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Nuclear Medicine Imaging in Emergency Room and Priority Clinical Decision Making

Nosheen Fatima and Maseeh uz Zaman

In the present era, medical imaging (both morphological and functional) plays a significant role in the management of critically ill patients in the emergency room (ER). There is general tendency that the healthcare providers in ER are traditionally trained to rely on medical imaging, particularly morphological (radiological) procedures. The major challenge for ER doctors is to find out an appropriate balance between over-testing in fear of missing diagnosis or under-testing in climate where financial, legal, and insurance impacts speak high. There is a real need to sensitize the ER physicians about the existing role of Nuclear Medicine (NM) in certain critical conditions, either as first-line or complementary imaging.

The proven higher sensitivity and evolving cost effectiveness of NM procedures have resulted in major paradigm shift about its clinical utility in certain acute conditions, where anatomical imaging is either silent or has concerns of allergic and contrast reaction as there is nothing like contrast reaction in NM procedures.¹

Unfortunately, over the last two decades NM could not find fair space in major guidelines of emergency imaging due to diffusion of new generation computed tomography (CT) and magnetic resonance imaging (MRI) modalities, dominating the radiological societies. However, recently a separate section of NM imaging has been added in the practical guides of emergency imaging.² Emergency radiology is an established entity in United States and generally considered an active facility for 24 hours a day and seven days a week for any tertiary care hospital all around the world, but statistics of NM emergency functionality is not remarkable. As per published data of 1995, only 29% of NM centers in United Kingdom were offering on-call services,³ with no recent updates in statistics till to date. In Pakistan, there are a fair number of NM centers, both in private and public sectors primarily under the umbrella of Pakistan Atomic Energy Commission (PAEC) in all four provinces. However, to

the best of authors' information only 1-2 NM private centers are offering on-call services on 24/7 basis. The basic reason of significant underutilization is limited access of NM services in ER of many hospitals. Ideally, NM services should be available round-the-clock, but the cost implication of 24/7 active NM services is huge. It can be justified on concrete ground of emerging facts of cost effectiveness of NM with better patient outcome.⁴

The Society of Nuclear Medicine and Molecular Imaging (SNMMI) and European Association of Nuclear Medicine (EANM) defined and released the revised second version of "Guideline for Tele Nuclear Medicine" in 2013 for NM interpretation and consultation remotely from the area where the study has been originally acquired.⁵ The main indications to provide on-call NM services during off-peak hours or for routine cases in areas where NM is underserved or if center is absolutely dependent on one NM consultant who may happen to be out of station. These guidelines comprehensively discuss the fundamental requirements for functionality of Tele NM services, like work station system specification, mandatory requirement of patient's information on reporting end, data confidentiality, and above all, importance of hospital communication policy between reading and ordering physicians in cases of panic results.^{6,7}

The utility of NM services in acute conditions can be divided into the indications in ER, and indications other than ER for priority decisions.

NM Indications in ER include lung ventilation and perfusion scintigraphy (V/Q study) for pulmonary embolism (PE), resting myocardial perfusion imaging (MPI) for acute coronary syndrome (ACS), tagged red blood cell (RBC) imaging for lower gastrointestinal (GI) bleed and testicular scintigraphy for patients presented to ER.

The V/Q study is the most common NM indication in ER for PE. However, computed tomography pulmonary angiography (CTPA) has essentially replaced the V/Q study for diagnosis of PE; but due to the proven sensitivity and feasibility, many societies and guidelines still prefer V/Q study as the preferred choice in PE.⁸ Irrespective of choice, the indication of imaging in PE is mainly depend on pre-test clinical probability based on various models. The major challenge in diagnosis of PE is lack of satisfactory gold standard which poses difficulties in assessment of accuracy of diagnostic tests. A follow-up is considered best available benchmark to

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rule out recurrence of PE or making alternative diagnosis.⁹ Depending on the availability of V/Q or multi-detector CT (MDCT), the imaging is indicated in all pre-test clinical probabilities in hemodynamically stable patients except low probability with non-critical D-dimer while V/Q is recommended as second line of indication next to echocardiography due to feasibility preference over MDCT in hemodynamically unstable patients. V/Q study has higher sensitivity and specificity compared with the MDCT.¹⁰ V/Q study is 99% effective in 50% of cases where CTPA is contraindicated. There is 35-40% reduction in patient's absorbed dose who has a V/P SPECT protocol as compared to MDCT,¹¹ and considered preferred imaging choice in suspicious of PE in pregnancy with 4% reduction in maternal radiation dose. However, there has been a debate about fetal dose and large body of data favors that fetal radiation absorbed dose is either equivalent or lesser than MDCT in V/Q study during first trimester. However, this would be increased thereafter which could be optimized either using half dose protocol with perfusion first or two-day protocol, if ventilation study is need.¹²

One of major diagnostic challenges for ER doctors is a patient with persistent chest pain having negative sets of cardiac enzymes and equivocal ECG changes. A resting myocardial perfusion imaging (MPI) has a proven >99% negative predictive value (NPV) to rule out acute coronary syndrome (ACS) with high degree of confidence and also predicts the high event-free survival, as well. The cost effectiveness of resting MPI algorithm as a 'gatekeeper' to admission for patients with ACS has been well documented in numerous trials.^{13,14} By using resting MPI algorithm, patients with low probability can be identified and discharged safely.

Tagged RBC scintigraphy is a very sensitive and non-invasive functional imaging modality to localize an active lower GI-bleed as low as 0.05-0.2 ml/minute, which is the lowest among other competitive modalities like contrast or CT angiography.⁸ In addition to localize sites of active GI-bleeding, tagged RBC imaging also serves as gatekeeper for aggressive treatment (surgery or arteriography) versus those who can be managed conservatively. Additionally, tagged RBC imaging either with SPECT or SPECT-CT provides useful supplemental anatomical information that benefits patient management and improves diagnostic accuracy. Due to proven sensitivity of 93%, a negative GI-bleed scan may obviate the need for emergency arteriography with reported good prognosis.¹⁵

Testicular scintigraphy serves as gatekeeper in acute painful scrotum to differentiate acute epididymo-orchitis for conservative management with testicular torsion to be managed surgically with a sensitivity of 90-100% and specificity of 89-98%, respectively. However, as per American College of Radiology (ACR) Appropriateness Criteria 2014, Doppler ultrasound is recommended to be

the first line imaging in painful scrotum due to limitations of radiation, availability and false studies in testicular scintigraphy.¹⁶ Nevertheless, testicular scintigraphy is still considered in equivocal Doppler studies prior to surgical exploration.

NM Acute Indications other than ER: Brain perfusion scintigraphy for brain death declaration, skeletal scintigraphy in acute bone insult, renal scintigraphy in transplant dysfunction, and hepatobiliary scintigraphy in acute cholecystitis or localization of bile leak are few good examples of NM indications other than ER; but considered critical indications, due to certain priority decisions, absolutely based on imaging results.

Declaration of brain death has social, religious, legal, and ethical impacts. Brain perfusion scintigraphy may be performed as an ancillary test in the evaluation of patients for brain death. In the scenario of organ donation, before patients' organs are harvested for donation, declaration of death may have technical limitations associated with clinical and electroencephalographic assessments of brain activity in conditions like hypothermia, drug intoxication, and brain injury; and in patients where brain death may be the result of criminal activity.¹⁷ Brain perfusion scintigraphy is simple, sensitive, specific, and reliable tool to confirm brain death with a high level of confidence. False negative studies can be minimized by adequate bolus injection of isotope and reporting by experienced nuclear physician.¹⁸

Conventional radiography is the principal method of investigation in patients with suspected acute skeletal trauma. Skeletal scintigraphy has a proven higher sensitivity in a window where plain x-ray is falsely negative prior to demineralization or to localize the unspecified fracture site and may be helpful in timely management in certain traumatic or non-traumatic bone pain. Major role of skeletal scintigraphy in UK in timely diagnosis and management of scaphoid fracture with sensitivity and specificity of 100% and 98%, respectively; when second imaging is negative after 14 days of trauma.¹ Other indications are occult fracture of pelvis or femur, acute osteomyelitis, battered baby syndrome, chronic regional pain syndrome, stress fracture, shin splint, and sports trauma. A negative skeletal scintigraphy excludes any bone insult, and plays major role in legal and insurance aspects of disputed accident or military medicine cases.

Renal transplant scintigraphy is usually performed to evaluate graft dysfunction in the first few days or first few weeks after surgery, but it may also be performed in patients who experience an acute deterioration of renal function months after successful transplantation. It can be helpful for distinguishing conditions requiring surgical management like vascular or ureteral obstruction affecting the transplant from those with parenchymal

complications that can be managed conservatively like acute tubular necrosis or acute rejection.¹⁷

Hepatobiliary scintigraphy has high diagnostic accuracy in diagnosing acute cholecystitis (AC) and is considered as an excellent second tier test for the diagnosis of AC in the work-up of indeterminate cases by sonography. Hepatobiliary scintigraphy is specific for localization of bile leak in posttrauma and postsurgical cases.

In addition to above indications, there are other acute scenarios where NM has proven its clinical efficacy like infection imaging for pyrexia of unknown origin (PUO), renal cortical imaging for suspected renal trauma or CSF leak studies.

Nuclear medicine has been losing ground on the front of imaging services in ER due to logistic, technical, and human-resource constraints and tendency of NM personnel towards fixed work hours. In order to prove the role of NM in acute conditions as a first line and alternative or complementary to conventional imaging, there is a dire need to change attitude towards on-call service or to avail Tele NM option to be visible on clinical scenario.

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