NR.: 10712/1/18.11.2016

PROTOCOL PENTRU EXAMINARE SPECT/CT

Ediția 2016

1. ELABORAT

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2. VERIFICAT IN CADRUL CONSILIULUI MEDICAL

Nr. crt.	Nume și prenume	Funcția	Data	Semnătura
2.1.	**Cosmin Lisencu**	Director medical	18. 11. 2016	
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2.5.	**Marilena Cheptea**	Director de ingrijiri	18. 11. 2016	

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Nr. crt.	Nume și prenume	Funcția	Data	Semnătura
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3.3.	**Anca Burca**	Director financiar contabil	18. 11. 2016	
3.4.	**Marilena Cheptea**	Director de ingrijri	18. 11. 2016	

4. SITUAȚIA EDIȚIILOR ȘI A REVIZIILOR

Nr. crt.	Ediția/Revizia în cadrul ediției	Componenta revizuită	Modalitatea reviziei	Data la care se aplică prevederile ediției sau reviziei ediției
4.1.	Ediția I, rev. 0	Emitere		2016

- The report will include a description of the:
  - Shape
  - Position
  - Size
  - Contour
  - Presence or absence of nodules in the thyroid area and the activity of the gland, each lobe, and of the nodules
  - Presence of any special findings on the scintigraphy

Key Points

- There are controversial studies regarding the usefulness of Tl-201 thyroid scintigraphy using early/delay images for increasing the accuracy of differential diagnosis between malignant and benign nodules.
- Until nowadays the method has been used only as a complementary one.

Name of examination

7.3.5.11 Thyroid Scintigraphy with Ga-67 Citrate Gamma Camera

Radiopharmaceutical:

- Gallium-67 (Ga-67) citrate

Principle:

- Accumulation mainly due to increased capillary permeability occurring during the inflammation processes.

Technique:

- Patient preparation: No special preparation needed
  - Attention to breastfeeding and child – bearing age patients (see chapter of Radioprotection)
- Dose: 5 mCi (185 MBq)/patient of Ga-67 citrate.
- Injected I.V. 24 h are necessary for waiting, after the injection for the first images. Delay images may be registered at 48 h.
- Patient position: Supine.
- Gamma camera
  - Medium energy general purpose (MEGP) collimator at 300 keV
- Acquisition:
  - Spot planar acquisition.
  - First image at 24 h and the next image at 48–72 h.
  - Anterior and posterior position using gamma camera.
  - 128 × 128 matrix.
  - Min 500,000 counts/image.
  - Spot images on the region of interest may also be obtained.
  - SPECT is usually recorded with 360° acquisition of 20–30 s/image, for a total collection time of 20 min, along with the cross-sectional presentation.
- Processing: There are special PC programs for image processing; additional analysis of counts in different region of interest (ROI) may be used; image interpretation.

Clinical applications:

- Diagnosis of inflammatory process involving the thyroid gland

Necessary additional examinations:

- Thyroid ultrasound
- Serologic inflammatory tests
- Fine needle aspiration biopsy (FNAB)

Comments:

- It is a rarely used method.
- Evaluation of the thyroid may occur during other investigations of the organs.

Reports:

- The report will include a description of the normal distribution and pathologic uptakes.

Name of examination

7.3.5.12 Thyroid Scintigraphy with I-123/131 MIBG – Gamma Camera

Radiopharmaceutical:

- Metaiodobenzylguanidine (MIBG) or iobenguane is a combination of an iodinated benzyl and a guanidine group. It may be labeled with I-131 for imaging and for treatment, or with I-123 only for diagnosis.

Principle:

- MIBG enters the neuroendocrine cells by an active uptake mechanism via the epinephrine transporter and is stored in the neurosecretory granules, resulting in a specific concentration in contrast to the cells of other tissues.

- Theoretical considerations and clinical experience indicate that the I-123-labeled agent is to be considered the radiopharmaceutical of choice as it has a more favorable dosimetry and provides better image quality allowing an accurate anatomical localization by the use of SPECT/CT hybrid systems. Nonetheless, I-131-MIBG is widely employed for most routine applications mainly in adult patients because of its, ready availability and the possibility of obtaining delayed scans.

Technique:

- Patient preparation: A special topic in MIBG scans is the blocking of the thyroid gland if the target organ is not the thyroid.
- If the scan is performed for the diagnosis of a neuroendocrine pathology involving the thyroid gland, the blocking protocol should not be used; but if the scan is performed for the diagnosis of other sites, the protocol must be applied in order to avoid the trapping of the substance, mainly by the highly receptive thyroid tissue.
- Tracer injection, dosage, and injected activity MIBG, diluted in compliance with the manufacturer's instructions, is administered by slow intravenous injection (at least 5 min) in a peripheral vein. The preparation should have a high specific activity.
- The activity administered to adults should be:
  - I-131-MIBG: 20–40–80 MBq (0.6–1.2 – 2.2 mCi).
  - I-123-MIBG: 400 MBq (10.8 mCi).
  - The activity administered to children should be calculated on the basis of a reference dose for an adult, scaled to body weight according to the schedule proposed by special preparation.
- Patient position: Supine
- Gamma camera
  - A single (or multiple) head gamma camera with a large field of view is necessary to acquire planar and/or tomographic (SPECT) images. Fusion images with SPET/CT hybrid systems can improve diagnosis accuracy. The use of modern SPECT/CT systems is highly recommended.
  - Low energy high-resolution or general-purpose (LEHR or LEGP) collimators, for I-123 MIBG. Medium energy collimators may improve image quality, by reducing scatter while preserving acceptable sensitivity (i.e. without increasing acquisition time).
  - I-131-MIBG: high energy, parallel hole.
- Acquisition:
  - The timing of imaging: scanning with I-131-MIBG is performed 1 and 2 days after the injection and can be repeated the third day, or later.
  - Scanning with I-123-MIBG is performed between 20 and 24 h. Selected delayed images (never later than day 2) may be useful in case of equivocal findings in day 1.
  - The patient should be placed in the supine position.
  - Views: WBS with additional limited – field images or spot images.
  - Imaging field I-131-MIBG: WBS (speed 4 cm/s) or both anterior and posterior limited-field or static spot views (>150 K counts) of head, neck, chest, abdomen, pelvis, upper and lower extremities.
  - Imaging filed I-123-MIBG: WBS (speed 5 cm/s) or both anterior and posterior limited-field or static spot views (about 500 K counts or 10 min acquisition) of head, neck, chest, abdomen, pelvis, upper and lower extremities. In neuroblastoma patients, for head imaging both anteroposterior and lateral views are recommended. Spot views are often superior to whole body scans in contrast and resolution, especially in low count regions, and therefore they are preferable in the case of young children (who may bear much easier this exam, longer in total time, but with interruptions in between).
  - A pixel size of about 2 mm requires a 256×256 matrix or a 128×128 matrix with zoom. For quantification: different levels of approximation can be adopted for attenuation correction. The basic method of geometric mean between conjugate views can be improved using a standard source-phantom based method.
  - SPECT protocol consists in 120 projections, in 3-degree steps, in continuous or step and

shoot mode, 25–35 s per step. The data are acquired on a 128×128 matrix. In case of non-cooperative patients, it is possible to reduce acquisition time using 6° steps, or a 64×64 matrix with shorter time per frame.
  - In SPECT/CT imaging, the CT image should be taken with high resolution in order to have a better characterization of the anatomical surroundings. These images are also important for dosimetry calculations (uptake and size of the tumor).
- Processing: No particular processing procedure is needed for planar images. In case of SPECT, one should take into account the different types of gamma camera and software available. Careful choice of processing parameters should be adopted in order to optimize image quality. Iterative reconstruction with a low pass post-filter often provides better images than filtered back projection. Any reporting should clearly state the methodology adopted for image processing and quantification.

Necessary additional examinations:
- Thyroid ultrasound
- Fine needle aspiration biopsy (FNAB)
- Laboratory test results (plasma and urinary catecholamine dosage, CEA, 5-HIAA (5-hydroxyindoleacetic acid), NSE (neuron-specific enolase) chromogranin A, calcitonin, etc.)
- Results of any other imaging studies (CT, MRI, US, X-rays)
- History of recent biopsy, surgery, chemotherapy, hormone therapy, and radiation therapy

Clinical applications:
- MIBG scintigraphy is used to image tumors of neuroendocrine origin, particularly those of the neuroectodermal (sympathoadrenal) system (pheochromocytomas, paragangliomas, and neuroblastomas).
- Although other neuroendocrine tumors (e.g., carcinoids, medullary thyroid carcinoma) can also be visualized.
- In addition, MIBG can be employed to study disorders of sympathetic innervation, for example in ischemic and not ischemic cardiomyopathy as well as in the differentiation between idiopathic Parkinson's syndrome and multisystem atrophy.

Comments:
- I-123 MIBG avoids hazardous irradiation due to beta emitters.
- I-131 MIBG scan may have prognostic value in perspective therapy with I-131 MIBG.

Reports:
- The nuclear medicine physician should record all information regarding the patient, the type of examination, the date, the radiopharmaceutical, the dose, concise patient history, all correlated data from previous diagnostic studies and the clinical questions.
- The report to the referring physician should describe: whether the distribution of MIBG is physiological or not; all abnormal areas of uptake (intensity, number, and site; if necessary, retention of MIBG over time); comparative analysis: the findings should be related to any previous information or results from other clinical or instrumental examinations.
- Interpretation: A clear diagnosis of malignant lesion should be made if possible, accompanied by a differential diagnosis when appropriate; comments on factors that may limit the accuracy of scintigraphy are sometimes important (lesion size, artifacts, interfering drugs, etc.).
- Same requirements as in other scintigraphy.

Normal image and uptake:
- *Physiological distribution of MIBG*
  - The uptake of radiolabeled MIBG in different organs depends on catecholamine excretion and/or adrenergic innervation. Since MIBG is excreted in the urine, the bladder, and urinary tract show intense activity.
  - Mainly the liver normally takes up MIBG; smaller uptake is described in spleen, lungs, salivary glands, skeletal muscles, and myocardium.
  - Normal adrenal glands are usually not seen, but faint uptake may be visible 48–72 h after injection in up to 15% of cases when using MIBG I-131.
  - Free iodine in the bloodstream may cause some uptake in the digestive system and in the thyroid (if not properly blocked). No skeletal uptake should be seen. Extremities show only slight muscular activity.

- *Pathological*: MIBG soft tissue uptake is observed in primary tumor and in metastatic sites including lymph nodes, liver, bone, and bone marrow. The increased uptake in the skeleton (focal or diffuse) is indicative of bone marrow involvement and/or skeletal metastases (Fig. 7.53).
- *Sources of error*:
  - Clinical and biochemical findings that are unknown or have not been considered
  - Insufficient knowledge of physiological MIBG biodistribution and kinetics
  - Small lesions, below the resolution power of scintigraphy
  - Incorrect patient preparation (e.g., pelvic) views cannot be correctly interpreted if the patient has not voided before the acquisition
  - Lesions close to the areas of high physiological or pathological uptake; tumor lesions that do not uptake MIBG (e.g., changes in differentiation, necrosis, interfering drugs, etc.)
  - Patient motion (mainly in children)
  - Increased diffuse physiological uptake (hyperplastic adrenal gland after contralateral adrenalectomy); increased focal physiological uptakes (mainly in the urinary tract or bowel); thyroid activity (if no adequate thyroid blockade is performed)
  - Urine contamination or any other external contamination (salivary secretion)

Figure

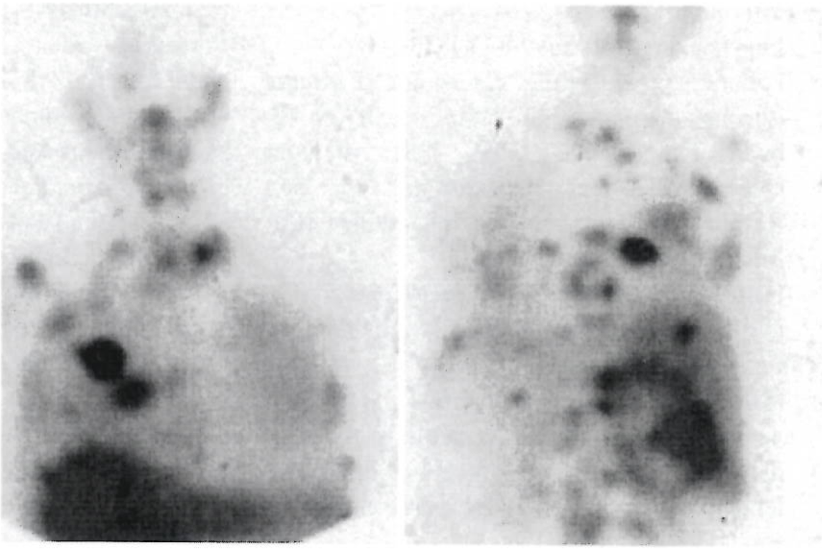

Fig. 7.53 I-123 MIBG – AP and PA incidences scan of metastatic medullary thyroid carcinoma

Name of examination

7.3.5.13 Thyroid Single Photon Emission Computed Tomography (SPECT) and SPECT/CT

Radiopharmaceutical:
- All anterior described radiopharmaceuticals most suitable Tc-99m MIBI, I-123-MIBG, and Tl-201 chloride.

Principle:
- This technique offers better localization of the lesions.

Technique:
- Patient preparation: According to the radiotracer used.
- Patient position: supine.
- Acquisition: SPECT is usually recorded with 360° acquisition for 30 s/image, for a total of 64 images "step and shoot".
- 128 × 128 matrix.
- CT spiral low dose, tube voltage 130 keV, pitch 1.5, rotation time 1 s.

- Processing: There are special PC programs for image reconstruction and processing; filtered back projection; attenuation correction.

Clinical applications:

- Diagnosis mainly of tumors and distant metastasis.

Necessary additional examinations:

- Thyroid ultrasound
- Serologic tests
- Fine needle aspiration biopsy (FNAB)

Comments:

- It is not a frequently used method in the algorithm of thyroid diagnosis.
- The evaluation of the thyroid may occur during the investigation of other organs.

Reports:

- The report will include a description of the normal distribution and pathologic uptakes.

Name of examination

7.3.5.14 Orbital Single Photon Emission Computed Tomography (SPECT) with Tc-99m DTPA for the Evaluation of Graves' Ophthalmopathy (GO)

Radiopharmaceutical:

- Tc-99m DTP – Tc-99m diethylenetriamine pentaacetic acid

Principle:

- Tc-99m DTPA is a chelate, primarily excreted by glomerular filtration. It is uniformly distributed throughout the extracellural space and does not normally cross the blood-tissue barriers. The uptake has been reported as related to the inflammatory process, disappearing with resolution of the infection/inflammation.
- The theoretical basis of the method is that the high capillarisation and edema in the orbit may be reflected on Tc-99m DTPA images in GO.

Technique:

- Patient preparation: No special preparations
- Patient position: supine
- 7 MBq/kg patient (370–500 MBq) Tc-99m DTPA intravenously
- Acquisition starts at 20 min after the injection
- Acquisition:
  - 128 projections by a four-headed SPECT (a double headed camera may also be used).
  - On the sum of six transaxial slices containing the entire bulbar region of the skull, a triangle- like region of interest (ROI) is drawn (orbital ROI-OR).
  - This ROI is "slipped" to the right temporal region of the brain as reference site (brain ROI-B). The count ratios of OR/B must be calculated.
  - SPECT is usually recorded with 360° acquisition for 30 s/image, for a total of 64 images "step and shoot."
  - 128 × 128 matrix.
- Processing: There are special PC programs for image reconstruction and processing; filtered back projection; attenuation correction.

Clinical applications:

- Differential diagnosis of Graves' ophthalmopathy sensitive or resistant to the immune suppressive therapy.

Necessary additional examinations:

- Orbital ultrasound
- Ophthalmic measurements of the ocular globes
- Serologic tests
- MRI T_2 time of relaxation

Comments:

- Even if this method is minimally aggressive, safe, easy, and cheap, it is not a frequently used method in the algorithm of GO diagnosis.
- Comparing with MRI, this nuclear medicine test has a better physiologic response to the therapy definition requested by the endocrinologist.
- The orbital uptake of the radionuclide (activity uptake, AU) is calculated (references values – 4.7–12.2 MBq/cm^3).
- The most frequent AU higher than 12.2 MBq/cm^3 is the value considered, that GO is active and sensitive to immune suppressive therapy.

The technique described above and the following images (Figs. 7.54, 7.55, 7.56, 7.57, and 7.58) were obtained with the courtesy of Prof. Galuska Laszlo from the department of Nuclear Medicine of the University of Debrecen, Hungary.

Name of Examination

8.3.3.7 Parathyroid Scintigraphy SPECT and SPECT/CT

Radiopharmaceuticals:

- Technetium-99m MIBI in double tracer or single tracer

Principle:

The examination is based on the intention to have a better anatomy localization of parathyroid disease, improving the sensitivity and sensibility of the nuclear tests in hyperparathyroidism diagnosis.

Technique:

- The preparation of the patient is realized according to the tracers used.
- The SPECT, SPECT/CT, and pinhole SPECT have been used and have the ability to locate more precisely the sites of the hyperfunctioning parathyroid than simple planar imaging and allow the detection of smaller lesions.
- The SPECT study should be acquired immediately following early planar acquisitions (to avoid false-negative results due to parathyroid adenomas with rapid washout) with the patient in the same position, using a matrix of 128 × 128 for 120 projections every 3° (360° rotation) and with an imaging time of 15–25 s/ per projection and suitable zoom factor.
- SPECT/CT provides fused images of functional and anatomical modalities, which considerably improve the interpretation of findings of individual procedures.
- Pinhole SPECT study should be acquired immediately following early planar acquisitions with the patient in the same position with 32 projections over 180° with a circular orbit. The acquisition time per step may be set to 40 s. The main characteristics of the pinhole collimator are a 3-mm aperture and an inner focal length of 205 mm.
- Processing:
  - No special processing for planar images is needed.
  - For SPECT processing, transaxial tomograms are reconstructed by filtered back-projection using a low pass filter without attenuation correction. Attenuation correction can be useful when using SPECT/CT.
  - The two sets of planar images (early and delayed) are visually inspected. Focal areas of increased uptake, which show either a relative progressive increase over time or a fixed uptake, which persisted on delayed imaging, must be considered pathological hyperfunctioning parathyroid glands.
  - The SPECT or SPECT/CT images give information about the correct position of the hyperfunctioning gland, especially if deep in the neck or ectopic. The use of volume rendering of parathyroid SPECT images might be helpful for visualization.

Clinical applications:

- Diagnosis of hyperparathyroidism

Necessary additional examinations:

- Clinical examination; remember to discuss and to examine the patient *BEFORE* the injection, in order to limit the hazardous radiation exposure.
- Thyroid and parathyroid ultrasound.
- Serologic tests: serum level of PTH, serum and urinary level of calcium and phosphates, and alkaline phosphate.

Reports:

- The reports respect the general format of the department with all the identification data of the patient, the institution, and the physician.
- The report should include the timing of acquisition of the images. Planar images must be labeled to show the type of projection and the region imaged. SPECT should include the reconstruction of images in the three axes (coronal, sagittal, and transaxial) (Figs. 8.14 and 8.15).
- The report will include the positive diagnosis of parathyroid adenoma and the lateralization and if is possible the most accurate localization.

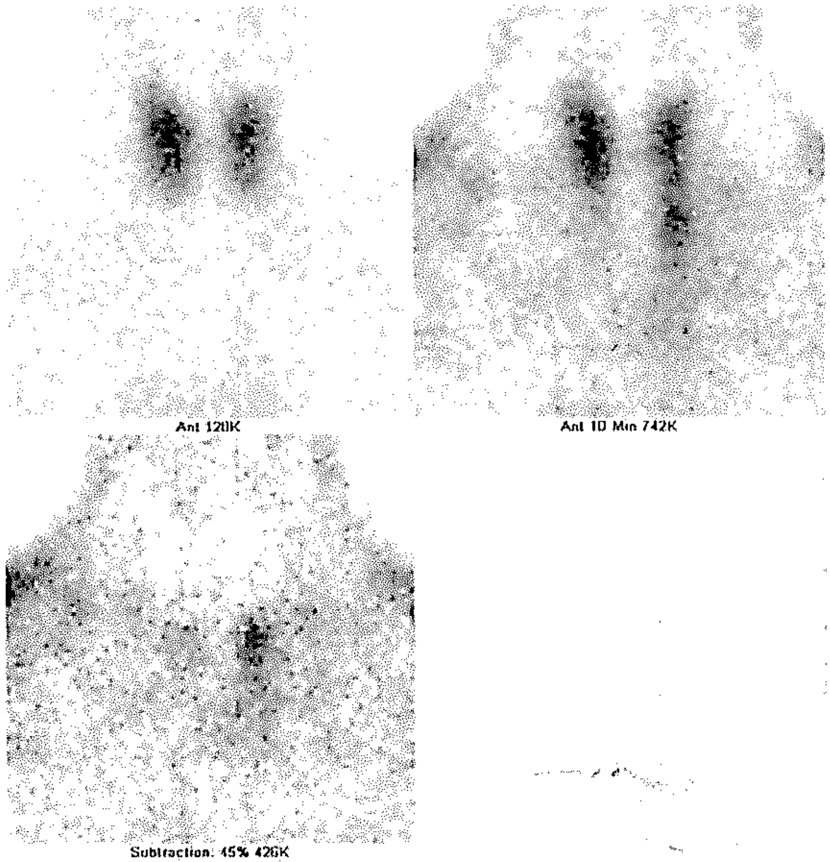

Fig. 8.14 Tc-99m MIBI planar scan; inferior left parathyroid adenoma

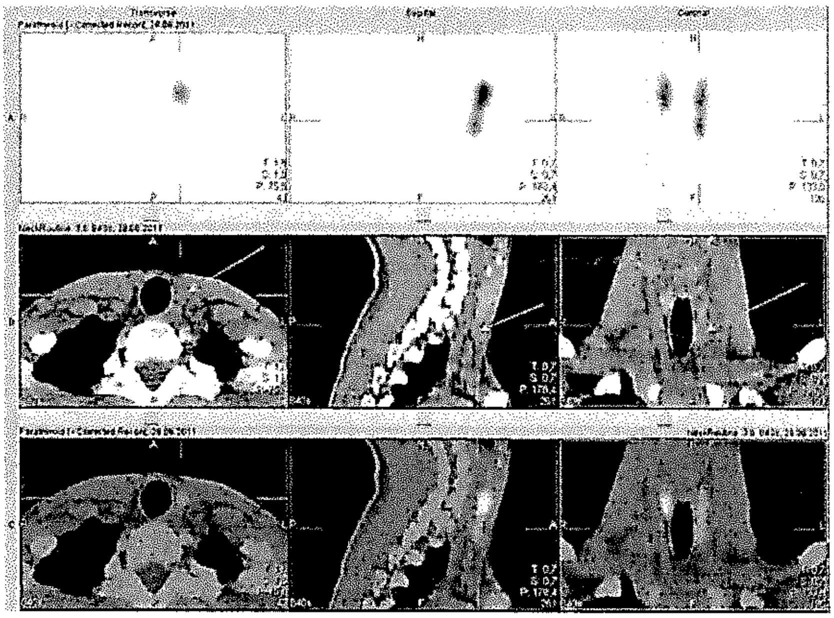

Fig. 8.15 SPECT/CT Tc-99m MIBI (With the courtesy of Dr. Andries G. – County Hospital Cluj-Napoca)

I-123-MIBG molecular imaging has also been used for NET but have the greatest efficacy in patients with pheochromocytoma, paraganglioma or neuroblastoma. Some tumors, negative on In-111 octreotide scintigraphy, can be better seen with I-123-MIBG.

Positron emission tomography F-18-fluorodeoxyglucose (FDG) imaging, although successful for many solid tumors, has generally not provided additional information about the extent of the disease for well-differentiated NET because of their generally lower proliferative activity.

F-18 FDG PET imaging may be used to characterize tumor aggressiveness with higher FDG uptake (expressed as SUV values) having a worse prognosis. This may be helpful when the tumor seems more aggressive than the histology indicates, and additional information for FDG imaging may result in changes of treatment.

Prior studies have shown C11-5-hydroxytryptophan (HTP) PET to be a promising imaging modality for the detection of NET. The serotonin precursor 5-HTP labeled with C-11 was used and showed an increased uptake and irreversible trapping of this tracer in NET. Other new PET imaging agents for NET include F-18-DOPA, Ga-68-DOTA-TOC, Ga-68-DOTA-NOC and F-18-PGluc-TOCA. In addition, Tc-99m-depreotide, which has a greater affinity to somatostatin receptor 3, has also been used for tumor imaging. Although these novel imaging techniques are promising, clinical experiences are limited.

Name of examination

10.2.1 NET Imaging with In-111 Octreoscan

Radiopharmaceutical:

- In-111 pentetreotide (Octreoscan)

Principle:

- Octreoscan is a radiolabeled analogue of somatostatin, indicated for the scintigraphic localization of neuroendocrine tumors bearing somatostatin receptors.

Technique:

- Patient preparation:
  - Bowel preparation, especially for abdominal suspected lesions
  - Hydration and frequently voiding of the urinary bladder
  - Attention to diabetic patients where may cause paradoxical hypoglycemia
  - Temporarily withdrawal of octreotide therapy
  - Attention to breastfeeding and childbearing age patients (see chapter of Radioprotection)
- Dose: 3–6 mCi (11–220 MBq)/patient
- Injected I.V.
- It is necessary to wait 4–6 h after the injection for the first images. Delay images may be registered at 24 h or 48–72 h.
- Patient position: supine
- Gamma camera
  - Medium-energy general purpose (MEGP) collimator
- Acquisition:
  - The gamma camera is positioning anteriorly and next posteriorly or simultaneous in dual head camera.
  - Photon peaks at 172 and 245 keV and 20% windows.
  - 256×256 matrix.
  - Min 500,000 counts/image.
  - WBS speed 3 cm/min.
  - Also, spot images on the region of interest and lateral views of head/neck, chest and abdomen may be obtained.
  - SPECT is usually recorded with 60 projections of 6° each; or 90 projections of 4° each. Matrix 64×64.

  45–60 s/projection.
- Processing: There are special PC programs for image processing; additional analysis of counts in different region of interest (ROI) may be used.

Clinical applications:

- Diagnosis and management of receptor bearing gastro-entero-pancreatic (GEP) neuroendocrine tumors and carcinoid tumors; other non-GEP neuroendocrine tumors.

- Diagnosis of carcinoid; islet cell carcinoma; gastrinoma; glucagonoma; insulinoma; VIPoma; motilinoma.

Necessary additional examinations:

- CT, MRI
- Ultrasound
- Serologic tests of specific tumor markers
- Fine needle aspiration biopsy (FNAB)

Comments:

- If there is no uptake of Octreoscan, the use of somatostatin analogues in the treatment is discouraged.

Reports:

- The report will include a description of the normal distribution and pathologic uptakes; the report should mention the correlation of nuclear findings with the morphological images.

10.3 Nuclear Therapy of Neuroendocrine Tumors

The primary treatment of neuroendocrine tumors (NET), such as the carcinoid, is surgery with curative intent or with the intent to debulk the tumor mass. In 80% of patients with NET for whom this is impossible, alternatives such as external beam radiation therapy or chemotherapy are suboptimal because these well-differentiated tumors are relatively unresponsive. Most of these tumors express somatostatin receptors, especially subtype 2, in high abundance, which very rapidly bind and internalize targeted peptides. Somatostatin analogues, such as octreotide, can be used to treat carcinoid syndrome, and recent studies have also demonstrated substantial effects on tumor growth characteristics and modest prolongation of survival.

The rationale for using radiolabeled somatostatin analogues is based upon the evidence that they rapidly accumulate in the up-regulated overexpressed somatostatin receptor-containing tumors. Somatostatin peptide analogues, coupled with a complexing moiety (DOTA) can be labeled with the beta-emitters Y-90 or Lu-177. By targeting somatostatin receptor-positive tumors, they may deliver a tumouricidal radiation dose, and regression has been demonstrated after therapy with radiolabeled somatostatin analogues.

Somatostatin acts through interaction with receptors expressed on the surface of cells (in both normal and malignant tissues), named as somatostatin receptors. Five subtypes have been characterized and named somatostatin receptor subtype 1-5 (SSTR1-5).

The **octreotide** is a somatostatin analogue with the structure:

D-Phe^1-Cys^2-Phe^3-D-Trp^4-Lys^5-Thr^6-Cys^7-Thr^8(ol)

Researchers found that if Phe^3 is substituted with Tyr^3 it is possible to labeled with radioiodine isotopes, both for diagnostic and for therapy.

D-Phe^1-Cys^2-Tyr^3-D-Trp^4-Lys^5-Thr^6-Cys^7-Thr^8(ol)

Octreotide was derivatized with diethylenetriaminepentaacetic acid (DTPA) on the amine terminus. Attaching this chelate to the peptide allowed radiolabelling of the molecule with In-111.

Following that step, with the aim to find the best agent for PRRT, the chelating agent, DTPA, (coupled to octreotide) was substituted with DOTA (tetra-aza-cyclo-dodecane-tetraacetic acid), which enabled the radiolabelling of this conjugate with Y-90, Lu-177 or other radionuclides.

DOTATOC: DOTA-Phe^1-Tyr^3-Octreotide

DOTANOC: DOTA-Nal^3-Octreotide (DOTA-Naphythyl-alanine conjugate with octreotide)

Octreotate is another peptide analogue of somatostatin, which differs from octreotide where the C-terminal amino acid residue is threonine (instead of threoninol in octreotide)

DOTATATE: DOTA-Thy^3-Thre^8-Octreotide (Octreotate)

Lu-177 is a medium-energy beta-emitter with a maximum tissue penetration of 1.6 mm and a physical half-life of 6.7 days. It also emits medium- and low-energy gamma radiation, which can be used for quantitative imaging and dosimetry. Binding of Lu-177 octreotate in NET expressing somatostatin receptor subtype-2 is nine times higher than that of the standard diagnostic imaging agent In-111 octreotide and

9.4 Adrenal Medullary Scintigraphy

Pheochromocytomas are catecholamine-secreting neoplasms arising from chromaffin cells.

There is a well-known rule of "ten." Approximately:

- 10% are malignant.
- 10% are bilateral.
- 10% occur in children.
- 10–20% are extra-adrenal in origin (paragangliomas), usually in the abdomen or pelvis but occasionally in the neck or mediastinum.

Because anatomical imaging studies are nonspecific and may not be sensitive for the presence of extra-adrenal foci, bilaterality, or metastatic disease, adrenal medullary scintigraphy may play a major role in the diagnosis of patients with pheochromocytoma, paraganglioma or neuroblastoma. This is especially important in view of the several-fold higher perioperative complication rate associated with reoperation.

Radiopharmaceuticals:

- Metaiodobenzylguanidine (MIBG-Iobenguan) is a guanethidine analogue similar to norepinephrine that is taken up by adrenergic tissue via expressed plasma membrane norepinephrine transporters and intracellular vesicular monoamine transporters.
- The uptake may be inhibited by a variety of pharmaceuticals including sympathomimetics, antidepressants, and some antihypertensives, especially labetalol. These must be withheld for an appropriate length of time before MIBG administration.
- The radiopharmaceutical may be labeled as I-123-MIBG or I-131-MIBG

Activity administered:

- 400 MBq (aprox.10 mCi) I-123 MIBG
- 20 MBq (aprox.0.5 mCi) I-131 MIBG

Effective dose equivalent:

- 6 mSv (600 mrem) I-123 MIBG
- 3 mSv (300 mrem) I-131 MIBG

Patient preparation:

- I-123 MIBG: Lugol's solution or (6 drops/day) a saturated solution of potassium iodide (100 mg twice a day) begun the day prior to the administration of the radiopharmaceutical and continued for 4 days afterwards.
- I-131 MIBG: Lugol's solution or (6 drops/day) a saturated solution of potassium iodide (100 mg twice a day) begun the day prior to the administration of the radiopharmaceutical and continued for 7 days afterwards. The pediatric doses are 25–50% lower than those of adults, related to age and weight.

Gama camera:

- I-123 MIBG: collimator – low-energy, high-resolution, parallel-hole
- Images acquired: whole body images, anterior and posterior, 10 min per step, at 24 h (and 48 h as needed)
- I-131 MIBG: collimator – high-energy, general purpose, parallel-hole (I-131 MIBG)
- Images acquired: SPECT of abdomen; whole body images, anterior and posterior, 20 min per step, at 24 and 48 h (and 72 h as needed)

Although both I-131 and I-123 have been used to label MIBG, I-123 is preferred because of its favorable dosimetry and imaging characteristics. Plasma clearance of MIBG is rapid, with 50–70% of the dose excreted unchanged into the urine within 24 h. Due to the release of free radioiodine from the radiopharmaceutical, the co-administration of stable iodine to block thyroid uptake is necessary.

Physiological activity is typically seen within the liver, spleen, bladder, and salivary glands. Faint activity is seen in the normal adrenal medulla in 16% of cases using I-131-MIBG and in over 25% of the cases using I-123-MIBG.

Relatively faint activity is also seen in the myocardium and lungs, especially in early images. Free radioiodine will localize to the gastric mucosa and later in the colon. The uterus may be visualized during menstruation. Importantly, no skeletal activity is normally present. Anatomical variations in the renal collecting system may lead to false-positive imaging results.

9.4.1 Clinical Applications

The diagnosis of pheochromocytoma is made by the laboratory demonstration of elevated