International Journal of Surgery 41 (2017) S48–S54

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Nasotracheal prolonged safe extubation in acute respiratory failure post-thyroidectomy: An efficacious technique to avoid tracheotomy? A retrospective analysis of a large case series

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HIGHLIGHTS

- An innovative technique to manage postoperative acute respiratory failure.
- Prolonged safe extubation allow a good respiratory ability and a fast clinical symptoms resolution.
- In our series the prolonged safe extubation success rate was 84.2%.

ARTICLE INFO

Article history:
Received 18 December 2016
Received in revised form
28 March 2017
Accepted 29 March 2017

Keywords:
Nasotracheal safe extubation
Total thyroidectomy
Acute respiratory failure
Laryngoscopy
Nasotracheal tube
Prolonged safe extubation

ABSTRACT

Background: Acute respiratory failure is a rare life threatening complication following thyroid surgery and its incidence is reported as high as 0.9%. Clinical presentation of severe acute respiratory failure is characterized by dyspnea, inspiratory airways distress, hypoxia and its standard current management is the orotracheal intubation and safe extubation. In case of persistent distress, tracheotomy is mandatory. The Authors, analysing a large acute respiratory failure clinical series, describe an innovative treatment of this severe condition: the nasotracheal prolonged safe extubation.

Methods: Patients treated at our Intensive Care Unit for acute respiratory failure following thyroid surgery from January 2004 to December 2013, were reviewed. Demographic data including gender, age, clinical presentation, laryngoscopic findings, management and outcome during a 24-months follow-up after treatment were collected and evaluated. Moreover, the strategy for prolonged nasotracheal safe extubation was carefully described.

Results: Nineteen out of the 2853 patients scheduled for thyroid surgery (0.66%) at our University Hospital, developed post-operative acute respiratory failure. All of them were treated by nasotracheal prolonged safe extubation. The success rate in avoiding highly invasive treatment was of 84.2%, since only 3 patients needed definitive tracheotomy (15.7%).

Conclusions: In our series, the prolonged safe extubation reduced the almost totality of expected tracheotomies in patients with acute respiratory failure following thyroid surgery (84.2%), demonstrating its feasibility and efficacy. It was a well tolerated and minimal invasive procedure that allowed a good respiratory ability and a fast clinical resolution of the laryngeal functional impairment.

1. Introduction

Acute respiratory failure (ARF) is a dangerous event that influences potentially the outcome of any surgical procedure. It is

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http://dx.doi.org/10.1016/j.ijsu.2017.03.082
1743-9191/

defined as the failure to wean from the ventilator within 48 h after surgery or unplanned intubation/reintubation intraoperatively or postoperatively [1,2]. ARF is a life-threatening condition, even if often only temporary and spontaneously recovering. Neck surgery is considered the main risk factor for ARF and its incidence following thyroid surgery amount to 0.9% [3–5]. Laryngeal Recurrent Nerve (LRN) injury due to traction, compression or neurotmesis, unilateral LRN paresis associated with laryngeal oedema (venous stasis, Reinke's oedema), compressive airways haemorrhage (paratracheal hematoma), tracheomalacia and in addition laryngeal oedema are considered the main causes of ARF [6–10].

Clinical presentation of severe ARF is characterized by dyspnea, inspiratory airways distress and hypoxia. The standard current management of this condition is the orotracheal intubation and safe extubation. In case of persistent distress tracheotomy is mandatory [11,12]. Nevertheless, orotracheal tube compression, especially utilizing large size devices, may cause vocal folds and tracheal walls lesions, worsening the pre-existing oedema and delaying ventilation, phonation and deglutition recovery [11–14]. Safe extubation, generally performed using airways exchange catheter (AEC), can lead to displacement, self-extubation, aspiration, laryngotracheal or bronchial lesions or perforations, determining life-threatening complications such as hemoptysis or pneumothorax [15–17]. On the other hand, tracheotomy rapidly solve ARF but is an highly invasive procedure, with considerable morbidity and as a consequence poorly satisfactory for the patients. Beyond its early impact on perioperative outcomes, postoperative ARF has been also associated with decreased long-term survival and increased hospitalizations and costs [1,18,19].

Analysis of ARF post-thyroidectomy clinical series, in line with the PROCESS criteria, evaluating feasibility, effectiveness and outcomes of the nasotracheal prolonged safe extubation (PSE) were the aims of this study [20]. In addition, its ability in reducing the number of expected tracheotomies was evaluated. According to our experience, it was considered as a less invasive therapeutic procedure, reducing the number of expected tracheotomies and avoiding undesired prolonged orotracheal intubation sequelae.

2. Patients and methods

2.1. Study design

Under approval of the internal ethical board (ethical committee, n. 395), we conducted an observational retrospective study according to the principles established in the Helsinki Declaration. Patients, or their next of kin, were asked for informed consent.

Data of patients affected by severe ARF observed at our Intensive Care Unit (ICU) from January 2004 to December 2013 were retrospectively reviewed. Failure of oxygenation, carbon dioxide clearance, or both of these, associated with an increase plasma hydrogen ions concentration (pH < 7.30) were considered as the main ARF diagnostic criteria [21,22]. In every case severe ARF following thyroid surgery with failed extubation on awakening from anaesthesia and need of tracheal reintubation was the admission diagnosis. Previous ischemic heart disease, mild-severe heart failure (NYHA > 2), severe or relapsing chronic obstructive pulmonary disease, fever with tachypnea, infiltrative laryngeal tumor, infiltrative extra glandular masses, were considered as exclusion criteria.

In every case, LRN impairment was diagnosed by laryngoscopy. Each patient was treated by PSE and in case of failure recovery of ARF after the 4th endoscopic check (8 days), a definitive tracheotomy was routinely placed.

In case of true vocal folds impairment, on the advice of the otorhinolaryngologist, voice therapy was indicated. Recurrent laryngeal nerve palsy was considered permanent if there was no recovery six months after surgery. Clinical status, laryngoscopic pictures and outcome during a 24-month follow-up were also reported.

2.2. PSE technique

After ICU admission, all patients were standardly monitored (ECG, hearth rate, blood pressure, pulsoximetric O_2 saturation), and according to Miller and Cole, underwent corticosteroid therapy (methylprednisolone 20 mg/i.v. every 12 h) and cuff-leak test [23]. Afterwards, PSE was started according to the described procedures for safe-extubation [17,19]. Firstly, we injected 3 ml of a mixture of lidocaine 2% and mepivacaine 2% into the nasal cavity and the upper airways. We removed the tracheal tube leaving a guidewire (Baxter®, hydrophilic Teflon TM, ID 0.035, length 150 cm) in the airway to facilitate emergency re-intubation. Subsequently, we performed a diagnostic rhino-laryngoscopy by a video bronchoscope (rlFBS) Pentax FB 18, Ø 6 mm (Fig. 1a); during rlFBS, the guidewire was removed from the oral cavity, and replaced in the trachea through the endoscope operative channel. Finally, rlFBS was removed, leaving the guidewire *in situ*. An AEC (Cook® No. 11; ID 4 mm) was placed over the guidewire. A small cuffless nasotracheal (NT) tube (Rüsch® SilkoClear FlexTM ID 4.5 mm or 5 mm, length respectively 25 or 26 cm) was inserted by a twisting movement over the AEC (Fig. 1b and c); another rlFBS was performed (through the contralateral nostril) to assess the position of the NT tube. Its tip has to be positioned at least 2 cm over the vocal cords. AEC and guidewire were removed and a phonetic valve was placed on the NT tube, fixed to the nose by VBM® Endofix NasalTM tube holder (Fig. 2a and b). Patient spontaneously breathed through the NT tube and an oxygen support was added. A nasogastric tube for enteral feeding was positioned (Fig. 1d), and in addition intravenous post-operative pain therapy and thoracic physiotherapy were started.

Airway and vocal cord conditions were reassessed every 48 h by rlFBS. When breathing resumed without inspiratory airways distress, dyspnea and hypoxia, and the upper airway oedema and vocal function improved, the NT tube was definitively removed. Only the guidewire was left for 6 h longer, and it was finally removed in absence of relevant clinical events (Fig. 3a). To prevent complications and to assess oral feeding, the patient was observed for 24 h longer. If airway obstruction persisted at the 4th reassessment, and endoscopic pattern or clinical conditions did not improved, a tracheotomy was performed. During long-term follow-up, patients underwent otorhinolaryngologist laryngoscopy to assess vocal cord function and ventilation recovery. The patients affected by unilateral vocal fold paresis were submitted to voice therapy. The protocol was performed twice a week for 6 months; in particular, hard glottal attacks and pushing, half-swallow boom and abdominal breathing exercises were applied [24,25]. Voice therapy aimed to improve glottal closure without causing supraglottic hyper function, developing abdominal support for breathing and improving intrinsic muscle strength and agility.

2.3. Statistical analysis

Data were compared with a chi-square test. Statistical significance was defined as $p > 0.05$ with a Confidence Interval (CI) at 95%.

3. Results

During the above reported period, 2853 patients-2278 women and 575 men with a female/male ratio = 4/1 and a mean age of 48 years-underwent thyroid surgery at our university hospital.

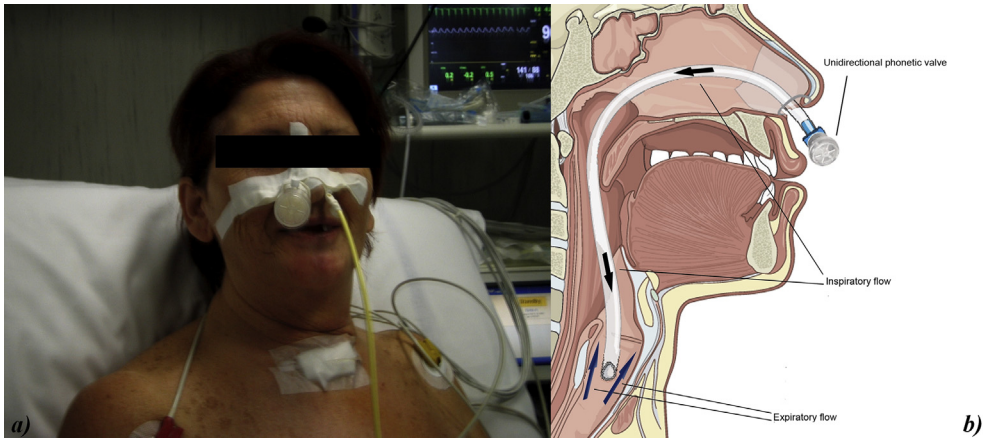

Fig. 1. Titrated safe extubation: a) uncuffed nasotracheal tube in site with phonetic valve (see in the text); b) the inspiration occurs through the tube with the opening of the phonetic one-way valve; the closed valve force the exhalation flow along the physiological anatomical way surrounding the tube.

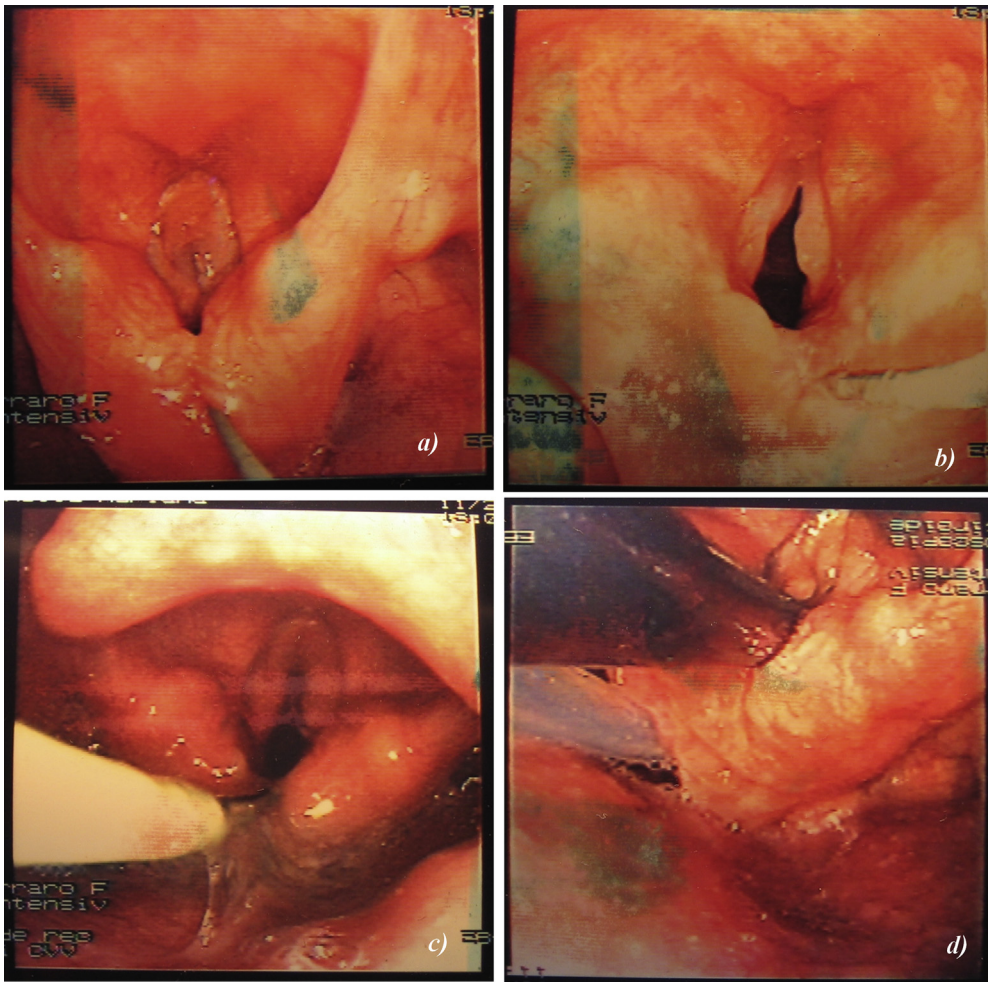

Fig. 2. Prolonged safe extubation and videoendoscopic check: a) extubated patient during inspiratory tirage with nasotracheal guidewire in site. b) passive opening of the vocal cords during exhalation. c) nasotracheal placement of a an airways exchange catheter (AEC) on the guidewire after failed extubation. d) nasotracheal reintubation on the tube exchange; at the bottom of the box there is the nasogastric tube in site.

Nineteen patients (0.66%), 15 women and 4 men with a mean age of 54 years (range 33–64), who underwent total thyroidectomy for multinodular goiter (n = 9), cervicomediastinic goiter (n = 5) or differentiated thyroid carcinoma (n = 5), developed post-operative ARF and were enrolled in the study. The mean Simplified Acute Physiology Score (SAPS) II was 14.90. The cuff-leak test was positive in 12 out of 19 patients.

The first laryngoscopic evaluation for diagnostic purposes

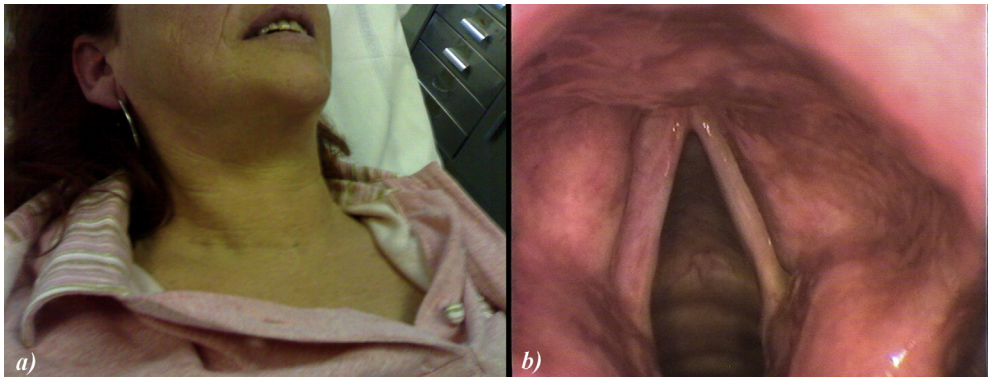

Fig. 3. a) Woman of 57 years successfully treated by prolonged safe extubation after 30 days; b) Rhino-laryngoscopy: resolution of the edema and hyperemia of the vocal cords, along with the complete recovery of the vocal cords.

showed:

- Glottis oedema and hyperemia of the vocal cords in all patients (100%);
- Bilateral vocal cords with hypokinesia in paramedian position in 10 patients (52%);
- Hypokinesia of the right vocal cord in 3 patients (15.7%);
- Hypokinesia of the left vocal cord in 2 patient (10.5%);
- Bilateral vocal cord adduction paresis in 4 patients (21%).

Subsequently, only 3 women of the 19 observed patients (15.7%), corresponding to 0.1% of the population undergone thyroid surgery, affected by ARF due to bilateral vocal cords adduction paresis with a mean SAPS II of 15.02, underwent temporary elective tracheotomy. Their vocal cord function recovered respectively 30 and 90 days later; tracheotomy tubes were then removed and stoma spontaneously closed without further complications. In the group of PSE successfully treated patients (ARF recovery without tracheotomy), 13 women and 3 men, with a mean SAPS II 15.07, definitive extubation was performed after a mean period of 5 days (range 2–9 days). In each patient, the NT tube was well tolerated. The PSE success rate in avoiding tracheotomy was 84.2%. Rosato et al. reported a success rate in avoiding tracheotomy following orotracheal intubation and safe extubation of 50% [26]. Therefore, the PSE success rate in avoiding tracheotomy was significant higher than orotracheal intubation as reported by Rosato ($\chi^2 = 4.48$, $p = 0.034$). Laryngoscopic assessments, performed by otorhinolaryngologist during follow-up, showed the resolution of the edema and hyperemia of the vocal cords, along with the complete recovery of the vocal cords motility in all patients (Fig. 3b). Unilateral hypokinesia in 5 patients (26.3%), and a bilateral hypokinesia in 6 patients (31.6%), were observed. An incomplete functional recovery was observed in 3 patients with bilateral hypokinesia (15.7%) and in all patients with bilateral paresis (4 patients, 21%), who were referred to voice therapy. Four patients with bilateral hypokinesia and two patient with bilateral paresis had complete functional recovery; single vocal fold recovery was observed in four patients with bilateral paresis.

No complications were reported during PSE procedure, without clinically significant variations of vital signs. In addition, all patients showed an excellent compliance during the treatment, reporting a high comfort level.

4. Discussion

ARF is a life threatening complication associated with early and long-term mortality and high costs [2]. Rosato et al. reported an incidence of 0.6% (58 cases) in a large population of patients (9599 patients) undergone thyroidectomy, similar to the one observed in the presented series (0.66%) [26]. A “classical” orotracheal intubation was always carried out, while a tracheotomy was finally necessary in 29 patients (50%), representing 0.3% of the Rosato thyroidectomy series. In our experience, in all ARF patients treated by PSE procedure, a tracheotomy was required in only three out of 19 cases (15.7%), representing 0.1% of the population undergoing thyroidectomy. The reported data demonstrate the prophylactic role of PSE in post thyroidectomy ARF patients.

In fact, on the basis of the clinical evidence and of the data compared between our findings and those reported by Rosato et al. ($\chi^2 = 4.48$, $p = 0.034$), PSE resulted more effective than standard management in preserving airways and avoiding tracheotomy. Therefore, our success rate in avoiding tracheotomy was 84.2% compared to the 50% following orotracheal intubation reported in the Italian series [26]. In our experience, PSE procedure, compared to the classical ARF treatments, also showed several advantages. When orotracheal reintubation is preferred, the presence of a large-caliber tube across the larynx and close to the vocal cords delay oedema recovery [11]. This observation explains the authors' choice, based on previous experience with translaryngeal open ventilation (TOV), about the use of a smaller caliber NT tube sized between 4.5 and 5 mm ID [27]. It resulted less invasive and more compliant with the larynx anatomy. Moreover, we chose a reinforced silicone tube manufactured by Rüsch® SilkoClear FlexTM (Fig. 1b and c) because it presented the lowest external/internal diameter ratio (1.4 mm). A NT tube of this size, better tolerated by the patient and less reflexogenic than the orotracheal one, tends to place itself in the posterior interarytenoid space. Therefore, it greatly reduces vocal cords compression, local oedema and the risk of decubitus as well. Moreover, because of its smaller size, it does not fully occlude nasal meati, preventing sinuses and nasal cavities infections. The reported advantages may favour a spontaneous breathing (Fig. 2), avoiding mechanical ventilation, sedation and curarization. The same advantages are barely achievable by orotracheal or standard nasotracheal tubes, which require analgosedation.

Even if the PSE procedure was always effective in our series, its use could have some limitations. In case of respiratory failure associated with reduced breathing force, i.e. chronic obstructive pulmonary disease (COPD), the procedure maybe ineffective since the flow resistance increases because of the NT small diameter compared to the orotracheal one [27]. In order to maintain the flow we would have to increase the pressure gradient, causing dynamic hyperinflation in patients with COPD [28]. Nevertheless, TOV through the NT tube would be effective also in those patients, as

described by Skrobik and Gregoretti [29]. The circumstances that make the patients unable to be awake and spontaneously breathe, such as psychiatric disorders (i.e. severe anxiety), the non-compliance to the NT tube and/or to the nasogastric tube needed for feeding when NT tube is *in situ*, also could be limitations for the PSE use. Other limitations could be represented by anatomic abnormalities making impossible the NT tube positioning (i.e. turbinate hypertrophy, nasal polyps, narrow nasal cavity) and by all the conditions causing hyperventilation, hypersecretion and severe cough (i.e. smoking, severe asthma). Although, the patients undergoing PSE need a close monitoring since the NT tube, especially in the first hours of ARF, guarantying the airway patency and a sudden, accidental extubation causes a new ARF. These limitations and shortcomings are represented in Table 1.

During the classic safe extubation it is possible to oxygenate, and not to ventilate the patients through the AEC [15,17]. In contrast, during the PSE procedure, patients, could be oxygenated through the NT tube by increasing FiO_2 and, if needed, it is possible to support breathing by applying a ventilator. When planning the procedure, to reduce the permanence of the AEC in the airways, we preferred a guidewire that was left "alone" during the last phase of the PSE procedure (final 6 h) to facilitate an emergency reintubation.

We preferred this procedure for the following reasons. A reduction of the risk of AEC complications, extensively described by Benumof et al., and recently reported by Loudermilk et al., was observed [15,17]. In addition, the fiberoptic assessment of the glottis was performed in absence of any device. Patient comfort increased and walking during intensive care was allowed, with sensible reduction of muscle hypotrophy.

In our experience, soft silicone NT tube was well tolerated and thanks to a physiological drainage of bronchial secretions, no patient experienced respiratory distress. Comparing this approach to a classic safe extubation, according to Loudermilk et al., who maintains an AEC in the patients' airways for 24 h before discharging, it must be remarked that 3% of the observed patients (one out of 40) required AEC removal [17]. Tolerance to NT tube may be higher than to AEC, but further studies are needed to substantiate these findings. During the procedure, we utilized a phonetic valve that allowed phonation improving the drainage of bronchial secretions on the outer surface of the tube, maintaining its patency. This is due to the patient capacity to inhale only through the NT tube since, in presence of oedematous laryngeal mucosa, it collapses on the tube walls Exhalation, instead, can only occur outside the tube because the unidirectional phonetic valve eliminates all intraluminal flow (Fig. 2) that splays the soft oedematous mucosa tissue generating enough space for the secretions drainage, avoiding intraluminal deposits. They are considered a frequent cause of respiratory distress in mechanically ventilated patients.

Finally, beyond its early impact on perioperative outcomes, postoperative ARF has been also associated with increased hospitalizations and costs. Data from the Health Grade 2009 of US, estimated in 1.82 billion US dollars the excess cost attributable to the medical care system for postoperative respiratory failure alone, between the years 2005–2007 [1]. Moreover, Dimick et al., found respiratory complications to be the most costly among the four major postoperative complications (respiratory, thromboembolic, cardiovascular and infections) and then procedures and process of care that can effectively reduce its incidence are highly desirable [30].

The main limitations of this retrospective study was the limited number of treated patients and the absence of a control group treated with conventional procedures. The lesson to be learned from this case series is that ARF after total thyroidectomy, especially in case of benign pathology, is a dramatic and not uncommon event, representing the most dangerous acute complication after neck surgery. Tracheotomy is a price too high for the patient. The PSE, as described by the Authors is a feasible and useful, even if not innovative application, which could prevent tracheotomy, in almost all ARF patients. Nevertheless, our results do not allow to drawn definitive conclusions and must to be cautiously considered and confirmed in a larger multicentric series.

Table 1
Limitations and shortcomings of PSE technique.

Non-compliant patients (i.e. severe anxiety)
Impossible nasotracheal tube positioning for anatomic abnormalities (i.e. turbinate hypertrophy, nasal polyps, narrow nasal cavity).
Hyperventilation not allowed for nasotracheal tube small inner diameter, even if adequate for spontaneous breathing at rest (it could be necessary to sedate the patient and apply PSV).
Need for nasogastric tube because of the impossible oral feeding (the presence of nasotracheal tube causes incomplete closure of the glottis during swallowing).
Dangerous accidental displacement (i.e. in case of hypersecretion with severe cough). It causes a rapid re-obstruction of the glottis with new ARF.

5. Conclusions

ARF post thyroidectomy is a life threatening complication with significant medium and long-term sequelae. According to recent Endocrine surgery guidelines, tracheotomy is indicated only in case of safe extubation failure. PSE was firstly described by the Authors with the aim to reduce the number of the expected tracheotomies. It is a well tolerated and minimal invasive procedure, that allowed a good respiratory ability and a fast clinical resolution of the laryngeal functional impairment. In our series, PSE success rate in avoiding tracheotomy was 84.2% demonstrating its feasibility and efficacy, moreover ensuring a negligible morbidity. Considering the number of patient treated in the study, further investigations are needed to better define and confirm the introduction of PSE in routinely clinical practice.

Declaration

All Authors have no conflict of interests.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

Internal ethical board (ethical committee, n. 395).

Sources of funding

Authors have no source of fundings.

Author contribution

Fausto Ferraro: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Claudio Gambardella: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Renato Patrone: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and

editing of the manuscript.

Domenico Testa: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Luigi Santini: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Raffaele Marfella: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Pierluigi Fusco: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Celestino Pio Lombardi: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Alessandro Sanguinetti: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Andrea Polistena: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Nicola Avenia: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Giovanni Conzo: Partecipated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Conflicts of interest

Authors have no conflict of interest.

Guarantor

Fausto Ferraro.

List of abbreviation

ARF	Acute respiratory failure
RLN	Recurrent Laryngeal Nerve
AEC	Airways exchange catheter
ICU	Intensive Care Unit
PSE	Prolonged safe extubation
rlFBS	Rhino-laryngoscopy by a video bronchoscope
NT	Nasotracheal
SAPS II	Simplified Acute Physiology Score
TOV	Translaryngeal open ventilation
COPD	Chronic obstructive pulmonary disease

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