Nodular disease and parafollicular C-cell distribution: results from a prospective and retrospective clinico-pathological study on the thyroid isthmus

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Abstract

Objective: The isthmus represents a peculiar, as yet partially unexplored, thyroid gland area.

Aim of the study: To assess i) the prevalence and clinico-pathological features of solitary thyroid isthmic nodules (STIN); ii) the frequency of medullary thyroid carcinoma (MTC) arising from the isthmus; and iii) the C-cell distribution in the isthmus of patients with MTC and benign nodular thyroid disease (NTD).

Subjects and methods: Patients referred from 2006 to 2008 for STIN were prospectively recruited, and underwent serum calcitonin (Ct) measurement and fine needle aspiration cytology (FNAC). MTCs diagnosed from 1993 to 2005 were retrospectively searched. Immunohistochemistry was performed using anti-Ct antibodies on lateral lobes and isthmi of 50 benign NTD and 50 MTC cases.

Results: From 1993 to 2005, 150 patients underwent surgery for MTC. All patients had the neoplasm located in lateral thyroid lobes, none in the isthmus. In the 3 years following, 192 STIN patients (40 (21%) males, 152 (79%) females; mean age: 46.2 ± 7.1 years; 6.4% of NTD subjects) were recruited. All had normal Ct concentrations. FNAC was malignant or suspicious for malignancy in 14 (7.3%) patients. Histology found malignancy in 17 (9%) cases, MTC in none. C cells were disclosed in lateral thyroid lobes of 100% MTC and 77% benign NTD patients; isthmi were free of C cells in either group.

Conclusions: STINs are significantly less likely to be MTC in patients presenting with sporadic disease. Therefore, Ct screening is not warranted in these subjects. Nonetheless, STINs are more likely to be neoplastic and deserve equal attention as those of the lateral lobes.

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Introduction

Nodular thyroid disease (NTD) is frequently observed in the clinical practice (1). Indeed, on thyroid ultrasound, NTD prevalence approaches 50% in iodine-deficient areas (2). Fortunately, malignant neoplasm is rarely seen, accounting for 5% or less of thyroid nodules (1, 2). Medullary thyroid carcinoma (MTC) is a neuroendocrine tumor, regarded as the most aggressive of well-differentiated thyroid carcinomas, with a survival rate of 50% at 10 years (3). MTC arises from parafollicular C cells, which are responsible for both the production and the release of calcitonin (Ct), a peptide hormone (4). MTC is sporadic in about 75% of the cases, whereas its familial counterpart – isolated or in the context of MEN type 2 syndrome – accounts for the remainder of the cases (5).

Several studies (6–12) on sporadic MTC have demonstrated that the earlier the diagnosis the better the prognosis of MTC. Ct has been shown to represent a sensitive marker for MTC, leading to the early diagnosis of the neoplasm even when fine needle aspiration cytology (FNAC) discloses benign features (as occurs in nodules smaller than 10 mm).

Based on such evidence, the European Thyroid Association (ETA), developing the guidelines for the management of differentiated thyroid carcinoma (13), recommended the use of Ct screening in all patients with thyroid nodule(s). In 2006, the American Thyroid Association (ATA) published its guidelines addressing thyroid nodules (14), where Ct screening was not recommended due to its low specificity, the high prevalence of thyroid nodules in the general population, the rarity of MTC, and the costs of the test. In June 2009, the ATA
had published specific guidelines for the diagnosis and
the management of MTC (15) and, again, although
recent studies from the United States have confirmed the
European observations and cost-effectiveness of the test
(16), C₄ screening was not recommended.

Immunohistochemical studies (17, 18) conducted in
autopsy series from 1990s failed to demonstrate any
evidence of C cells in the isthmus of normal thyroid
glands. Similarly, no C cells were detected at immuno-
histochemical examination in the isthmus of patients
who underwent total thyroidectomy for MTC or C-cell
hyperplasia (CCH) (19).

To the best of our knowledge, no studies – either
retrospective or prospective – have been conducted so
far to assess both prevalence and clinico-pathological
features of solitary thyroid isthmic nodules (STIN). Based
on the hypothesis that in the absence of C cells in
the thyroid isthmus MTC should not occur, the present
study was designed to answer the following questions:
what are prevalence and clinico-pathological features of
STIN? What is the distribution of parafollicular C cells
in the thyroid of subjects with MTC and benign NTD?

Patients and methods

Aim of the study

The aim of the present study was to assess i) the
prevalence and clinico-pathological features of STINs; ii)
the frequency of MTC in STIN; and iii) C-cell
distribution in the isthmus of patients with MTC and
benign NTD.

Study design

To assess the prevalence and clinico-pathological
characteristics of STIN, a 3-year prospective study was
conducted, whereas to evaluate the frequency of MTC in
patients with STIN, both a retrospective and a
prospective study were performed.

i) Retrospective study. A database research having
‘MTC’ and ‘histology’ as keywords, and spanning
the period from January 1993 to December 2005,
was made from the files of the sections of
Pathology of both the Catholic University of
Rome and the University of Modena and Reggio
Emilia, Italy. Once MTC cases were selected, the
following data were retrospectively sought: age,
sex, the neoplasm origin (sporadic or hereditary),
and the location of the neoplasm within the
thyroid gland.

ii) Prospective study. During the period from January
1, 2006 to December 31, 2008, 4723 consecutive
patients with suspected NTD were referred to
the Division of Endocrinology, ‘A. Gemelli’
Hospital – Catholic University of Rome, and to the

Endocrine Outpatient Clinics of ‘Ramazzini’
Hospital – Azienda USL of Modena, Italy. Inclusion
criteria were a) male and female patients; b)
Solitary palpable nodule of the thyroid isthmus;
c) solitary nonpalpable nodule of the thyroid
isthmus ≥10 mm in its largest diameter; d)
Solitary nonpalpable isthmic nodule smaller
than 10 mm, showing ultrasound features suspi-
cious for malignancy (microcalcifications, unde-
defined margins, and intra-nodular vascularization).
Exclusion criteria were a) the presence of multiple
thyroid nodules; b) solitary thyroid nodules affect-
ing the lateral lobes (including those located in the
boundary zones between the lateral thyroid lobes
and the isthmus); c) nonpalpable isthmic nodule
smaller than 10 mm lacking ultrasound features
suspicous for malignancy; d) patients previously
evaluated for nodular goiter by FNAC and/or C₄
measurement; e) patients reporting a family
history of MEN and those previously thyroidecto-
mized for sporadic MTC; f) patients with hyper- and
hypothyroidism without nodules; g) patients in
follow-up for thyroid diseases; and h) patients not
confirmed to have thyroid diseases.

To evaluate the distribution of parafollicular C cells
in the thyroid glands of subjects with either MTC or benign
NTD, 50 consecutive cases of MTC (both familial and
sporadic) found through the retrospective database
research and 50 cases of nodular goiter consecutively
diagnosed after total thyroidectomy during the 3-year
prospective study were selected.

Patients

During the 12-year period of the retrospective study,
21 288 thyroidectomies were performed in our
institutions.

During the 3-year period of the prospective study,
3978 patients with thyroid nodules were evaluated at
our institutions. Of these, 256 (6.4%) presented with a
solitary nodule of the thyroid isthmus. In total, 222
patients fulfilled the criteria of the study design but
30 dropped out of the study either because they refused
FNAC and/or surgery (n = 8) or because they were lost to
follow-up after the first visit (n = 22). Of the remaining
192 patients, 111 (58%) were recruited by the Institute
of Endocrinology of the Catholic University of Rome, and
81 (42%) were recruited by the Endocrine Outpatient
Unit of ‘Ramazzini’ Hospital of AUSL Modena. When
matched for gender, age, C₄, and TSH concentrations,
no significant differences were found among the patients
recruited by the two different institutions.

All patients satisfying the inclusion criteria under-
went the following procedures: a) blood sample for the
measurement of serum TSH and C₄ concentrations and
b) ultrasound-guided FNAC.

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When the TSH value was abnormal, serum-free thyroxine (FT4) and free triiodothyronine concentrations were also measured. Furthermore, patients with suppressed serum TSH concentrations underwent 99mTc Technetium-thyroid scan, to detect autonomously functioning nodules.

Surgery was always recommended if one of the following criteria was met: a) FNAC diagnostic or suspicious for malignancy (indeterminate included); b) repeated (>2) nondiagnostic FNACs; and c) complaints of compressive symptoms (dysphagia and dyspnea). All patients gave informed consent to the diagnostic and therapeutic procedures.

**Methods**

**CT assay** Serum Ct concentrations were measured in the laboratories of the institutions involved in the study, using the same two-site chemiluminescence immunoassay (immunoluminometric assay, Nichols Institute Diagnostics, San Juan Capristano, CA 92675, USA).

**Ultrasound and fine needle aspiration biopsy** Thyroid ultrasound was performed utilizing a Philips En Visor C machine (Philips Medical Systems SpA, Monza, MI, Italy). Ultrasound-guided fine needle aspiration biopsy was performed on nodular areas with 23–27 gauge needles, using a 7.5–13 MHz probe. Multiple direct smears were prepared, and May-Grunwald–Giemsa and Papanicolau stainings were employed.

**Surgery** Patients recruited in the 3-year prospective study design with a benign FNAC and compressive symptoms underwent isthmusectomy. In case of a suspicious or repeatedly nondiagnostic FNAC, frozen sections of the nodule(s) were obtained for intraoperative histological examination to decide the definitive surgical extension. In all patients undergoing surgery following a cytological diagnosis of malignancy, total thyroidectomy was the procedure of choice completed by a lymphadenectomy in case of lymph node involvement.

**Histological and immunohistochemical examination of surgical specimens** Given that isthmus has no standard size (20), in this study isthmic region was considered as the thyroid tissue interposed between the two lateral lobes.

MTC cases found through the retrospective 12-year database research were all reviewed.

In the 100 cases of total thyroidectomy selected to identify the presence of C cells throughout the isthmus and the lateral thyroid lobes, microscopic slides were obtained by three formalin-fixed and paraffin-embedded 5 mm large specimens of thyroid tissue devoid of nodules: one derived from the middle of the isthmus, one from the middle of the right thyroid lobe, and one from the middle of the left thyroid lobe. Immunohistochemical studies were performed on such tissues by means of an automated immunostainer (Benchmark, Ventana, Tucson, AZ, USA) using antibodies directed against Ct (polyclonal: Ventana; microwave antigen retrieval). CCH was defined as the presence of more than 50 C cells in a single low-power field (×10 magnification) in both thyroid lobes (21), of solid nests of C cells with >7 cells per nest, or of follicles completely surrounded by C cells.

**Statistical analysis**

Results are reported as mean±s.d. All statistics were conducted using the commercially available software program SPSS for Windows, release 10.0 (SPSS Inc., Chicago, IL, USA).

**Results**

**Retrospective study**

Of 21 288 cases of thyroidectomy performed in our institutions in the period from January 1993 to December 2005, 150 (0.7%) MTCs were discovered: 126 of the sporadic form and 24 of the hereditary form (nine with familial MTC (FMTC) and 15 with MEN 2A). The diagnosis of MTC was confirmed by our pathologists in all the 150 cases. Sixty-five (43.3%) patients were males, 85 (56.7%) were females, with a female to male ratio of 1.3 to 1, ranging in age from 9 to 83 years (mean: 55.2±7.2 years; median: 59 years). The results of cytological examination before surgery are reported in Table 1. The neoplasm was located within the right lateral lobe of the thyroid gland in 84 (56%) cases and in the left lateral lobe in 66 (44%) cases; it was detected in the thyroid isthmus in none of the cases.

**Prospective study**

Of 192 subjects with solitary isthmic nodule recruited in the study, 40 (21%) were males and 152 (79%) were females, with a female-to-male ratio of 3.8 to 1.

**Table 1 Results of fine needle aspiration cytology in 150 patients with medullary thyroid carcinoma.**

<table>
<thead>
<tr>
<th>Cytological examination</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeatedly nondiagnostic</td>
<td>0</td>
</tr>
<tr>
<td>Benign</td>
<td>21</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>11</td>
</tr>
<tr>
<td>Suspicous for malignancy</td>
<td>40</td>
</tr>
<tr>
<td>Malignant</td>
<td>74</td>
</tr>
<tr>
<td>Not performed</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
</tr>
</tbody>
</table>
The mean age was 46.2 ± 7.1 years (range: 21–84 years; median: 49 years). Mean serum TSH concentrations were 3.7 ± 2.3 mIU/l. One hundred and eighty-six patients (97%) were euthyroid, four patients (2%) were hypothyroid (three with subclinical and one with overt hypothyroidism) due to Hashimoto’s thyroiditis, and two patients (1%) were overtly hyperthyroid due to Graves’ disease. Mean serum CT concentrations were 2.2 ± 0.4 pg/ml and were normal in all 192 patients. Thyroid ultrasound detected hypoechoic nodules in 156 patients (81%), isoechoic nodules in 27 (14%), and hyperechoic nodules in 9 (5%). The mean diameter of isthmic nodules was 29.5 ± 8 mm (range: 8–52 mm). The results of cytological examination are reported in Table 2. Fourteen (7.3%) nodules harbored cytological features suspicious for or consistent with papillary thyroid carcinoma (PTC). In no case was a cytological diagnosis of MTC given. In total, 113 subjects were followed up with observation only, 31 (with cytological diagnosis of ‘benign colloid nodule’) were treated by L-T4 TSH-suppressive therapy, 48 underwent thyroidectomy (total thyroidectomy in 26 cases and isthmusectomy in 22 cases) (Table 2). Histological examination demonstrated a benign nodule in 31 cases and a malignant neoplasm in 17 (9%) cases. Of the 17 cases diagnosed with malignancy, 16 were PTCs (of which, eight (50%) were smaller than 10 mm in their largest diameter), and one was a follicular carcinoma. In no case was there evidence of a MTC.

**Immunohistochemical study**

In Fig. 1, the results of immunohistochemical study are reported.

A positive reaction to CT immunostaining was observed in the lateral thyroid lobes of all 50 (100%) patients with both sporadic and hereditary MTC. CCH (Fig. 2A) was demonstrated in 14 out of 14 (100%) patients affected by hereditary MTC (FMTC or MEN2A), and in 26 out of 36 (72%) subjects with sporadic MTC. On the contrary, no CT-positive cells were seen in the isthmi of either group (Fig. 2B). Similarly, in 38 out of 50 (76%) patients with benign NTD, CT reaction was positive within the lateral thyroid lobes; however, contrary to the picture found in MTC patients, in these benign NTD cases, C cells appeared as sparse or even isolated (Fig. 2C) and CCH criteria were never met. Again, no CT-positive cells were found in the isthmi of this patient group (Fig. 2D).

**Table 2** Results of fine needle aspiration cytology (FNAC) in 192 patients with solitary isthmic nodules and consequent treatment.

<table>
<thead>
<tr>
<th></th>
<th>Repeatedly nondiagnostic</th>
<th>Benign</th>
<th>Indeterminate</th>
<th>Suspicious for malignancy</th>
<th>Malignant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2 (1.1%)</td>
<td>171 (89.1%)</td>
<td>5 (2.6%)</td>
<td>7 (3.6%)</td>
<td>7 (3.6%)</td>
</tr>
<tr>
<td>Submitted to surgery</td>
<td>2</td>
<td>27</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Treated by TSH-suppressive therapy</td>
<td>0</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Followed without therapy</td>
<td>0</td>
<td>113</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

FNAC, fine needle aspiration cytology; TSH, thyrotropin.

**Figure 1** Summary of immunohistochemical examination results in 50 patients with medullary thyroid carcinoma (MTC) and 50 patients with benign nodular thyroid disease (NTD).
observations, failing to detect C cells in the thyroid isthmus of patients with CCH (15, 16). CCH is defined as the presence of more than 50 C cells in a single low-power field (×10 magnification) in both thyroid lobes (21), of solid nests of C cells with > 7 cells per nest, or of follicles completely surrounded by C cells. Although the occurrence of CCH has been reported in patients with benign diseases (25), some authors consider CCH as a preneoplastic event, especially in patients with hereditary MTC. In the surgical series of Wahl et al. (19), the isthmi of 58 patients with both normal and elevated pre-operative serum Ct concentrations (due to either CCH or MTC) were investigated by immunohistochemical studies; Ct-positive cells were seen in none of them. The authors concluded that isthmus-preserving total bilobectomy removes all C cells and that total thyroidectomy is not necessary in patients with CCH. Because of the few papers published in the literature on this topic and the small number of patients with FMTC included in our series, the possibility that patients with RET proto-oncogene germline mutations present with multifocal disease involving the isthmus cannot be definitively ruled out and should be investigated by further studies.

Discussion

General considerations

To the best of our knowledge, this study represents the first work investigating the clinico-pathological characteristics of solitary nodules arising from the thyroid isthmus, and in particular their association with MTC.

The thyroid isthmus and the parafollicular C cells

In our series, we have not found either parafollicular C cells or C cell-derived tumors in the thyroid isthmi of patients with both benign NTD and MTC. To perform immunohistochemical investigations, we used antibodies against Ct because several studies have shown that this is the most effective method to detect parafollicular C cells (16, 17, 22). During embryonic development, C cells migrate from the ventral parts of the fourth branchial pouch or the ultimobranchial bodies into the thyroid gland that descends caudally from the median anlage (23). Within the thyroid, C cells have a peculiar distribution. Indeed, autopsy studies conducted on normal thyroid glands in the 1970s and 1980s, when specific anti-Ct antibodies were not available yet (24), found that parafollicular C cells were distributed symmetrically in both lateral lobes, concentrated in a zone in the upper two-thirds of the lateral lobes bilaterally. When the isthmus was investigated, few scattered cells or even no cells were seen. Subsequently, studies using more accurate techniques for Ct immunostaining confirmed previous
At present, the recession of the world economy invariably affects the decisions of the Western governments on health policy. Thus, we do believe that, on the one hand and owing to actual evidence, CT screening should be performed in NTD patients and, on the other hand, the problem of cost deserves special consideration. In a recent study recruiting a large series of patients with NTD, we have identified a subgroup, i.e. subjects younger than 40 years, who should not be candidates to undergo the routine measurement of CT, because in these individuals (without a family history of MEN) we did not observe any cases of MTC. Now, based on the results of the present study, we propose that another patient subgroup, i.e. NTD subjects with solitary nodules of the thyroid isthmus, should not undergo CT testing routinely. In Italy, the total cost of a single basal CT measurement averages 45€. In our 3-year prospective study, of 3978 patients referred with NTD to our institutions, no sporadic MTCs were disclosed in the 875 patients younger than 40 years (data not shown). The cost avoidance of not performing the CT test in our patients aged <40 years and in those presenting with solitary isthmic nodules (1062 subjects altogether) would have saved 47,790€ (about $66,900).

The thyroid isthmus and nonparafollicular C cell-derived tumors

This is the first study investigating the clinicopathological characteristics of patients with solitary isthmic nodule. In our series, the prevalence of nodules located within the thyroid isthmus only was low with respect to the nodules located in the thyroid lateral lobes. Indeed, patients with a solitary isthmic nodule accounted for 6.4% of the whole NTD population recruited in the study. The female to male ratio of ~4 to 1 is similar to that found in previous NTD prevalence studies (29). Nonetheless, the mean and median age of our patient group – 46.2 years and 49 years respectively – averages that reported in other NTD series (29).

However, our results have also demonstrated some differences compared to nonselected NTD populations recruited previously. For instance, in our series, a primary malignant neoplasm was found in 9% of the patients with solitary isthmic nodules. Previous studies (30, 31) have reported a frequency of cancer lower than 5% in subjects with NTD. Further prospective studies are needed to confirm whether subjects with solitary isthmic nodule truly present a higher risk of thyroid cancer than subjects with nodules located in the lateral lobes. Interestingly, in our series, almost all tumors were PTCs. Such data demonstrate that thyroid isthmic nodules behave as their lateral thyroid lobe counterparts. Indeed, since goiter prevention policy by iodine supplementation has become a priority in the western countries (in Italy, a specific law has been passed recently to make iodine salt supplementation mandatory), a decrease in the incidence of follicular thyroid carcinomas has been observed (32). On the other hand, an increase in the frequency of PTCs has been shown worldwide (33–35). This event is likely due to the thyroid nodule management effects after the nuclear Chernobyl accident, as reflected by the fact that half of PTCs in our series were microcarcinomas (36).

Conclusions

Lesions of the isthmus are significantly less likely to be MTC in patients who present with sporadic disease. Therefore, CT screening is not warranted in these subjects. Nonetheless, STIN are more likely to be neoplastic and deserve equal attention as those of the lateral lobes.

Declaration of interest

There is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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