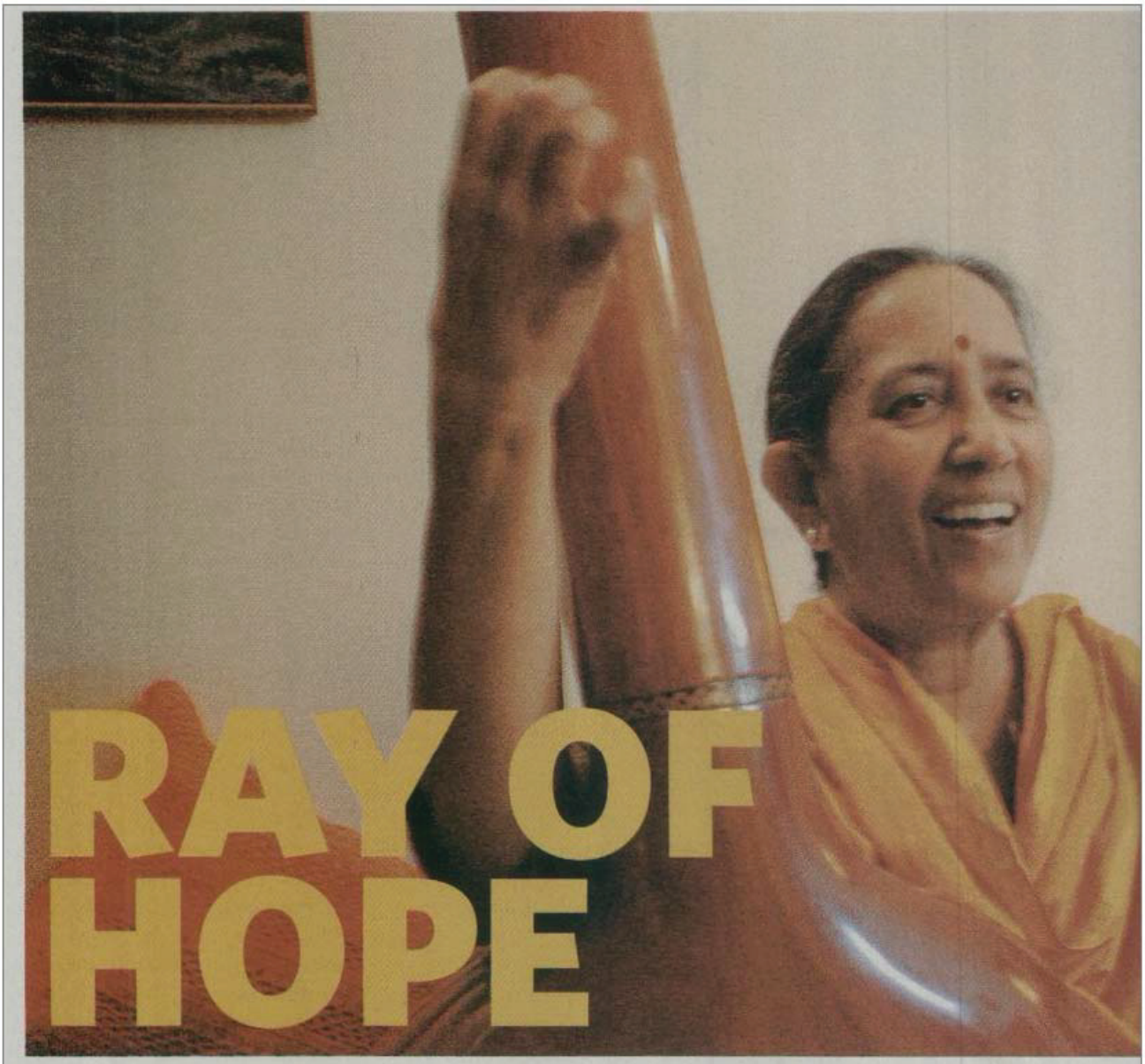
The Week



RAY OF HOPE

Nuclear medicine is revolutionising treatment

By Gunjan Sharma

Meera Subramaniam's life got a new lease when her breast cancer specialist at Indraprastha Apollo Hospital in New Delhi told her that she did not require removal of sentinel nodes for biopsy. Normally, doctors have to remove the sentinel nodes—lymph nodes—of the arm for biopsy in breast cancer patients to check if the cancer has spread. But thanks to nuclear imaging technique, positron electron tomography (PET) and contrast enhanced computed X-ray tomography (CECT) can detect the spread of the cancer without removing the sentinel nodes.

"My cancer had not spread to the lymph nodes. It not only saved me from chemotherapy, but also saved my arms, which become highly susceptible to infection if lymph nodes are removed," says Subramaniam, who is doing masters in Carnatic music at Delhi University.

Nuclear medicine is revolutionising medical treatment, especially cancer treatment, through its imaging and therapeutic modalities. More health care centres are using it to diagnose and treat varoius medical conditions. In imaging, it aids functional study of the organ unlike conventional

It not only saved me from chemotherapy, but also saved my arms, which become highly susceptible to infection if lymph nodes are removed.

Meera Subramaniam

radiation imaging (CT and MRI), which aids only structural study. "CT scan or MRI does not tell if the tumour is active or dead. Nuclear medicine does. It helps doctors determine the treatment procedure. For example, in cancer patients, chemotherapy is given on the basis of activeness of the tumour. It saves a patient from unnecessary radiation. For best results, we combine nuclear imaging techniques with conventional radiations," says Dr Uma Ravishankar, head, department of nuclear medicine, Indraprastha Apollo Hospital.

Nuclear medicine therapy uses very small amount of radioactive materials, or radiopharmaceuticals, which emit gamma rays that can be detected externally by special types of cameras—gamma or PET cameras. These cameras work in conjunction with computers to form images that provide functional details of the organ being imaged. The radionuclide substances used in nuclear imaging are usually either synthesised radioactive substances, like technetium, or radioactive forms of elements that are naturally found in the body, such as iodine.

These images are precise and tumours that are even smaller than one centimetre in diameter canbe detected. Recently, Dr Ethel Shangne Belho of Sir Ganga Ram Hospital, New Delhi, detected breast cancer in a young woman using PET CT (a combination of PET and CT scan), which was not detected even by MR mammography, which is currently considered a gold standard in breast disease evaluation by cancer specialists. "It's a medical breakthrough. We generally miss such small tumours, especially when they are present in denser areas of the body like the breast," says Dr Ramesh Sarin, oncologist at the Indraprastha Apollo Hospital.

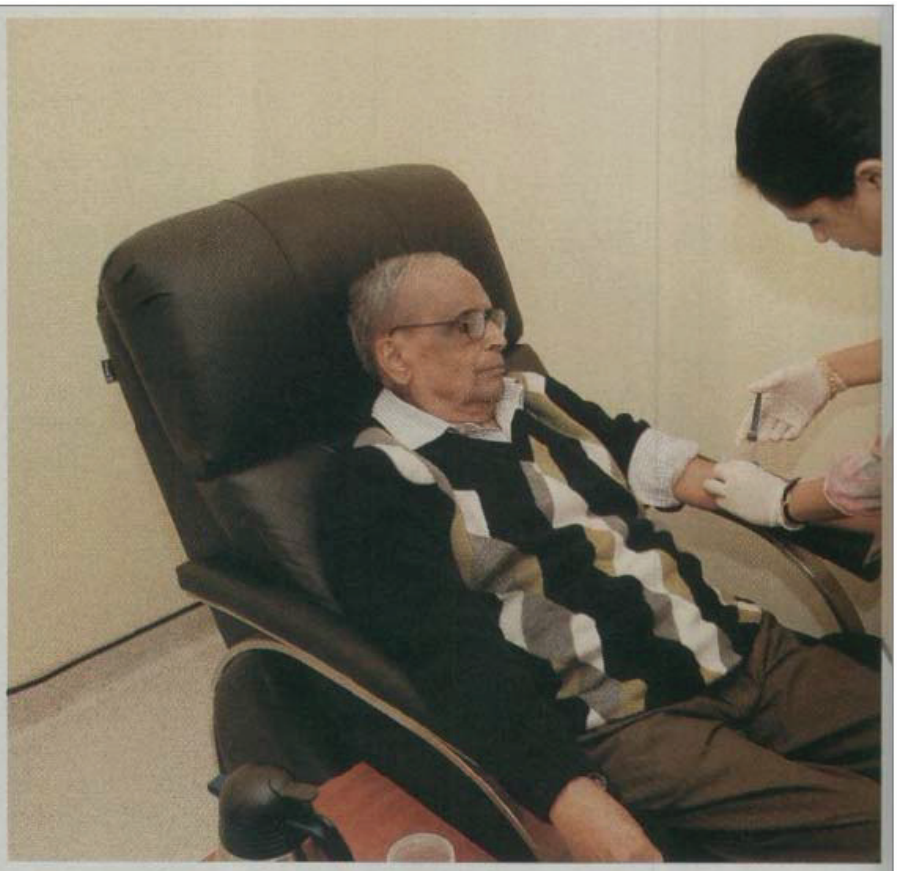
Apart from detecting tumours, doctors have started using nuclear medicine in other diseases as well, most importantly, in finding out blockages in the heart arteries and their viability. Nuclear physicians believe that 65 per cent of people who show an artery blockage in angiography do not require angioplasty. In angiography the blockage would be detected, but sometimes there would be adequate

HOW IT WORKS

First a very low level radioactive chemical, called radiopharmaceuticals such as strontium-89, samarium-153, technetium-99 or rhenium-186, is given to the patient intravenously or orally. These radiopharmaceuticals are developed with respect to the organ's absorption pattern, so they travel to the part of the body to be studied. The radionuclides then emit gamma ray signals, which are measured by a gamma camera. The gamma camera has a large scintillating crystal detector. These crystals detect the emitted radiation signal and convert that signal into faint light. The light is then converted to an electric signal, which is then digitised (converted into a computer signal) and reconstructed into an image by a computer. The resulting image is viewed on the system monitor.

Unlike an X-ray or CT examination, in which the radiation comes out of the X-ray or CT system and then passes through the patient's body, in nuclear medicine the radioactive material introduced into the patient emits rays which are then detected by the gamma camera. The levels of radiation involved in nuclear medicine studies are much less than what one is exposed to in a conventional X-ray or CT scan.

K.M. Raghunathan, 78, was diagnosed with colon cancer in January 2008. The disease was at tertiary stage and had already spread to various organs of the body. He underwent surgery and chemotherapy which did not help much. Then, he underwent radioactive ablation. "I am getting fitter by the day," he says.



blood supply to the 'affected' part by smaller arteries or by the same artery.

"It's a non-invasive procedure. We make the person run on the treadmill and inject Thelium isotope at the peak of exercise. This radioisotope is taken by the blood entering the artery. With the help of gamma cameras, we can find out the exact blood flow through the artery. Then we compare this blood supply with the blood supply in the resting stage. Also, we can detect the viability of cells. If radioisotope is taken by myocardial cells, it means they are alive. No treatment helps if the cells are already dead," says Dr A. Malhotra, head, department of nuclear medicine at the All India Institute of Medical Sciences. Thousands of studies have shown that if Thelium test of a person is normal, chances of his getting a heart attack are less. It has 95 per cent sensitivity and is the most reliable test to find out the patient's susceptibility to a heart attack.

Nuclear medicine is also being used to find out various bone-related problems. Many inflammatory and infected conditions of bone—for example, different types of arthritis and osteomylitis—can be detected using nuclear medicine. Besides, stress fractures—common among athletes and belly dancers—can also be detected. "Even cracks, which are not visible in conventional

GENTLE CARE

Often parents get scared when doctors suggest nuclear medicine for children. The reality is that it is safer than conventional radiation therapy. Doctors have extensively been using it in diagnosing various health problems, like biliary atrasia (a condition in new borns where there is no connectivity between liver and bile duct), gastroentero reflux (which causes persistent vomiting in new borns), hydronephrosis (obstruction to the drainage of urine from the kidney) and Meckel's diverticulum (a rare condition in which there is severe lower intestinal bleeding).

Nuclear imaging techniques help doctors find the exact cause and relevant treatment of the disease. "These tests are precise and safe. In fact, soon we will be using nuclear imaging techniques to find out the exact cause of attention deficient disorder, hyperactivity and traumatic brain injuries," says Dr Rajiv Chabbra, paediatrician and neonatal intensivist at Artemis Hospital, Gurgaon.

PHOTOS: ARVIND JAIN

THE LATEST IN NUCLEAR MEDICINE

Radioimmunotherapy, currently under clinical trial phase, has shown great results in treating lymphomas and leukaemia, which do not respond to conventional chemotherapy. Doctors use radio-labelled antibodies to treat cancer. "This therapy targets only cancerous cells with minimal side effects on the body. Besides, a lot of neuroendocrinal tumours, generally present in lungs and gastrointestinal tract, are being treated using nuclear medicine these days," says Dr C.S. Bal, chief of nuclear medicine therapy, AIIMS.

Targeted alpha therapy (TAT) is also under clinical trials, especially for the control of dispersed cancers. In this therapy, the short range of energetic alpha rays enters the targeted cancer cells and destroys them. Laboratory studies are encouraging, and clinical trials for leukaemia, cystic glioma and melanoma are currently underway.

Doctors say nuclear imaging will soon be tracking the exact cause behind eating disorders such as anorexia nervosa and bulimia. Even traumatic brain injuries could be studied with the help of molecular imaging techniques.

imaging, can be found out using nuclear imaging techniques," says Dr Surya Potharaju, head of nuclear medicine at Artemis Hospital, Gurgaon.

Neurological disorders such as Alzheimer's disease can now be detected using nuclear imaging techniques. Radioactive isotope traces the blocks of degenerative tissues in brains which lead to memory loss.

In its therapeutic form, nuclear medicine provides both cure and palliative care depending on the type of cancer. Isotopes that emit beta rays are used to treat a disease. These rays kill or block the diseased cells in the body. For cancer of thyroid, it is a tested cure. Vijay Laxmi Dhar, 74, a resident of Jammu, got to know of her cancer of thyroid last May. She was immediately operated upon and after a month, given Iodine-131 therapy. She is hale and hearty now. "There was absolutely no pain after the therapy. I only had to remain isolated for four days after that. So I was a little scared and feeling bored. But that's all," says Dhar.

When a cancer spreads, a surgery is not possible. Any kind of conventional radiation also does not help. Nuclear medicine helps not only extend the life but relieve pain in the last days. "It may sound awkward, but the major trauma to cancer patients is the pain they suffer during their last days. A single shot of nuclear medicine can relieve these patients from deadly pain for six to seven months. These patients otherwise have to pop up a cocktail of expensive painkillers which are not as effective," says Ravishankar.

Even in cases of metastasis—when the cancer spreads to other body parts—nuclear therapy is very useful. "The cancer can spread to various organs such a bones, liver, pancreas. So, we need something that can find out the cancer cells, attack them without harming the normal tissues. We combine radioisotopes with glucose molecules in these patients. Since glucose intake of cancer cells is very high, as soon as we inject the nuclear medicine, it is absorbed by them. The radioisotope then destroys the cancer cells. It increases the life span of the patient, though a cure is not possible at such a late stage," says Dr C.S. Bal, chief of nuclear medicine therapy at AIIMS.

Rajan Kumar, 44, was diagnosed with cancer of the pancreas and liver in 2008, which was at its later stage. Surgery was not possible, neither was there any conventional remedy available. Lutium-177, a radioisotope, gave him a new life. Kumar has started showing signs of recovery and is under treatment at AIIMS.

The best thing about nuclear therapy is that it works even when the disease stops responding to chemotherapy. The therapy works

Magic potion: After iodine-131 therapy, Vijay Laxmi Dhar is hale and hearty now

well in joint-related problems, including a condition in which sinovial fluids get accumulated in the joint, making them painful. "It kills the sinovial membrane that secretes the fluid and improves the quality of life in such patients," says Potharaju.

Many people get a scare even at the mention of nuclear medicine. What they do not know is the fact that nuclear medicines are much safer than conventional radiation and are free of side effects. A single exposure to nuclear medicine has the same or even less effect on the body compared to an X-ray. They are like any other medicine which are available in various forms such as injections, syrups or tablets. The only difference is that the patient emits rays from the body. So one has to remain isolated for some time (from 8 hours to 4 days depending on the treatment). "In fact, it is a safer and preferred modality for children," says Dr B.R. Mittal, head, department of nuclear medicine, Post Graduate Institute of Medical Science, Chandigarh, and president, Society of Nuclear Medicine India. "Nuclear medicine has come a long way in India in the last five years," he says. "We are looking forward to newer advancements in imaging as well as therapy."

RADIOISOTOPES USED IN NUCLEAR MEDICINE

Bismuth-213: Used in targeted alpha therapy (TAT), especially for cancers

Chromium-51: Label red blood cells and quantify gastrointestinal protein loss

Cobalt-60: Sterilising

Dysprosium-165: Synovectomy treatment of arthritis

Erbium-169: Relieve arthritis pain in synovial joints

Holmium-166: Diagnosis and treatment of liver tumours

Iodine-125: Cancer brachytherapy (prostate and brain). Also to evaluate the filtration rate of kidneys and to diagnose deep vein thrombosis in the leg. In radioimmuno-assays to show the presence of hormones in tiny quantities

Iodine-131: Treatment of thyroid cancer and imaging the thyroid. Diagnosis of abnormal liver function, renal blood flow and urinary tract obstruction

Iron-59 (46 d): In studies of iron metabolism in the spleen

Molybdenum-99: Used as the 'parent' in a generator to produce technetium-99m

Palladium-103 (17 d): To make brachytherapy permanent implant seeds for early stage prostate cancer

Phosphorus-32 (14 d): In the treatment of polycythemia vera (excess red blood cells). A beta emitter

Potassium-42: For the determination of exchangeable potassium in coronary blood flow

Rhenium-186: For pain relief in bone cancer

Rhenium-188: To beta irradiate coronary arteries from an angioplasty balloon

Samarium-153 (47 h): Very effective in relieving the pain of secondary cancers lodged in the bone. Effective for prostate and breast cancer. Beta emitter

Selenium-75: Used in the form of seleno-methionine to study the production of digestive enzymes

Sodium-24: For studies of electrolytes within the body

Strontium-89: Very effective in reducing the pain of prostate and bone cancer. Beta emitter

Technetium-99m: Used to image the skeleton and heart muscle in particular, and also for brain, thyroid, lungs (perfusion and ventilation), liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lacrimal glands, heart blood pool, infection and numerous specialised medical studies

Xenon-133: For pulmonary (lung) ventilation studies

Ytterbium-169: For cerebrospinal fluid studies in the brain

Yttrium-90: For cancer brachytherapy and as silicate colloid for the relieving the pain of arthritis in larger synovial joints. Pure beta emitter and of growing significance in therapy