Review Article

Reconstructive and rehabilitating methods in patients with dysphagia and nutritional disturbances

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Abstract

As diverse as the causes of oropharyngeal dysphagia can be, as broad is the range of potential therapeutical approaches. In the past two decades, methods of plastic-reconstructive surgery, in particular microsurgically revascularised tissue transfer and minimally invasive, endoscopic techniques of every hue have substantially added to the portfolio of reconstructive surgery available for rehabilitating deglutition. Numerically, reconstructing the pharyngolaryngeal tract following resection of squamous-cell carcinomas in the oral cavity, the pharynx and the larynx has been gaining ground, as has functional deglutitive therapy performed to treat posttherapeutical sequelae.

Dysphagia and malnutrition are closely interrelated. Every third patient hospitalised in Germany suffers from malnutrition; ENT tumour patients are not excluded. For patients presenting with advancing malnutrition, the mortality, the morbidity and the individual complication rate have all been observed to increase; also a longer duration of stay in hospital has been noted and a lesser individual toleration of treatment, diminished immunocompetence, impaired general physical and psychical condition and, thus, a less favourable prognosis on the whole. Therefore, in oncological patients, the dietotherapy will have to assume a key role in supportive treatment. It is just for patients, who are expected to go through a long process of deglutitive rehabilitation, that enteral nutrition through percutaneous endoscopically controlled gastrostomy (PEG) performed at an early stage can provide useful and efficient support to the therapeutic efforts.

Nutrition and oncology are mutually influencing fields where, sooner or later, a change in paradigms will have to take place, i.e. gradually switching from therapy to prevention. While cancer causes malnutrition, feasible changes in feeding and nutrition-associated habits, including habitual drinking and smoking, might lower the incidence of cancer worldwide by 30 to 40% (American Institute of Cancer Research 1999).

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Esse oportet, ut vivas, non vivere ut edas. / Thou shouldst eat to live, not live to eat.

Cicero 106 - 43 B.C.

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1. Introduction

Swallowing and breathing as well as their co-ordination in man are indispensable, vital movements which, frequently, one becomes aware of not until relevant impairment or complaints are experienced. Swallowing comprises three key functions: Ingestion and transport of food, removal of saliva, and protecting the lower airways from aspiration. Swallowing involves complex interaction of 26 groups of muscles which, being co-ordinated through the deglutition centre in the brain stem, are innervated bilaterally in both motor and sensory terms through five pairs of cranial nerves (N. V, VII, IX, X and XII) as well as the cervical nerves C - C, with the substantially motor innervation taking place through the vagus nerve. Eating and drinking, while being necessary for nutrient supply, reflect awareness of life and are synonymous with communicating and social integration. An oropharyngeal dysphagia can threaten the patient's life through insufficient oral diet with consecutive malnutrition and weight loss and, in the event of an aspiration, through recurrent pulmonal infections [1]. With disturbed food intake and difficulty in swallowing not infrequently considered by other people as an external stigmatisation, those affected often face inevitable social isolation.

2. Anatomy and Physiology of Swallowing

The anatomical basis of a physiological act of swallowing, in addition to the oesophagus, is the orofacial system. This corresponds to the anatomical structures of the nozzle which are involved in the primary functions, i.e. breathing and swallowing, in the secondary functions, i.e. articulation and phonation, as well as in non-oral communication, i.e. facial expressions and gestures. There are rigid parts including the nasal cavities, paranasal sinuses, the stomatognathic system, and the supraglottic part of the laryngeal skeleton, as well as parts variable in terms of volume and shape, i.e. the oral cavity, the pharynx, and supraglottic laryngeal soft tissues [2].

As reported by Logemann (1983) swallowing is a four-stage act [3]. The *oral preparatory phase* which includes eating can be controlled voluntarily. Solid and semisolid food constituents, once examined by specific receptors of the front third and mid-third of the tongue to ascertain their volume, taste and temperature, are chewed up and mixed with saliva. From this mass, a bolus is then formed and, towards the end of the chewing phase, held enclosed by the tongue in the palatal front to mid areas in the so-called lingual basin. The average bolus volume ranges from 5 to 20 mL [4]. The *oral phase* comprises transport of the bolus into the pharynx until the deglutition reflex is triggered. As the food comes into contact with the bases of the palatoglossal archs the swallowing reflex is initiated. From this time onwards, the act of swallowing cannot be controlled voluntarily any more. The *pharyngeal phase* is a speedy reflex chain of movements that comprises the following individual actions: Velopharyngeal closure, lingual closure with the pharyngeal back-wall, superior-anterior movement of the hyoid bone, superior-anterior movement of the larynx, laryngeal closure: Closure of the glottis - Closure of the vestibular fold - Closure of the epiglottis, pharyngeal contractions.

McConnell compared this oral and pharyngeal phase of the act of swallowing with a pressure-generator mechanism of two pump systems: an oropharyngeal propulsion pump and a hypopharyngeal suction pump. The combination of tongue-induced thrust and pharyngeal peristalsis entails a positive pressure in the pharynx and circumscribes the function of the oropharyngeal propulsion pump. The hypopharyngeal suction pump, in turn, through contraction of the hyomandibular muscles, causes elevation of the larynx while opening the pharyngo-oesophageal sphincter with subsequent negative pressure. A superior-anterior movement of the larynx leads to passive lowering of the epiglottis, closing the laryngeal inlet. Reflex inward movement of the vocal folds and the vestibular folds occurs at the same time. The larynx so positioned under the root of the tongue, with

improved epiglottic tilt, provides additional protection from aspiration [5], [6]. The *oesophageal phase* commences as the pharyngeal contraction arrives at the constrictor muscle of the pharynx, followed by contraction of the muscle of the same name. It is through peristaltic waves that the bolus is propelled from the upper to the lower oesophageal sphincters. Upon completion of the individual act of swallowing, the upper and the lower oesophageal sphincters are maintained in a continuous tonus. The latter, in the area of the upper sphincter, prevents air from entering the oesophagus during inspiration and, in the area of the lower sphincter, it prevents gastric contents from flowing back into the oesophagus.

3. Diagnosis of Oropharyngeal Dysphagia

Basic diagnosis performed to identify oropharyngeal dysphagia, while involving targeted taking of the case history, comprises phoniatric examination including a videoendoscopically controlled swallowing trial as well as radiographic videocinematography of the act of swallowing [1], [7]. The thoracic organs should be X-rayed so as to exclude pulmonary changes associated with aspiration. Given potential interaction of the oropharyngeal and oesophageal phases, additional examinations may be necessary on a case-by-case basis: Upper intestinoscopy, oesophageal manometry including ph metering, oesophageal endosonography, oesophageal function scintigraphy, cervical spine X-ray, pulmonary scanning to quantify aspiration, MRI of the act of swallowing and the brain [1], [8], [9]. The common examination by means of the ENT speculum and direct laryngo-hypopharyngoscopy using Stuckrad's magnifying laryngoscope as well as the flexible laryngo-pharyngoscope (3.5 or 2.4 mm dia.), which may be considered a screening examination when watching out for an oropharyngeal dysphagia, permit detailed examination of the orofacial, the velopharyngeal and the hypopharynge-laryngeal regions. In these examinations, both the static conditions (resting observation) and the dynamic functional interaction in voluntary and and reflex movements are assessed from the following perspectives: Phonation, articulation, swallowing of saliva, food. The assessment is complemented by compiling the retching, the palatal and the cough reflexes as well as by testing the sensibility and the temperature perception. Particular attention is paid to observing the vocal fold mobility and voluntary laryngeal closure at the glottic and supraglottic levels during phonation, straining and coughing. The examiner should palpate the patient's laryngeal-hyoid elevation in swallowing and check the patient's posture of the head and the body when eating. In case of dysphonia, auditive assessment of the voice provides an indication of insufficient glottic closure; in case of a gurgling quality of the voice, it is indicative of saliva/bolus parts being present in the glottis. Aphonia and huskiness may be attributable to vocal fold paresis. Frequent hawking and coughing are suggestive of an aspiration. Dysarthric and aphonic symptoms are typical in neurogenic dysphagia. The functional cornerstones of the act of swallowing are bolus formation, bolus control, triggering of the deglutition reflex, pharyngeal peristalsis, laryngeal closure, laryngeal-hyoid elevation, opening of the pharyngo-oesophageal segment, and oesophageal bolus passage. It is only through a combined radiologic-endoscopic diagnosis, i.e. radiographic videocinematography (the synonym being videofluoroscopy) and a videoendoscopically controlled swallowing trial, that one can provide meaningful information about all the parameters [10]. In transnasal flexible endoscopy of the patient (VEED = videoendoscopic evaluation of dysphagia, FEES = fibre-optic endoscopic evaluation of swallowing), the fibre endoscope may be left in place during the act of swallowing. This enables the pre-swallowing and post-swallowing findings to be visualised. The examination starts by observing when saliva is swallowed. In the videoendoscopically controlled swallowing trial, while being prepared for aspiration, food of varied consistency (liquid, pasty, solid), stained with food colourant or methylene blue, is administered (Table 1 (Tab. 1)). Using a flexible fibre-optic endoscope, it is possible to visualise secretory accumulation in the valleculae and the piriform sinus, leaking, penetration, aspiration as well as nasal and hypopharyngeal regurgitation [1],[11] (Table 2 (Tab. 2)). Radiographic videocinematography is the method of choice when it comes to visualising those criteria which cannot be adequately assessed by means of the former: Aspirate volume, pharyngeal peristalsis, the upper oesophageal sphincter and the oesophagus (Table 3 (Tab. 3)) [12].

3.1 Terminology

Drooling: Food and saliva running down from the mouth in case of incomplete closure of the lips.

Leaking: Premature slipping of the bolus into the pharynx before the deglutition reflex is triggered.

Laryngeal penetration: Entry of food, saliva or gastric juice into the airways as far as into the inlet of the larynx.

Aspiration: Entry of food or saliva into the airways below the glottis.

Predeglutitive aspiration: Aspiration prior to triggering of the deglutition reflex, early chyme transit into the valleculae and the piriform sinus while the larynx is still open and unprotected because of disturbed oral bolus formation and control, or late - or lack of - triggering of the deglutition reflex.

Intradeglutitive aspiration: Passage of bolus material during triggering of the deglutition reflex, through the incompletely closed glottic plane.

Postdeglutitive aspiration: Aspiration of food material increasingly retained in the valleculae and the piriform sinus, into the re-opening glottis.

Regurgitation: Reflux of bolus material into the pharynx, the larynx or the oral cavity because of retrograde movements in the oesophagus.

Nasal regurgitation: Damming up of bolus material because of incomplete velopharyngeal closure in the nasopharynx.

Transit time of bolus: Time it takes for the bolus to advance from the oral cavity into the stomach; the transit time varies in the oral preparatory phase, being < 1 s in the oral phase, ≤ 1 s in the pharyngeal phase, and 3-9 s in the oesophageal phase [13].

Odynophagia: painful swallowing [14].

4. Causes of Oropharyngeal Dysphagia

4.1 Morphological Causes

Table 4 (Tab. 4) summarises all dysphagia-related diseases which are attributable to a morphological correlate. Many of these diseases, predominantly the tumours, need to be attended to by surgical treatment for causal therapy. It must not be underestimated that some of the operations required will bring about a change in the physiological act of swalling as the cervical soft parts are traumatised. Advances in minimal invasive endoscopic surgery in the pharynx and the larynx experienced in the past 15 years have substantially contributed to minimising postoperative secondary sequelae. Therefore, to elucidate a dysphagia of undetermined origin a search for diseases of the cervical spine is highly encouraged (Figure 1 (Fig. 1), Table 4 (Tab. 4)).

4.2 Neurogenic Causes

The manifold causes of neurogenic dysphagia are presented in Table 5 (Tab. 5). Frequently, it is associated with speech disorders, speech defects, paraphonia and respiratory embarrassment. Dysphagia attributable to diseases of the nervous system may occur with and without aspiration [14]. A lacking cough reflex with "silent aspiration", which occurs in some 40% patients with neurological dysphagia, and, not infrequently, patients' lacking awareness of a disturbance present a problem [1]. Apoplectic shock is the disease which most frequently results in dysphagia. As reported by Smithard et al., dysphagia has been observed in one third of the stroke patients [15]. Dysphagia of neurogenic genesis is a domain of functional conservative therapy. However, emphasis should be given to patients with tumours of the posterior crania fossa who suffer from a jugular foramen syndrome with aspiration-associated dysphagia. In such a case, along with the functional swalling therapy, surgical action is necessary for rehabilitation (Table 5 (Tab. 5)).

5. Surgical and Endoscopic Therapy of Oropharyngeal Dysphagia

5.1 Tumours

For carcinoma of the oral cavity, the pharynx and the larynx, one has to differentiate between dysphagia caused by the tumour and dysphagia attributable to therapeutic measures. Pretherapeutical dysphagia as a principal sign is suggestive of malignant growth in the oropharyngeal region. Studies by Rosen and co-workers showed that, in 41% of the patients with Stage III and IV carcinomas in the oral cavity and the pharynx, aspiration was verifiable by videocinematography already at the time of initial diagnosis [16]. The size and the localisation of the primary tumour, as well as the substance defect resulting after resection, the surgical access and the method of reconstruction all determine the extent of postoperative dysphagia. While the size and localisation of a tumour cannot be influenced, it is possible for both the surgical access and the practicability of plastic reconstructive surgery to be individually adjusted. The following criteria are of causal relevance to the extent of dysphagia following therapy of malignant growth in the oral cavity, the pharynx and the larynx:

- Postoperative substance defects and scars having an impact on the motor response and the sensitivity in the affected areas, considering that currently identical relevance to the act of swallowing is attached to both nerval qualities.
- Cranial nerve lesions (N. V, VII, IX, X, XII). These can be caused by the primary tumour, by cervical lymph node metastasis and by therapy thereof.
- Tracheostomy.
- Radiation.

Referring to local tumours of identical size and localisation, transoral laser surgery is markedly advantageous over transcervical surgical techniques. To begin with, there is no access morbidity. Tracheostomy can be dispensed with in the majority of the cases [17]. Where organ-preserving surgery, where justifiable from an oncological perspective, provides a favourable morphological and functional starting position for rehabilitation of the patient and, thus, for a quality-of-life benefit, it should be taken into account that organ preservation is not identical with function preservation [18]. Irrespective of the approach pursued, whether conventional surgery or laser surgery, in case of loss of more than 50% of a functional unit in the oral cavity and the pharynx, as a rule, complex soft-tissue defects are experienced that cannot be primarily closed or left to secondary granulation. In particular, resection of complete organs in the region of the upper respiratory and swallowing tract, including total glossectomy, total palatal resection, laryngectomy and transverse pharyngo-laryngectomy, are known to entail severe functional deficits becoming manifest as oral and pharyngeal dysphagia, aspiration, nasal regurgitation, disturbed articulation or disturbed generation of vocal resonance as a function of defect localisation. Tumour removal to be performed in sano calls for an appropriate reconstruction potential that clearly reduces the operating surgeon's doubt as to whether the defect can be closed on completion of surgery [19], [20]. Nevertheless, one should be aware of the fact that any tissue replacement can compensate for lack of volume, but not or only partially for mobility and sensitivity. It was not until the mid-sixties that marked progress was experienced in the plastic reconstructive surgery of the oropharyngeal region. Prior to that, plastic reconstructive surgery in the cephalocervical region had been mainly restricted to closing facial skin defects by local flapping. The first major breakthrough was seen when McGregor, in 1963, described a reconstruction method for the oral cavity by using a forehead ribbon-flap. In 1965, Bakamjian inaugurated the deltopectoral flap which, then and over a decade, represented the standard method adopted to close major defects in the cephalocervical region. Disadvantages of McGregor's forehead flap and, possibly, Bakamjian's deltopectoral flap were both the unsatisfactory cosmetic result and the need to reposition the flap ribbon in a second, even though minor operation. Free revascularised transplants, first put to clinical use in major numbers in the seventies, have failed to maintain hold in cephalocervical surgery to date. Pioneering work was done in 1959 by Seidenberg who proposed to transplant a jejunal segment to replace the hypopharynx and the cervical oesophagus including vascular anastomosis, and put the idea into practice in animal experimental work. The first transplantation of a free revascularised jejunal segment in man was carried out by Roberts and co-workers in 1961. Given the short inconstant vascular pedicle of the superficial iliac circumflex artery and the comparatively large volume, the inguinal flap was abandoned as a free revascularised transplant. Just beginning, the use of

microsurgically revascularised transplants in the cephalocervical region was choked in the late seventies by vascular-pediculate myocutaneous island flaps, which were easily and reliably dissected and did not require microvascular anastomosis. In 1976, Olivari presented in his method and dissection technique the latissimus dorsi flap, and in 1979 Ariyan put before the public the pectoralis major flap. However, both myocutaneous island flaps were restricted in their applicability; not all of the regions in the oral cavity, the oropharynx and the hypopharynx could be reached because of the limited length of the vascular muscle pedicle and often the flaps were very bulky [21]. The oral surgeons Reuther and Steinau as well as the ENT specialists Meyer and Schultz-Coulon essentially contributed to ensuring that microsurgically revascularised transplants became established in plastic reconstructive surgery of the cephalocervical region. They preferably used the microsurgically revascularised jejunal transplant; Reuther and co-workers employed the antimesenterically incised jejunal segment as patch in the oral cavity or the oropharynx; Meyer and Schultz-Coulon adopted the jejunal segment maintained in its tube shape for reconstruction of the hypopharynx [22], [23], [24]. Clinical experience shows that the jejunal patch, while having a low mechanical load withstand capability, tends to shrink. It is, however, a substantial disadvantage that laparotomy is needed for jejunal-segment resecting which involves an additional major risk for the oncologic patient. The dissection technique of the fasciocutaneous forearm flap was developed by the Chinese workers Yang and Gufan in 1978. In 1982, Mühlbauer and co-workers made the microsurgically revascularised fasciocutaneous forearm transplant public knowledge outside China and it has since competed with the jejunal free flap. The forearm transplant too is thin and supple. Given these properties which permit good modelling of the transplant, the forearm transplant is suited to close flat defects including mucosal replacement in the oral cavity and the pharynx. Harii was the first to describe reconstruction of the hypopharynx by means of a forearm transplant shaped into a tube [25]. Investigations by Baumann and co-workers showed that, in the region of the oral cavity and the oropharynx, the forearm transplant is incorporated at the level of the surrounding mucosa and adjusts very well to the latter. Under the influence of the intraoral environment, the skin graft being typically whitish at the beginning then takes on an increasingly rosy colour, so it is different to tell from the neighbouring mucosa. In addition to macroscopic adaptation, a microscopic adaptation of the antebrachial epithelium to the local mucosa is seen. Differentiation between the various layers, i.e. the basal-cell layer, the prickle-cell layer, the granular layer and the horny layer, is typical of the orthokeratotic squamous epithelium of the antebrachial skin. Once the donor epithelium has been exposed to the oropharyngeal environment for two years, no such differentiation is noticed any more. The granular-cell layer will then be entirely missing. Orthokeratosis changes to parakeratosis that is typical of those areas of the oral and the pharyngeal mucosa which are exposed to a lesser mechanical load, with isolated goblet cells occurring [26]. The fasciocutaneous forearm flap gained importance from a functional perspective as well. In 1989, Hagen presented the establishing of a permanent voice fistula using a free forearm flap following laryngectomy.

Contrary to initial mistrust, complications and side-effects on the donor-site defect in case of fasciocutaneous forearm flap are minor [19], [20]. Most frequent complications observed which are expected to be tolerated by patients are sensibility disorders of the thumb and the first two fingers of the hand concerned; these are attributable to an alteration of the superficial branch of the radial nerve. Today, in addition to the jejunal flap and the fasciocutaneous forearm flap, a great many donor areas are available for microsurgically revascularised tissue transfer, including the latissimus dorsi muscle flap, the rectus abdominis muscle flap, the gracilis muscle flap, flaps from the scapula region, flaps from the iliac-crest region, and the fibula flap, which all have become established in reconstructive surgery in the cephalocervical region.

5.1.1 Tumour Localisation in the Oral Cavity

Substance defects in the region of the lips, jaws, body of the tongue and floor of the mouth, with motor and sensibility disorders, impair the oral preparatory phase and the oral phase. Reduced bolus control and impaired chewing, retarded oral transport and repeated tongue movement, delayed pharyngeal swallowing as well as reduced laryngeal elevation and cricopharyngeal opening in case of loss of the oral-diaphragm muscles are signs of dysphagia often noted postoperatively (Table 6 (Tab. 6)). Incomplete closure of the lips results in drooling. Impaired oral bolus control occurring in case of

tongue and oral-diaphragm defects may entail leaking accompanied by predeglutitive aspiration. For the glossal function, the primary governing criterion is mobility, followed by the volume of the remainder of the tongue. Therefore, patients with primary closure of the wound or CO laser technology with air-dressing for tongue partial resection of less than 50% have a favourable prognosis with respect to the swallowing function. Where the extent of a hemiglossectomy is exceeded, with co-existing complex oral-diaphragm defects, closure of the defect by a myocutaneous flap or a microsurgically revascularised graft is indicated from a functional perspective. Hsiao and co-workers, by adopting videofluoroscopy, proved that, in terms of function, primary closure after partial glossectomy in excess of 50% is less favourable than restoring the volume of the tongue by a fasciocutaneous forearm flap. In contrast to primary closure, the forearm flap yielded a better tongue-to-palate contact with good passage of the bolus [27]. The deeper the defect in the floor of the mouth, the greater should the graft be. Jejunal free interposition reconstruction is the graft of choice for extensive lining of both the cheek and the lateral oral diaphragm. At the transition from the oral cavity to the oropharynx, however, satisfactory functional results can also be achieved by using the fasciocutaneous forearm flap [27], [28], [29]. Hara and co-workers, in their patients, did not see any differences with respect to functional outcomes between the fasciocutaneous forearm flap and the forearm flap used as an alternative following intraoral reconstruction [29].

The free flaps of the scapula region are advantageous in that they can be harvested as osteocutaneous flaps. This, while closing the soft-tissue defect, also permits mandibular reconstruction following continuity-interrupting mandibular resection. For restoring the mandibular continuity, Remmert has recommended to use fibula grafts in conjunction with other microsurgically revascularised grafts for intraoral soft-tissue replacement [30].

Following total glossectomy, given the lack of propulsive tongue force, reduced laryngeal elevation and delayed opening of the pharyngo-oesophageal sphincter, there is a high risk of combined pre-, intra- and postdeglutitive aspiration. The high-volume grafts from the latissimus dorsi muscle and the rectus abdominis muscle are suitable for tongue replacement following total or subtotal glossectomy [31], [32]. Remmert [33], for defect closure following tumour resection in the region of the body of the tongue, favoured the neurovascular infrahyoid fascial flap named after this worker. For large defects of the tongue, it has turned out to be disadvantageous that the muscle graft must be additionally covered with another free graft (forearm flap). As claimed by the worker, this neurovascular flap, in contrast to the non-innervated myocutaneous island flaps and fasciocutaneous grafts, is characterised by a markedly lower tendency to shrink and a voluntary muscular contraction.

Interestingly enough, Yoleri and Mavioglu reported in the year 2000 that they used a free gracilis muscle transplant for tongue replacement following 90% glossectomy. The only motor nerve of the gracilis muscle, a branch of the obturator muscle, was anastomosed to the hypoglossal nerve. The postoperative EMG revealed re-innervation of the graft with active mobility. Oral aspiration-free food intake was possible [34].

5.1.2 Tumour Localisation in the Oropharynx

Tumour resection in the oropharynx impairs both the oral and the pharyngeal swallowing phases. The pattern of disturbances comprises reduced bolus control, slower-than-normal bolus propulsion, restricted pharyngeal-wall contraction, and reduced hyoid-laryngeal elevation. These result in insufficient airway protection with combined intra- and postdeglutitive aspiration. As proposed by Walther [35], sufficient triggering of the reflex pharyngeal phase of swallowing can be expected if at least half of the oropharyngeal segment is retained. Circumscribed defects in the tonsillar region, the lateral pharyngeal wall as well as the base of the tongue can undergo primary closure, or be left to secondary granulation after laser surgery, with no marked dysphagia occurring. The base of the tongue represents a highly sensitive structure for the proper sequence of the pharyngeal act of swallowing. As described by Steiner and co-workers laser surgical resection, even of advanced carcinomas of the retrolingual region, is possible within certain limitations, with good functional results achieved. Exclusion criteria because of severe dysphagia anticipated, accompanied by permanent aspiration, are a verifiable tumour infiltration (greater than 2 cm) of the intrinsic lingual muscles and/or tumour infiltration of the extrinsic muscles of the tongue greater than 4 cm. Furthermore, a high risk of

severe persisting aspiration exists with laser surgical basilingual resection performed in combination with extensive resection of the lateral pharyngeal wall and the rear oral cavity or supraglottic structures including the pre-epiglottic space [36]. The fasciocutaneous forearm graft, given its good passive mobilisability and the thin and usually glabrous proportion of skin, is suited for pharyngeal tissue replacement. As claimed by Remmert [33], the fasciocutaneous forearm flap in combination with an infrahyoid fascial flap represents an optimal approach following complete resection of the base of the tongue. For reconstruction of the complete base of the tongue, a laryngeal pull-up should be consistently performed so as to preclude aspiration. Non-absorbable suture material is employed to tie the thyroid cartilage together with hyoid bone to the bony chin. Ventrocranial displacement causes the oesophageal inlet to widen while enhancing the protective effect of the new base of the tongue, as well as an indirect increase in volume of the reconstructed lingual portions with reduction of the dead space of the oral cavity [33]. Smith and co-workers insist that the functional results after oropharyngeal defect closure as seen for jejunal and fasciocutaneous forearm flaps did not differ [37]. Use of the forearm flap is also indicated for replacement of the soft palate [19], [38], [39]. Without restoring the velopharyngeal closure following resection of the soft palate, in combination with the hard palate as may be appropriate, both nasal regurgitation and rhinophonia aperta have been observed. In the light of own experience gathered with 158 patients, the worker prefers the fasciocutaneous forearm flap both in the oral cavity and in the oropharynx (Figure 2 (Fig. 2)).

5.1.3 Tumour Localisation in the Hypopharynx and the Larynx

For a swallowing function to be rehabilitated following larynx-preserving tumour surgery, it is an essential requirement that a movable arytenoid cartilage be retained, whereas for respiration without tracheostoma the circumference of the annular cartilage must be maintained. Basically, rehabilitation of swallowing after transoral laser surgery, as long as the known limiting structures in the larynx and the pharynx are maintained is more advantageous as the extralaryngeal muscles as well as the supplying nerves, in particular the superior laryngeal nerve, can be treated gently. The following pathophysiological components can give rise to aspiration after laryngeal and hypopharyngeal surgery:

- Retention in the inlet of the larynx with consecutive secondary intradeglutitive aspiration after swallowing;
- Late triggering of the deglutition reflex with predeglutitive aspiration being possible because of pharyngeal sensibility disorders;
- Incomplete laryngeal closure;
- Reduced laryngeal elevation after transection of the suprahyoid muscles;
- Reduced pharyngeal contraction;
- Silent aspiration because of a reduced or missing cough reflex.

The main problem ensuing from supraglottic partial resection of the larynx is intradeglutitive aspiration as a result of the loss of two out of the three laryngeal closure mechanisms (epiglottis, vestibular folds, and aryepiglottic folds). Extending the resection into the base of the tongue will clearly impair the prognosis of dysphagia. Vertical partial laryngeal resection, despite incomplete glottic closure, is better compensated for with respect to the power of swallowing than a horizontal supraglottic partial laryngeal resection [18]. As reported by Steiner et al. as well as Rudert and Hoft, swallowing and thus oral food intake following larynx-preserving transoral laser surgical resection of hypopharyngeal carcinomas (preferably T and T) are impaired to a minor extent only [40], [41]. Transcervical larynx-preserving surgery has also been reported for laryngeal and hypopharyngeal carcinomas with unilateral thyroid-cartilage and cricoid-cartilage destruction. While Hagen favoured a fasciocutaneous forearm flap consisting of two separate epithelial islands without cartilaginous filling, Siegert et al. preferred reconstruction of the hemilarynx from costicartilage including chondrosynthesis used to support a fasciocutaneous forearm graft for mucosal replacement [42], [43]. Following laryngectomy, no negative hypopharyngeal pressure is built up and, hence, there is failure of active opening of the pharyngo-oesophageal segment. Therefore, to minimise the resultant increase in resistance occurring as the bolus passes, it is recommended that myotomy of the cricopharyngeal musle be performed

during laryngectomy in a preventative approach. Where in addition to laryngectomy, partial or even total hypopharyngectomy is required with a need for plastic reconstructive surgery, the disorder pattern is more pronounced.

The following plastic reconstructive methods are available for one-operation restoring of pharyngeal continuity after laryngo-pharyngectomy: vascularised myocutaneous island flaps, microsurgically revascularised forearm flap, jejunal free interposition, free colon interposition, transdiaphragmal gastric pull-up.

Studies conducted by Walther as well as Walter et al. who look at initiation of swallowing as the key criterion for general deglutitive coordination are of interest when it comes to selecting the reconstruction method in the pharynx as well as at the pharyngo-oesophageal junction. As reported, the critical regions are the inlet and the outlet of the pharynx at the beginning and the end of the pharyngeal phase of swallowing. The topographical correlates are the base of the tongue and the pharyngo-oesophageal segment. Resection at the base of the tongue leads to volume deficiency which, in turn, is noted manometrically in terms of a pressure decrease. Hence, plastic reconstructive surgery must be carried out to fill in preferably tissue that is missing at the root of the tongue, thereby enabling swallowing to be initiated. Resecting at the pharyngo-oesophageal juncion entails circular defects which add to the change in size between the wide-lumen pharyngeal tube and the oesophageal inlet. For this application, low-volume reconstruction is required so that the resistance presented for the bolus to pass is kept small and passive channelling of the bolus be ensured as may be necessary [35], [44]. These requirements are primarily satisfied by jejunal interposition, with the fasciocutaneous forearm flap ranking second. Frick and co-workers [45], Oniscu et al. [46], Bhathena [47], and Benazzo et al. [48] favour a jejunal loop for total pharynx reconstruction. Germain and co-workers [49], Bootz et al. [50], Urken [51] and Scharpf and Esclamado [52] advocate fasciocutaneous forearm flaps for total or subtotal reconstruction of the pharynx. In the face of own experience, good results are obtained with the fasciocutaneous forearm flap which, shaped into a tube either alone or together with the remaining hypopharyngeal mucosal strip, is anastomosed at the base of the tongue and at the oesophagus (Figure 3 (Fig. 3)). Simultaneous implanting of a Provox voice prosthesis is possible. Germain and co-workers [49] and Bootz et al. [50] proposed that the forearm flap be sutured U-shaped paramedian to the prevertebral fascia. In addition, both the oropharyngeal posterior wall and the oesophageal posterior wall must be adapted to the prevertebral fascia. A salivary drain tube is placed temporarily so as to preclude wound dehiscence. These steps provide a 'downcomer' that is widely open to permit unrestricted passage of the bolus into the cervical oesophagus. Disa and Cordeiro approved the fasciocutaneous forearm flap for partial hypopharyngeal defects of less than 50% only, so stenoses can be ruled out [53]. The jejunal free flap, unlike the more robust fasciocutaneous flaps, shows a very sensitive response to postoperative, including transitory, hypoxia. Less severe sequelae include an anastomotic leak between the intestine and local tissue, with subsequent narrowing, as described for 20 to 30% of the cases [45], [54]. Primary graft necrosis has been reported for 6 to 13.5%. Alternatively, it has been proposed to use a transverse colon graft, which is more resistant to ischaemia, to restore pharyngeal continuity following transverse laryngo-pharyngectomy. However, those publications were only related to small numbers of patients [55], [56]. Placement of a Provox voice prosthesis between the tracheal posterior wall and transposed colon has been reported to be practical [57]. In addition to fasciocutaneous free flaps and intestinal grafts, the transdiaphragmal gastric transposition first described in 1960 is being discussed for circular replacement of the pharynx. Triboulet and co-workers, Martins, Jones et al. and Ullah et al. have insisted that this operative technique is indicated which, while including laryngo-pharyngectomy, comprises complete oesophagectomy for major hypopharyngeal carcinomas with tumour infiltration of the cervical oesophagus. Those who advocate this method anticipate better oncosurgical results from radical removal of mucosa of the upper swallowing tract that is potentially considered for a second carcinoma [54], [58], [59], [60]. Compared with harvesting of fasciocutaneous flaps, all visceral reconstruction methods have an inherently greater-than-normal donor morbidity. Since the prognosis of advanced hypopharyngeal carcinomas is as bad as ever, this aspect should be definitely taken into account in selecting the suitable reconstruction method. The pectoralis major myocutaneous flap which is considered a reliable reconstruction approach to closing hypopharyngeal soft-tissue defects, in particular of pharyngocutaneous fistulae, - because of its rigid volume - increases the resistance

which the bolus encounters in passing [61]. A look into the future was taken by Strome et al. who, in 2001, successfully performed laryngeal and pharyngeal transplantation in man [62] (Table 7 (Tab. 7)).

5.1.4 Dysphagia after Irradiation

The incidence of dificulty in swallowing after radiation was reported as roughly 40%, with motility disturbances predominantly observed in the oral and the pharyngeal phases [63]. While the acute radioreaction because of mucositis is mainly characterised by odynophagia, chronic salivary-gland impairment with xerostomia, mucosal oedema and fibrotic changes in pharyngeal and cervical soft tissue comes to the fore in the course of time. Late triggering of the deglutition reflex, poor base of the tongue to pharyngeal wall contact, diminished pharyngeal peristalsis, reduced epiglottic tilt, and restricted hyoid laryngeal elevation all have an impact on deglutition [64], [65]. Retention of food and saliva as well as pre-, intra- and/or postdeglutitive aspiration can be demonstrated consecutively [66], [67]. In a study conducted in patients with Stage III and Stage IV oral and oropharyngeal carcinomas, Scheithauer et al. provided evidence that a primarily combined percutaneous/interstitial radiation did not yield better functional results than observed after resection of the tumour with subsequent radiotherapy [68].

5.2 Stenoses

Stenoses of the oesophagus are congenital or acquired, malignant or benign, of primary or secondary origin. The endoluminal dilatation therapy is symptomatic, not causal. There is a basic difference between bouginage of the stricture with balloon dilatation, and bouginage with dilators of increasing size which are slid over a previously placed guide wire. At any rate, it is recommended that bouginage be performed with image converter control. Today, bouginage as the sole therapeutical measure is only acceptable for benign cicatricial stenoses including ring and web formation [69], [70]. For malignant stenoses, it is considered a preparatory measure for supplementary endoscopic techniques.

Malignant stenoses

Since less than 40% of the patients presenting with oesophageal cancer, when first diagnosed, are suited for tumour resection with a curative objective, endoscopic palliative therapy is of great importance. A total five-year survival rate of less than 5% and a six-month median survival with unresected tumour document the poor prognosis of oesophageal cancer. Therefore, eliminating the agonising dysphagia is the prime consideration of all therapeutic efforts.

Hence, already in the seventies of the 20th century, plastic tubes were implanted in the oesophagus so as to recanalise the lumen. The size of the endoprosthesis and the rigidity of the material used called for aggressive prior dilatation of the tumour stenoses, which were accompanied by a correspondingly high complication rate, mainly perforations and bleeding.

The development of self-expanding metal stents in the nineties marked a considerable advance in interventional endoscopy. Within a short period, these stents which may be made of stainless steel, an aluminium alloy or a titanium-nickel alloy (the synonym being nitinol), proved to be an efficient therapy concept for quick and minimum-complication elimination of dysphagia in oesophageal stenoses [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94]. It is by covering the stents with a polyurethane sleeve that tumour growth is efficiently counteracted through the stent meshes. A plastic sleeve or a nylon crochet thread is used to fix the covered or non-covered flexible expandable metal stents on a positioning catheter in folded condition. Once released, flexible expandable metal stents, with a small diameter of the implantation system (8 mm), feature a wide lumen (max. 23 mm) and they are hardly at the risk of becoming dislocated. Also stenoses near the oesophageal inlet which, because of the pressure which the proximal bell exerts on the cricoid region as well as the risk of becoming disclocated towards oral, are not suitable for plastic tube implantation can be controlled by adopting this method. The stents are placed while making combined use of imaging, endoscopy and radioscopy. The introducing catheters are provided with radiopaque markers to facilitate intraoperative visualisation. While the stent including the carrier system was developed for handling with the flexible endoscope our experience shows that, in the region of the cardiac orifice and the cervical oesophagus, the stent can be reliably placed by using the

rigid tube in front of the stenosis under visual control. Control endoscopy can be performed by means of the flexible device at any rate.

A randomised prospective study undertaken to compare the most common expandable metal stents - Ultraflex® stent, Flamingo Wall stent®, Gianturco Z stent - did not yield any statistically significant differences with respect to therapeutical success and complication rate experienced in implanting [95]. However, the relatively large physical differences of the various expandable metal stents can be advantageously used for the individual localisations in the oesophagus. Once deployed, the Gianturca stent does not undergo a change in length. The Wall stent® and the Ultraflex® stent, when released, become shorter by roughly 30%. In the light of own experience gathered, covered Ultraflex® stents - given their flexibility - have turned out to be useful also for stenoses in the cervical oesophagus and in case of deviation occurring in the course of a stenosis as a result of additional extraluminal tumour growth from outside, in all oesophageal sections. This was confirmed by Profili et al., even though with non-covered nitinol stents [96].

With the larynx preserved, however, placing a stent in the tumour-affected hypopharynx or upper oesophagus is not technically feasible. Following laryngectomy or laryngo-pharyngectomy, correct stent positioning - in case of tumour recurrence - is well managed at the difficult-to-treat hypopharyngo-oesophageal junction (Figure 4 (Fig. 4)). The Ultraflex® stent is knit from a single thread of a highly flexible titanium-nickel alloy. The stent ends that open in a slightly bell-shaped configuration have a rounded mesh termination without sharp edges. As the finger ring is retracted the suture crochet knots serving to compress the stent on the delivery catheter are unraveled in a circular manner, gradually deploying the stent. When the stent is released the position of the metal endoprothesis cannot be corrected any more. The radial forces of the Strecker stent gradually dilate all the strictures to the maximum stent diameter. Immediately after implantation, the stent is deployed 60-80% only, especially in areas of high-degree constriction.

Conditions resulting from migration or stent ends overgrown with granular tissue present a problem and need to be treated. Verified histologically, the pressure necroses caused by the metal meshes are replaced by granular or fibrosing tissue covered with squamous epithelium. Exuberant granulation tissue on the uncovered stent parts is treated with argon plasma coagulation. Currently, argon plasma coagulation is the most efficient method for recanalising occluded metal endoprotheses, with the metal filaments of the stent not being damaged.

Benign stenoses

While expanded-metal stent placement has become firmly established in the palliative therapy of malignant obstructions, it is still an exception in benign stenoses [97], [98], [99]. Given the very bad prognosis for patients with oesophageal cancer, with a very short survival, long-term effects of the stent implanted in the oesophagus are not yet adequately known. The restraint exercised in case of benign stenoses is due to the problems incurred with stent extraction which, in most cases, entails destruction of the stent and may cause oesophageal injury. The Choostent[™], which is continuously coated with a polyurethane membrane, opens up new prospects in the endoscopic therapy of benign oesophageal stenosis. Two small bands are fastened to the inner ends of the stent to enable the stent to be removed as may be necessary. For patients with cicatricial stenoses at the hypopharyngo-oesophageal junction following transverse laryngo-pharyngectomy, expanded-metal stent placement should be considered an individual useful alternative where, at the given time, other invasive treatment would not be reasonable for, or disapproved of by, the patient. Where patients present with a benign disease there should always be a possibility of removing the stent or resecting the stenosis, and it should be technically feasible for the operating surgeon.

5.3 Fistulae

5.3.1 Pharyngocutaneous Fistulae

The pharyngocutaneous salivary fistula, being the most frequent postoperative complication after laryngectomy, has been reported to have an incidence in the range from 5.5% to 39%. Predisposing factors for their development, while including the extent of pharyngeal soft-tissue resection and the

type of pharyngeal closure, are preoperative radiation, R1 resection, superinfection of the operating area, and comorbidity of the patient (diabetes mellitus, arterial sclerosis) [100], [101], [102], [103], [104], [105]. Potential treatment includes direct draining, i.e. saliva-draining or saliva-bypassing, intervention as well as reconstructive surgery. Spontaneous closure is achieved only if there is little salivation permitting sufficient sticking of the granulation surfaces. It can be facilitated very efficiently by temporary implanting of a Montgomery salivary bypass tube [106], [107]. Neumann and Schultz-Coulon [104] proposed for cases of a pharyngocutaneous fistula that a pharyngostoma be consistently created at an early stage. From the author's viewpoint, a subtly differentiated approach is necessary so as to avoid overtreatment. A localised pharyngocutaneous fistula may develop as a result of suture dehiscence because of an infection if in the primary surgery only little hypopharyngeal mucosa was resected. Laryngectomy performed to treat an advanced tumour restricted to the endolarynx represents a typical situation. Specific systemic antibiosis and careful local wound treatment allow such fistulae to heal up as expected. Large pharyngocutaneous fistulae develop if the primary surgery was accompanied by a extensive hypopharyngeal-mucosa resection and, subsequently, primary pharyngeal closure was forced or total flap or transplant necrosis occurred after plastic reconstructive surgery. In such cases, spontaneous closure of the fistula cannot be expected. To condition the neighbouring vital tissue it is recommended that a pharyngostoma be created or a temporary salivary bypass tube be placed. Bakamjian's deltopectoral flap and the myocutaneous pectoralis major flap have proved to be reliable methods for definitive closure of the pharyngeal fistula. Nasogastral tubes, specifically when left in situ for any lengthy period, produce additional pressure necrosis on the hypopharyngeal and the oesophageal mucosa. It should, therefore, be decided at an early stage to perform PEG so as to maintain enteral nutrition. Experience shows that, in patients presenting with a pharyngocutaneous fistula, the nasogastral tube should not be left in place in excess of three weeks. Frequently occurring infections with multiresistant Serratia marcescens, which is known as a so-called catheter germ (tracheotomy cannula!, nasogastral tube!), present problems in the therapy. León and co-workers and Varvares et al. propagated the placing of a Montgomery salivary bypass tube intraoperatively in the primary tumour surgery to protect the pharyngeal suture and, thus, prevent a pharyngocutaneous fistula from developing, in particular in patients where the continuity of the pharynx was restored by plastic reconstruction [106], [107].

5.3.2 Tracheo-oesophageal Fistulae

Oesophago-tracheo-bronchial fistulae at adult age can develop because of necroses of an infiltratingly growing oesophageal or bronchial carcinoma. In patients affected, they lead to aspiration and dyspnoea, accompanied by an elevated risk of pulmonal infections, to fast deterioration in the general state of health and, while survival is short, patients suffer a lot. Where an oesophago-tracheo-bronchial fistula develops, surgical treatment with a curative aim - given the advanced tumour growth - is not practical any more. Palliative surgery is little promising and, on the face of a mortality rate in excess of 50%, it is a high-risk chance. Today, endoscopic intervention with sealing of the fistula by single stenting of oesophagus or trachea, or double stenting of oesophagus and trachea, is the method of choice, in most cases permitting fast change of the symptoms for the better which, considering the short life expectancy of only few months, is critically relevant to the quality of life [108], [109]. The self-expanding covered oesophageal stents indicated for the therapy of oesophageal stenoses in Section 6.2 are suited to bridge oesophago-tracheal fistulae. The implantation technique in the oesophagus is identical. Oesophago-tracheal fistulae can also be sealed by means of tracheal stents which, like for the oesophagus, are available as self-expanding stents of nitinol (covered Ultraflex Pulmonary Stent), or made of silicone with polyester mesh (Polyflex Stent). For tracheo-oesophageal fistulae close to the bifurcation, use can be made of the y-shaped Dynamic stent which was modelled on the human trachea. A tracheal leg and the two bronchial legs produce the y-shape. On the Dynamic stent, the function of the bridges of cartilage that stabilises the geometry of the trachea is performed by horseshoe-shaped metal clips embedded in a silicone matrix. Exactly as on the real trachea, a flexible dorsal diaphragm enables a sufficient dynamic reduction of the cross-section to be achieved so efficient coughing is possible, thereby reducing mucostatic problems. Where technically practical, it is advisable that, to start with, the primarily pathologically altered organ either the oesophagus or the trachea - be provided with a stent. In 80 to 90% of the cases, sealing the

fistula sufficiently with a stent is successful. Exceptional cases call for synchronous stenting of the trachea and the oesophagus [110], [111]. Given the pressure exerted by both stents in a double-stenting approach on fibrotic bradytrophic tissue previously damaged by radiation, chemotherapy and/or surgery in the tracheal and the oesophageal region, a size reduction of the fistula can - as a rule - hardly be expected. While the improvement in survival is small in case of tumour-induced oesophago-tracheal fistulae, the gain in the quality of life is crucial. As is true for dealing with incurable tumour patients everywhere, while considering the overall practicality of interventional oesophagoscopy or tracheo-bronchoscopy, one has to scrutinise consistently on a case-by-case basis whether the therapeutic measures would actually prolong the patient's life, and not the patient's dying.

5.4 Hypopharyngeal Diverticulum

The hypopharyngeal diverticulum is one of the infrequent causes of dysphagia and odynophagia. It was probably first described by Abraham Ludlow in 1764 who had performed the postmortem examination of a 60-year-old patient with fatal dysphagia. The post-mortem revealed a large hypopharyngeal diverticulum which extended into the thorax. More than 100 years later, in 1877, Zenker described an identical condition. He defined the disease as blind loops at the pharyngo-oesophageal junction. Mörsch and Judd (1962) found that the incidence of Zenker's diverticulum in the overall population is 0.02%. Squamous cell carcinoma developing in Zenker's diverticulum is considered a rare phenomenon [112]. The hypopharyngeal diverticulum represents a sacculation of mucosa and submucosa in Laimer's triangle between the oblique part and the loop-shaped part of the cricopharyngeal muscle. Dysphagia, Globus hystericus, regurgitation of undigested food and halitosis are determining symptoms in cases of hypopharyngeal diverticulum. The diagnosis is confirmed by a double-contrast pharyngogram. Further endoscopic analysis of Zenker's diverticulum is a task to be accomplished by means of rigid endoscopy. With flexible endoscopy, in case of both blind insertion of the device and insertion with visual control, there is always a short distance in the pharyngo-oesophageal segment that cannot seen. For patients presenting with Zenker's diverticulum, one must not underestimate the substantial perforation risk ensuing from blind intubation of the diverticular sac. Surgery is the therapeutical method of choice for Zenker's diverticulum. Basically, there are two surgical techniques: Resection of the diverticular sac via cervical access with myotomy of the cricopharyngeal muscle, and endoscopic transmucous myotomy of the cricopharyngeal muscle. Endoscopic diverticulostomy in which the common wall (or septum) of the pars fundiformis of the cricopharyngeal muscle in the hypopharynx between the diverticular sac and the oesophagus is transected, dates from Mosher and was improved in the thirties by Seiffert and Dohlmann. The transcervical surgical technique which - in addition to transecting the diverticular septum - includes resecting the diverticular sac, was worked out in its present form by Seiffert (1933) and Denecke (1953). Over many years, it had been considered the method of choice. In the past 15 years, a fundamental change in paradigms has taken place in the surgical treatment of Zenker's diverticulum. Ey (and co-workers) preferred diverticular surgery 'from outside' and still in 1990 expressly recommended it to colleagues in their paper "Chirurgische Behandlung der Dysphagien im Bereich des pharyngo-ösophageal Übergangs" in the proceedings published by the Deutsche Gesellschaft für Hals-Nasen-Ohren-Heilkunde, Kopf- und Hals-Chirurgie [113]. Endoscopic transecting of the common wall was considered therapeutically inadequate and a high-risk approach on the face of unforeseen bleeding from an A. lusoria (aberrant artery) from the left aortic arch. It is thanks to Weerda and co-workers, Van Overbeek, and Hoffmann et al. [114], [115], [116] that the endoscopic technique has become widely established. Numerous publications have documented good clinical success [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127]. Once a rigid diverticuloscope is inserted and spread the common wall incised with a knife by adopting the technique initially encouraged by Seiffert and Dohlmann, or by electrocoagulation, will tighten. Transmucous myotomy of the transversal cricopharyngeal muscle fibres causes the diverticulum and the oesophagus to become a single space (Figure 5 (Fig. 5)). Currently, there are two competing techniques of diverticulostomy: Transecting with the CO laser [116], [121] and transecting with the stapler [Synonym: linear cutter, endo-clip suture cutter] [118], [119], [120], [122], [124], [125], [127]. Both techniques were performed with a rigid endoscope under microscopic control, with Weerda's

distending diverticuloscope being the most common instrument in the German-speaking region. Where the stapler originally developed for laparoscopic surgery is used the diverticular septum is stapled in a single operation in three rows at each cut edge, and is transected at the same time. The first description was given by Collard et al. and Martin-Hirsch and Newbegin who, in 1993 and independently of one another, used the stapler for hypopharyngeal diverticula [128], [129]. Hoffmann and co-workers and Maune continue to favour diverticulostomy with the carbod dioxide laser which, as they believe, can be successfully used even for small diverticular sacs [116], [130]. Van Overbeek who, in 1981, was the first to perform diverticulostomy with the CO laser under microscopic control, has surgically treated 646 patients with Zenker's diverticulum and, thus, has most extensive experience in the endoscopic diverticular surgery [115]. Having compared all endoscopic techniques (Dohlmann's technique, CO laser, stapler), he considers the stapler technique the most reliable method to minimise the risk of mediastinitis [115]. Complications most feared after endoscopic hypopharyngeal diverticulostomy are mediastinitis and intraoperative bleeding [131], [132]. Since every time diverticulostomy is performed the mediastinum is opened, placing a transnasal tube for enteral feeding and systemic antibiosis should both be mandatory postoperatively. Several workers have recommended that the mucosal edges be sealed with fibrin glue after CO laser application and mucosal sutures be endoscopically placed laterally at the hypopharyngeal-diverticular junction [131]. Van Overbeek reported that, for the extensive series of patients with Zenker's diverticulum treated by him endoscopically, the rate of mediastinitis was 2.2% [115]. Sommer and co-workers advised that the diverticular septum be scanned by using a dedicated Duppler ultrasonic probe to detect any vessels of atypical course as may be present [131]. Today, the open, conventional technique is only indicated where patients present with very large diverticular sacs that extend into the thorax [133]. One should exercise restraint when considering recent reports about diverticulostomy performed in the course of flexible oesophagogastroscopy [134], [135], [136]. The endoscopic approach and conventional surgery are of an equal standing when judging the postoperative functional outcome. Given the minimum invasiveness, the short time surgery takes, minimum traumatisation of unaffected tissue, preservation of the recurrent nerve, and repeatability, endoscopic diverticulostomy by laser surgery has become established as the therapeutical method of choice for Zenker's diverticulum.

5.5 Traumata

5.5.1 Perforations

Hypopharyngeal/oesophageal perforations are infrequent traumata which, however, consistently represent emergency situations because of the vital risks involved. As surgical intervention increases, 80% of all hypopharyngeal/oesophageal perforations are iatrogenic and intraluminal, caused by instrumental manipulation [137]. Today, it is estimated that, in 10 000 endoscopies performed, one to three iatrogenic oesophageal perforations occur, with the site of predilection being in the cervical section in about 50% of the cases. While, irrespective of the pathological finding, when rigid endoscopes are used the risk of perforation is considered to be the greatest in the third physiological constriction, lesions at the hypopharyngo-oesophageal junction are more frequent in flexible endoscopy. The perforation rate in fibre-optic endoscopy of the oesophagus has been reported to be in the range from 0.018 to 0.093%. In the literature, a perforation risk from 0.1 to 0.5% was attributed to rigid oesophagoscopy [138], [139]. In case of pathological oesophageal findings, the incidence of perforation is in the area of 0.25%. Predisposing risk factors are diverticula, severe cervical spondylosis, megaoesophagus, foreign-body indigestion with pre-existing mucosal lesions, oesophageal cancer and endoscopic intervention such as bouginage, stent implantation and laser therapy [140], with accidentally swallowed foreign bodies being special cases. Primarily traumatic, intraluminal oesophageal perforation resulting from foreign-body indigestion and iatrogenic oesophageal lesion may overlap. Despite proper practice, a pre-existing perforation may become larger when a sharp-edged pointed foreign body is extracted. The lethality of the oesophageal perforations is in the range from 10 to 50%. A lethality two to five times greater than usual has been observed in cases of therapy of an oesophageal perforation performed after a time lag. Even today, a perforation that goes untreated would have a fatal outcome almost throughout. Where there is reason to suspect a hypopharyngeal/oesophageal perforation has occurred in conjunction with an endoscopic

intervention, immediate elucidating action needs to be taken in conformity with the phased scheme shown in Figure 6 (Fig. 6). Definitive treatment after a lesion has been confirmed is a function of the localisation of the injury, the cause of the perforation, the size of the perforation, injury of adjacent structures, extent of infection, and the time that has passed from the actual perforation until the diagnosis is established. As a rule, the clinical symptoms of a perforation of the hypopharynx and the cervical oesophagus clearly differ from distal oesophageal lesions where focus is on the picture of an acute abdomen. In cases of an iatrogenically perforated hypopharynx or cervical oesophagus, the insufflation typical of flexible upper intestinoscopy often leads to a pronounced emphysema of the cervical soft parts. A characteristic feature of a perforating injury of the upper aero-digestive tract is Minnigerode's sign: Cervical emphysema between the cervical spine and the oesophagus in a lateral soft X-ray of the cervical spine. Where a hypopharyngeal or oesophageal perforation is suspected it is recommended that an X-ray picture be taken of swallowing with a water-soluble contrast medium. Over 90% of the oesophageal perforations in the mid-third and the lower third can be verified by adopting this examination technique, whereas in the hypopharynx and the cervical oesophagus the reliability of diagnosis is as little as 60%. False-negative findings are presumably attributable to the contrast medium quickly passing through the hypopharynx and the cervical oesophagus, with the contrast medium insufficiently wetting the mucous membrane. Currently, imaging diagnosis through a CT scan is considered the safest radiological method of identifying an injury of aeriferous organs in the mediastinum. A CT scan reveals even minute air accumulations in the posterior mediastinal area, providing an indirect indication even before such accumulations would be seen in the conventional pneumograph [141], [142]. Given the risk of bacterial contamination, in particular that ensuing from insufflation, many workers consider flexible oesophagogastroscopy contraindicated if and when a perforation is suspected. On the face of uncertain information obtained from X-ray diagnosis, rigid hypopharyngo-oesophagoscopy is justified if performed by an experienced endoscopist where a perforation is suspected at the hypopharyngo-oesophageal junction. Also where insufflation is dispensed with, the hypopharyngeal mucosa with the slant end of the oesophageal tube can be distended to permit safe inspection. Nevertheless, where hypopharyngeal and oesophageal perforations are identified - irrespective of their original causes -, rigid and flexible endoscopy should not be regarded as techniques complementing one another rather competing [143]. The conservative therapy comprises absolute abrosia, placing a nasogastral or nasojejunal tube, systemic antibiosis, and intensive-care treatment. It is consistently an integral part of the overall therapeutical concept, adding to endoscopic or surgical therapy [144], [145], [146]. Where perforations extend into the mediastinum in a covered form, it is appropriate for the lesion to be filled with fibrin glue [140]. Sealing a perforation that is open into the mediastinum, in the oesophageal mid-third with a covered expanding-metal stent and pleural drainage has a prognosis quo ad vitam that is more favourable than thoracotomy which is associated with a higher complication rate. Recent larger perforations of the hypopharynx and the cervical oesophagus are closed by primary suture through cervical access in combination with cervical mediastinotomy [145]. Where the cervical oesophagus is found to be perforated the sinistral transcervical access is chosen. In case of a hypopharyngeal lesion, the access depends on the affected side. Dissection is made medial of the cervical vascular sheath. Hypopharynx/cervical oesophagus can be found between the larynx or the trachea and the deep cervical fascia. The lesion is roofed with two layers (mucosa, muscularis) using time-lag resorbable suture material in introverted single-button technique and supplemented with sufficient drainage from the operating area and the upper mediastinal area. As the spectrum of minimal invasive therapy in the oesophagus becomes broader the perforation risk increases. Hence, an awareness of this problem area must be created among those colleagues who perform the endoscopy. Immediate elucidation is needed whenever there is reason to suspect a hypopharyngeal/oesophageal perforation following an endoscopic intervention. The shorter the time interval between a perforation as may have occurred in the hypopharynx/oesophagus and definitive therapy, the better is the prognosis. As reported by Nagel et al. and Mai et al., the "golden period" is within the first 12 hours; in case of surgical care after 24 hours, a drastic increase is seen for both the morbidity and the lethality [141], [147]. When making the diagnosis and therapeutical measures are initiated within the first 24 hours, the mortality is in the range from 10 to 25%. When diagnosed later, the mortality increases up to 74%. As a rule, where a recent oesophageal perforation is given surgical treatment within the first 24 posttraumatic hours. direct suture closure is possible. However, for primary suture, insufficiency rates of up to 25% have

been described [141], [146]. Compared with intraluminal lesions of hypopharynx and oesophagus, external injuries have been rare. They only occur in conjunction with an open cervical injury caused by brutish offence, accidents or with suicidal intent. A combination of external hypopharyngeal/oesophageal trauma and injury of the larynx and trachea or the large cervical vessels represents a typical injury pattern. Special emphasis is placed on transcervical surgical therapy with restoration of the integrity of the organ(s) concerned.

5.5.2 Acid/Caustic Burns and Scalds

The so-called corrosive pharyngitis or oesophagitis is predominantly caused by accidental or suicidal ingestion of alkaline solutions and, to a lesser extent, of acids [148], [149]. In children, burns are often accidental as a result of taking 'products' by mistake, thinking they are liquid food. Acid burns occurring as coagulation necrosis mainly lead to gastric lesion, as polyrospasm entails a longer retention time in the stomach. Caustic burns characterised by colliquative necrosis preferably affect the oesophagus because of a reflex cardiaspasm. Burns of the mucosal membrane fall into three degrees of severity:

Degree I - Mucosal reddening and oedema

Degree la - Locally confined

Degree Ib - Circular

Degree II - Erosion and shallow ulceration with fibrinous coats

Degree III - Deep ulceration with haemorrhaghic parietal necrosis and even complete gangrene of the oesophageal wall

In case of Degrees II and III burns, intoxication causes shock symptoms to develop, with circulatory breakdown and renal failure and even multiorgan failure. In 3 to 5% of the cases, oesophageal or gastric perforation occurs, entailing mediastinitis or peritonitis as applicable. These complications have an inherent lethality of 50-70%. In addition to the apparent therapy of the systemic intoxication, oesophago-gastroscopy is desirable to be performed within the first 48 hours so as to determine the extent of the acid/caustic burn, while combining this with the placing of a nasogastral tube. Parenteral feeding and broad-band antibiosis are imperative. Corticosteroid therapy performed in the acute or subacute phase following oesophageal burn to preclude strictures is controversial. Ulman and Mutaf, in an extensive study of 246 children conducted from 1975 to 1994, did not find a positive effect of corticosteroid therapy on wound healing and, in particular, on stricture formation [150]. However, current publications from the years 2002 [151] and 2004 [152], [153] have documented that corticosteroid therapy contributes to minimising the risk and, above all, the severity of cicatricial strictures after oesophageal burns in children. Recommended doses varied from 1.5 to 2.0 mg prednisone per kg/day [151] to 1 g methylprednisone per day [152]. As well as early bouginage, Huang et al. [153] advised that the burnt oesophagus be given support by a nasogastral tube for a month. While, primarily, a conservative therapy management would seem to be desirable, early surgery with gastrectomy and transabdominal oesophageal resection may be necessary in case of a perforation. Unless severe strictures can be adequately controlled by long-time bouginage, oesophageal resection with restoration by a bridging colon graft is indicated. The incidence of oesophageal carcinomas following burns is in the area of 7%, the average interval between burn trauma and development of a carcinoma being 30 to 40 years. Pharyngeal and oesophageal scalds predominantly affect infants aged 2 to 3 years, who drink hot liquids while unattended. Therapy recommendations are identical to those given for treatment of caustic burns.

6. Surgery of Paralytic Dysphagia

While the act of swallowing in its complexity is controlled bilaterally by the cranial nerves V, VII, IX, X, XII, the motor innervation is predominantly influenced by the vagus nerve. Even the sole failure of a vagus nerve can lead to the clinical picture of paralytic dysphagia. In patients presenting with a one-sided paralysis of deglutition, the pressure increase in the pharynx due to muscular contraction entails dilative expansion of the paralysed side of the pharynx. Pressure increase in the hypopharynx, in conjunction with persisting contraction of the pars fundiformis of the cricopharyngeal muscle, causes

the chyme bolus to be forced into the nasopharynx because of velar insufficiency, and into the trachea as a result of incomplete glottic closure. This process characterises the intradeglutitive aspiration. On relaxation of the muscles, the chyme retained in the dilated paralysed hypopharynx during the phase referred to as postdeglutitive aspiration is aspirated into the glottis as it opens. Thus, there is a permanent risk of life-threatening aspiration pneumonia. In cases of bilateral paralysis of deglutition, the symptoms and signs are more pronounced and associated with stridor [154], [155]. The time and the scope of surgical action depend on the patient's individual situation, specifically on the extent of aspiration. Both an epithelialised tracheostoma and PEG lend themselves for immediate action in the event of life-threatening complications experienced with permanent aspiration. Where patients present with a primarily unilateral paralysis of the group of caudal cranial nerves, the four-stage approach inaugurated by Denecke in 1961 has not seen any loss of up-to-dateness. It comprises

- 1. Myotomy of the cricopharyngeal muscle
- 2. Reconstruction of glottic closure
- 3. Resection of the dilated paralytic pharyngeal wall
- 4. Fixation of the paretic-side soft palate to the posterior pharyngeal wall.

Establishing an epithelialised mucocutaneous tracheostoma and the possibility of an intratracheal dressing complement the concept. Propagated by Ey et al. and designed to protect the deep air passages from aspiration, the intratracheal dressing consisting of ointment-soaked gauze tamponage was later replaced with tracheal cannulas with low-pressure cuff or obturating laryngeal stents [113]. [156], [157]. External and transoral endoscopic techniques are available for vocal fold medialisation [158], [159], [160], [161], [162], [163], [164]. Initially propagated by Denecke, external vocal fold medialisation by implanting a cartilaginous chip has not proved to be a best-practice approach. Allogenic materials, such as silicone, ceramics, hydroxylapatite, then used as an alternative for augmenting the vocal fold failed to stand the test of time. Currently, the technique introduced by Friedrich, in which a titanium sheet is placed into a thyroid cartilage window from outside (Titanium Vocal Fold Medializing Implant (Figure 7 (Fig. 7)), appears to be promising. Given the special design of the titanium sheet, the vocal fold can be medialised variably and widely [165], [166]. As reported by Hacki et al., vocal fold augmentation by collagen injection (Zyplast[®]) to treat glottic-closure insufficiency in patients following tumour surgery or in cases presenting with neurological diseases in a greatly reduced general condition of health is still clinically relevant [167], [168]. Surgical treatment undertaken to cope with a life-threatening chronic aspiration in cases of bilateral paralysis of deglutition is aiming at isolating air passages and food passages, at least temporarily.

One differentiates

- 1. Laryngeal closure techniques (glottic closure described by Montgomery, epiglottic closure described by Remacle or Brookes and Mc Kelvie, vestibular fold suturing as encoured by Pototsching);
- 2. Laryngo-tracheal separation;
- 3. Laryngo-tracheal diversion [169].

These surgical techniques are basically characterised in that they are reversible. For both laryngo-tracheal separation and laryngo-tracheal diversion, as a rule the trachea must be completely transected between the third and the fourth tracheal rings. In both techniques, the caudal tracheal remnant is used to form the epithelialised tracheostoma by infolding into the cervical skin. In laryngo-tracheal separation, the cranial tracheal remnant is closed as a blind sac, whereas in laryngo-tracheal diversion it is diverted into the oesophagus. Both techniques are technically demanding; they jeopardise the recurrent nerve on either side and result in scarring that impairs their reversibility [170]. The invasiveness of the surgical techniques is not necessarily identical with the successful outcome of rehabilitation of swallowing. Linke and co-workers gave an account of good success experienced when treating the bilateral paralysis of deglutition with a combination of cricopharyngeal myotomy and glottopexy as proposed by Montgomery [155].

7. Functional Therapy of Oropharyngeal Dysphagia

Oropharyngeal dysphagia with or without aspiration in neurologic diseases, resulting conditions after surgical treatment and/or irradiation of patients with malignant tumours of the oral cavity, pharynx and larynx, following neurosurgical intervention in the posterior cranial fossa, after cervical-spine surgery as well as after long-time intubation are all indications for rehabilitation of swallowing with phoniatric-logopaedic care, with sufficient and aspiration-free oral feeding of the patient being the key objective of treatment. As described by Bartolome, the functional therapy of swallowing is focussed on three aspects: Causal treatment methods applied to rehabilitate disturbed functions, compensatory therapeutical methods adapted to facilitate swallowing by means of substitute strategies, and aids that assist the dysphagic patient in adapting to his or her environs (Table 8 (Tab. 8)) [171]. Current aspects of the functional therapy of swallowing in neurologic patients are summarised in "Neurogene Dysphagien - Leitlinien 2003 der DGNKN" [172]. In the clinical ENT routine, however, patients following treatment of malignant tumours in the cephalocervical region will outnumber others. The elements of functional rehabilitation of swallowing following the treatment of malignant tumours in the oral cavity, the pharynx and the larynx and in neurogenic dysphagia are identical, and they are chosen to suit the pattern of dysfunction and combined into a treatment plan (Table 9 (Tab. 9)), with posttherapeutical rehabilitation comprising swallowing as the primary function as well as phonation and articulation as the secondary functions [173]. Surgical treatment of advanced carcinomas of the oral cavity, the pharynx and the supraglottis requires the hospital to have resources to facilitate deglutitive rehabilitation of patients. As a rule, postoperative day 10 is appropriate for rehabilitation to commence. Fibre-optic endoscopically controlled swallowing of methylene blue may be very helpful for orientation prior to commencement of deglutition training [174]. For in-patients, a daily therapy session of not less than 45 min should be scheduled in which everyday support is the leitmotif. Pursuant to the Heilmittelrichtlinien (German guidelines for medical measures) adopted on 16 March 2004, up to 60 outpatient therapy units may be prescribed upon completion of hospital treatment. Biofeedback methods may be pursued so as to improve learning in deglutition training. Transnasal flexible videoendoscopy for visual biofeedback has increasingly become routine practice [175], [176]. From the author's viewpoint, the following current books providing detailed guidance are particularly suited for deglutition training:

- Nusser-Müller-Busch R. Die Therapie des facio-oralen Traktes F.O.T.T. nach Kay Coombes. Springer 2004 [177]
- Motzko M, Meynczak U, Prinzen C. Stimm- und Schlucktherapie nach Larynx und Hypopharynxkarzinomen. Urban & Fischer 2004 [178]
- Hotzenköcherle S. Funktionelle Dysphagie-Therapie. Schulz-Kirchner 2003 [179]

8. Non-oral, Enteral Dietotherapy

8.1 Basic Principles of Dietotherapy

Enteral feeding through dedicated tube systems is one of the comparatively recent methods of treatment. It is not until the mid-seventies of the 20th century that the first fully balanced diet was inaugurated [180], [181], [182], [183]. Tube feeding with liquid formula diets represents the most efficient and lowest-risk approach to long-term application - provided the gastrointestinal tract is functional - so as to preclude malnutrition and its negative sequelae. The feeding tube applied through percutaneous endoscopically controlled gastrostomy (PEG) has been increasingly found to constitute the alternative to the nasogastral tube. Beside neurologic and psychic disorders, malignant tumours of the oral cavity, the pharynx and the oesophagus represent the most frequent indication for PEG. Even today, 30 to 50% of all oncological patients are malnourished. In an attempt to combat this consistently, the Deutsche Gesellschaft für Ernährungsmedizin (DGEM) - in 2004 - demanded that interdisciplinary nutrition be increasingly established in hospitals. The key diagnostic means for identifying malnutrition is to analyse daily food intake in terms of quantity and quality. In patients with an intact gastrointestinal tract capable of absorption, who cannot eat adequately for more than four days, enteral nutrition with liquid formula diets available for sip feeding and tube feeding is indicated. Pursuant to the DGEM Guideline for enteral nutrition: Oncology (2003), clinically relevant malnutrition

is assumed in case of loss of 10% or more of the body-weight. A daily oral energy supply of less than 500 kcal implies abstinence from food. An energy intake of less than 60 to 80% of the daily demand is insufficient [184]. The time in which a bolus of a given consistency can be swallowed is considered indicative of whether or not adequate oral feeding is possible. In case of more than 10 s per bolus transport, additive tube feeding is necessary. Similarly, where more than 10% of the bolus is aspired with the cough reflex preserved, or in case of aspiration of smaller bolus amounts while the cough reflex is missing, no oral feeding should be allowed [1]. It is an essential advantage of enteral nutrition compared with parenteral nutrition that the function of the gastrointestinal tract is maintained. On the intestine proper, in addition to a motility disturbance occurring in starvation phases, a quickly onsetting mucosal atrophy was observed, in particular of the proximal small bowel, with reduction in villous height and diminishing activity of the brush border enzymes [185]. A great many severe infections in oncologicl patients was attributed to intestinal bacterial permeation because of impaired integrity of the intestinal mucosa [186]. The nutritive efficiency of enteral nutrition and avoiding the adaptive changes of the gastrointestinal tract which occur in case of total parenteral nutrition predestine its primary use [185]. In the ESPEN Guidelines for Nutrition Screening 2002, the following parameters were proposed for verifying malnutrition or assessing its risk: the body-mass index (BMI), weight loss in the past three months, oral food intake in the preceding week, severity of the basic disease, and age. Patients presenting with a weight loss > 5% in one month or with a BMI < 18.5 with the general condition impaired at the same time, or with an oral food intake of less than 25% of the normally required energy supply in the past seven days, irrespective of the severity of the basic disease, need to undergo a supportive nutrition therapy [187]. A diminished total protein concentration in the serum with albumin as the main component is considered a definite sign of malnutrition. Given their short half-life, the transport proteins prealbumin (2 days) and transferrin (8 to 10 days) better reflect short-time changes in the nutritional state and are, therefore, excellently suited as follow-up and success parameters of a dietotherapy. The synergism of malnutrition and neoplasma with respect to a decrease in immunocompetence is undisputed. Lymphocytopenia in peripheral blood has been considered a typical sign of a malnourished patient [188], [189], [190]. Patients who either are unable to swallow or cannot be fed adequately in quantitative and qualitative terms per vias naturales, may be tube-fed. The tube system, the route of application and the target of the tube tip must be chosen to suit the given patient [191], [192], [193], [194]. Potential targets for the tube are the stomach, the duodenum or the proximal jejunum, with the stomach to be preferred from a physiological perspective. Tube-tip localisation distal of the inferior duodenal flexure will reduce the aspiration risk.

8.2 Feeding Tubes

8.2.1 Transnasal Feeding Tubes

Transnasal feeding tubes should not be used for purposes other than short-term feeding. Made of polyurethane or silicone, 8-14 Ch. dia. feeding tubes are considered by patients a foreign body causing trouble in the swallowing tract, preventing complete velopharyngeal closure. Moreover young normal subjects, with a transnasal tube placed, exhibited a slower swallowing act [195]. The serious risk of reflux oesophagitis with ulceration, bleeding and stenosis (so-called "tube oesophagus") as exists with the nasogastral indwelling tube can be avoided by using a percutaneous feeding tube. The maximum period for which a transnasal gastric feeding tube can be tolerated should not exceed four weeks.

The ENT specialist is believed to be familiar with the handling of a transnasal jejunal (or nasojejunal) tube, the so-called Bengmark tube. It is suited for short-term application in patients with a high aspiration and reflux tendency. The tube is placed into the stomach. It is advanced into the jejunum through normal bowel movement.

8.2.2 Percutaneous Feeding Tubes

The feeding tube applied through percutaneous endoscopically controlled gastrostomy (PEG) has been increasingly found to constitute the alternative to the nasogastral tube. Where enteral nutrition is presumed to continue for more than three weeks, a decision in favour of a PEG should be taken from

the start. It is specifically in patients presenting with carcinomas in the oropharyngeal region, for whom a long period of rehabilitation of swallowing is likely, that the PEG can be included in the overall diagnostic and therapeutical approach. It has appeared to be appropriate for the PEG to be performed either in the course of pretherapeutic panendoscopy of the upper airways and the upper food passages [196], [197], or immediately before oncosurgery [198], [199], [200]. As a rule, the PEG is a low-risk, minimally invasive procedure and, where an endoscope can be passed through the oesophagus, PEG is absolutely contraindicated only where patients present with severe clotting disorders, peritonitis, massive ascites, lack of diaphanoscopy [201]. Percutaneous endoscopically controlled gastrostomy performed in Germany in 140,000 cases annually to maintain enteral nutrition is a frequent medical intervention [202]. As well as neurologic and psychic basis diseases, ENT tumours are the most frequent indication for PEG [203], [204], [205], [206], [207], [208], [209], [210], [211]. In 2002, by general consent with physicians and employees of the Bonn University Faculty of Protestant Theology, the "Ethische Orientierung zur Ernährung über PEG-Sonde" (Ethical guide to feeding via PEG tube) was issued, clearly formulating that, in cases of malignant tumours in the oropharyngeal region and in the oesophagus, enteral nutrition via PEG is indicated as a vital and palliative measure if this is the only means to preserve the patient's life [212]. The two fundamental PEG techniques performed are the transoral cord pull-through technique and the direct-puncture method. The technically varied procedures of the two methods also entail a different in-situ support of the tubes in the stomach. Both methods have one thing in common: The patient is gastroscoped while in supine position. Following adequate insufflation of the stomach, the suitable puncture site is found in the left epigastrium by finger pressure from outside, with the gastric mucosa bulging as can be visualised endoscopically, and by diaphanoscopy. Ample insufflation of the stomach is necessary so that the organ is separated from the liver, the spleen, the small bowel and the transverse colon, and contact as wide as possible is established between the gastric wall and the abdominal wall. The best puncture site is at the transition from the mid-third to the outer third of a connecting line between the umbilicus and the middle of the left costal arch [185], [210], [213], [214], [215]. Several workers have recommended transnasal preliminary mirroring as far as the stomach using a "thin-gauge" paediatric gastroscope so as to bypass a tumour-affected oral cavity [216], [217].

PEG using the "pull" method

First introduced by Gauderer and Ponsky in 1980, the PEG using the "pull" method was modified in Germany by the working group of Keymling and, currently is the most widespread gastrostomy method. Gastroscopically controlled, the stomach is punctured with a cannula following skin incision in the diaphanoscopy-positive region. The pull-through thread is threaded through the cannula; it is then endoscopically caught with forceps and passed out of the mouth by retracting the gastroscope. This done, the PEG tube including the inner retaining plate is tied to the extraoral end of the pull thread. Pulling the other thread end, which percutaneously protrudes from the abdominal wall causes the tube to be pulled perorally and then through the gastric wall and the abdominal wall. Retained in the stomach, the inner retaining plate provides reliable protection from dislocating into the intraperitoneal space. The PEG tube is fixed to the abdominal skin by attaching the outer retaining plate [213], [218].

PEG using the direct-puncture method

Currently discussion is in hand over the controversy as to which PEG method is the best one for the ENT tumour patient. The "pull " method is uncontestedly the method of choice where patients present with normal anatomical conditions in the region of the upper food passages. However, it has the following inherent risks for the ENT tumour patient:

- 1. The inner retaining plate of the PEG tube passes through the tumour-affected pharynx or oesophagus without optical monitoring. Tumour-infiltrated anatomical structures are at a greater-than-normal perforation risk.
- 2. Tumour cells from the pharynx or the oesophagus may be carried along the inner retaining plate into the fresh abdominal wound, with the risk of iatrogenic implantation metastases developing in the gastric wall or the abdominal wall [219], [220], [221], [222], [223], [224], [225], [226], [227], [228], [229], [230], [231], [232], [233], [234], [235], [236], [237], [238], [239], [240], [241], [242], [243], [244], [245].

It is by performing a PEG by the direct-puncture method that these risks can be eliminated. In 1984,

Russel and Vestweber introduced the PEG performed by adopting the direct-puncture method. Frequently used, the balloon catheter has been regarded to have a high inherent dislocation risk. Hashiba and co-workers [246], Brown et al. [247], and Sontheimer and Salm [248] pursued the idea of permanently fixing the gastric wall to the abdominal wall by minimally invasive gastropexy [246], [248]. The T-fasteners (synonym: Cope anchors) described by Brown et al. are employed even today so as to establish a close permanent contact between the anterior gastric wall and the abdominal wall (Cope gastrointestinal suture anchor set; Cook). In 1993, a new, very reliable interventional direct-puncture technique for PEG was developed in Japan, using an easy-to-handle applicator for gastropexy.

The gastropexy, which consists of two separately localised mattress sutures placed between the ventrolateral trunk wall and the anterior wall of the stomach under gastroscopic control, guarantees that, within a circumscribed area necessary for the PEG, the two peritoneal layers are safely fixed to one another (Freka Pexact CH15®). Thus, it is almost ruled out that the balloon catheter placed in the centre of the two gastropexy sutures by direct puncture could become displaced into the free abdominal cavity [190], [248], [249], [250] (Figures 8-12 (Fig. 8), (Fig. 9), (Fig. 10), (Fig. 11), (Fig. 12)). The placing of percutaneous replacement tubes (including Flocare Gastrotube, button with retaining balloon, mushroom-shaped silicone button) which is necessary because of a defect of the PEG tube, or considered appropriate so as to improve the patient's comfort through a gastrostoma which in primary PEG was supplied with gastropexy, is unproblematic and uncomplicated. All button systems have in common a small, discrete outer retaining plate and a nonreturn valve which prevents gastric juice from exiting. Different shaft lengths of the button are available to permit individual adjustment as a function of the abdominal-wall thickness. Patients with the button system can have a bath or shower, do sports and go swimming without any restrictions. Such improvements add to enhancing the acceptance of these tubes [251] (Figure 13 (Fig. 13)).

PEG-related complications

In the current literature, the general complication rate in the PEG has been reported to be in the range from 5 - 33%. The method-induced lethality has been found to be below 1%. Severe complications (peritonitis, bleeding) requiring laparotomy, or a longer stay in hospital because of the intervention, have been noted in less than 3% of the cases. A pneumoperitoneum as seen in up to 40% after PEG is spontaneously resorbed, and does not call for surgical intervention [252], [253], [254]. Similarly, gastrocolic fistulae attributable to 'including' the transverse colon in puncture are rare, and often symptom-free over longer periods of time [255], [256], [257], [258], [259], [260], [261]. The most frequent milder complications are peristomal wound infections, their incidence estimate being 8 - 30%. Antibiotic prophylaxis prior to PEG has been discussed controversially for the past ten years. There are as many advocates of prophylactic antibiotics as there are opponents [262], [263], [264], [265], [266]. Current randomised studies have provided evidence to the extent that perioperative antibiosis under PEG, while being particularly cost-efficient in oncological patients, significantly reduces the rate of peristomal wound infections [267], [268], [269], [270]. A single antibiotic prophylaxis using Ceftriaxon 30 min prior to PEG has been recommended [190], [271], [272]. The buried bumper syndrome is a comparatively rare, severe late complication in the "pull" method, in which the inner retaining plate penetrates the gastric wall [273], [274], [275], [276], [277], [278], [279]. To date, the direct-puncture technique has been considered to have a high inherent risk for the tube to become dislocated into the free abdominal cavity [280], [281], [282], [283], [284], [285]. Gastropexy prior to direct puncture of the anterior wall of the stomach and subsequent placing of the tube essentially contribute to reducing this risk. Motsch and co-workers reported about 660 patients successfully treated with a PEG tube by adopting the direct-puncture technique with a mean indwelling period of 8 months [190]. Classical PEG not being practical in case of complete impassability of the pharynx and the oesophagus, percutaneous tubes can be placed with sonographic or radiological control (CT, radioscopy) considering, however, that both methods are still inferior to the conventional technique with respect to effort needed, safety and follow-up [286]. CT-Controlled percutaneous gastrostomy is also potentially suited where positive diaphanoscopy cannot be accomplished, including in cases of hepatomegaly or following gastrointestinal intervention. CT-Controlled gastrostomy is advantageous over fluoroscopically guided and endoscopic approaches in that it clearly visualises all anatomical structures situated in the puncture route. In imaging-controlled percutaneous gastrostomy, only PEG

sets for direct puncture can be applied, preferably with gastropexy [287], [288], [289], [290], [291], [292], [293], [294], [295], [296]. Where the upper food passages are totally obstructed, laparoscopic percutaneous gastrostomy represents a useful alternative [297]. The author's experience shows that, in ENT-related problem cases, a gas-sterilised gastroscope can be advanced intraoperatively via the opened pharynx into the stomach and the PEG tube safely placed by adopting the direct puncture method under endoscopic control. Today, laparotomy-assisted gastrostomy (Witzel's gastrostomy), given its higher abdominal complication rate, is considered only if and when none of the minimally invasive techniques can be performed.

8.3 Enteral Application Technique

Tube feeding can be administered continuously or intermittently. In continuous feeding, also referred to as continuous-drip application, diet is tube-fed in a non-intermittent process at a defined flow rate (24 h feeding, e.g. at 20 mL per hour). Of the two modes of application, i.e. gravity-controlled perfusion or by nutrition pump, pump-assisted feeding should be preferred [193], [194]. Intermittent feeding - also described as bolus application - is characterised by maintaining feeding-free intervals. It requires gastral localisation of the tube tip. This should be preferred in patients presenting with proper emptying of the stomach and where a normal absorptive function of the gastrointestinal tract is ensured, for the following reasons: Maintain the nerval, hormonal and enzymatic regulatory mechanisms through the stomach's dilating stimulus; maintain the stomach's acido-protective function through alimentary intervals; simulate a normal physiological food intake.

8.4 Tube Feed and Dosing

The basal metabolic rate of tumour patients who, while being on a normal diet, undergo an oncological therapy is in the range from 20 to 25 kcal per kilogramme of the common body-weight per day. The energy supply must be corrected for a stress factor and adjusted to the intensity of physical exercise. Standard diets, synonymous with nutrient-defined formula diets, mainly contain intact macromolecular food ingredients retained in their original form. While, referred to caloric content, consisting of approx. 50 to 60% carbohydrates, 10 to 15% protein and 25 to 40% fat, they contain all the other essential food ingredients (vitamins, trace elements), with 300 mosm/L indicating that they are roughly iso-osmolar. One millilitre of a standard has an energy density of 1 kcal (Table 10 (Tab. 10)). For nutrient-defined formula diets, a fully functional gastrointestinal tract is of the essence. Once taste corrigents (also referred to as masking flavours) are added, standard diets may also be used for sip feeding. In concentrated form with a high caloric (1.5 kcal/mL) or protein content (> 15%) they are intended to be used exclusively for supplementary nutrition. Bulkage may be added to standard diets so as to maintain the natural bowel function. Thirty to 40 kcal/kg/IBW as liquid standard formula diets per tube will satisfy the daily nutrient demand. The usual rule of thumb is that a standard-weight tumour patient requires 30 kcal/kg to keep the body-weight constant. The demand for a standard-weight patient is 2 to 2.5 L standard tube per day (at an energy density of 1 kcal/1 mL). However, tube feeding should be such that small initial doses are used and then gradually increased over several days until optimum amounts are reached. It is recommended that, after long alimentary abstinence or following parenteral nutrition, a balanced low-calorie bulkage-free initial tube feed (0.5 kcal/mL) be used that has a low osmolarity (130 mosm/L) and a high content of free fluid. Special diets, also referred to as chemically defined diets, differ from the standard diets with respect to the qualitative and quantitative composition of the various food ingredients. A predestined example of this is oligopeptide diet in which mainly oligopeptides produced through hydrolysis are offered as protein source, along with a relatively high proportion of oligosaccharides and medium-chain triglycerides. Thus, the absorption of individual ingredients of diet is largely independent of the presence of pancreatic enzymes and bile. These diets are indicated in cases of reduced absorptive capacity of the bowels and pancreatic insufficiency. Due to the osmolarity which is high on average compared with the nutrient-defined formula diets, continuous application is required via a duodenal tube [186], [191], [298]. Where a patient, rather than being exclusively administered formula diets, is given formula diets for supplementing, the quantity of food must be calculated individually and proportioned as necessary. The patient's fluid requirement can be largely met through the free liquid contained in the tube feed,

taking into account that 1 mL standard tube feed is equal to a fluid equivalent of 0.8 mL only. Hence, substitution for differences as may exist referred to the patient's individual requirement is necessary (e.g. by administering still mineral water or tea). A patient's fluid requirement can even increase for a number of reasons including temperatures above normal, secerning wounds, in patients suffering from diarrhoea, or vomiting, or carrying a tracheostoma (Table 1 (Tab. 1)). Tubes must be regularly syringed to preclude occlusions. Suitable rinsing liquids include still mineral water, chamomile tea or fennel tea (not less than 50 to 60 mL) (Table 11 (Tab. 11)). At times of budgeting of medical treatment, feeding via a PEG tube offers a cost-saving yet low-complication and efficient approach to maintaining adequate physiological and enteral nutrition in patients with insufficient oral food intake. This is confirmed by own experience gathered with 775 oncological patients at the University of Magdeburg ENT Clinic. Enteral feeding compared with total parenteral nutrition is markedly more cost-effective, with daily therapy cost being about two to 2.5 times lower. Pursuant to the DGEM-Leitlinie Enterale Ernährung: Onkologie, the daily average cost incurred for enteral nutrition including placing the PEG tube and providing patient care is €12.00 for a median period of use of 180 days [184]. To date, there has been no scientific evidence that improving the nutritional status alone will better the cancer patient's prognosis in the long run. A patient given assistance from the perspective of nutritional medicine is enabled to better tolerate specific tumour therapies without their adverse effects on the nutritional status [190]. The relationship between nutritional status, general state of health and quality of life is of particular relevance. As long as, while the disease is progressing, the quality of life can be ensured the cancer patient may not be refused adequate nutrition [299]. The feeding tube applied through PEG is appreciated by the patient who responds with a high compliance [190], [300].

8.5 Complications with Enteral Nutrition

The most frequent complications experienced with enteral nutrition are of a gastrointestinal origin, such as diarrhoea, nausea/vomiting, obstipation, and sensation of repletion. In addition to enteral nutrition as such, also therapeutical measures such as antibiosis, chemotherapy and radiotherapy can give rise to complaints in the gastrointestinal region. The incidence of diarrhoea under enteral tube feeding is in the range from 2 to 68% depending on the definition of diarrhoea. As well as the composition of the formula diet and its mode of application, medicines and infections too may cause diarrhoea. Systemic antibiosis with subsequent pseudomembranous enterocolitis due to selection of Clostridium difficile is one of the frequent causes. In addition to tube feeding through a nutrition pump, the patient should be elevated by 30° during and after food administration in those cases where a high tendency of aspiration and regurgitation exists [301] (Table 12 (Tabl. 12)).

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Figure 1: Cervical spine X-ray picture: Spondylophytes on the ventral face of the cervical vertebral bodies in Forrestier's disease



Figure 2: Soft palate replaced by a microsurgically revascularised forearm flap, 14 days postoperatively





Figure 3:

- a) Intraoperative site following transverse laryngo-pharyngectomy
- b) Fasciocutaneous forearm flap shaped into a tube and sutured into the circular hypopharyngeal defect

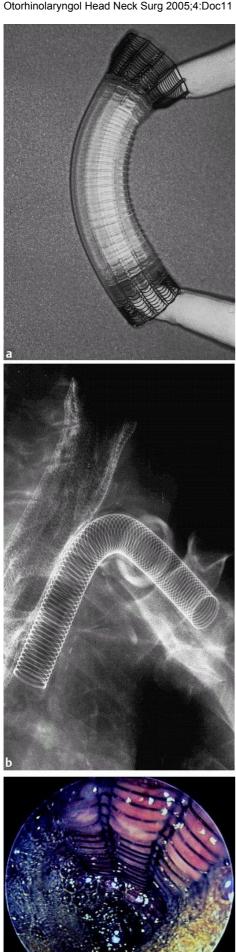


Figure 4:

- a) Self-expanding nitinol stent (non-covered);
- b) Native X-ray picture of cervical soft parts: Nitinol stent on hypopharyngo-oesophageal junction following laryngectomy;
- c) Endoscopic view of the non-covered nitinol stent





Figure 5:
a) Endoscopic view of diverticular septum after inserting Weerda's diverticuloscope;

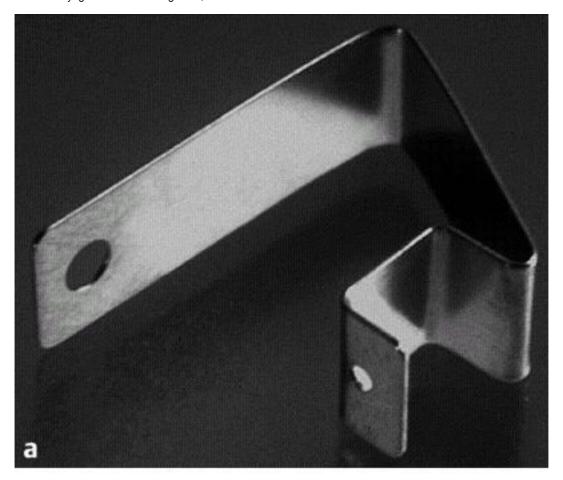
b) Status after transecting the diverticular septum with a CO laser

Diagnostik und Therapie bei Verdacht auf Hypopharynx- bzw. zervikaler Ösophagusperforation

Nativ-Röntgendiagnostik der Halsweichteile, des Thorax und des Abdomens Emphysem (subkutan Hals und Brustwand, Mediastinum) nein ja Rö-KM-Darstellung (wasserlöslich) von Ösophagus und Pharynx extraluminale ohne patholog. KM-Depots Befund CT-Hals und Thorax Beobachtung Re-Hypopharyngo-Ösophagoskopie Entscheid über definitive Therapie endoskopisch chirurgisch

Figure 6: Diagnosis and therapy in patients where hypopharyngeal or cervical oesophageal perforation is supected

konservativ



Schildknorpelfenster

Titanimplantat

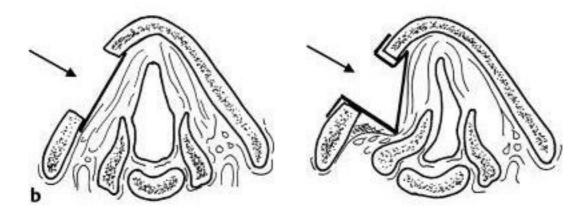


Figure 7: Thyroplastic surgery for vocal fold medialisation

- a) Titanium Vocal Fold Medializing Implant® introduced by Friedrich;
- b) Technique: An approach in which the titanium implant is introduced through a thyroid cartilage window to medialise the vocal fold

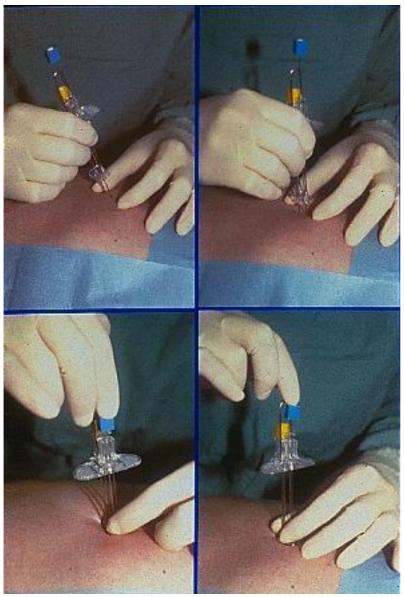


Figure 8: PEG by adopting the direct-puncture technique (Freka Pexact CH15®) following gastropexy: Two gastropexy sutures are placed at about 2 cm spacing in the diaphanoscopy-positive region. Puncture of the abdominal wall with a gastropexy applicator for gastroscopic detection of both cannulas in the stomach

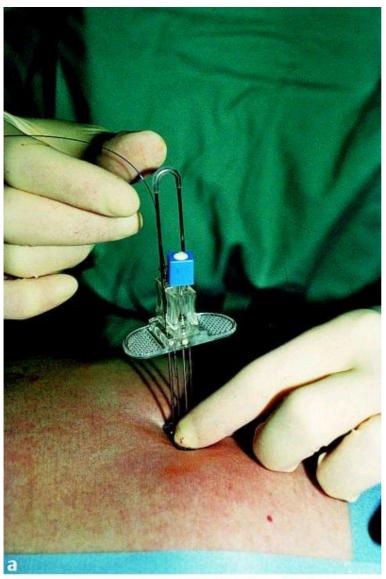




Figure 9: Threading a monofil thread until the end of the thread passes through the wire loop of the gastropexy applicator.

- a) Macroscopic picture;
- b) Endoscopic view





Figure 10:

- a) Fixing the thread;
- b) following removal of the gastropexy applicator, tying the mattress suture



Figure 11: Following stab incision of skin and fascia, direct puncture of the stomach is performed by means of a trocar witha close-fitting peel-away catheter; the stiletto is removed once the stiletto tip is identified with the peel-away catheter over two centimetres length in the stomach; the stiletto is removed; the latex-coated balloon catheter is advanced through the horizontal peel-away outer sleeve; the balloon is filled with 4 mL distilled water

- a) Macroskopic picture;
- b) Endoscopic view.



Figure 12: Removing the peel-away catheter by pulling apart both shanks. Completing the intervention while fitting and fixing the retaining plate

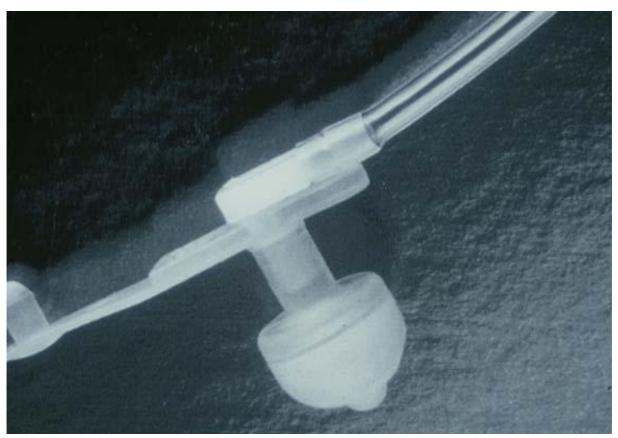


Figure 13: Percutaneous replacement tube - Button -

Level 0	No dysphagia
Level 1	Dysphagia for solid diet only
Level 2	Dysphagia for soft diet
Level 3	Dysphagia for liquids

Table 1: Classification of dysphagia [302]

Severity 1	Aspiration of chyme retained in the aditus and the laryngeal ventricle while the cough reflex is preserved.
Severity 2	Aspirate volume of approx. 10% of the bolus, with the cough reflex preserved.
Severity 3	Aspiration of less than 10% of the bolus, with the cough reflex reduced, or a volume of more than 10% with the cough reflex preserved.
Severity 4	Aspiration of more than 10% of the bolus, with cough reflex missing.

Table 2: Severities of aspiration based on cineradiographic function analysis [Hannig et al. 1995]

Severity 1	Occasional aspiration while the cough reflex is preserved.
Severity 2	Permanent aspiration with the cough reflex preserved, or occasional aspiration without cough reflex, with good voluntary expectoration.
Severity 3	Permanent aspiration without cough reflex, with good voluntary expectoration.
Severity 4	Permanent aspiration without cough reflex, without voluntary efficient expectoration.

Table 3: Severities of aspiration on the grounds of videolaryngoscopic findings [Schröter-Morasch 1996]

Oropharyngeal	- Cheiloschisis, gnathoschisis, palatoschisis.
	 Inflammations in oral cavity, pharynx, hypopharynx and supraglottis, and their complications (including epiglottitis, parapharyngeal abscess)
	 Tumours of the oral cavity, oropharynx, hypopharynx and supraglottis including post-therapeutical sequelae after surgery, radiotherapy and chemotherapy.
	- Hypopharyngeal diverticulum.
	- Extrapharyngeal compression: Nodular goitre, surgery and diseases of the cervical spine, including Forrestier's disease.
	- Acid/Caustic burns.
	- System diseases (sclerodermia, amyloidosis, graft-versus-host reaction)
Oesophageal	- Oesophageal atresia.
	- Oesophago-tracheal fistulae.
	- Gastro-oesophageal reflux disease.
	- Oesophagitis, including aphthous stomatitis, herpes.
	- Foreign body ingestion.
	- Cicatricial stenosis (Schatzki rings, webs).
	- Traction diverticulum
	- Oesophageal tumours.
	- Extra-oesophageal compression ensuing from thoracic diseases (including aortic arch aneurysm, aberrant subclavian artery, mediastinal tumours).

Table 4: Morphological causes of dysphagia

CNS	- Stroke.				
	- Degenerative diseases: Amyotrophic lateral sclerosis, Parkinson's disease.				
	- Multiple sclerosis				
	- Cerebral paresis				
	- Dementia, Alzheimer's disease.				
	- Encephalitis, poliomyelitis.				
	- AIDS.				
	- Tumours of the posterior cranial fossa.				
	Craniocerebral traumata. Intoxications Side-effects of drugs (including sedatives, neuroleptics).				
	- Arnold-Chiari malformation.				
PNS	- Cranial nerve palsy (N. V, VII, IX, X, XII).				
	- Basicranial tumours: Chordoma, meningioma.				
	- Carcinomatous meningiosis.				
	- Meningitis.				
	- Guillain-Barré syndrome (polyradiculitis).				
	- Neuropathy (ethanol toxic, diabetic).				
Neuromuscular	- Goldflam's disease.				
junction	- Oesophageal achalasia.				
	- Botulism.				
	- Lambert-Eaton syndrome.				
Muscle	- Dermatomyositis.				
	- Polymyositis.				
	- Endocrine/Metabolic myopathy.				
	- Muscular dystrophy.				

Table 5: Neurogenic causes of dysphagia (Denk, Bigenzahn 1998)

Localisation of tissue defects	Malfunction	Potential type of aspiration
Lips, jaws, tongue, floor of the mouth	Bolus uptake, bolus forming	predeglutitive
Lips, tongue, floor of the mouth	Bolus control	predeglutitive
Primary trigger areas (bases of the palatoglossal archs)	Triggering of the deglutition reflex	predeglutitive
Tongue	Oral transport; laryngeal elevation	pre-, intradeglutitive postdeglutitive
Base of the tongue, pharynx	Pharyngeal transport	postdeglutitive
Base of the tongue, supraglottis, glottis	Laryngeal closure, pharyngeal transport	intra-, postde glutitive
supra-, infrahyoid muscles	Laryngeal elevation, opening of the pharyngo-oesophageal sphincter	intra-, postde glutitive
Scarring of the pharyngo- oesophageal sphincter	Opening of the pharyngo- oesophageal sphincter	postdeglutitive

Table 6: Dysphagia following oncosurgery in the oral cavity, pharynx and larynx

Therapeutic intervention	Preventive surgical step	
Resection with consecutive vagus nerve paresis	Vocal fold medialisation	
Supraglottic/supracricoid laryngectomy	Attaching the residual larynx to the hyoid/base of the tongue	
Supraglottic/supracricoid laryngectomy	Suspending the larynx on the mandible	
Hypopharyngeal diverticulectomy, partial resection of the larynx	Cric opharyngeal myotomy	
Tumour resection	Plastic-reconstructive surgery on the tongue, velum, pharyngeal wall	
Tumour resection	Tracheostomy	

Table 7: Preventive reduction of aspiration induced by surgery

Causal therapeutical methods Stimulation Mobilisation techniques Autonomous movement exercises Compensatory therapeutical methods Compensation by patient Anteflexion of the head Poise changes: Retroflexion of the head, extension Rotating the head to the affected side Lateral position Supraglottic swallowing (easy breathhold) Swallowing manoeuvres: Super-supraglottic swallowing (effortful breathhold) Double/multiple swallowing Effortful swallowing Mendelsohn manoeuvre (voluntary elevation of the base of the tongue towards the pharynx) Compensation by diet Placing the diet Dietetic measures (including instant thickeners) Auxiliaries Eating and drinking aids Intraoral prosthetic devices

Table 8: Components of functional rehabilitation of swallowing as proposed by Bartolome (1993)

	Causal measures	Compensatory measures	Dietetic measures
Impaired oral bolus control	Tongue exercises	Anteflexion of the head	Preferably pasty diet, Thickening of liquids
Disturbed retraction of the base of the tongue	Tongue exercises for strengthening, Masako manoeuvre	Anteflexion of the head, Mendelsohn manoeuvre	Diet having a good sliding quality
Retarded triggering of the deglutitive reflex	Thermal-tactile stimulation of the palatine archs, tongue exercises	Supraglottic swallowing, Anteflexion of the head	Diet with a particularly low or high temperature, Acid bolus
Insufficient glottic closure	Tension exercises, special phonation exercises	Supraglottic swallowing, Rotating the head towards the unaffected or the affected side	Thickening of liquids
Dysfunction of the upper oesophageal sphincter	Laryngeal-elevation exercises for elevating the dorsum of the tongue, Shaker manoeuvre	Mendelsohn manoeuvre	Fluid or liquid if appropriate
Reduced pharyngeal peristalsis	Whistling, sucking, hissing	Tilting the head to the unaffected side, Rotating the head towards the paretic side, Effortful swallowing, Double or multiple swallowing if appropriate	Diet having a good flowability
Disturbances of the oropharyngeal and/or laryngeal sensibility	Stimulation of the relevant oral mucosal regions	Supraglottic swallowing in case of silent aspiration, Double or multiple swallowing	Higher-intensity gustatory and temperature stimuli

Table 9: Frequent dysphagia patterns and related methods (Leitlinien 2003 der DGNKN)

Chemically defined diets (CDD) Low-molecular substrates	Nutrient-defined diets (NDD) High-molecular substrates	
Energy density	Energy density	
1 kcal (4.2 kJ)/mL for standard diet	1 kcal (4.2 kJ)/mL for standard diet > 1.5 kcal (6.3 kJ)/mL for modified diets or diets adjusted to the particular disease	
Proteins/Amino acids	Proteins/Amino acids	
Free amino acids and/or dipeptides and tripeptides	Intact proteins from milk, soybeans or meat	
Carbohydrates	Carbohydrates	
Mono-, di- and oligosaccharides (e.g. glucose, maltodextrines)	Poly- and oligosaccharides (e.g. starch, maltodextrines)	
Fats	Fats	
Triglycerides and specific fatty acid patterns (mainly MCT)	Triglycerides (LCT>MCT*)	
Vitamins/Minerals	Vitamins/Minerals	
as per the requirements detailed in Appendix 6 of § 14b of the DiätVO	as per the requirements detailed in Appendix 6 of § 14b of the DiätVO	

^{*} LCT = Long-chain triglycerides; MCT = Medium-chain triglycerides

Table 10: Classification of balanced diets

1 to	4 to	7 to	10 to	13 to	15 to
less than					
4 years	7 years	10 years	13 years	15 years	19 years
1,550	1,900	2,000	2,200	2,400	2,700
mL/day	mL/day	mL/day	mL/day	mL/day	mL/day
110 mL/	90 mL/	65 mL/	50 mL/	40 mL/	35 mL/
kg BW					

Indicative figures of fluid supply for adults				
19 to less than 25 years	25 to 1ess than 51 years	51 to less than 65 years	65 years and older	
2,400	2,300	2,000	1,800	
mL/day	mL/day	mL/day	mL/day	
30 mL/	30 mL/	25 mL/	25 mL/	
kg BW	kg BW	kg BW	kg BW	

Day	Total daily dose of tube feed in mL	Dose mL/h	No-diet interval in h
1	500	5 x 100	3
2	980	7 x 140	2
3	1,020	6 x 170	2
4	1,470	7 x 210	2
5	1,920	8 x 240	2

Table 11: Tube feed and dosing

Complication	Cause	Prevention/Therapy
Diarrhoea	Excessive increase in amount of tube feed/day Fast administration of tube feed. Tube diet too cold. High osmolarity (> 300 mosm) Lactose intolerance. Malabsorption of fat. Hypoalbuminaemia.	Take slow initial doses into account. Reduce/Check rate of administration. Room temperature. Use isotonic nutrient solution; initially dilute hyperosmolar nutrient solutions. Low-lactose or lactose-free tube feed. Use low-fat tube feed or MCT-containing tube diet. Administer chemically defined diet and/or
	Long-time antibiotics therapy. Chemotherapy/Radiotherapy.	perform parenteral nutrition until the absorptive capacity of the small bowel is restored. Check drug schedule/Antidiarrhoetics. Antidiarrhoetics.
Nausea/ Vomiting	Fast administration of tube feed. Contamination of diet; bypass devices.	Reduce/Check rate of administration. Change bypass devices every 24 hours. Hygienic handling of administration systems. Once opened, bottles containing tube diet may be stored in refrigerator for not more than 24 hours.
Spasm/ Flatulence	Fast administration of tube feed. Lactose intolerance. Malabsorption of fat.	Reduce/Check rate of administration. Low-lactose or lactose-free tube feed. Use low-fat tube feed or MCT-containing tube diet.
Regurgitation/ Aspiration	Gastric retention.	Reduce rate of administration. Prefer duodenal tube. Elevate upper part of the body during food intake.
Obstipation	Inadequate fluid intake. Insufficient supply of bulkage.	Increase fluid supply, fluid balance. Use nutrient preparation with bulkage.

Table 12: Gastrointestinal complications in enteral nutrition - causes, prevention, therapy