Introduction

Surgery represents a medical discipline frequently involved in patient complaints if compared to other specialties as Clinics (1,2). In Italy, statistical reports from 2018 show that Orthopedics, General Surgery, Gynecology and Obstetrics are the specialties most involved in cases of alleged medical malpractice related to therapeutic errors, resulting respectively equal to 21%, 13.5% and 11.5% (3).

In the context of malpractice due to surgery errors, a not negligible percentage of complaints regard the thyroid surgery complications and, in particular, the recurrent laryngeal nerve (RLN) injuries during thyroidectomy, representing the 0.1–8% (4,5).

In the context of malpractice due to surgery errors, a not negligible percentage of complaints regard the thyroid surgery complications and, in particular, the recurrent laryngeal nerve (RLN) injuries during thyroidectomy, representing the 0.1–8% (4,5).

These injuries, as pointed out by other authors (6), could happen during surgical activities or in post-operative period.

During the intra-operative stage, the nerve damage is often associated with its improper identification and isolation that mostly occur when the nerve detection...
appears to be difficult in relation to anomalies of common landmarks resulting from anatomic variations or alterations due to the thyroid disease or previous surgery (7). The nerve damage can be determined directly by the use of electric devices or retractors, or can be related to compression phenomena due to the inclusion in the ligation of the lower thyroid vessels (8); it may be also associated with abnormal traction activities performed to promote the dislocation and removal of bulky goiters in which adhesion phenomena between nerve and gland parenchyma can often occur [Table 1 (9)]. On the other hand, the RLN injuries may not depend on surgical activities being able to be related to endotracheal intubation; in this regard, some authors suggest several mechanisms as the compression of RLN between the cuff and the overlying thyroid cartilage, when the endotracheal tube cuff is positioned in the subglottic region (10,11).

During post-operative stage, the RLN injuries can occur in the early or late period. In the first case, the main cause of nerve damage is the compression mediated by haematoma due to post-surgical bleeding; thus, the nerve damage is related to hypoxic phenomena for vasa vasorum compression and occlusion. In the second case, abnormal scars and fibrotic reactions can involve the RLN with functional alteration resulting generally progressive, up to the complete cord paralysis.

The intra-operative RLN damage results in more or less clinical pictures, from neurapraxia (the temporary loss of function with full recovery after a short time) to axonotmesis and neurotmesis (associated respectively with irreversible reduction and loss of nerve function) (12).

The RLN injuries can be unilateral or bilateral. The unilateral lesion produces the loss of innervated muscles function and, consequently, the immobilization of the vocal cord mainly in paramedian or median position, determining phonation alteration which depend on both the position assumed by the vocal cord and the possibility of compensation promoted by the contralateral one (13). In such cases, the phonatory damage can be modest especially when an adequate speech therapy is implemented leading to the substantial regression of voice disorder; however, the voice affection can recur through the year for fibrotic phenomena involving the over-stressed mobile cord. The bilateral nerve damage is characterized by repercussions on voice and breathing, even serious; generally, the respiratory disorders, up to severe dyspnea, occur when the cords position is paramedian or median, while the voice dysfunction (dysphonia or aphonia) prevails in intermediate position (14).

The prognostic judgment appears to be difficult because the clinical evolution is unpredictable even if it is certainly unfavorable in cases with nerve resection. The poor and unpredictable functional outcome following RLN injury has been attributed to the chaotic, misguided reinnervation of the larynx (12). Moreover, another aspect that could affect the choice of the more adequate temporal interval to

<table>
<thead>
<tr>
<th>No.</th>
<th>A. Unpredictable</th>
<th>B. Predicable</th>
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<tbody>
<tr>
<td>1</td>
<td>Atypical RLN pattern</td>
<td>Previous neck surgery</td>
</tr>
<tr>
<td>2</td>
<td>RLN anterior to the thyroid gland</td>
<td>Previous radiotherapy</td>
</tr>
<tr>
<td>3</td>
<td>RLN fixed, splayed or entrapped</td>
<td>Cancer</td>
</tr>
<tr>
<td>4</td>
<td>RLN posterior to Berry ligament</td>
<td>Graves’ disease</td>
</tr>
<tr>
<td>5</td>
<td>Anteriorly located RLN to the Zuckerkandl’s tuberculum</td>
<td>Lymph node metastases</td>
</tr>
<tr>
<td>6</td>
<td>Branched RLN</td>
<td>Retrosternal goiter</td>
</tr>
<tr>
<td>7</td>
<td>Antevascular RLN</td>
<td>Thyroiditis</td>
</tr>
<tr>
<td>8</td>
<td>Thin RLN</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Invaded RLN</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Non-RLN</td>
<td></td>
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</tbody>
</table>

RLN, recurrent laryngeal nerve.

Table 1 Preoperative (A) unpredictable and (B) predicable RLN risk situations. Atypical courses of the RLN are observed in approximately a quarter of the thyroid gland operations. Preoperatively unpredictable risk situations, which can only be detected intraoperatively, are one of the main reasons for using neuromonitoring not only selectively but also routinely. Furthermore, the surgical experience pertaining to the identification, exposure, and protection of the RLN has a demonstrable influence on the nerve paresis rates (9).
evaluate the RLN damage effects is the therapy performed
to promote the functional recovery. Anyway, some authors
report that the assessment of RLN injuries outcome should
be performed a long time after surgery, more than one year
(13,14).

For the aforementioned characteristics, the RLN
injuries are a source of concern to both surgeons and
patients, representing also a cause of malpractice litigations.
Anecdotally, we noted that in some litigations it is not
always possible to identify a direct relationship between
nerve injury and the endocrine surgery. In light of this,
the authors provide (I) a literature review on the RLN
injuries related to thyroid surgery aiming to better define
the peculiarities of medicolegal assessment; (II) we
propose a rigorous standardized evaluation practice for
each lesion of the recurrent laryngeal nerve that allows,
among the different reference indices, to monitor the
quality of surgery delivered throught the analysis of the
clinical documentation. We present the following article
in accordance with the NARRATIVE reporting checklist
(available at http://dx.doi.org/10.21037/gs-20-203).

Materials and methods

Search criteria

This review has been conducted employing the PubMed,
Medline, Cochrane Central, Scopus, Web of Science
and Science Direct database. On these websites, articles
between 1973 and 2016 were searched, using the key terms
“recurrent laryngeal nerve”, “injury”, “thyroidectomy”,
“near total thyroidectomy”, “professional liability”.
Specifically, the research has been restricted using variable
combinations of the keywords. As inclusion criteria, the
articles had to provide data on causes of RLN injuries
and on prevention activities, both useful to evaluate the
hypothetical assumptions for medical liability. Moreover,
articles evaluating the malpractice litigation in this field
were included. Thus, articles were excluded by title, abstract
or full text for irrelevance to the topic in question. Multiple
Authors (including Coroner and Endocrine Surgeons) review the generated a list of articles.

Data abstraction

Data were extracted from studies satisfying the inclusion and
exclusion criteria and verified by all the authors [Table 2 (15)].
Any disagreements were resolved by consensus. Variables
extracted included: study design, patient demographics,
RLN complication rates, litigation assessemnt, follow-up.

Analyses

Our outcome of interest included RLN injury complication
rates, rates of RLN monolateral and bilateral injury, verdicts
on RLN injury, malpractice/litigation from RLN injury
following thyroidectomy, transient and bilateral RLN injury,
medicolegal assessment of RLN injury, documentation of
RLN injury. According to statistics, it was not possible to
conduct a meta-analysis model of these studies because
the outcome of interest was not reported with a uniform
standard and there was significant heterogeneity among
studies in terms of design and patient characteristics.
Furthermore, most of the studies in the review were case
series and not comparative studies.

Results

Study and information selection

A total of 29 articles evaluating the main inclusion criteria
were identified (Figure 1). The analysis of these works
showed that several authors agree with the necessity of
RLN identification and isolation during thyroid surgery
to reduce the risk of nerve injury (16-20); in this regards
it was also underlined the importance to standardize the
activities of RLN identification to avoid the nerve damage
during surgery (21,22). On the other hand, it must be also

Table 2 Inclusion and exclusion criteria for literature search (15)

<table>
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<tr>
<th>No.</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
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<tbody>
<tr>
<td>1</td>
<td>Primary data from prospective and retrospective observational studies</td>
<td>Review article</td>
</tr>
<tr>
<td>2</td>
<td>Human Studies</td>
<td>Studies with no relevant extractable outcomes</td>
</tr>
<tr>
<td>3</td>
<td>Technical reports</td>
<td>Studies not published in English or Italian language</td>
</tr>
<tr>
<td>4</td>
<td>Case reports</td>
<td>Duplicate article</td>
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highlighted that some authors reported the risk of nerve injury related to these activities, suggesting thyroidectomy without identifying RLN (23).

**Synthesis of individual results**

On the basis of literature review, the evidences supporting the role of routine RLN identification in injuries prevention are several (24,25). This prevention appeared also improved by the implementation of intraoperative neuromonitoring techniques (26-29) even if, in complicated cases, it appeared to be useful in identification but not in eliminating the risk of nerve damage (25-30). Authors stated to carefully consider justification if neural monitoring is not used in pre-operative predictable risk procedures (26-32). One article reported that neural monitoring was subject of pleading in 57% malpractice litigations (32). In 43% of the other cases the technology was not considered because (I) non standardized usage, (II) no neural monitoring documentation included/printed in the clinical reports (32). Thus, the usefulness of neuromonitoring is not unanimously confirmed (31,32).

**Effect of interventions**

Authors agree the importance to document pre-existing laryngeal impairment (Table 3).

Other important considerations for medico-legal evaluation of RLN injuries related to thyroidectomy regard the factors affecting negatively the adequate identification of nerve, which could be associated with increased risk of nerve injury. Some of these factors are the malignancies or the inflammatory processes complicated by nerve mounting (23,33), the intraoperative hemorrhage due to both inappropriate vessels ligation or resection of very vascularized masses, the reoperation in relation to anatomical alterations or fibrotic process involving the nerve (34-37).

With particular reference to the risks related to the reoperation, several authors reported that thyroid surgery should be performed just “in a single time” (38,39). Moreover, the usefulness of near-total thyroidectomy is reported to prevent the RLN injuries in high risk cases and especially when the gross extrathyroidal extension of the disease occurs (40). This surgery option involves removal of all grossly visible thyroid tissue, leaving only a small amount (<1 g) of tissue adjacent to the recurrent laryngeal nerve near the ligament of Berry and follows the same total thyroidectomy technique (5,35,41,42); it represents a safe option only in the expert surgeons (43).

**Discussion**

Several factors can determine RLN injuries due to...
thyroidectomy which could be related to surgeon error determining patient complaints. The reported review summarizes the main aspects of this field to provide medicolegal considerations useful for evaluation of professional liability.

The medicolegal analysis must be aimed to the assessment of the cause of nerve damage and, thus, if it is related to surgical activities or not (the so-called causal link) (44). This is because the injury might be previously developed as complication of the thyroid disease. It is well known that malignancies, toxic goiters and thyroiditis can determine infiltration, compression or traction of nerve (45-47). Thus, the pre-operative and post-operative physical examination, reporting accurate data on breathing and voice, as well as the laryngoscopic evidences, carefully reported in clinical records, are fundamental tools for evaluation of the damage chronology (Figure 2).

The medicolegal analysis of complained professional liability could be more difficult in cases showing close connection between RLN injury and thyroidectomy. The

<table>
<thead>
<tr>
<th>No.</th>
<th>Pre-operative</th>
<th>Intra-operative</th>
<th>Post-operative</th>
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<tbody>
<tr>
<td>1</td>
<td>Patient thyroid history</td>
<td>Surgical report</td>
<td>Laryngeal examination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Intraoperative findings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Identification of RLN</td>
</tr>
<tr>
<td>2</td>
<td>Pre-operative imaging</td>
<td>Pictures</td>
<td>Follow-up</td>
</tr>
<tr>
<td>3</td>
<td>Patient symptoms</td>
<td>Video</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pre-operative laryngeal examination</td>
<td>Neural monitoring</td>
<td></td>
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</table>

**Table 3** The importance of documentation in thyroid surgery. Documentation is required and includes pre-existing laryngeal or RLN impairment, intraoperative and postoperative findings. Neural monitoring records nerve signal for early differentiation between RLN related and unrelated voice changes.

**Figure 2** Relationship between RLN injury and patient, surgeon, technique and technology related variables. RLN, recurrent laryngeal nerve; EBD, energy based devices.
surgical performance should be evaluated considering the characteristics of the thyroid disease and the data emerging from operative notes. The identification and preservation of nerve should be reported in surgical records, representing a factor for liability admission or rejection. The lack of the data could be justified if the RLN identification is demonstrated as standard of care at institution. However, the identification of nerve may not rule out the admission of surgical error especially in cases showing thyroid disease not complicated. On the other hand, the performed or not identification could be irrelevant in RLN damage considered as nonpreventable complication and, for example, in cases showing severe anatomical alteration due to the gland pathology; in such cases the surgeon liability may be rejected as long as the complication has been disclosed to the patient during the informed consent process. Accordingly, all the information about the thyroid disease belonged from preoperative analysis and, above all, the morphological description of surgical site registered in operative notes are essential for medicolegal evaluation (Table 3). An extensive review of all medical documentation is important and include patient thyroid history, preoperative radiologic imaging, pre-operative symptoms, pre- and postoperative laryngeal examination, exhaustive surgical report with intraoperative findings, identification of RLN, pictures, and videos. All this variables are important to document any pre-existing airway impairment or correct surgical deliberations. Furthermore, we focus on the analysis of possible increased risk factors for RLN injury as the underline thyroid disease (Cancer, Graves’ disease increases the risk of nerve injury), patient neck anatomy (increased BMI), the experience of the surgeon, if nerve was identified, if nerve had unpredictable preoperative risk anatomy situation (if described in the surgical report), finally the proper and standardised use of IONM. Subsequently, the discussion of the clinical case must be multidisciplinary with the coroner, a technical expert (surgeon expert in thyroid surgery), the insurer, the hospital administration.

The neuromonitoring can offer data about the intraoperative occurrence of nerve lesion (30-32). Moreover, whilst the usefulness of monitoring in RLN injuries prevention is not unanimously confirmed, the improper use or the non-use could represent a reason for medical malpractice due to error in the surgical technique (41,48,49). However, it is important in the operative notes a statement that demonstrates that the RLN was visualized and was intact (i.e., neural monitoring) at the end of the procedure, that demonstrates that the RLN was visualized and was intact (i.e., neural monitoring) at the end of the procedure, whilst the usefulness of monitoring in RLN injuries prevention is not unanimously confirmed, the improper use or the non-use could represent a reason for medical malpractice due to error in the surgical technique (41,48,49). However, it is important in the operative notes a statement that demonstrates that the RLN was visualized and was intact (i.e., neural monitoring) at the end of the procedure, especially after the first dominant side/lobe is excised before completion the contralateral side (Table 4).

The RLN damage occurring in the late post-thyroideectomy period mostly lead to not detecting liability in surgical activities because it is often related to fibrotic phenomena determining nerve traction or compression.

The above outlined confirms what has been reported by

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**Table 3** The power of laryngeal examination and neural monitoring for causal link evidence. The standards of RLN management include extensive knowledge of RLN anatomy, visual identification and functional confirmation of RLN (neural monitoring), nerve exposure, training and certainly pre- and postoperative laryngeal examination (L1 and L2, respectively). Only the association between laryngoscopy and neuromonitoring can confirm the causal link between RLN injury and surgery.

<table>
<thead>
<tr>
<th>No.</th>
<th>Causal link</th>
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<tbody>
<tr>
<td>1</td>
<td>L1 negative, normal vocal cord movement</td>
</tr>
<tr>
<td>2</td>
<td>Pre-dissection/baseline vagal nerve stimulation (V1) and RLN (R1) normal**</td>
</tr>
<tr>
<td>2</td>
<td>Loss of EMG signal or reduced EMG signal (&lt;100 mcV) during thyroid surgery^</td>
</tr>
<tr>
<td>3</td>
<td>Intraoperative suspect of RLN palsy</td>
</tr>
<tr>
<td>4</td>
<td>Loss of EMG signal or reduced EMG signal end surgery (V2 and R2)^</td>
</tr>
<tr>
<td>5</td>
<td>L2 positive for RLN palsy/paralysis, vocal cord impairment</td>
</tr>
</tbody>
</table>

EMG, electromyography; RLN, recurrent laryngeal nerve; L1, preoperative laryngeal examination; L2, postoperative laryngeal examination; V1, pre-dissection stimulation of vagal nerve; R1, pre-dissection stimulation of RLN; V2, post-dissection stimulation of vagal nerve; R2, post-dissection stimulation of RLN. **Definition of normal EMG signal (functionally intact RLN): EMG biphasic waveform, satisfactory amplitude (>200 mcV) and latency. ***If L1 negative, but V1 and R1 EMG signals absent, hypothesize vocal cord injury due to intubation. L2 will demonstrate edema, hematoma, or direct injury to the vocal cord. ^Definition of loss of EMG signal: (a) normal vocal cord movement at L1, (b) initial EMG satisfactory, (c) no EMG response with stimulation at 1–2 mA, (d) low response <100 mcV with stimulation at 1–2 mA, (e) no laryngeal twice, (f) neural monitoring trouble shooting algorithm applied systematically.
other authors regarding to both the surgical information provided to the patient and the details recorded in the clinical documentation (32). The clinical records must be completed accurately and comprehensively to demonstrate that the medical activities have been performed as the practice standard requires. This is because, the data recorded in the documentation have a higher probative value than anamnestic information and testimonial evidence. In case of RLN damage, the correct evaluation of the (a) individual case/disease, (b) the procedure, (c) the position of surgeon (experience), (d) the use of technology (neural monitoring), (e) and comprehensive documentation, are all useful to draw conclusions from the standpoint of surgical deliberations and forensic (41).

Furthermore, the most common approach to treating RLN injuries includes voice therapy and phonosurgery. Treatment begins with voice therapy involving a qualified speech pathologist who works on voice placement and air flow with the patient. Complete abstinence from high modules of vocal sound source for 5–7 days, followed by slow and careful performance at normal phonation, can be very helpful in repairing of normality. A surgeon can employ phonosurgery. From a medico-legal point of view, we believe it is very important (I) the early diagnosis of nerve injury through the routine execution of postoperative laryngoscopy at patient discharge; (II) in the presence of nerve injury, referral of the patient to the voice specialist. There is some evidence in the Literature that the earlier the rehabilitation treatment of the voice, the better the outcomes (32, 48, 49).

Finally, sources of malpractice litigation in thyroid surgery are not confined to RLN injury (31). According to the review by Abadin et al., all permanent and transient consequences of thyroid surgery constituted malpractice claims (i.e., wound repair, permanent hypocalcemia, wrong site surgery, postoperative bleeding, wrong surgery, unnecessary or inadequate surgery, delayed surgery, oesophagus perforation, infections and death) (31).

Conclusions

The evaluation of medical malpractice due to iatrogenic RLN injuries can be difficult. The practitioners involved in the medicolegal analysis of patient complaints related to this thyroidectomy complication need an in-depth knowledge of surgical technique, damage prevention activities and related clinical picture. To this must be added an adequate competence in the evaluation of the causal link (relation between the event and the injury and between that injury and the temporary/permanent impairment) based on the rigorous application of the medicolegal method. In this regards the analysis of causal link need of the forensic practitioners with collaboration of a specialist in this surgery field (1).

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Footnote

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