Outcomes and Risk Factors for Complications of Laser Ablation for Thyroid Nodules: A Multicenter Study on 1531 Patients

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Background: Image-guided laser ablation therapy (LAT) of benign thyroid nodules demonstrated favorable results in randomized trials with fixed modalities of treatment. The aim of this retrospective multicenter study was to assess the effectiveness, tolerability, and complications of LAT in a large consecutive series of patients from centers using this technique in their routine clinical activity.

Patients: Clinical records of 1534 consecutive laser-treated nodules in 1531 patients from eight Italian thyroid referral centers were assessed. Inclusion criteria were as follows: solid or mixed nodules with fluid component up to 40%; benign cytological findings; and normal thyroid function.

Methods: LAT was performed with a fixed-power protocol, whereas the number of applicators and illumination times were different according to target size. From one to three illuminations with pull-back technique and with a total energy delivery based on the nodule volume were performed during the same session. Patients were evaluated during LAT, within 30 days, and 12 months after the procedure.

Results: Total number of treatments was 1837; 1280 (83%) of nodules had a single LAT session. Mean nodule volume decreased from 27 $\pm$ 24 mL at baseline to 8 $\pm$ 8 mL 12 months after treatment ($P < .001$). Mean nodule volume reduction was 72% $\pm$ 11% (range 48%–96%). This figure was significantly greater in mixed nodules (79% $\pm$ 7%; range 70%–92%) because they were drained immediately before laser illumination. Symptoms improved from 49% to 10% of cases ($P < .001$) and evidence of cosmetic signs from 86% to 8% of cases ($P < .001$). Seventeen complications (0.9%) were registered. Eight patients (0.5%) experienced transitory voice changes that completely resolved at the ear-nose-throat examination within 2–84 days. Nine minor complications (0.5%) were reported. No changes in thyroid function or autoimmunity were observed.

Conclusions: Real practice confirmed LAT as a clinically effective, reproducible, and rapid outpatient procedure. Treatments were well tolerated and risk of major complications was very low. **(*J Clin Endocrinol Metab* 100: 3903–3910, 2015)**

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Abbreviations: BTN, benign thyroid nodule; FT4, free T_4; LAT, laser ablation therapy; US-g, ultrasound guided.

Image-guided tissue ablation with both thermal and nonthermal sources (1) has been used with favorable results in percutaneous treatment of benign thyroid nodules (BTNs) (2–4). Ultrasound-guided (US-g) ablation with laser was the first procedure to be proposed for these applications (5) and, since the initial feasibility studies (6–8), both noncontrolled and prospective randomized trials (9–20) have confirmed the clinical effectiveness and safety of this technique. Due to its moderate cost and its efficacy as an outpatient procedure, laser ablation therapy (LAT) is now increasingly used in thyroid referral centers.

The currently available data come mostly from limited series of patients in prospective clinical trials, characterized by strict enrollment criteria and standard modalities of treatment (15–17, 19, 20) and do not provide a clear definition of the actual effectiveness and risk of complications of LAT in real practice. In fact, clinical outcomes and type and incidence of adverse effects are strongly influenced by variables such as structural (solid, mixed, or cystic) characteristics of nodules, size and location of the target lesion and local expertise and treatment algorithm (12, 13, 19, 20).

The aim of this retrospective multicenter study was to assess the effectiveness, tolerability, and type and rate of complications of LAT for benign thyroid nodules in the current clinical practice of eight centers operating with this technique in Italy.

Materials and Methods

After a consensus meeting, a multidisciplinary board of endocrinologists, interventional radiologists, and surgeons developed and approved a database for the retrospective assessment of the efficacy, tolerability, and risk of complications of LAT in the treatment of benign thyroid nodules.

This multidisciplinary team, under the supervision of an external monitor, reviewed the clinical records of more than 2500 patients from those centers that have adopted this technique during the last 10 years. Based on the recommendations of the multidisciplinary team, the individual centers have ruled out from the study all the patients with the following characteristics: 1) incompleteness of data concerning the cosmetic appearance or the tolerability, side effects, and complications of the procedure; 2) dropout at follow-up; 3) patients not eligible for the study because of abnormal baseline thyroid function or concomitant treatment modalities; 4) treatments performed during the initial period of the learning curve of laser technique; and 5) use of treatment algorithms with variable or uncertain output energy power or illumination time. After a careful assessment of the entire population, treatment modalities, characteristics of the nodules, volume reduction after LAT, and frequency, type, and management of complications, 1531 patients were registered.

Patients

Eight Italian thyroid referral centers with specific expertise in minimally invasive treatment of thyroid lesions participated in the study. LAT was performed in all these centers with the same commercially available ultrasound system equipment (EchoLaser; Elesta) and with a similar treatment and follow-up protocol. In five centers, procedures were performed by endocrinologists, in two by interventional radiologists, and in one by surgeons. All institutes had at least 2 years' experience in LAT and performed more than 20 thyroid thermal ablation procedures per year. Patients enrolled in the previously published Italian Multicenter Study (21) or in other randomized controlled trials were not included in the present series.

The study was conducted in compliance with the Helsinki Declaration and the local bioethics committees. Informed consent for each procedure was obtained from all patients; informed consent was waived for this retrospective investigation. The research was approved by the institutional review board of each participating center.

Inclusion criteria for LAT were the presence of pressure symptoms or cosmetic concerns due to thyroid nodules, repeat benign cytological findings, normal serum TSH and free T_4 (FT4) values, and hypoactive cold appearance at radionuclide thyroid scan in patients with low-normal serum TSH level. At variance with the Italian Multicenter Study, performed on solid nodules only (21), the present series included nodules of variable volume and structure, and, specifically, mixed lesions with a fluid component up to 40% .

Five treatment variables were present: number of applicators, number of illuminations and total energy delivery, modality of local anesthesia, conscious sedation regimen, and analgesic treatment during and immediately after the treatment session.

Routine coagulation tests were performed before the procedure and included prothrombin time, partial tromboplastin time, and platelet count. A general consensus among centers was followed on the basis of the guidelines used for interventional procedures in other organs, such as liver, kidney, or lung (22).

Technique

Treatment procedures followed those previously applied and published elsewhere (8). Briefly, the number of introducer needles and of optic fibers (from two to four applicators) to be inserted was based on nodule size. Under US-g, the introducer needles were inserted into the target thyroid nodule along its longest axis.

Each treatment was performed with a fixed-power protocol (3W), but the illumination time was different case by case according to target size, shape, and structure. Each illumination time ranged from a minimum of 400 seconds to a maximum of 600 seconds to maintain the total energy applied between 1200 and 1800 J per fiber. Depending on the size of the nodule, one to three consecutive illuminations with a pullback technique were performed during the same treatment session. In mixed lesions with a relevant fluid part, the drainage of the fluid component was performed immediately before laser illumination according to the described technique (20).

Follow-up

Patient follow-up was performed on the basis of previous recommendations (8, 9, 17, 19). Patients were evaluated during and immediately after the LAT session, within 24 hours, during

periprocedural session (within 30 d), and 12 months after the procedure. In the event of complications, the related imaging examinations were performed immediately after symptom onset. Local pressure symptoms and clinical assessment of cosmetic signs were evaluated according to previously published criteria (23) and according to the criteria set out by the multidisciplinary team. Briefly, local symptoms were evaluated by means of a questionnaire assessing the presence/absence of one the following symptoms: 1) no symptoms; 2) mild pressure complaint; or 3) neck constriction and/or swallowing difficulty. The clinical assessment of the signs of nodular goiter was performed by visual inspection of the following: 1) nodule not visible; 2) nodule visible only with hyperextended neck; or 3) nodule visible at a distance greater than 1 m. The use of analgesics or other drugs and the duration of treatment were recorded. All patients who showed minor voice changes were evaluated by an ear-nose-throat specialist with fiber optic laryngoscopy.

Questionnaire

The questionnaire administered by each center included the following: modality of local anesthesia, conscious sedation and/or analgesia regimen; number and size of nodules; number of treatment sessions; nodule volume and serum TSH, FT4, and thyroperoxidase antibodies at baseline and 12 months after LAT; number and types of major or minor complications and side effects; and management of complications, time of their detection and period, or treatment required for their recovery.

The definition of complications was consistent with the standardized terminology and reporting criteria for image-guided tumor ablation proposed by other authors (22) and with the classification criteria suggested by the Society of Interventional Radiology (24). A major complication was an event that, if left untreated, could be life threatening, could result in minor or prolonged hospital stay, or could lead to permanent adverse sequelae with substantial morbidity and disability. All other complications were considered minor.

Side effects were considered common untoward and undesired consequences that did not require an increase in level of care. A numeric scale (visual rating scale) was used to rate pain intensity (0, no pain, to 10, severe pain) (25). Accordingly, the pain was categorized as mild (<4 of 10), moderate (5 of 10 to 6 of 10), or severe (>7 of 10). Pain lasting less than 3 days was judged as acute.

The nodule populations were classified by the multidisciplinary team, in agreement with the data available in the literature (12, 26, 27), into three classes according to baseline volume: nodules with initial volume of 13 mL or less were classified as small, those between 13.1 and 30.0 mL as medium, and those greater than 30 mL as large. Two physicians (C.M.P. and E.P.) with substantial experience in the management of patients undergoing LAT prepared the questionnaire and contacted the centers.

Statistical analysis

Statistical analysis was performed by using the Statistical Package for Social Science (SPSS), release 15.0. Continuous variables were expressed as mean ± SD and categorical variables displayed as frequencies and compared using the χ^2 or Fisher test, as appropriate. A value of $P < .05$ was considered statistically significant.

Results

Clinical records from January 2004 to December 2013 were reviewed. The study included 1534 benign thyroid nodules in 1531 patients (444 male/1087 female patients; mean age 54.1 y) who were ablated percutaneously through LAT. The number of nodules treated at each center ranged from 36 to 341.

The mean volume of the treated nodules was 27 ± 24 mL (range 1.4–216 mL). The total number of treatment sessions was 1837. One thousand two hundred and eighty of 1534 nodules (83%) were treated with a single LAT session, 205 (13%) with two sessions, and 49 (3%) with three sessions (mean 1.2, range 1–3; Table 1). The total energy delivery in the different nodules ranged from 1200 to 1800 J using a single applicator and a single illumination to 14 400–21 600 J with four applicators and three illuminations. The drainage of the liquid component, when present, was performed immediately before thermal treatment. All nodules were benign at cytological assessment.

Effectiveness

Mean nodule volume in solid and mixed nodules decreased from 27 ± 24 mL at baseline to 8 ± 8 mL 12 months after treatment ($P < .001$). LAT induced a mean nodule volume reduction at 12 months that ranged from 48% to 96% (mean 72% ± 11%) vs baseline. In the subgroup of nodules with a fluid component up to 40% (mean 30% ± 6%), mean volume decreased from 12 ± 18 mL at baseline to 2.4 ± 2.3 mL 12 months after treatment ($P < .001$), with a mean volume reduction of 79% ± 7% (range 70%–92%). The volume reduction in small, medium, and large nodules was 73% ± 10%, 73% ± 11%, and 71% ± 10%, respectively.

Serum TSH and FT4 levels did not change significantly at the 12-month check-up vs the baseline values (1.7 ± 0.7 vs 1.6 ± 0.7, $P = .394$ and 11.7 ± 1.4 vs 11.8 ± 1.8, $P = .674$, respectively).

Local symptoms score improved from 49% to 10% of cases ($P < .001$) and evidence of cosmetic signs changed from 86% to 8% of cases ($P < .001$). In more detail, the local symptoms score improved from 15% to 3% in small nodules ($P < .001$), from 42% to 11% in medium nodules ($P < .001$), and from 90% to 19% in large nodules ($P < .001$). Evidence of cosmetic score improved from 80% to 5% in small nodules ($P < .001$), from 86% to 8% in medium nodules ($P < .001$), and from 93% to 14% in large nodules ($P < .001$).

Complications rate

Seventeen complications (0.9% of the whole number of LAT sessions) were recorded, including 8 major (0.5%)

Table 1. Demographic Data, Effectiveness, Incidence of Major and Minor Complications, and Side Effects in Eight Participating Centers

Hospital	Patients, n, Males/ Females	Age, y[a]	BTNs, n	Volume of BTNs[a]	Sessions, mean	VR at 12th mo	Patients Treated With Two or More BTNs, n	Local Anesthesia	Sedation, Yes/No	Major Complications, n, %[b]	Minor Complications, n %[b]	Side Effects, n, %[c]
Albano Laziale	341, 110/231	51.5 ± 13.7	341	13 ± 12 (2–126)	1,5	6.7 ± 10		Yes	No	1 (0.3)	1 (0.3)	37 (10.9)
Atri	138, 22/116	52.1 ± 12.1	138	13 ± 9 (1.5–45)	1	7.6 ± 8		Yes	Yes	3 (2.2)	2 (1.4)	20 (14.5)
Alzano Lombardo	36, 4/32	58.6 ± 15.0	36	5 ± 3 (2–21)	1	8.4 ± 5		Yes	Yes	0 (0.0)	0 (0.0)	1 (2.8)
Bari	45, 10/35	52.0 ± 13.3	45	24 ± 19 (1.4–93)	1	9.2 ± 13		Yes	Yes	1 (2.2)	0 (0.0)	13 (28.9)
Cosenza	242, 62/180	54.4 ± 11.8	242	19 ± 13 (1.9–84)	1	7.6 ± 8		Yes	No	0 (0.0)	0 (0.0)	54 (22.3)
Livorno	334, 111/223	51.6 ± 31.1	337	49 ± 18 (10–78)	1.4	6.8 ± 8	3	No	No	1 (0.3)	0 (0.0)	184 (54.6)
Perugia	58, 26/32	58.1 ± 8.9	58	25 ± 29 (7–215)	1.1	7.6 ± 7		Yes	Yes	2 (3.4)	2 (3.4)	51 (87.9)
Perugia	189, 81/108	56.1 ± 9.9	189	20 ± 24 (3–216)	1.1	7.3 ± 11		No	Yes	0 (0.0)	4 (2.1)	71 (37.6)
Pisa	148, 18/130	52.6 ± 13.0	148	47 ± 27 (6–172)	1.1	7.2 ± 11		No	Yes	0 (0.0)	0 (0.0)	32 (21.6)
Combined Hospitals	1531, 444/1087	54.1 ± 14.3	1534	27 ± 24 (1.4–216)	1.2	7.2 ± 11	3			8 (0.5)	9 (0.6)	463 (30.2)

[a] Mean ± SD.

[b] Value calculated per LAT sessions.

[c] The values include all side effects intraoperatively and within 24 hours days after the procedure.

and 9 minor (0.5%) complications (Table 2). No patient had life-threatening complications (24) or required overnight admission, intensive care, or surgical repair. A statistically significant difference was detected among the centers ($P = .003$, $P = .011$, and $P < .001$, respectively). The rate of major complications was lower in patients treated without local anesthesia or with no conscious sedation than in those managed with local anesthesia and conscious sedation (0.15% vs 0.81%, $P = .086$, and 0.22% vs 0.98%, $P = .066$, respectively). Conversely, complaints of side effects were more frequent in subjects treated without local anesthesia (2.08% vs 0.93%, $P = .082$, and 41% vs 22% $P < .001$, respectively).

Table 2. Complications and Side Effects in 1531 Patients Who Underwent LA of Thyroid Nodules

	Complications and Side Effects, n, %[b]					
		Time of Detection				
	Type of Complications (SIR Class)[a]	Intraoperatively	Immediately Postoperatively (Within 24 h)	Periprocedural (Within 30 d)	Delayed (After 30 d)	Time to Recovery, d
Major						
Voice change	(C)		8 (0.5)[c]			2–84
Minor						
Hematoma	(B)		8 (0.4)			2–10
Skin burn	(B)		1 (0.1)			10
Side effects						
Pain	(A)					
Mild		194 (10.6)	61 (3.3)			1
Moderate		30 (1.6)	34 (1.9)			1–2
Severe			4 (0.2)			2–3
Vasovagal reaction	(A)	12 (0.7)				
Cough	(A)	1 (0.1)				
Fever (37.5°C-38.5°C)	(A)		141 (7.7)			1–4

Abbreviation: SIR, Society of Interventional Radiology.

[a] SIR guideline criteria (24).

[b] Value calculated per LAT sessions.

[c] Detected in nodules with large volume greater than 30 mL.

Major complications

Eight patients (0.5%) experienced voice changes occurring immediately after the procedure, and fiberoptic laryngoscopy confirmed an ipsilateral vocal cord palsy. In six of these cases (75%), thyroid nodules were close to the inferomedial portion of thyroid, whereas in two cases (25%), the target lesions were near the lateral margin of the gland. All patients recovered their voice completely within 2–84 days (mean 22 d) after oral administration of corticosteroids for a time ranging from 2 days to 2 weeks (Table 2). Fiberoptic laryngoscopy was performed after 3 months in all these cases and demonstrated recovery of normal function of the vocal cords.

Minor complications and side effects

Nine minor complications (0.5%) were reported, including subcapsular or perithyroidal hematoma and skin burn in eight and one patients, respectively (Table 2). Hematomas were small (<5 mL) and disappeared within 1–6 hours after a 30-minute compression. The only case of skin burn occurred accidentally in a single center in the early phase of the learning curve (Figure 1). Healing occurred after 10 days with oral administration of antibiotics.

All minor side effects (intraoperatively and within 24 h) after the maneuver were recorded in 463 of 1837 LA sessions (30.2%) (Table 1). During LTA sessions 194 patients (10.6%) experienced mild and 30 (1.6%) moderate burning pain, with sensation of local heat sometimes radiating to the jaw, ipsilateral dental arch, mandibular angle, or shoulder, and, rarely, thoracic back pain. These side effects lasted a few seconds and disappeared as soon as the laser was switched off.

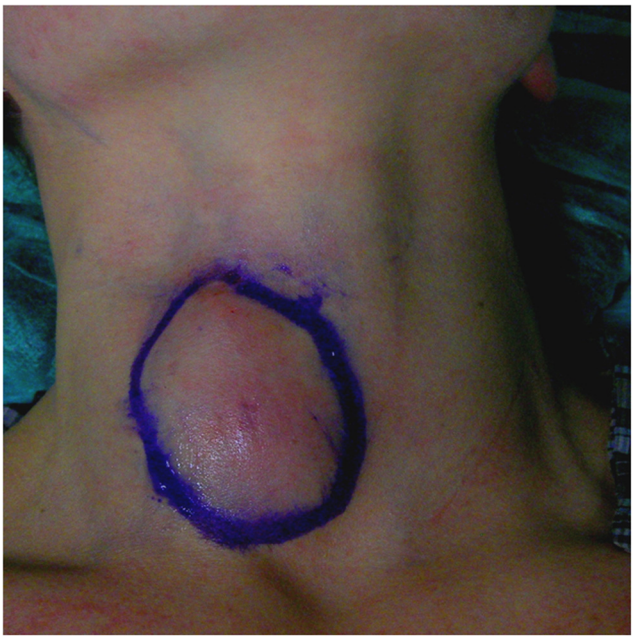

Figure 1. Neck of a 38-year-old woman at the end of the LAT session. The picture shows the actual features of the skin burn that may be induced by LAT. The injury is represented only by a small size area of erythema in the puncture sites (arrow) of the fine needles used for laser ablation technique.

There were 12 intraoperative cases of vasovagal reactions (0.7%), with sweating and difficulty in breathing. Tilting the bed in Trendelemburg position controlled symptoms within a few minutes. Cough occurred in one case (0.1%) and disappeared as soon as the laser energy was turned off.

Mild, moderate, and severe pain were reported in 61 (3.3%), 34 (1.9%), and 4 (0.2%) patients, respectively, immediately or within 24 hours of the procedure. In all cases pain was controlled with oral analgesics and disappeared within 3 days. One hundred forty-one patients (7.7%) experienced mild or moderate fever (up to a maximum of 38.5°C) lasting up to 3 days that disappeared with antipyretics (acetaminophen tablet 1000 mg) or corticosteroids (prednisone tablet 5 mg). No complications or side effects were observed within 30 days after the treatment sessions. All the above data are summarized in Table 2.

Discussion

US-g laser thermal ablation is increasingly used in the treatment of symptomatic or steadily growing thyroid nodules that are benign at cytological assessment (2–4). Several randomized controlled trials and a few experts' reviews state that LAT is a well-tolerated and substantially safe procedure (2). Because these data come mostly from selected series of patients treated with a fixed algorithm, they may not provide the actual definition of the effectiveness, tolerability, and risk of complications of the procedure in everyday clinical practice. Thus, the present study was based on a consecutive series of unselected benign nodules of variable size and structure. Patients were treated in the participating centers during their usual clinical activity with the same equipment and technique but with a case-by-case modality of treatment and a total energy delivery based on the initial volume.

This large retrospective series demonstrates that LAT induces, mostly with a single treatment, a clinically relevant volume reduction, with a mean nodule decrease that ranges from 48% to 96% (mean 72% ± 11% vs baseline) 12 months after treatment. The volume reduction registered in this study was definitely greater than in previous prospective randomized trials on LAT of solid cold nodules (6, 15–19). This higher effectiveness was due to several factors. In the present series, up to four optical fibers were used for large volume lesions, and the total energy delivery was increased according to the baseline size of the

lesion to be ablated. Our results demonstrated that if there is a direct correlation between the amount of energy delivered and the baseline volume of the nodule, a greater volume reduction may be attained (27). In mixed nodules, moreover, the preliminary drainage of the fluid component allowed a marked volume decrease (79% ± 7%) with results similar to those reported with other techniques (such as radiofrequency) in nodules with a large fluid component (28–30).

Serum levels of TSH and FT4 did not change significantly 12 months after laser treatment. These data confirm previous reports from randomized controlled trials on the risk of thyroid function and autoimmunity changes (16, 17).

Whereas various and even severe complications of LAT have been described in previous reports (12, 31, 32), in the present series, major complications of LAT were rare (0.5% of cases). Voice changes occurred in nodules of large volume (>30 mL) that were located close to the inferomedial portion of the thyroid. Operators should thus be aware of the risk of injury to the recurrent laryngeal nerve when treating areas near the presumptive path of recurrent laryngeal nerve, especially when using multiple fibers. No damage to the trachea wall or nodule colliquation, anecdotally reported in previous case reports, was recorded. These unusual complications were probably due to incorrect positioning of the laser fiber tip by an operator in the initial phase of his learning curve (32) or by delivery an excessive amount of energy (12). Indeed, liquefactive changes can occur if more energy than needed to induce coagulative necrosis is released in the target tissue (12).

The low rate of major complications in the present series is due to the use of the procedure established since the early 2000s (8) with multiple heat sources and a pullback technique. The use of thin (21 G) needles allowed a nontraumatic positioning of optical fibers into the target and the accurate monitoring of the treatment (27). The rate of major complications was lower in patients treated without local anesthesia; a higher frequency of side effects was observed in those patients treated with local anesthesia. These data can be explained by the role pain played during the treatment. The onset of pain that occurs when heat reaches the thyroid capsule represents a useful alarm symptom, inducing the operator to repositioning the fiber tip at a safety distance (at least 10 mm) from the vital cervical structures, thus reducing the risk of complications. The preliminary use of a local anesthetic, on the contrary, might mask pain, which therefore appears later when the side effects are already occurring (33).

Minor complications were infrequent as well (0.5%). Small perithyroidal or subcapsular hematomas were rapidly controlled without treatment. Skin burn was rare, and a single skin burn occurred in a nodule treated with more than three illuminations (Figure 1). In this case the high temperature of the proximal portion of the needle caused a scorching of the skin while it was being removed from the neck. At the end of LAT session, a rapid extraction of the needle while keeping the output off easily prevents this minor but unpleasant complication. Rapidly resolving vasovagal reactions were probably due to stimulation of carotid sinus, neck hyperextension, or anxiety. Low-grade fever sometimes observed in large size nodules was probably due to the release of mediators of the inflammatory response after massive ablation-induced cell death.

Noteworthy, these results were obtained without the specific methods for the protection of critical structures, such as the liquid-isolating region technique or the swallowing of cold water, that are used with the radiofrequency or microwaves ablation (34–37). In particular, before inserting MW antenna, a mixture of 0.9% lidocaine and physiological saline may be infused into the appropriate area of the surrounding thyroid capsule to achieve a liquid-isolating region and to protect the vital structures of the neck (carotid artery, trachea, esophagus, and nerves) (36). During the multiple imaginary radiofrequency ablation units (38) adjacent to the esophagus, the patient may be asked to swallow cold water (34); to prevent skin burns at the electrode puncture site, an ice bag may be applied during the procedure. Finally, because radiofrequency current passes through the heart during thyroid radiofrequency ablation, the use of bipolar electrodes is always suggested to avoid potential complications such as myocardial infarction and arrhythmia in patients with cardiac problems (34).

This study was not formally designed to include the costs of procedures, but the financial advantages of the management with LAT of symptomatic benign nodules are clear. The price of a disposable LA device is about 350 USD and includes the rent of the laser generator, and the team of operators (two physicians and one nurse) is engaged for a total of 30 minutes. The treatment does not require hospitalization or any routine postprocedural follow-up because the rate of complications is definitely low. No thyroid function monitoring is needed.

Conclusions

Most benign thyroid nodules are asymptomatic and remain nearly stable over time. However, a fair number of patients of them (especially in borderline iodine deficient regions) show a slow but progressive growth that, due to the lack of medical treatments, is the cause of patient concern, repeat medical consultations, and, frequently, of thyroid surgery. A single laser treatment performed with a nodule-tailored approach in the outpatient clinic on nod-

ules, which are becoming clinically symptomatic is followed in clinical practice by relevant reduction of the nodule volume and by clear improvement of mechanical symptoms and undesirable cosmetic appearance. Volume reduction continues over time until 12 months after initial treatment and remains stable for at least a few years with thyroid function completely maintained (19). Indeed, a single LAT induces a high rate of volume reduction in solid nodules, with this figure increasing significantly in mixed nodules with fluid component up to 40%. Results, even in large nodules, are comparable with those reported with other techniques in smaller lesions (26, 38–40). Due to the use of fine needles, the risk of major complications are lower than those reported with other thermal treatments (34, 37).

In light of the data provided by this study and of the robust evidence of 2 decades of literature, laser thermal ablation is confirmed as a clinically effective, well-tolerated, and safe minimally invasive technology for nonsurgical management of symptomatic benign thyroid lesions.

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