calma/IAEA)

"We don't have national guidelines and standards in diagnostic radiology in Kenya because we don't have enough data," says Dr. Wambani. "And we don't have the data because we lack adequate funds to collect statistical information from hospitals all over the country."

Data is necessary because worker and patient radiation exposure are inextricably linked. Containing patient dose levels will mean lowering doses delivered to medical workers as well. This is where the IAEA comes in.

The Agency's Department of Technical Cooperation is undertaking a project at the Kenyatta National Hospital in the capital Nairobi, and at the Moi Teaching and Referral Hospital Eldoret, a teaching institution outside the capital. Both are being used as model sites where radiation dose information is gathered, analysed and then used to create diagnostic reference levels for Kenya. Dr. Wambani says attempts are being made to expand the project to all the hospitals in Kenya's eight provinces.

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Measure for Measure

by Sasha Henriques

The IAEA is drafting guides for proper use of diagnostic imaging technology

There has been a boom in the use of ionizing radiation for diagnosis and treatment of illnesses all over the world. This is generally good, contributing to accurate diagnosis of disease and preventing unnecessary exploratory surgery. Research has shown that with these tests there is a tendency towards overuse, and up to 50% of the machines involved in these procedures may not be set up correctly. Jim Malone in the IAEA's Radiation Protection of Patients Unit addresses some of the possible risks.

Question: Patients sometimes get too much radiation. Does the equipment have to be old for this to be a problem?

Jim Malone: No. I know of very new digital equipment which was set up in two clinics. For a long period patients were getting eight to 10 times the dose they needed because the equipment was set up that way, and the technologists didn't notice.

This is a big problem with digital equipment — you get a perfect image every time regardless of the dose. It's not like film where you're guided by an image that's too dark or too light. Digital systems pull the image into an area where it's nicely visible no matter what the dose.

A big problem with older equipment was that you'd get a dreadful image and have to repeat the procedure. But with modern equipment you get a nice image no matter what and you may be getting it at the right dose, at half the dose, or at 10 times the dose.

Question: Where does the problem come from?

JM: If you don't have well trained technologists you get much more of this type of thing. You need staff, maintenance, and quality assurance, all of which have a very high overhead in training. Modern equipment is very particular. You need people who are well trained on the specific machine that they're working with.

That's a bigger problem today than it was 20 years ago. Then, the equipment was fairly generic and didn't have a lot of possibilities. It couldn't do as much, but you couldn't go as far wrong with it.

You also have problems if you don't have the equipment regularly maintained. This is a bigger problem in developing countries because they often don't have the budget to sustain the equipment.

But even in the best funded and best resourced places, to make sure the equipment is doing what it's supposed to, you need a quality assurance programme. So one of the things the IAEA advocates is having a good quality assurance programme for whatever equipment you've got.

Question: What are good Quality Assurance protocols?

JM: Studies have been undertaken to find out what is the best technical and clinical way to do a chest radiograph or a paediatric CT scan of the abdomen for example. The information is available, practitioners just need to use it. Good radiology involves a partnership with the industry which supplies the equipment. In diagnostic radiology the relationship between the industry and users in clinics and hospitals is not entirely satisfactory.

There was an audit done in the Nordic countries that found that roughly 20% of the examinations were of no value to diagnosing or solving the problems patients were experiencing. There was also a survey done in an American emergency room which found that 45% of the examinations weren't of any serious value.




Dean Calma/IAEA

Even in the best funded and best resourced places...you need a quality assurance programme. So one of the things the IAEA advocates is having a good quality assurance programme for whatever equipment you've got.

—Jim Malone

If you have lower back pain for example, and you go to your doctor and he recommends that you have what's called a lumbar spine x-ray, the only thing you can be sure of, is that that x-ray is normally not so useful. Lumbar spine x-rays are high dose examinations, and unless you have other complicating factors, they will tell absolutely nothing that's of any value in deciding how the back pain will be treated. It's really like a placebo.

So the first step in any protocol is: "Is this examination of any use? Is it worthwhile?"

The next aspect of the protocol is that for heavier people you need more x-rays than for small people. So your protocol should include adjustments for the size and shape of the person.

It's well known for example that for years children were receiving much higher doses than they needed because with CT scanning, the same protocols were used for children as for adults. This is now improving.

Question: What is the IAEA doing?

JM: This is an issue that we're putting a lot of effort into. The key is to distribute information and develop good protocols. We are producing publications, training materials, courses and advice on our website to meet these needs. This includes trying to get good protocols suitable for children, and which are size-dependent in adults.

But it's hard to give a simple answer because the field is developing all the time. And as soon as you've got one problem sorted out another one crops up. So, as soon as you've addressed the issues plaguing plain radiography with film, film goes out of style and you have digital imaging. As soon as you've solved issues with digital imaging and film, they become less important than CT scanning. And you sort CT scanning out in an environment where MRI is beginning to find a foothold.

So we're shooting a moving target. Trying to create patterns of stable good practice in an evolving field is very difficult.

Also, one of the weaknesses in trying to set up quality assurance programmes is that it demands highly trained technical input that isn't always easily available to a hospital.

Question: If doctors know that the scans you mentioned earlier are useless, why do they keep ordering them?

JM: The reasons are grounded in all kinds of things that are common to all forms of human behaviour.

♦ People get into the habit of doing them. For example, there's a really strong habit of doing chest x-rays for people seeking employment and for people going to the operating theatre for surgery. In western countries neither of those practices has any value unless people have other symptoms. They only add to the radiation burden.

♦ Protocols are not up-to-date.

♦ There's often an economic/business incentive to do the scan even though it's useless. That's obviously in systems where medicine isn't socialised.

♦ Knowledge sharing isn't good enough. Creation and dissemination of knowledge is an area that needs a lot of work. Because valuable knowledge is local, just as patterns of disease and treatments are local. What's the best answer might not be the same in every part of the world. You might have very good MRI equipment but an inexperienced team. So it might be better to go for a CT scan, because then at least you have a chance of getting the right answer.

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