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Transoral access for endoscopic thyroid resection

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Abstract
Background Endoscopic neck surgery is requested by an increasing number of patients. The access trauma of the axillary, breast, and chest approaches is greater than with open or video-assisted surgery. The authors tested the feasibility of the sublingual transoral access, which they believe is the most promising minimally invasive endoscopic access to the thyroid gland from outside the neck region.
Methods The sublingual transoral access was first evaluated in two fresh human cadavers. An experimental investigation then was performed using a porcine model. A total of 10 endoscopic transoral thyroidectomies were performed in 10 pigs using a modified axilloscope with an obturator, ultrasonic scissors, and a neuromonitoring system to identify the recurrent laryngeal nerve.
Results A complete transoral thyroid resection was achieved with both the human cadavers and all the living pigs. Despite the complexity of the anatomic region, the transoral procedure was astonishingly easy to perform. In the animal study, the time from the introduction of the obturator just above the larynx to its removal was 59 s. The average overall operation time was 50 min. The neuromonitoring system permitted the regular function of the recurrent laryngeal nerves on both sides to be proved after removal of the thyroid gland. The pigs were observed for another 2 h after the operation. No complications occurred during the operation or afterward.
Conclusions Endoscopic transoral thyroid resection is possible. It proved to be a safe procedure in living pigs and astonishingly easy to perform. The results may be helpful for thyroid resections in humans using a similar access, as suggested by the thyroidectomies in human cadavers preceding this study.

Keywords Goiter · Minimally invasive · Thyroid surgery · Transoral

For thyroid surgery, minimally invasive and endoscopic procedures have become increasingly important for patients. It is the aim of such procedures to achieve an optimal cosmetic result while keeping the access trauma acceptable. Use of the term “minimally invasive” in the context of the axillary or breast access has been criticized, so it seems quite consequential to choose an access as near to the thyroid gland as possible (the transoral access) while guaranteeing an optimal cosmetic result.

Methods

Before embarking on the proof-of-concept study using 10 live pigs, we performed complete transoral thyroidectomies on two fresh human cadavers using exactly the same instrument and technique used subsequently with live pigs. Institutional approval for endoscopic neck surgery was sought and obtained from the local ministry in charge of animal studies (Ministerium für laendliche Entwicklung, Umwelt und Verbraucherschutz: protocol 32-44456 + 10#47299/2006).

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The pigs, weighing an average of 35.4 kg, were intubated by means of a 7-mm endotracheal tube with electrodes (Medtronic, Jacksonville, FL, USA), which later made it possible for the neuromonitoring system to be used to identify the recurrent laryngeal nerve. As a first step, we made an in-center infralingual incision (Fig. 1) 15 mm long 10 mm from the lower yaw.

We proceeded with a blunt dissection, visually controlled through an obturator that is part of a modified axilloscope (Wolf-Endoskopie, Knittlingen, Germany) (Fig. 2) with a diameter of 20 mm. After the floor of the mouth under the platysma had been dissected, the instrument was pushed forward gently to the larynx (Fig. 3). Once the obturator was removed, carbon dioxide (CO_2) gas was inflated at a pressure of 6 mm Hg. Further preparation was done with 5-mm ultrasonic scissors (Ethicon Endosurgery, Norderstedt, Germany).

In the course of our experiments, we used a tiny additional medial access (3.5-mm incision) 15 mm below the larynx to introduce a small fixation forceps through a 3.5-mm trocar. We performed a complete thyroidectomy in all 10 pigs involved in the study, identifying and checking the recurrent laryngeal nerve in each case, first visually and then by using the neuromonitoring system. The parathyroid glands were identified and left untouched. We did not remove the thymus gland, which is particularly well developed in pigs.

Results

We were able to perform a complete thyroid resection in both human cadavers via the transoral approach without

Fig. 1 Sublingual incision for access to the thyroid gland in a pig

Fig. 2 Modified axilloscope for preparation

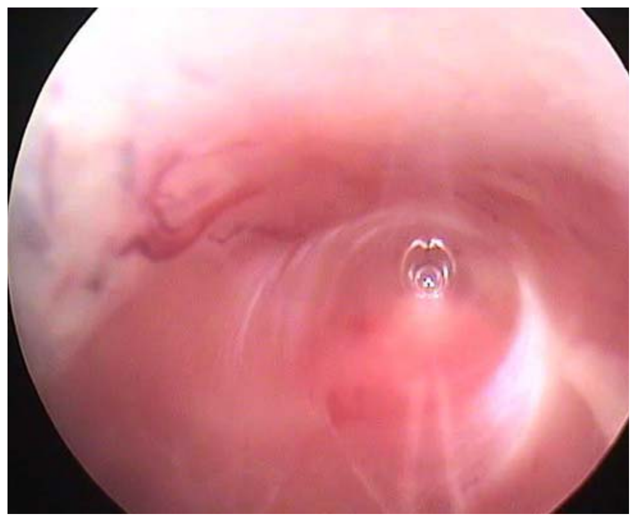

Fig. 3 Visually controlled blunt dissection

major difficulties (Fig. 4). Despite the complexity of the anatomic region, the transoral procedure was astonishingly easy to perform.

In all 10 living pigs, we were able to dissect using the obturator without any bleeding whatsoever. The average operation time from the introduction of the obturator just above the larynx to its removal was 59 s (range, 35–102 s). We did not notice any complications such as injuries to other structures or bleedings during this part of the operation, nor did the creation of a 3.5-mm access in the front neck region under visual control cause complications for any of the pigs.

It was unnecessary to put a clip on vessels supplying the thyroid gland. During lateral dissection, we identified the arteria thyroidea inferior in 18 of the 20 lobes managed by surgery, so we were able to use them as a routing structure for finding the recurrent laryngeal nerve. We then identified this nerve and the vagus nerve using the bipolar

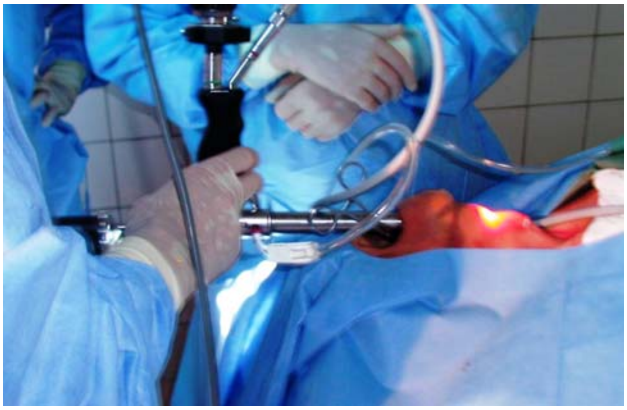

Fig. 4 Transoral access to the thyroid gland in a fresh human cadaver

neuromonitoring probe, which had been introduced through the 3.5-mm trocar. This was done successfully in 16 lobes of the thyroid gland (7 on the left side and 9 on the right side). At that time, we could not find either of the recurrent nerves in one pig. After cutting the A. thyroidea inferior with the ultrasonic scalpel, we completely dissected the entire lobe and removed it as a whole transorally through the tube of the axilloscope.

Then we again identified the recurrent laryngeal nerves and the vagus nerves on both sides. After resection, all 20 recurrent laryngeal nerves were found and identified (Fig. 5), which proved that no nerves had been injured in any case. No lesion whatsoever could be found.

We first removed the 3.5-mm trocar and inserted a redon drain, after which we removed the axilloscope and did a sublingual suture of the mucosa. Because no bleeding occurred during the entire operation, neither swab nor ejector were used.

The average operation time was 50 min (range, 27–103 min). The average weight of the specimens was 5.2 g (Table 1). The pigs were observed for another 2 h after surgery, but did not show any signs of hemodynamic instability or secondary hemorrhage. The documented bleeding 2 h after the procedure was 0 to 4.5 ml (average, 2.2 ml), regardless of the operation time or the weight of resected tissue. We performed a postmortem examination of the operation area and documented the operation results.

Discussion

Cosmetic aspects have become increasingly important in thyroid surgery. It therefore is important to develop endoscopic or minimally invasive techniques for operating on the thyroid and parathyroid gland because scars in the front neck region are especially prominent. Young women in particular consider such scars as disturbing or even disfiguring, even when they are quite small and unobtrusive [1–3].

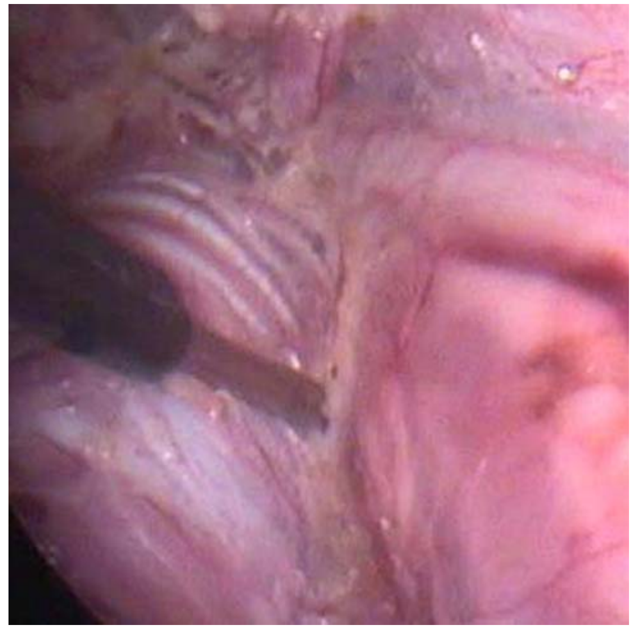

Fig. 5 The neuromonitoring system used to test the recurrent laryngeal nerve on the right side after complete resection of the thyroid gland

In 2001, Miccoli [4] described a video-assisted resection of the thyroid gland, for which an incision of only 20 mm in the front neck region was necessary. However, the era of endoscopic endocrine neck surgery had already begun with the first description of a parathyroidectomy using CO_2 inflation [5] in 1996. Less than 2 years later, Yeung [6] reported on endoscopic thyroid resections. Since then, quite a number of similar reports have been published, all of them describing an access outside the front neck region. Such accesses include lateral neck [7], chest [8, 9], axillary [9–12] or a combined bilateral breast–axillary [13, 14] access. It is the aim of such procedures to achieve an optimal cosmetic result while keeping the access trauma acceptable [15, 16].

Use of the term “minimally invasive” in the context of axillary or breast access has been criticized. A long access approach cannot be called minimally invasive, even if the cosmetic result is good. It is therefore important to apply significant preconditions and standards of open endocrine surgery to endoscopic techniques to avoid a compromise that favors cosmetic aspects at the expense of the patient’s security and the quality of the result [17]. This is particularly valid concerning the extent to which thyroid tissue is resected. Often, the resection of an isolated node is contrary to the demands of endocrine surgery but more easily realized with endoscopic techniques than with a complete resection. It follows that the measure of resection must be the same with endoscopic or minimally invasive endocrine surgery as with conventional operation techniques [18].

Table 1 Details on weight of the animal, time for access to the larynx, operation time, identification of recurrent laryngeal nerve, weight of resected tissue, bleeding and postmortem examination in each pig ($n = 10$)

	Weight of animal (kg)	Access time to the larynx (s)	Operation time (min)	Successful identification of RLN (L = left, R = right) before thyroid resection	Weight of resected tissue (g)	Bleeding(ml) until 120 min. after end of operation	Complete resection in postmortem examination
1	34.6	46	78	L, R	4.3	2.8	+
2	32.8	83	103	L, R	4.9	2.7	+
3	38.4	102	46		4.6	4.5	- (1.9 g right upper pole in situ)
4	38.2	63	45	R	6.5	3.2	+
5	40.0	56	48	L, R	6.8	2.4	+
6	33.8	69	42	L, R	4.3	3.0	+
7	34.5	52	33	L, R	4.9	0.7	+
8	35.7	35	27	L, R	4.7	0	+
9	33.8	39	37	R	5.8	2.3	+
10	32.1	47	41	L, R	5.2	0.4	+

The operating times achieved in our animal experiments (and the cadaver studies) were relatively short, although the procedure may take a bit longer in real patients. However, we have the impression that this technique is not very complicated and may not be too difficult to perform for humans.

Another important point is the security of the recurrent laryngeal nerve. Most of the authors reporting on endoscopic thyroidectomy call for an intraoperative identification of this nerve [4, 12, 13, 17]. In difficult cases, the neuromonitoring system is seen as quite helpful and thus is increasingly requested. This aspect also has not yet been given due consideration in endocrine endoscopic surgery.

We therefore believe that the following requirements for endoscopic thyroid surgery should be met: The access trauma must be as small as possible, not significantly exceeding the access approach of open video-assisted surgery. The access itself must be sufficiently near the thyroid gland to deserve the term minimally invasive and not just endoscopic [19].

The result of the operation must be optimal, no matter what access was chosen. If the scars in the front neck region disappear, this should not entail scars in other places that are larger than those caused by open surgery [8]. It must be possible to resect the specimen of thyroid tissue in all cases. Particularly in the case of follicular neoplasias, it is vital to safeguard the complete integrity of the resected tissue so it can be classified correctly. Extraction of the thyroid gland via the modified axilloscope is comfortable. This is one big advantage of the described procedure because the resected thyroid tissue does not come into contact with other tissue in the access channel.

Our experience shows that by using the aforementioned procedure, the transoral access to the larynx under visual control does not cause any problems. The access approach follows the symmetric structure of the neck, which allows a better orientation in the operation field than any of the lateral approaches. The most complicated step with the lateral procedures is correct access through the muscles because there are no landmarks to facilitate orientation [6, 8, 11].

Terris et al. [18] also emphasizes the good overall view the surgeon has when using a front neck access in endoscopic surgery that an axillary access does not offer. In 2004, these authors described the “superior” external access above the thyroid gland in an animal experiment, for which an incision in the chin area and another auxiliary two resp. four incisions in the neck were made.

Our experiences with the axillary access in humans and the transoral access in this study show that identifying the recurrent laryngeal nerve is easier than in open surgery because the views transmitted by the camera are enlarged. Although we agree that neuromonitoring is not mandatory with conventional thyroid surgery, we are very much in favor of using it when evaluating new minimally invasive techniques. Feasibility of performing neuromonitoring in animal experiments is one parameter for objectively determining the potential feasibility of transoral thyroid resection.

Endoscopic preparation with the ultrasonic scissors permits resection without any bleeding. Even the vessels of the upper pole can be cut without clipping, although the temperatures the ultrasonic scissors produce when cutting may be a problem. The extraction of the tissue is comfortable, which is one great advantage of the described procedure.

Another problem is sterility of the access region because it is difficult to disinfect the mucosa. Experiences with endonasal endoscopic skull-base surgery show that in most cases, postoperative infection can be avoided by administering antibiotics perioperatively [20]. Further studies might show whether abscess formation is a likely problem with transoral thyroid surgery.

The complete transoral thyrodectomy performed with two human cadavers that preceded this study showed that despite the differences between the porcine and human anatomies, this approach may very well be applicable in humans as well. Of course, the application of the procedure will presumably be limited by the size of the goiter. However, we suggest conducting a further study using fresh human cadavers before it actually is tested with human patients.

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