RADIONUCLIDE METHOD IN MEDICAL EMERGENCIES AND COMPLICATIONS OF ACUTE DISEASES AND INJURIES

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ABSTRACT

The data generalized in the article characterize radionuclide method as a highly informative technique for diagnosing a number of acute diseases and traumas as well as their complications. It is shown that each radionuclide technique aims at solving a particular clinical problem and has a strictly determined place in the algorithm of making a diagnosis. Emergency radionuclide techniques give important information helping decide on a treatment plan or amount of surgery in such acute conditions as pulmonary embolism, acute occlusion of main arteries, small bowel obstruction, complicated forms of cholelithiasis, acute myocardial infarction, positional compression syndrome, liquorrhea in traumatic brain injury, differential diagnosis of renal colic including acute surgical abdominal diseases etc. The main objective of twenty-four-hour nuclear medicine department is improvement and modification of urgent radionuclide techniques and determination of their place in the diagnostic algorithm of medical emergencies in order to improve promptness and quality of medical care.

Keywords: scintigraphy, medical emergencies, complications of acute diseases and injuries.

AMI — acute myocardial infarction

HBS — hepatobiliary scintigraphy

PCS — positional compression syndrome

PE — pulmonary embolism

RP — radiopharmaceutical

TBI — traumatic brain injury

Urgent and accurate diagnosis in medical emergencies often requires the use of all available options, including radiation, in order to decide on prompt and adequate treatment [1—4].

Analysis of literature shows that the radionuclide method is generally used in routine diagnostics, and largely for diagnosis of chronic diseases.

Our experience of emergency care hospital indicates that radionuclide diagnostics successfully solves the current clinical problems arising in case of emergency caused by acute internal and surgical diseases and traumas.

Despite technical differences, the major advantages of radionuclide methods are functionality, ease of performing, high sensitivity in the early diagnosis of functional and structural disorders, absence of adverse reactions, moderate radiation exposure and the possibility of obtaining quantitative parameters.

Effective use of radionuclide techniques in acute care patients requires strict determination of each technique's position in the diagnostic algorithm in a particular emergency clinical situation, as well as awareness of capabilities and limitations of radionuclide methods.

Emergency radiodiagnostic studies give important information for determination of treatment strategy or amount of surgery in emergency conditions such as pulmonary embolism (PE), acute occlusion of main arteries, small bowel obstruction, complicated forms of cholelithiasis, acute myocardial infarction (AMI), positional compression syndrome (PCS), liquorrhea in traumatic brain injury (TBI), differential diagnosis of renal colic with acute surgical abdominal diseases [5—10], etc.

Radionuclide Diagnostics Department of N.V. Sklifosovsky Institute was organized by the member of the RAEN, prof. A.I. Ishmukhametov (1933—2004) in 1972. He had been the head of the Department more than 30 years and developed the basic principles of emergency nuclear medicine. Scientific and practical developments using radiopharmaceuticals (RP) were exhibited at the Exhibition of Economic Achievements of the USSR, and were awarded 5 certificates and 2 medals. Fourteen monographs and more than 20 theses having made a major contribution to the science and practice had been written under the direction of A.I. Ishmukhametov. His followers successfully work in institutions in Russia, neighboring countries and far abroad. A.I. Ishmukhametov was honored with the "Excellence in Healthcare" award and was also awarded the State Scientific Grant of the RAS, which is generally given to outstanding scientists in Russia. His name is included into international bibliographic edition (Cambridge). The Academic Board of N.V. Sklifosofsky Institute recommended nomination of A.I. Ishmukhametov to the award of the title of the Honoured Scientist of Russian Federation. Currently, his disciples continue to work on upgrading emergency radionuclide techniques and determination of their place in the diagnostic algorithm in medical emergencies, in accordance with principle concepts A.I. Ishmukhametov followed.

In contrast to the other radioisotope laboratories in Moscow and Russia, the Radionuclide Diagnostics Department of N.V. Sklifosovsky Institute is open 24 a day, and also provides epy the choice and modification of radiodiagnostic techniques in accordance with emergency

conditions and needs of the scientific and clinical departments of the Institute. Emergency radionuclide diagnostics requires two simultaneously operating gamma cameras and 24-hour-service teams of doctors, consisting of a radiologist and two nurses for each device. Being a part of a multidisciplinary emergency care hospital, the department of radionuclide diagnostics needs highly skilled medical and nursing staff, continually improving qualification at specialized courses. In complex diagnostic cases, consultations between a radiologist and a head of the department take place, also involving clinicians and diagnosticians of other fields. An important condition for effective work in medical emergencies is cooperation with other diagnostic services.

The Institute has about 25,000 patients annually undergoing hospital treatment with 6,000–7,000 of cases requiring radionuclide studies, and 25—30% of the studies are carried out in an expedited manner (Fig. 1).

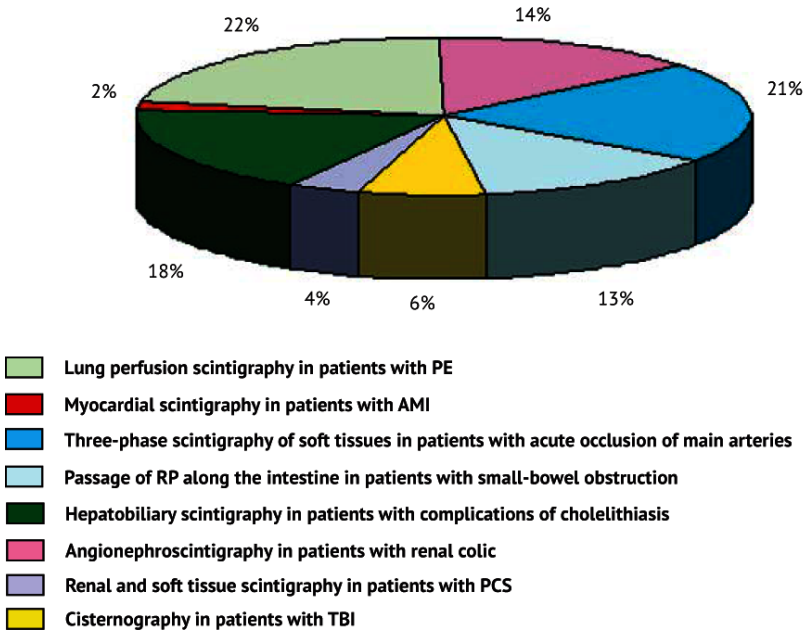

Fig. 1. Emergency radionuclide studies

Notes: AMI — acute myocardial infarction; RP — radiopharmaceutical; PCS — positional compression syndrome; PE — pulmonary embolism; TBI — traumatic brain injury

The amount of studies together with its quality grows annually, traditional techniques and new methods develop and the area of its use widens. Since the Institute has become one of Moscow's leading hospitals, providing treatment to patients with PE, the number of patients referred for lung perfusion scintigraphy with suspected PE has grown recently (Fig. 2). Scientific analysis of lung perfusion scintigraphy (RP — Macrotech ^{99m}Tc, labelled macroaggregates of albumin) showed that radiographic findings (no changes in the existing perfusion defects, the presence of perfusion defects corresponding the focal, infiltrative or pneumosclerotic changes)

and the results of ultrusonography of veins should be considered for the correct interpretation of scintigraphy data as well.

We offer exact diagnostic algorithm that has proven its superiority in order to improve the efficiency of diagnosis of PE. The sequence "chest X-ray — ultrasonography of veins —lung perfusion scintigraphy" has increased the diagnostic efficiency (accuracy) of the method by 22% (99% against 77%). If the given set of methods does not allow the diagnosis of PE to be made undoubtedly, especially in patients with chronic obstructive pulmonary disease and pneumosclerosis, then CT angiography is performed, and after that, in the case of persistent doubts about the diagnosis and in the absence of contraindications, angiopulmonography is carried out. According to our data, less than 10% of patients need these methods. In the absence of any defects after perfusion scintigraphy, PE can be safely excluded. Due to the high reproducibility of the method, perfusion scintigraphy is essential for assessing the effectiveness of thrombolytic or anticoagulant therapy in dynamics.

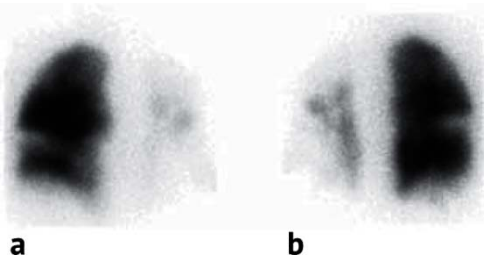

Fig. 2. Scintigraphy image of PE with nonvisualized left lung: a — front view; b — rear view

In some cases of AMI, Pyrphotech ^{99m}Tc accumulated in necrotic zone is administered. The technique is generally used when clinical manifestations do not correspond to instrumental examination and biochemical test. Scintigraphy is greatly valuable in the diagnosis of repeated myocardial infarction in the area of scar formation. Scientific analysis of the results showed that in cases of suspected AMI the procedure is most suitably to be performed 24 hours after and no later than 5 days since the expected onset of AMI (Fig. 3).

The amount of radionuclide procedures in emergency vascular surgery has increased over the past decade. Analysis of findings have shown that the three-phase scintigraphy with Pyrphotech ^{99m}Tc can help improve diagnosis and decide on management for vascular surgery patients, as it allows to assess soft tissue ischemia and circulatory compensation in acute arterial occlusion of lower extremities of different origin (Fig. 4). Radionuclide method also allows to determine the localization of necrotic soft tissue changes in patients with critical lower extremity ischemia and the amount of required necrectomy. Radionuclide imaging of tissue blood flow in acute thrombosis should follow ultrasonography and/or angiography and should also be performed 1—2 days after admission, and within an hour after admission in patients with PE.

Since 2000, radionuclide study has become a regular procedure in the Institute evaluating the RP passage along the intestine in patients with small bowel obstruction. The method reduced the amount of surgical intervention in patients with adhesive small bowel obstruction (by 25—30%) and helped choose conservative treatment preferable for patients with repeated abdominal surgeries. The results of scientific research showed that the radionuclide study of gastric evacuation and passage along the intestine in patients with adhesive small bowel obstruction, including early adhesive small bowel obstruction is highly efficient (97—98% sensitivity) and recommended to be widespread used in emergency surgical gastroenterology. Scintigraphy is performed with plain radiography and abdominal ultrasonography as a whole, parallel to conservative therapy and stands third after diagnostic radiography and ultrasound imaging (Fig. 5).

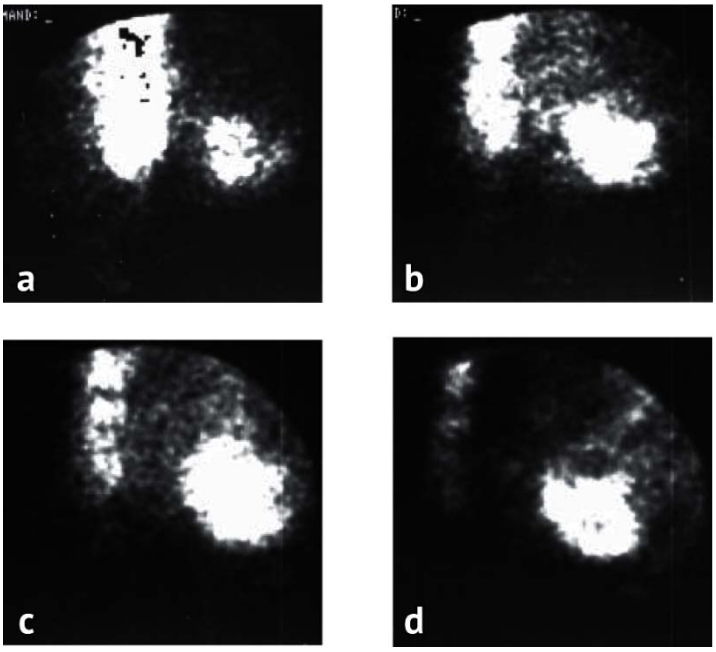

Fig. 3. Scintigraphy image of lateral AMI: a — front view; b — anterolateral view 30 .; c — anterolateral view 45 .; d — lateral view 60.

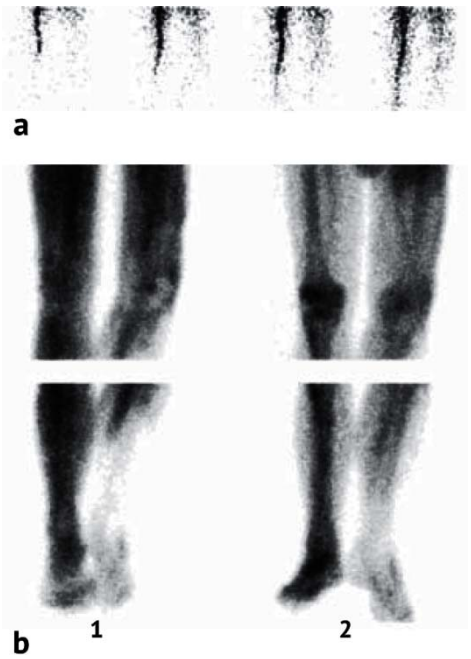

Fig. 4. Scintigraphy images of acute thrombosis of the left iliac artery: a — loss of blood flow starting from the level of the iliac artery; b — loss of blood supply to the tissues of the lower leg and foot with a slight enchancement in the bone phase (1 — tissue phase, 2 — bone phase)

One of the most recently used methods is the hepatobiliary scintigraphy (HBS) with Bromesida ^{99m}Tc, which is non-invasive and easily performed screening procedure for all patients with cholelithiasis arriving to the hospital in acute conditions. HBS is annually performed in about 500 patients with acute calculous cholecystitis before cholecystectomy. Normal biliary function revealed at HBS allows cholecystectomy without magnetic resonance cholangiography and invasive direct X-ray contrasting (endoscopic retrograde cholangiopancreatography) to be performed. In the modern diagnostic algorithm of complicated forms of cholelithiasis, invasive diagnostic methods are appropriate to apply after obtaining a positive result of ultrasound examination, HBS and MR cholangiography (in a given order). Biliary function of the liver and state of the extrahepatic bile duct in patients from the waiting list for liver transplantation and as well as graft function in the post-transplant period should be taken into the account. Postoperative liver bilomas, damaged bile ducts and biliary anastomotic failure are indications for HBS (Fig. 6). Due to the low radiation dose, HBS may be repeated to assess the effectiveness of the surgical or conservative treatment.

The advantages of angionephroscintigraphy with Pentatech ^{99m}Tc revealing signs of acute occlusion of the urinary tracts, are high sensitivity, low radiation exposure and the absence of adverse reactions to radiopharmaceuticals (as opposed to radiocontrast agents). Patients with various diagnoses (acute appendicitis, acute cholecystitis, acute pancreatitis, trauma and injury of the abdomen, acute gastro-intestinal tract conditions, and acute gynecological diseases) are

referred from surgery departments to undergo renal scintigraphy for the differential diagnosis of acute urological disease. Due to the long-term practice, the diagnostic accuracy of the method in detecting acute urological pathology is 93.9%. Scintigraphy is a simple and easily bearable procedure for a patient, confirming renal colic in a short period of time (30 min) in combination with ultrasound imaging. In the Institute, we perform scintigraphy following ultrasonography in order to exclude renal colic (Fig. 7). Renal scintigraphy is normally used to monitor graft function after kidney transplantation as well. Radionuclide study allows us to assess perfusion, glomerular filtration rate and excretory function of the graft in heterotopic transplantation of cadaveric kidney in dynamics, assisting in the differential diagnosis of acute tubular necrosis and acute rejection crisis. The technique has a distinct advantage in the detection of urinary leaks and failure of uretero-cysto anastomosis (Fig. 8).

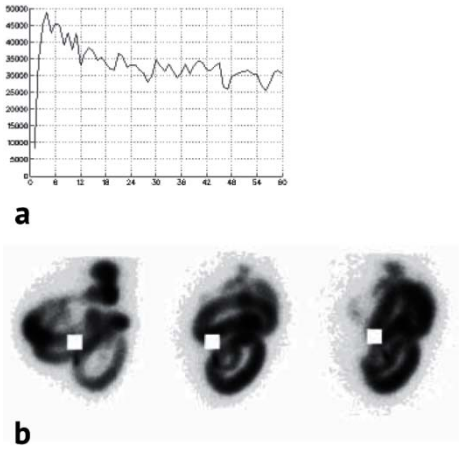

Fig. 5. Scintigraphy in adhesive small bowel obstruction: a — a curve of RP evacuation from the stomach; b — images made 2, 4 and 6 hours after administration of RP

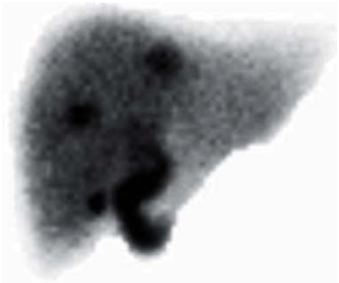

Fig. 6. Bilomas of the liver after suturing the ruptures of the organ

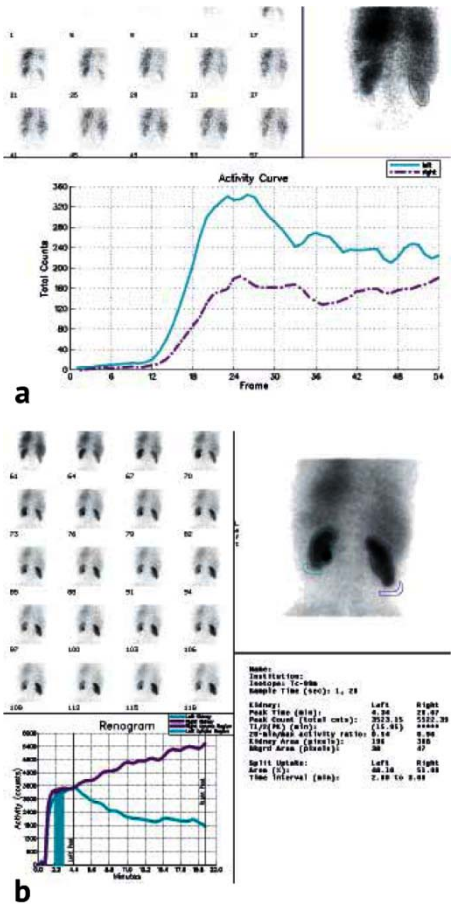

Fig. 7. Scintigraphy of the kidneys and urinary tract of a patient K.: a — hemodynamic phase; b — parenchymal phase

Radionuclide study with simultaneous assessment of renal function and identifying foci of muscle destruction with Pyrphotech ^{99m}Tc is particularly valuable in cases of PCS of soft tissue where the external clinical signs are mild, as well as to identify additional foci of necrosis (Fig. 9). The study is conducted on the 1st day of hospitalization of a patient, and it is considered to be a unique method of instrumental diagnostics in combination with biochemical tests. Analysis of the procedure findings in patients with PCS showed that the degree of renal damage depends on the prevalence of muscle destruction and does not depend on the severity of necrosis, characterized by the amount of RP accumulation in necrotic muscle. In addition, renal scintigraphy helps calculate filtration rate and assess excretory function of these organs in the course of extracorporeal blood correction, which is particularly important when severity of a patient's condition disagree with biochemical indices of nitrogen metabolism.

Emergency procedures should include radionuclide cisternography in TBI with endolumbar administration of a radiopharmaceutical, helping trace the circulation of liquor and reveal latent nasal or oto-liquorrhea, moreover, static images made with gamma camera should be accompanied by measuring nasal or ear tampons radiation (Fig. 10).

In addition to emergency conditions, radionuclide studies are performed in patients from the waiting list of organ transplantation. The study is also carried out in a post-transplant period in patients with heart disease (myocardial perfusion scintigraphy), lesions of the brachiocephalic arteries (cerebral perfusion scintigraphy), diffuse diseases of the lungs, liver and kidneys when the function of transplanted organs is monitored and when bone scan is performed in order to detect bone metastases, and also when assessing thyroid function, etc. In all the procedures, quantitative parameters are measured, which is particularly important for the assessment of the therapy effect in dynamics.

With the help of the radionuclide method, which is highly sensitive in detecting the area of bone tissue inflammation, diagnosis of such a serious complication of trauma as osteomyelitis is performed. Due to the possibility of obtaining quantitative parameters, bone scintigraphy is also used to evaluate the efficacy of surgical and conservative treatment of osteomyelitis. Just as throughout the world, we normally perform the procedure in order to detect metastatic lesions of the skeleton.

Recently, radionuclide technique revealing inflammatory foci in febrile patients using labeled autoleukocytes performed in cooperation with transfusion service has come into our practice. It allows focal leukocyte infiltration of vascular prostheses, catheters, and zones of appendiceal and postinjection infiltrates to be visualized.

Thus, the radionuclide method is of great assistance in the diagnosis, choice of treatment tactics and assessment the effectiveness of therapeutic measures in various acute conditions and their complications. The Radionuclide Diagnostics Department of N.V. Sklifosovsky Institute performs a large number of techniques (more than 15), occupying a particular place in the diagnostic algorithm for various types of pathology. The staffs are constantly making researches on development and improvement of techniques, promote them and introduce into clinical practice of general hospitals, including those of emergency. The Department has training courses for residents, advanced courses and accreditation courses for doctors. The Department is one of the leading units of diagnostic radiology in Moscow and Russia, and its major activity is the effective application of the radionuclide method in emergencies.

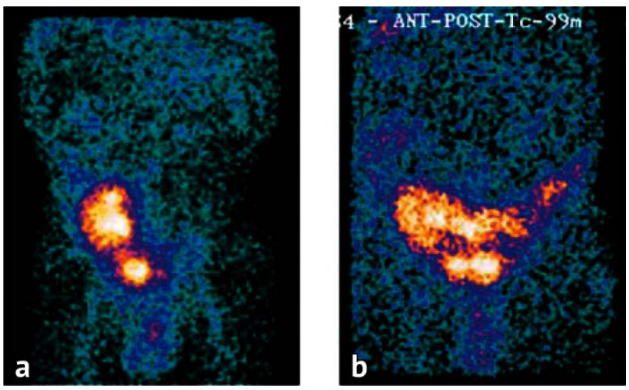

Fig. 8. Scintigraphy image of a patient with laceration of bladder mucosa in anastomotic area: a — 20th minute of the study; b — a delayed picture shows extraorgan delivery of a radiopharmaceutical, tracing urinary leaks

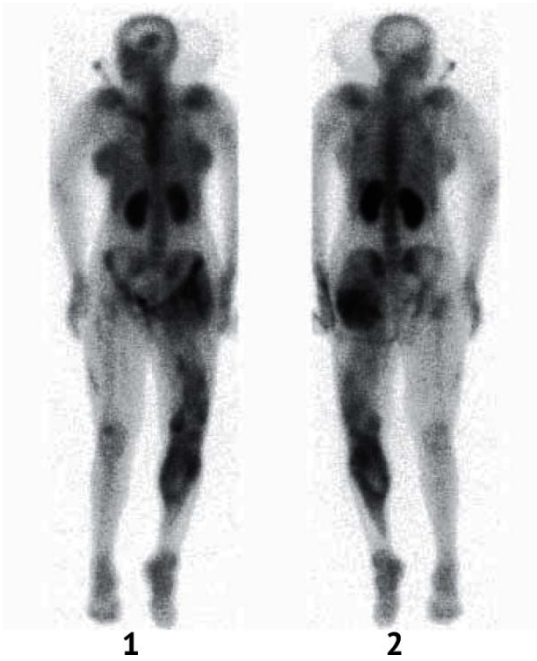

Fig. 9. Scintigraphy image of the destruction of the lower leg, thigh and buttock muscles in a patient with PCS associated with acute renal failure in the stage of anuria, bone phase: 1 — front view, 2 — rear view

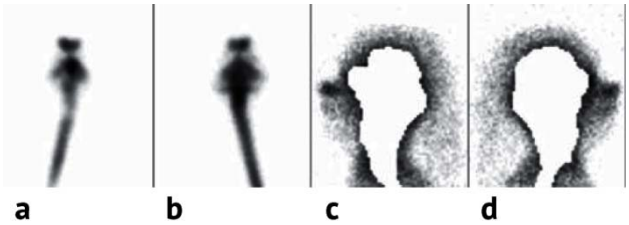

Fig. 10. Nasal liquorrhea in a patient with TBI, fracture of the ethmoid labyrinth: a, b — the front and rear views; c, d — lateral views

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