Leading Article

Radionuclide applications in paediatric gastroentrology

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Nuclear medicine is a speciality which uses trace amounts of short-lived radionuclides (radiotracers) for diagnosing and treating diseases. The majority of its clinical applications involve diagnostic imaging. Radionuclides (emitting soft gamma rays) coupled with organ or tissue specific compounds (radiopharmaceuticals) are introduced into the body through an intravenous or oral route; and later the target organ is imaged using a special instrument known as *"Gamma camera"*.

Nuclear medicine is a functional imaging modality evaluating organ function and metabolism at a cellular level. With the onset of disease, it is the functional derangement which occurs well before structural abnormalities take place. Thus, nuclear medicine, being functional imaging, has the inherent advantage of detecting a disease process well in advance before it is clinically apparent or detected by a test or other anatomical imaging modalities like ultrasonography (USG), computed tomography (CT) and magnetic resonance imaging (MRI)[1].

Nuclear medicine techniques are generally noninvasive and require little or no preparation. Contrary to belief, nuclear medicine scans give minimal radiation exposure in comparison to commonly performed radiological procedures. Radiopharmaceuticals have no systemic pharmacological effects and do not cause any allergic reactions[2].

Nuclear medicine techniques are increasingly used nowadays for a wide spectrum of clinical indications in neonates, infants and children. This article is an overview of clinical applications of nuclear medicine in evaluation of the gastro-intestinal system in paediatric practice.

Hepatobiliary scan

Hepatobiliary scan is performed using iminodiacetic acid (IDA) compounds as radiopharmaceuticals (e.g.Tc-99m Mebrofenin). These IDA derivatives are taken by the hepatocytes of the liver and later excreted through biliary system into gastro-intestinal tract (GIT) in a mechanism similar to bilirubin. Thus, hepatobiliary scintigraphy provides clinically useful information about the function of liver and drainage through biliary tract in a variety of pathological processes in children[3].

Neonatal jaundice syndrome: Hepatobiliary scan is commonly used for differentiating neonatal hepatitis from biliary atresia as the cause of neonatal jaundice. Tc-99m IDA scan can rule out biliary atresia in an infant if patent biliary tree is shown with passage of radiotracer into bowel. The literature reports 91% accuracy, 97% sensitivity, and 82% specificity for hepatobiliary imaging in diagnosis of biliary atresia[4].

Cystic fibrosis: Impairment of both intrahepatic and extrahepatic biliary drainage is an important cause of liver disease in cystic fibrosis. Hepatobiliary study has shown a characteristic pattern of left hepatic duct dilatation, delayed sub-hepatic drainage due to tapering of lower end of common bile duct, gallbladder dysfunction and delayed bowel transit of radiotracer in children with cystic fibrosis[3,5].

Cholecystitis: Acalculous cholecystitis in children is seen as a complication of prolonged illness, infection and trauma. Combined use of ultrasound and hepatobiliary scan is helpful in establishing its diagnosis. Hepatobiliary scan may show the characteristic pattern as described in adults viz. "non-visualization of gall bladder"[3,6,7]. Sometimes gall bladder may be visualized in acalculous and toxic cholecystistis. In this situation, Weissman et al suggested intervention with cholecytokinin (CCK). Gall bladder failing to contract on CCK intervention is indicative of acalculous cholecystitis[8]. The sensitivity and specificity of scintigraphy in diagnosis of acalculous cholecystitis ranges from 68-93% and 38-93% respectively[9].

Bile leak: Hepatobiliary scan is specific for demonstration of the site and severity of bile leak. A bile leak into subcapsular haematoma will localize radiotracer on the peripheral aspect of liver. Disruption of hepatic capsule or a tear in extrahepatic biliary tree will allow tracer to accumulate freely in dependent spaces of peritoneal cavity. If the amount of intra-

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peritoneal accumulation of tracer is greater than that entering the GIT, surgery is usually indicated[3].

Biliary cystic disease: Choledochal cysts are uncommon cystic anomalies of the biliary tree. Todani et al have classified choledochal cysts into five types[10]. Combined anatomic and functional imaging complete the imageological workup for choledochal cyst. USG and CT scan can show cystic lesion in relation to liver or biliary tree, but hepatobiliary scintigraphy confirms its biliary origin. Endoscopic retrograde cholangio-pancreatography (ERCP) is regarded as the gold standard amongst investigations for diagnosis and classifying choledochal cysts. Hepatobiliary scintigraphy has the advantage of imaging the entire biliary tree in its long axis, similarly to ERCP, but in a noninvasive way[3,11]. Occasionally an ovarian cyst, mesenentric cyst, bowel duplication cyst, pancreatic pseudocyst or duodenal diverticulum may mimic a choledochal cyst by virtue of their location. In such a clinical situation, hepatobiliary scintigraphy can be used to differentiate choledochal cyst from other cystic lesions. Caroli disease also shows characteristic pattern on scintigraphy. Hepatobiliary scan is used to differentiate polycystic hepatic disease from Caroli disease[3].

Gastro-oesophageal scintigraphy

Gastro-oesophageal reflux: Gastro-oesophageal reflux (GOR) is the most important disorder of the oesophagus and the lower oesophageal sphincter in early childhood1[2]. Carre reported that 1 in 500 infants requiring hospital consultation suffers from GOR. Fortunately, the majority of these kids (60%) recover spontaneously by 18 months. 30% continue to have symptoms till the age of 4 years. In the absence of treatment, 10% develop complications. GOR can cause failure to thrive related to vomiting, oesophagitis and oesophageal stricture. Anemia can occur as a consequence of chronic blood loss. On the other hand, GOR has been implicated as a cause of recurrent respiratory infections, asthma and sudden-death syndrome. Therefore, it is mandatory to investigate a possible GOR in case of chronic or recurrent lung pathology without any clear explanation[12,13].

Gastro-oesophageal scintigraphy is the most sensitive examination that can be used as a screening procedure to evaluate GOR and aspiration[12,14]. This technique was introduced in 1976 by Fisher and Malmud to substantiate GOR and to assess effectiveness of medical and surgical treatment[15]. Subsequently, availability and accuracy of other techniques like upper gastro-intestinal endoscopy and 24-hours pH monitoring, has resulted in gastro-oesophageal scintigraphy being performed less often in adults. However, the test has gained wide acceptance in paediatric practice because of its physiological and non-invasive character[16].

In infants and children gastro-oesophageal scintigraphy is performed with the baby lying supine under gamma camera for a period of at least one hour after oral ingestion or administration of radiolabeled liquid (Tc-99m S colloid mixed with orange juice / infant's formula / milk) via nasogastric tube. GOR is considered significant, if there are three episodes during examinations, reflux of activity reaching upper part of esophagus or regurgitates into mouth and evidence of pulmonary aspiration[17].

Meckel scan

Meckel scan is performed to demonstrate presence of ectopic gastric mucosa in Meckel diverticulum. Ectopic gastric mucosa in Meckel diverticulum is the most common source of serious GIT bleeding in children. Although only half of all diverticula contain ectopic gastric mucosa, essentially all bleeding Meckel diverticula do. The bleeding is the direct result of irritative effect of gastric acid secreted by heterotopic gastric mucosa on the adjacent small bowel mucosa. The site of resulting ulceration is usually the junction of the normal ileal mucosa and heterotopic gastric mucosa.

Meckel scan uses technetium 99m pertechnetate to demonstrate gastric mucosa. Technetium 99m pertechnetate, when given by intravenous route, accumulates in gastric mucosa, thyroid gland, salivary glands and the choroid plexus. On a cellular level, technetium 99m pertechnetate is taken up and secreted by mucus secreting cells of the stomach located in the neck and the surface of the gastric glands. When gastric mucosa exists in the abdomen outside the stomach (ectopic locations like Meckel diverticulum and Barrett oesophagus), it too will take up the technetium 99m pertechnetate, thus allowing it to get delineated on nuclear scan[16,17].

Tc-99m MAA lung perfusion scan

Hepatopulmonary syndrome: Lung perfusion scan has been proposed for demonstration of intrapulmonary shunts (IPS) in children with chronic liver disease. Early diagnosis of IPS may be useful for the management of children with severe liver failure.

Several methods have been proposed for diagnosis of IPS. Measurement of arterial blood oxygen tension (PaO2), while breathing 100% oxygen, is easily performed in adults but requires cooperation, which is difficult to obtain in infants. Echocardiography after injection in a peripheral vein of contrast material or microbubbles has been used[19]. This technique can be improved by trans-oesophageal echocardiography, but it requires oesophageal intubation and instrumentation.

A lung perfusion scan using intravenous injection of Tc-99m labeled macro-aggregated albumin (MAA) can demonstrate and quantify right to left IPS. Normal pulmonary capillaries (8-15 µm size) entrap these 20-100 µm MAA particles and do not allow them to cross towards the systemic circulation. But in the presence of IPS, a fraction of these particles escapes into systemic circulation and lead to visualization of extra-pulmonary activity (evidence of IPS)[20].

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