Original article

False-positive Iodine-131 whole-body scan findings in patients with differentiated thyroid carcinoma: Report of 11 cases and review of the literature

Faux positifs des scintigraphies corps entier à l’Iode 131 chez les patients présentant un carcinome différencié de la thyroïde : description de 11 cas et revue de la littérature

Leckzinscka Buton a, Olivier Morel b, Patricia Gault c, Frédéric Illouz a, Patrice Rodien a, Vincent Rohmer a, *

a Service d’endocrinologie, faculté de médecine, université Angers, centre hospitalier universitaire, 49933 Angers, France
b Département de médecine nucléaire, ICO Paul-Papin, 2, rue Moll, 49933 Angers cedex 9, France
c Centre hospitalier, 53000 Laval, France

Abstract

Background. – Iodine-131 (I-131) whole-body scan (WBS) plays an important role in the management of patients with differentiated thyroid carcinoma (DTC), to detect normal thyroid remnants and recurrent or metastatic disease. A focus of I-131 accumulation outside the thyroid bed and the areas of physiological uptake is strongly suggestive of a distant functioning metastasis. However, many false-positive I-131 WBS findings have been reported in the literature. Patient findings. – We describe a series of 11 personal cases of patients with DTC, collected from 1992 to 2011, in whom diagnostic or post-treatment WBS showed false-positive retention of I-131 in various locations. Summary. – False-positive accumulations of I-131 on WBS may be classified according to the underlying pathophysiological mechanisms: external and internal contaminations by body secretions, ectopic normal thyroid and gastric tissues, inflammatory and infectious diseases, benign and malignant tumors, cysts and effusions of serous cavities, thymic uptake, and other non classified causes. Conclusions. – Clinicians must be aware of possible false-positive findings to avoid misinterpretations of the I-131 WBS, which could lead to inappropriate treatments.

© 2013 Elsevier Masson SAS. All rights reserved.

Résumé


© 2013 Elsevier Masson SAS. Tous droits réservés.

1. Introduction

Well-differentiated papillary and follicular thyroid carcinomas (DTC) are the most frequent thyroid malignancies. Their prognosis is generally good after appropriate treatment, namely a total thyroidectomy with lymph node dissection, often followed by radioiodine therapy [1,2]. Iodine-131 (I-131) administration after surgery is used for both diagnostic and therapeutic purposes. The administration of high doses of I-131 destroys normal and malignant remnant thyroid tissue; it is followed by a whole-body scan (WBS), a highly sensitive method for the detection of a metastatic or recurrent disease [3]. Since iodine-trapping is
specific of thyroid tissue, I-131 WBS has a high specificity, and a focus of uptake is strongly suggestive of residual thyroid tissue or functioning metastasis. However, many false-positive I-131 WBS findings have been reported in the literature. They can be caused by physiological radioiodine accumulation or other various mechanisms [4]. Failure to recognize these artifacts may result in misleading conclusions, leading to inappropriate treatment (I-131 therapy or surgery). Thus, the possibility of false-positive findings on WBS must be kept in mind in order to avoid misinterpretations. We report here 11 cases of false-positive I-131 WBS in patients with DTC, from our personal experience in the department of Nuclear Medicine in Centre Paul-Papin in Angers, collected from 1992 to 2011.

2. Patients

2.1. External contamination

A 78-year-old woman (case no. 1) with a suspicious thyroid nodule underwent a total thyroidectomy (Table 1). Pathology revealed papillary thyroid carcinoma with metastases to cervical lymph nodes. She received 100 mCi of radioiodine for ablation. The I-131 WBS revealed cervical foci of uptake corresponding to metastatic lymph nodes, and a superficial area of increased I-131 accumulation in the region of the right hip, which was actually related to a handkerchief contaminated by nasal secretions in the patient’s pocket.

2.2. Breast location

A 37-year-old woman (case no. 2), who had just delivered a baby, presented with papillary thyroid carcinoma and underwent a total thyroidectomy. Postoperatively, she was treated with 100 mCi of I-131. The post-therapy WBS showed an uptake in the thyroid bed compatible with thyroid remnants, and a right anterior thoracic focus of uptake (Fig. 1), corresponding to the right breast on the I-131-single-photon computed tomography and CT scan (SPECT/CT) fusion scan (not shown here). Although the patient had stopped breastfeeding approximately 2 months before the I-131 therapy, the right breast uptake was related to the recent lactation.

A 48-year-old woman (case no. 3) underwent a total thyroidectomy for a papillary carcinoma. She was treated with 100 mCi of I-131. The post-therapy WBS showed a median cervical focus of uptake suggestive of thyroid remnants, and a left breast uptake. The patient underwent breast surgery and histological examination revealed lesions of mastosis.

2.3. Thoracic location

A 66-year-old woman (case no. 4) with a suspicious thyroid nodule underwent a total thyroidectomy. Pathology revealed

---

Table 1: Characteristics of patients with false-positive Iodine-131 whole body scan.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age at diagnosis (years)</th>
<th>Histology</th>
<th>TNM stage at diagnosis</th>
<th>Tg (ng/ml)/Tg Ab</th>
<th>False-positive 131-I localization on whole-body scan</th>
<th>Final diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>78</td>
<td>Papillary</td>
<td>T3 N1 Mx</td>
<td>395/negative</td>
<td>Right hip</td>
<td>Contaminated handkerchief</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>37</td>
<td>Papillary</td>
<td>T2 N0 M0</td>
<td>0/positive</td>
<td>Right anterior thoracic uptake</td>
<td>Breastfeeding</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>48</td>
<td>Papillary</td>
<td>T1 N0 M0</td>
<td>0.4/negative</td>
<td>Left breast uptake</td>
<td>Mastosis</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>66</td>
<td>Papillary</td>
<td>T1 N0 M0</td>
<td>0/negative</td>
<td>Left thoracic uptake</td>
<td>Bronchiectasis</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>56</td>
<td>Papillary</td>
<td>T1 N1 M0</td>
<td>0.4/negative</td>
<td>Right thoracic uptake</td>
<td>Bronchiectasis</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>58</td>
<td>Follicular</td>
<td>T3 N0 M1</td>
<td>190/negative</td>
<td>Right posterior basal thoracic uptake</td>
<td>Benign mesothelial cysts</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>38</td>
<td>Papillary</td>
<td>T3 N1 M0</td>
<td>0/positive</td>
<td>High anterior mediastinal uptake</td>
<td>Normal thymus</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>41</td>
<td>Papillary</td>
<td>T2 N0 M0</td>
<td>5.8/negative</td>
<td>Second lumbar vertebra</td>
<td>Lumbar arthritis L1-L2</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>70</td>
<td>Papillary</td>
<td>T1 N0 M0</td>
<td>7510/negative</td>
<td>Median pelvic uptake</td>
<td>Struma ovarii with carcinoid tumor</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>36</td>
<td>Papillary</td>
<td>T1 N1 M0</td>
<td>10.8/negative</td>
<td>Right pelvic uptake</td>
<td>Mucinous ovarian cystadenoma</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>44</td>
<td>Papillary</td>
<td>T2 N0 M0</td>
<td>33/negative</td>
<td>Median pelvic uptake</td>
<td>Uterine fibroma</td>
</tr>
</tbody>
</table>

F: female; M: male; Tg: thyroglobulin; Tg Ab: anti-thyroglobulin antibodies; TNM: Tumor Node Metastasis.

a TNM classification according to UICC (Union for International Cancer Control) 2005.
papillary thyroid carcinoma. The post-therapy WBS showed an uptake in the thyroid bed compatible with thyroid remnants, and a left thoracic focus of uptake (Fig. 2A). Tg level was less than 1 ng/ml, without anti-Tg antibodies. I-131 SPECT/CT fusion scan showed that thoracic focus of radiiodine uptake was located in the lower lobe of the left lung (Fig. 2B). Contrast-enhanced thoracic CT-scan showed that the lung lesion with I-131 uptake was most likely to be bronchiectasis (not shown here).

A 56-year-old woman (case no. 5) underwent a total thyroidectomy for a papillary thyroid carcinoma (pT2 N1b). Four days after administration of 100 mCi radiiodine, the post-therapy WBS showed tracer uptake in the thyroid bed compatible with thyroid remnants, and a right thoracic uptake related to bronchiectasis on the thoracic CT-scan.

A woman now aged 77 years (case no. 6) underwent a total thyroidectomy and two treatments with 100 mCi of iodine in 1992 for a minimally-invasive follicular thyroid carcinoma. In 1998, a biological recurrence occurred (Tg to 190 ng/ml after thyroid hormone treatment withdrawal), leading to the administration of two other treatments with 100 mCi of I-131. Both post-therapy WBS found three foci of uptake in the lower and posterior right thoracic area to be likely pulmonary metastases although the CT scan was normal. Six months after the last radioiodine therapy, thyroglobulin was undetectable in hypothyroidism. In 2005, a new biological recurrence occurred. Two other treatments with 100 mCi of I-131 were administrated a year apart and the post-therapy WBS showed the same three foci of uptake in the thoracic area (Fig. 3). CT scan, MRI, ultrasonography, 18F-FDG PET/CT were unable to find any abnormality in this region. A radioguided surgery using I-131 (100 mCi) was then performed. The surgeon identified and removed several small hot nodules located on the abdominal side of the right diaphragm. Pathology revealed benign mesothelial cysts. The thoracic foci of I-131 uptake had disappeared on the WBS performed 2 days after surgery.

A 38-year-old man (case no. 7) underwent a total thyroidectomy for a pT2 N1 papillary carcinoma. After thyroid hormone therapy withdrawal, Tg was undetectable with positive anti-Tg antibodies; the post-therapy I-131 (100 mCi) WBS revealed uptake in the neck suggestive of thyroid remnants and moderate focal uptake in the upper anterior mediastinum. The thoracic CT-scan showed a faint thymic densification. Six months later, Tg was 0.3 ng/ml in hypothyroidism with negative anti-Tg antibodies and negative I-131 (5 mCi) WBS. It was concluded that I-131 mediastinal uptake on the initial WBS was a non-specific thymic uptake.

2.4. Vertebral location

A 41-year-old man (case no. 8) with a suspicious thyroid nodule underwent a total thyroidectomy. Pathology revealed a papillary thyroid carcinoma. Subsequently, the patient underwent radioiodine ablation therapy with 100 mCi of I-131. The
WBS revealed a focus of radioiodine uptake on the low midline anterior neck compatible with thyroid remnants. A second focus of I-131 retention was localized in the second lumbar vertebra (L2). The Tg was 5.8 ng/ml, without anti-Tg Ab. Magnetic resonance imaging (MRI) revealed a L1-L2 discopathy related to arthritis, without abnormality of the vertebral body. It was assumed that the radioiodine vertebral uptake was related to lumbar arthritis probably in inflammatory phase. Six months later, successful ablation was confirmed (Tg < 1 ng/ml without anti-Tg antibodies and no abnormal I-131 uptake on a 5 mCi diagnostic WBS).

2.5. Pelvic location

A 70-year-old woman (case no. 9) underwent a total thyroidectomy for a 7 mm papillary carcinoma. Seven months after surgery, Tg level was very high, measured at 218 ng/ml under L-T4 therapy. After thyroid hormone treatment withdrawal, the Tg level rose to 7510 ng/ml and the patient was treated with 100 mCi of I-131. Five days after radioiodine administration, the WBS showed an intense tracer uptake in the thyroid bed suggestive of thyroid remnants and a large pelvic focus of uptake (Fig. 4). Ultrasonography showed a pelvic tumor, which was removed by surgery. Pathology revealed a right ovarian tumor containing mature thyroid tissue. The immunohistochemical staining was positive for chromogranin and synaptophysin, leading to the diagnosis of struma ovarii with carcinoid tumor. Two months after surgery, Tg level was less than 1 ng/ml under L-T4 therapy, without anti-Tg antibodies.

A 36-year-old woman (case no. 10) underwent a total thyroidectomy for a papillary carcinoma (pT1 m N1a). After thyroid hormone treatment withdrawal, the Tg level was 10.8 ng/ml without anti-Tg antibodies and the patient was treated with 100 mCi of I-131. The post-therapy WBS revealed an intense pelvic focus of uptake. The patient underwent a right ovariec- tomy and the histological examination revealed a benign mucinous cystadenoma, without thyroid tissue.

A 44-year-old woman (case no. 11) with multinodular goiter underwent a total thyroidectomy. Pathology revealed a bifocal follicular variant papillary carcinoma. Subsequently, the patient underwent radioiodine ablation therapy with 50 mCi of I-131. After thyroid hormone treatment withdrawal, the Tg level was 33 ng/ml without anti-Tg antibodies. The post-treatment WBS showed a cervical focus of uptake suggestive of thyroid remnants and a large abdominopelvic focus of uptake (20-cm pelvic mass with unclear limits on MRI). The hysterectomy removed a large uterine fibroid, confirmed by histological examination.

3. Discussion

Apart from normal and differentiated malignant thyroid tissue, physiological radioiodine accumulation exists in salivary and lacrimal glands, nasopharynx, gastric mucosa and breasts, because the Sodium-Iodide Symporter (NIS) is also expressed in these tissue cells [5], resulting in the active transport of iodine from the plasma into the secretory lumen of the organ. Moreover, urinary and gastrointestinal tracts and the liver can be seen on WBS since they are physiological routes of excretion of I-131.

Many I-131 false-positive findings have been published in the literature. In 2003, Carlisle et al., [3] reviewed and classified these cases according to the anatomic site of the uptake. Greenler et al., [6] in 1989, then Shapiro et al., [4] in 2000 proposed a classification based on the underlying patho-physiological mechanisms: external and internal contaminations by body fluids, ectopic normal tissues that usually trap iodine (thyroid tissue and gastric mucosa), inflamatory and infectious affections, benign and malignant tumors, cysts and effusions of serous cavities, thymic uptake, and other non classified causes. Table 2 presents a listing of all false-positive findings on I-131 WBS reported in the literature according to this classification.

Artifacts of contamination by body fluids, including urine, saliva, nasal secretions, sweat, breast milk, gastric liquid and faeces, represent the most common causes of false-positive I-131 WBS findings. External contaminations may be direct [7,8], such as excessive perspiration in the hair [3,9–11], or indirect [12,13]. Several authors described cases of false-positive localization of I-131 because of handkerchiefs soiled by nasal secretions or saliva [3,14–18], as in our case 1, or jewels contaminated by perspiration or saliva [3,19–21], but also medical devices, such as tracheostomy tubes or prostheses [6,22–25]. I-131 retentions related to external contaminations are typi- cal: they are usually superficial and they do not conform to any anatomic structure. Internal contaminations by body fluids often occur in a pathological context. Several cases of unusual uptake of I-131 by urinary tract have been reported, related to an ectopic kidney [22,26], a dilated upper calyx [27], or a
### Table 2 (Continued)

<table>
<thead>
<tr>
<th>Pathophysiological mechanisms</th>
<th>Case reports in the literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign and malignant tumors</td>
<td></td>
</tr>
<tr>
<td>Benign tumors</td>
<td>Peritoneal strumosis [113]</td>
</tr>
<tr>
<td>Breasts</td>
<td>Benign struma ovarii[^a] [48]</td>
</tr>
<tr>
<td>other affections</td>
<td>Ovarian cystadenoma [79]</td>
</tr>
<tr>
<td>Cysts and effusions of serous cavities</td>
<td></td>
</tr>
<tr>
<td>Cysts</td>
<td>Renal cyst [84,88]</td>
</tr>
<tr>
<td>Effusions of serous cavities</td>
<td>Pleural effusion complicating a mesothelioma[^a] [41]</td>
</tr>
<tr>
<td>Other non classified causes</td>
<td>Hyperplasia or normal thymus [3,23,92–98,100]</td>
</tr>
</tbody>
</table>
| Polycystic renal disease [28]; in these cases, I-131 retention is focal, seen on posterior views, and often disappears after hydration of the patient. Several cases of false-positive WBS related to I-131 uptake by the gastrointestinal tract were reported. Artifacts related to a salivary retention or a reflux of gastric secretion in the esophagus, typically show a midline thoracic uptake in continuity with the stomach. They occur either in a healthy [3,6,29], or pathological esophagus [30–35]; drinking a glass of water often removes I-131 accumulation on repeated images. Abnormal uptake in the colon [6] can be caused by various mechanisms: direct secretion of I-131 by the gastric or colonic mucosa, presence of the radiolabeled metabolites of thyroid hormones excreted into the bile, reduced colonic motility (induced

[^a]: Classified into two categories.
by hypothyroidism required prior to WBS). Laxatives administered several days before the scan may avoid these false-positive findings. However, it is not known if the physiological route of excretion of radiolabeled thyroid hormones, a focal I-131 uptake can be seen in the biliary tract, related to either morphological [36] or functioning [37,38] abnormalities. Salivary glands may be also strongly depicted [39,40]. Breast salivary glands represent a particular case among internal contaminations. Mimicking lung metastases, radiiodine retention by the lactating breast was frequently reported in the literature [3,6,16,41], often bilateral, sometimes asymmetric, or unilateral [42]. These uptakes may remain several weeks or months after stopping lactation, as in our case 2; they are related to the expression of the NIS by the glandular epithelium of the breast during lactation. Bakheet et al., [43] classified breast uptakes in four categories: “full”, “focal”, “crescent”, and “irregular” patterns. In our case 2, if a diagnostic I-131 WBS had been first performed showing a significant uptake, I-131 treatment could have been delayed, to avoid a false-positive finding on post-therapeutic I-131 WBS. An interval of at least 3 months between the end of lactation and the I-131 treatment is generally recommended. Cases of breast uptake in non-lactating women have also been published [44,45], as our case 3. Their mechanism is unclear. In a prospective study, Hammami et al., [44] estimated that the prevalence of such I-131 retention in the absence of recent breastfeeding was about 6%. They hypothesized that mammary uptake could be related to galactorrhea secondary to hyperprolactinemia induced by hypothyroidism, but the study did not confirm this hypothesis.

Even in ectopic localizations, normal thyroid and gastric tissues that usually trap I-131 retain this property and result in I-131 accumulation on WBS. Ectopic normal thyroid tissue may remain anywhere along the thyroglossal tract, following the migration of the gland during embryogenesis [46,47]. It may also appear in the ovary (struma ovarii) [48,49]. Ectopic gastric mucosa also concentrates iodine. Normal gastric mucosa may be anatomically displaced, in hiatal hernia [50–53] or some surgeries [54]. Normal gastric mucosa may be localized in diverticuli, such as Meckel’s diverticulum, due to abnormalities in embryological development [55]. Finally, gastric mucosa may appear by metaplastic transformation of esophageal epithelium caused by a chronic inflammation, such as Barrett’s esophagus [56].

Many observations of false-positive I-131 WBS findings caused by inflammatory or infectious diseases have been described. I-131 retention is related to increased blood flow caused by vasodilatation and increased capillary permeability. Mimicking lung metastases, inflammatory and infectious pulmonary diseases are the most commonly reported cases [57–61]. Our cases 4 and 5 are comparable to a case described by Song [62], where bronchiectasis trapped I-131. Regalbuto et al., [63] described I-131 uptakes in the legs in four patients, caused by post-traumatic superficial scabs. I-131 accumulation may also relate to the presence of a clot, rich in leukocytes, which have been reported to induce iodine organification by means of myeloperoxidase. Many other published cases are reported in Table 2 [6,22,64–69]. To our knowledge, our case 8, which describes I-131 uptake due to lumbar arthrosis in inflammatory phase, is a newly identified cause of false-positive WBS findings. However, we could also hypothesize that the uptake was a L2 micrometastasis, efficiently treated with the I-131.

Benign and malignant tumors may also trap I-131, due to multifactorial mechanisms: increased vascular permeability and increased blood flow by vasodilatation caused by inflammation, presence of ectopic thyroid tissue (struma ovarii), persistence of physiological iodine transport by tumors derived from epithelia (adenocarcinoma) that have NIS. Case reports of malignant tumors that retain I-131 include lung carcinomas [70–74], a primary malignant mesothelioma with pleural effusion [41], a disseminated gastric adenocarcinoma [75], liver metastases of a malignant struma ovarii [49], and salivary adenocarcinoma [76,77]. However, struma ovarii behave differently from other tumors and represent a particular cause of misleading diagnosis: they are generally benign tumors, composed of predominantly mature thyroid tissue; thus, in addition to I-131 uptake, Tg levels are elevated, as observed in our case no. 9. Published cases of benign tumors resulting in false-positive WBS findings are reported in Table 2 [78–83] including our case 10. Our case 11 describes a uterine fibroma resulting in a I-131 uptake; the mechanism underlying this I-131 retention is unclear.

Even in the absence of inflammation, cysts and effusions of serous cavities may trap I-131, by passive diffusion from the extracellular liquid into the cystic cavity, or by I-131 uptake by epithelial cells lining the cyst or the serous cavity. Many cases of cysts have been described, in various localizations [6,8,84–88]. In 2007, De Keizer et al., [89] published the case of a 38-year-old man, whom post-ablative WBS revealed an I-131 uptake in the liver area. The CT-scan showed an extrahepatic soft tissue lesion corresponding to the I-131 accumulation, and the patient underwent the surgical removal of the mass. The histopathological examination was consistent with a benign cystic mesothelioma. The immunohistochemical staining with polyclonal anti-NIS antibodies was negative. The speculated mechanism to explain this aberrant I-131 retention was a slow exchange of radiiodine between the cyst and its surrounding. Our case 6 is comparable to De Keizer’s case. Several observations of effusions of serous cavities with 131I accumulation have been reported, including: pericardial effusion [41,90,91] a scrotal hydrocele [6], and a pleural effusion that complicated a malignant mesothelioma [41]. In this last case, the mechanism explaining I-131 retention may associate inflammation related to the malignant mesothelioma, and passive diffusion of 131I in the pleural cavity.

I-131 uptake by the thymus was often described in the literature [3,23,92–96] as in our case 7. Mimicking lung metastases or mediastinal lymph nodes, thymic uptakes have high anterior mediastinal localizations, typically described as “arrowhead” or “dumb-bell”. They are more frequently visualized in young patients, and can be related to thymic hyperplasia or normal residual thymus. For example, Michigishi et al., [97] reported two cases of mediastinal I-131 uptake related to histologically proven thymic hyperplasia. Neither thyroid tissue nor metastatic foci of thyroid carcinoma were found in the gland and the I-131 retention disappeared after thymus removal. In 2000,
4. **Conclusion**

False-positive I-131 WBS findings are rare but not exceptional, as shown by our personal observations and cases published in the literature. They must be kept in mind, because misinterpretation of the WBS results in misleading diagnosis of metastatic or recurrent differentiated thyroid carcinoma. Simple actions can be undertaken. First, whatever the origin of the I-131 retention, anterior and posterior views on WBS may be completed by a SPECT/CT acquisition. A good preparation of the patient before the WBS can decrease or even suppress artifacts of contaminations by body secretions, which are the more common causes of false-positive I-131 WBS. Indeed, the ingestion of food that contributes to salivate, an abundant oral hydration and the use of laxatives several days before the WBS decrease the I-131 retention by salivary glands, and urinary and gastrointestinal tracts; ingestion of a glass of water immediately before the WBS avoids esophageal retention of I-131; external contamination can be avoided by a shower and shampoo, the removal of jewels and handkerchiefs, and the wearing of clean clothes. Patients’ questioning and clinical examination can reveal a medical history of cyst, tumor, a recent breastfeeding, or a current infectious disease. According to current practice, the observation of I-131 uptake suggestive of a functioning metastasis of a DTC must be considered together with serum Tg levels: if Tg is undetectable without Tg Ab, the I-131 accumulation is unlikely a metastasis, but rather a false-positive finding. Finally, anatomic or other functional imaging, such as FDG-PET/CT can distinguish, in some cases, between a false-positive I-131 WBS finding and a recurrent or metastatic disease [112].

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**


Wong KK, Zarruehsky NV, Cahill JM, Frey KA, Avram AM. Incremental value of diagnostic 131I SPECT/CT fusion imaging in the evaluation of differentiated thyroid carcinoma. AJR Am J Roentgenol 2008;191:1785–94.


