Scintigraphy and the thyroid: a great alliance!
K.Peremans, DVM, PhD, CertVR, DipECVDI

Department of Medical Imaging, Faculty of Veterinary Medicine, Ghent University,
Salisburylaan 133, B-9820 Merelbeke, Belgium
Kathelijne.peremans@ugent.be

Iodine has a major role in the physiology and pathophysiology of the thyroid gland. It is transported into the thyroid by the sodium-iodide symporter (NIS), stimulated by thyroid stimulating hormone (TSH). This mechanism forms the base of thyroid scintigraphy with radioactive iodine and pertechnetate. Radioactive iodine is transported inside the gland by the same NIS as cold iodine and will be organified into thyroid hormones. In the first years of thyroid scintigraphy, radioiodine-131 (\(^{131}\)I) was used for treatment as well as for imaging purposes. Due to its radiotoxic nature (beta particle emission) and its high energy gamma rays, it is not an ideal compound to use for diagnostic imaging. Another radioactive isotope of iodine can be used: \(^{123}\)I, a pure gamma emitter with consequently few radiotoxic side effects and an energy suited for conventional gamma camera imaging. However, it is very expensive and carries more radiation burden to the patient due to its longer effective half-life in comparison with \(^{99m}\)TcO\(_4^-\) (pertechnetate). Therefore it is not suited for daily clinical use. Nowadays pertechnetate is mostly used for diagnostic scintigraphy. It is also a pure gamma emitter with even better energy characteristics for gamma camera imaging. Although it is transported by the same NIS as iodine, it will not be organified.

Hyperthyroidism in the cat is the most common indication for thyroid scintigraphy. The scintigraphic diagnosis is based on visual inspection and/or quantitative analysis of the data. Visually higher uptake in the thyroid compared to the salivary glands is typical for hyperthyroidism. A ratio calculated between pertechnetate uptake in the salivary glands and thyroid lobes and percentage uptake of the injected activity in the thyroid are two methods used in the quantitative analysis. Subsequent treatment of these animals with \(^{131}\)I is nowadays common practice. The majority of cats are cured with one injection. The amount of activity needed is based on gland size and volume, amount of activity accumulated in the thyroid and clinical parameters (severity of symptoms and TT4). Patient based dose estimation is for practical reasons not commonly performed in veterinary medicine and this practice is still a matter of debate in human medicine.

Five percent of the cats needs a second injection. Five to 30% (depending on the literature source) becomes hypothyroid, but only a minority develops clinical signs of hypothyroidism. Up till now, no exact reason has been found to explain these variable treatment results. Several causes can be put forward such as the amount of injected activity and preclinical
parameters (less severe disease, preexisting kidney failure, prior treatment with antithyroid drugs, individual differences in thyroid kinetics). Bilateral involvement has been incriminated as a risk factor for development of hypothyroidism in cats. Thyroid scintigraphy is also of use in the diagnosis of primary hypothyroidism in dogs. In these animals lower uptake (ratio thyroid to salivary gland) or no uptake is pathognomonic. However, in some early cases of immune mediated thyroiditis, uptake may be normal or even increased. When congenital organification deficits are suspected, radioiodine should be used as pertechnetate will not be organified. Drug induced hypothyroidism will manifest as decreased or increased uptake of pertechnetate depending on the drug and the length of treatment. Secondary hypothyroidism can be differentiated from primary by scintigraphy after stimulation with TSH.

Thyroid scintigraphy is also of importance in the management of thyroid tumours. Depending on the degree of (de)differentiation of the tumour cells and associated expression of the NIS, uptake of pertechnetate will be absent or present. This has consequences for treatment options as only those tumours with pertechnetate uptake are possible candidates for radioiodine therapy. In human medicine, research on re-differentiating agents and gene manipulation to induce NIS expression is blooming business. The uptake of pertechnetate in thyroid tumours is distinctive. If uptake is evident, it will often be highly heterogeneous. In addition to regular planar imaging, tomographic studies can help in staging the tumour. Pulmonary foci of increased uptake are also taking up radioiodine and therapeutically benefit in the same way as the primary tumour of the radioiodine treatment. In some patients uptake in metastases is suppressed by the primary tumour and will become visible after its removal. Therefore, in humans debulking surgery is followed by radioiodine treatment in order to eradicate all thyroid tissue. Afterwards, these patients receive thyroid hormone supplementation. Monitoring therapy results with $^{131}$I whole body imaging is combined with plasma thyroglobuline measurements. Patients in remission will have no foci of increased uptake on the scintigraphic images and will have low thyroglobulines. The moment one of the parameters becomes abnormal, relapse is suspected. The major drawback of radioiodine treatment is the hospitalization time required due to radioprotective issues. Release criteria vary enormously between countries depending on local and national regulations. This results in a variable hospitalization time among institutions. International harmonization would be welcome in order to balance safety limits with animal welfare.

The most important factor that governs the amount of radiation emitted, is the amount of injected activity. A lower efficacious dose will reduce the surface dose-emission rate, i.e. radioactivity found in excreta and on the fur and paws, as well as hospitalization time respecting the ALARA (As low as Reasonable Achievable) principle. In this regard, administration of recombinant human thyroid stimulating hormone (rhTSH) to stimulate iodine
turnover may be an interesting compound. It is mainly used to reduce symptoms of hypothyroidism when human thyroid cancer patients are off thyroid hormone supplementation prior to the follow up whole body scan. rhTSH can also be used to increase uptake of radioiodine in the thyroid tissue, thus requiring a lower amount of activity. This has been demonstrated in humans and is under investigation in animals.

Further, pertechnetate scintigraphy can be indicated to identify the origin of cervical masses. Normal aspect and uptake of thyroid lobes rule out thyroid involvement and since salivary glands also accumulate pertechnetate, involvement of these structures can be evaluated.

Further reading


