If the act of swallowing is disturbed, aspiration can occur. Both careful anamnesis and improved diagnostics are necessary for a differentiated surgical treatment. A large proportion of complaints which have not been objectified up till now can be explained by the following techniques: we use rigid and flexible scopes for monitor-guided endoscopy.

1. DIAGNOSTIC

a. Endoscopy

The advantage of flexible endoscopy is that 3-dimensional relationships can be assessed in their natural functions. Endoscopy with a magnifying rigid laryngoscope results in a better picture of the larynx, but changes the natural relative positions in the pharynx because the tongue is put out. An uvula which moves during nasal endoscopy towards the nasopharynx signals the beginning of a velum-insufficiency. Even a very slight nasal aspiration can be recognized when the patients takes a sip of milk. The pharynx is cleaned when the patient drinks a sip of water afterwards. Attention must be paid to the width and symmetry of the pharynx, the position of the larynx in relation to the pharynx, the relation of the larynx to the neck lordosis, retention of saliva, places of intense contact between the tongue-base and the epiglottis, changes when the head is turned to the left or the right, phonation, and the hypopharynx during Valsalva manoeuvre or Müller manoeuvre. With the tip of the endoscope possible points of irritation can be directly approached. Beside this we can discover disturbances in sensitivity in the pharynx and the larynx. Retention of saliva without tumor is evidence of a disturbance. We use no surface anaesthesia. Both oesophagoscopy and tracheoscopy can be carried out by means of a nasopharyngoscope.

b. Radiography

The aforementioned examination technique cannot assess the function of the laryngopharyngeal system during the act of swallowing. This is possible by means of cineradiography or videoradiography with a sip of contrast fluid. Cineradiography can depict the bolus transport from the mouth to the oesophagus which only takes 0.7 sec with 50 pictures per second, and videoradiography with 48. In the picture to picture analysis 35 or 34 pictures of the act of swallowing can be assessed, i.e. every 2/100 of a second there is a measurement.

The measuring of the bolus course is possible by radiography with a recording device (second, frames) so that pathologically retarded actions can be diagnosed. The patient is in anterior-posterior and in lateral position (both angles of the jaw are on the same level). It is important that no contrast
fluid or contrasted marshmallow is used for the first sip; for the following sips a standard contrast fluid and a standard amount of this fluid (e.g. 10 ml) and marshmallow are recommended. When the patient has difficulty in swallowing solid food, contrasted marshmallows should be used. We recommend the Valsalva experiment to check the function, the phonation of "a" and "i," and the course of the contrast means including the cardia.

All the radiological examinations should be carried out under standard conditions as far as possible. Evaluation is made by means of a videorecorder and a monitor, a video imaging system and an Amiga computer with software.

For an exact analysis reference points were determined for every picture:

1a. the posterior wall of the pharynx and the palatum molle; or alternatively

1b. the back of the tongue at the level of the uvula

2. the tip of the epiglottis

3. the vallecula

4. the anterior margin of the hyoid

5. the arytenoids cranial protuberances

6. the petiolus

7. the anterior commissura of the vocal cords.

We began with the measurement of the swallowing act at the moment when the soft palate was lifted or when the tongue moved to ventral (Fig. 1).

The measurement is ended after the larynx has returned to its respiration position (Fig. 2).

As well as the time factor, the movements of the points of reference are determined with

**Fig. 1.** Points of measurement from above downwards in the lateral position. The back of the tongue, the epiglottistip, the vallecula, the anterior margin of the hyoid, the cranial protruberances of the arytenoid cartilages, the anterior commissura of the vocal cords.

**Fig. 2.** Points of measurement from above downwards in the lateral position. The back of the tongue, the epiglottistip, the vallecula, the anterior margin of the hyoid, the cranial protruberances of the arytenoid cartilages, the anterior commissura of the vocal cords.
Fig. 3. The movements of the points of reference are determined with the help of a system of coordinates, and are entered on an assessment paper. The beginning of deglutition is marked by shadows.

The help of a system of coordinates, and are entered on an assessment paper (Fig. 3). By these means dissociations of as little as 0.02 sec in the act of swallowing—either as far as time or space are concerned—can be recognized.

Which possibilities offers this method of assessment by the example of the bolus course?

At first the normal passage through the m. constrictor pharyngis inferior (Fig. 4), and then 2 patients with disturbances in swallowing:

A 90-year-old patient complains of a globus feeling, of disturbances in swallowing, and occasional coughing when eating. A dysfunction in the cricopharyngeus can be seen when the patient has swallowed contrast fluid, and it can be measured when the patient is in a standard position (Fig. 5). The dysfunction narrows the oesophagus to 24% of nor-
Fig. 5. A 90-year-old patient. The dysfunction (m. cricopharyngeus) narrows the oesophagus to 24% of normal in the lateral projection.

Fig. 6. A 75-year-old patient, 2 years after radiotherapy for a laryngeal carcinoma. A scar stenosis reduces the lumen to 45% of normal.

A 75-year-old man who had undergone radiotherapy for a laryngeal carcinoma 2 years previously also complained of difficulties during deglutition formed as a consequence of radiotherapy, limiting the diameter of the lumen to 46% of normal. This can be measured by radiography from lateral (Fig. 6). With this method we can diagnose slight deviations.

c. Manometry

Manometry of the oesophagus is an important additional method which supplies relevant data about pressure and thus allows of conclusions concerning neuro-muscular disturbances. The relevance of manometric examinations in the pharynx is a subject of controversy.

d. Electromyography

After endoscopy and X-ray videoradiography, electromyography used selectively gives us valuable additional information as to the degree of disturbance in muscle function. In the diagnosing of vagus paralysis electromyography of the M. cricothyroideus is helpful.

2. SURGICAL TREATMENT

On the basis of these diagnostic processes we must make indications for therapy. Conservative and surgical methods of treatment are at our disposal. Improved diagnostics moreover make the development of new endoscopic operation techniques possible.

a. The Diverticula

The following endoscopic surgery demonstrates the processes of

the treatment of the Zenker's diverticulum, the diverticulum of the membrana thyreohyoidea and of the pseudoepiglottis.

Symptoms are slowly increasing dysphagia and then regurgitation. On occasions aspiration is observed. The diagnosis can be assured by contrast fluid radiography. The function of the cardia should also be analyzed. Manometry gives valuable information about malfunction. The possibility of a tumor must be eliminated by differential diagnostics. The threshold of the diverticulum is severed through an endoscope by a CO₂-laser in the modified Dohlman technique. The musculus cricopharyngeus is severed simultaneously with the mucous membrane.

More than 400 cases are being treated successfully at the clinic in Groningen. The
complications rate corresponds with the rate after the classical diverticulum operation. The same technique of severing the threshold by means of the CO\textsubscript{2}-laser is used for the lateral pharynx diverticulum and on the pseudoglottis.

b. Slight Interarytenoid Aspiration

A postcricoid transposition flap is used with success on patients with interarytenoid aspiration in order to elevate the interarytenoid threshold. This form of aspiration is observed in slight neuro-muscular and/or neuro-sensitive disturbances, in which saliva or drinks overflow into the larynx via the lowest point, the arytenoid region (Fig. 7). Patients complain of the need to clear their throats, and cough both when eating and drinking and—in disturbances in sensitivity—also when resting. The indication is made by flexible endoscopy in combination with videoradiography. A cricopharyngeal dysfunction treated by myotomy has to be excluded.

If there is no dysfunction of the cricopharyngeus muscle, the surgical technique is as follows: only the incision of the mucous membrane should be carried out with the CO\textsubscript{2} laser after identification of the arytenoid cartilages. Preparation of the mucosa.

For the treatment of the interarytenoid aspiration we use a mucosal flap cut from the postcricoid area. The incision of the mucosa is made using the CO\textsubscript{2} laser. Preparation of the flap should be carried out by means of scissors. It is moved into the severed and partially excised scar tissue of the posterior part of the supraglottic area, and fixed there by suture and fibrin tissueglue (Fig. 8). An internal bandage consisting of a condom filled with foamed plastic, which just fills out the space thus created without pressure, is inserted transorally and held in position via the nose and the tracheostoma for 10-14 days.

The postcricoid mucosal flap creates an elevation of the interarytenoid region in cases of interarytenoid aspiration. Up till now we have used 13 postcricoid flaps, 4 cases were treated for supraglottic stenosis and 9 cases for interarytenoid aspiration. In 1 case we saw a failure caused by inadequate preparation of the post-cricoid flap.

c. N. vagus Paralysis

The large pouches of the membrana thyreohyoidea which arise during the vagus paralysis carry the risk of aspiration pneumonia. Because of this pouch formation and thus the intradeglutive retention of food in the pouch, aspiration can occur postdeglutively from the pouch (Fig. 9). The most frequent location is the muscleless triangle of the membrana thyreohyoidea—the place at which the cranial vessel-nerve supply enters

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{fig7.png}
\caption{Interarytenoid aspiration in cases of neuromuscular and/or neurosensitive disturbances.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{fig8.png}
\caption{If a cricopharyngeus dysfunction is excluded, we use a mucosal flap cut from the postcricoid-arytenoid region, in order to eliminate interarytenoid aspiration.}
\end{figure}
Fig. 9. Vagus paralysis on the left side with retention of saliva, cricopharyngeal spasm, palsy of the recurrence nerve and a large pouch with aspiration problems.

the larynx. This triangle is bordered by the hyoid on the cranial side, by the m. omohyoideus and thyrohyoideus ventrocaudally and by the m. constrictor pharyngis inferior on the dorsocaudal side. The weakness in the wall can be reinforced with concha cartilage or double fascia lata without touching the vessel nerve supply.

Normally there also exists a cricopharyngeal spasm. In this case we carry out a myotomy at the same time (Fig. 10).

*d. Severe Neurological Disorder*

The hyoid bone, thyroid, cricoid and arytenoid cartilages are closely linked to each other; at the same time they can be moved singly. The complicated intralaryngeal apparatus is built into the suspension of larynx and hyoid between the upper thorax aperture and the skull (Fig. 11). The position of the larynx in the digestive tract is so unfavourable when neuro-sensitive or neuro-muscular disturbances exist, that aspiration results.

Patients are advised to wait for a year in order to see whether the function returns spontaneously.

In pronounced disturbances the larynx must be moved away from the main swallowing tract towards cranial under the base of the tongue in order to diminish the risk of aspiration. After endoscopic examination, cinematography and direct electromyographic examination we achieve this by laryngohyoidopexy

with an approximation of the larynx to the chin. If the operation is carried out we recommend the following technique:

After circumcision of the tracheostoma, the skin flaps are prepared. The thyroid gland is reached and laid to the side of the trachea after the isthmus has been severed. Trachea and pharynx must be completely separated from the thyroid gland. This preparation is
Fig. 12. In severe cases of neurological disorders with aspiration—after a wide field myotomy (1) of the constrictor inferior muscle—we remove the larynx out of the bolus course under the tongue base. After dissection of the omohyoid, sternohyoid and sternothyroid muscle we perform the laryngohyoidopexy (2) and the larynx-chin approximation (3).

difficult because of the existence of scars from the tracheotomy. The n. recurrens must not be damaged.

The cricopharyngeus myotomy is carried out (Fig. 12).

i) Muscle dissection—The m. omohyoides and the m. sternohyoideus are severed on both sides in the proximity of the hyoid. In addition, the m. sternothyroideus is dissected close to the thyroid cartilage. The larynx must now be moved to cranial and ventral by a gentle pulling movement.

ii) Laryngohyoidopexy—The thyroid cartilage is fixed to the hyoid by 4 to 6 PDS sutures (2 × 0) (Fig. 12).

iii) Larynx-chin approximation—A strong strip of fascia lata is taken and put around the body of the hyoid in the median line. We attach it with sutures and fascia, open the approach to the chin by a submental incision, and bore a hole in the os mentale. The skin between chin and the body of the hyoid is undermined, sutures and fascia are drawn towards the chin by measuring the distance between chin and larynx and are fixed (Fig. 12). Normally a shortening of 2 cm is sufficient.

As the larynx hangs like a broad swing between the skull and the mandible, the ventral approximation functions as an elevation to cranial and ventral. The tilting of the epiglottis in order to protect the entrance of the larynx from aspiration is not successful after laryngohyoidopexy.

After suturing the patient is further tube-fed. A blocked cannula is also used postoperatively. The block can be removed when the compresses at the tracheostoma remain dry. 14 days after the operation of after swelling has disappeared we carry out cinematography with a water-soluble contrast fluid. Neurological after-treatment follows.

iv) The technique by an additional disorder of n. V and XII—If, amongst other things, the function of the Portio minor of the n. trigeminus and/or the n. hypoglossus is disturbed, or has ceased, the larynx is moved to dorsal, providing the facialis function is intact. It lies close to the posterior wall of the pharynx. The distance between vallecula and the posterior wall of the larynx is shortened. In this case the severing of the m. stylohyoideus with the ligamentum stylohyoideum and the venter mastoideus of the m. biventer near the hyoid is indicated.

e) Epiglottis Declination Plasty

As the epiglottis is held in a position slightly tilted to dorsal by the ligamentum thyreoepiglotticum, the epiglottial fat tissue, the plica glossoepiglottica and the plicae pharyngoepiglotticae, it is lowered towards dorsal by a lengthening of the plicae. By means of a transverse incision of the plica bilateral the epiglottis can be placed into the desired position. The defects in the mucous membrane are sutured in the longitudinal direction. The len-
gthening of the plicae guarantees that a complete tilting of the epiglottis can be avoided.

It may be necessary to repeat the epiglottis declination plasty by cutting into the plica glossoepiglottica and the ligamentum thyroepiglotticum in order to achieve protection from aspiration by means of the right position of the epiglottis. Occasionally sutures between the aryepiglottic fold and the epiglottis are necessary after desepitheliation.

I have tried to give an insight into the development of endoscopic plastic surgery of the larynx and pharynx. Endoscopic surgery is the most direct way of treating laryngopharyngeal problems. Additional scars, as those which arise when operations are carried out from the exterior, do not disturb the laryngopharyngeal function. This technique is becoming increasingly suitable for successful treatment without visible scars.

REFERENCES


