Surgical errors and risks – the head and neck cancer patient

Abstract

Head and neck surgery is one of the basic principles of head and neck cancer therapy. Surgical errors and malpractice can have fatal consequences for the treated patients. It can lead to functional impairment and has impact in future chances for disease related survival. There are many risks for head and neck surgeons that can cause errors and malpractice.

To avoid surgical mistakes, thorough preoperative management of patients is mandatory. As there are ensuring operability, cautious evaluation of preoperative diagnostics and operative planning. Moreover knowledge of anatomical structures of the head and neck, of the medical studies and data as well as qualification in modern surgical techniques and the surgeons ability for critical self assessment are basic and important prerequisites for head and neck surgeons in order to make out risks and to prevent from mistakes. Additionally it is important to have profound knowledge in nutrition management of cancer patients, wound healing and to realize and to be able to deal with complications, when they occur.

Despite all precaution and surgical care, errors and mistakes cannot always be avoided. For that it is important to be able to deal with mistakes and to establish an appropriate and clear communication and management for such events. The manuscript comments on recognition and prevention of risks and mistakes in the preoperative, operative and postoperative phase of head and neck cancer surgery.

Keywords: oncology, head and neck surgery, surgical mistakes, surgical risk, prevention of surgical error

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1 Introduction

Patients with malignant tumors oft he head and neck are one of the most challenging in head and neck surgery. So far, many questions are still not answered with constant mortalities for head and neck cancer patients, who rank 8th of all cancer derived deaths worldwide. Beside the overall survival organ function such as swallowing and speech is of high relevance for patients after cancer treatment. Surgical mistakes might have a high impact on both outcomes.

Multiple parameters play an important role in a successful and complication free surgical procedure. Head and neck cancer treatment should be performed at cancer centers involving all medical specialists, that are necessary for the decision process and treatment. Before surgery preoperative diagnostics and patient selection are the first important responsibilities the surgeon is involved. Mistakes at this stage can already have a high impact on the following surgical procedure. However, despite modern technical support and highly qualified medical staff mistakes cannot always be avoided. Therefore, it is an important part of the surgeons training and competence not only to be able to early identify potential risks but also to have thorough knowledge of the correct management and communication after mistakes occurred.

In the following, possible risk sources in head and neck cancer surgery, potential mistakes and their management are discussed based on the literature.

2 Basic principles and definitions

Different terms should be defined, while talking about surgical mistakes. Using a standardized terminology, the assessment of surgical mistakes, the communication about them as well as their analysis is simplified and becomes comparable.

An **adverse event (AE)** describes a harmful occasion, which is rather based on the treatment than on the disease. Adverse events are subdivided into avoidable and unavoidable AEs. E.g. a wrong perioperative antibiotic prophylaxis resulting in a postoperative wound infection is defined as AE. An AE is often associated with harm on a patient. Otherwise it is defined as near-harmful event in case of an AE, in which possible harm could be avoided. A **medical mistake** is defined as procedure with a wrong plan, an unfulfilled plan or no surgical plan at all. A mis-

take in this context is independent from an occurred damage. This definition suggests, that we have to encounter much more mistakes in clinical reality, than one might assume. Reason defined different kinds of mistakes. We talk about *slips*, when we describe a wrong visualization or selection, e.g. taking a wrong instrument. *Lapses* occur after lack of knowledge or attention, e.g. the surgeon thinks the instrument is the correct one, though it is not. We talk about a *mistake* in case of an incorrect plan or incongruent prerequisites for surgery. For example, a tumor can appear larger during surgery compared to the preoperative evaluation, which e.g. could cause a lesser invasive laser surgery turn into a more invasive surgical procedure. A *violation* describes a wanted and fully conscious disrespect of surgical rules [1].

The German Supreme Court finally defined **medical malpractice** as "… action, which lacks diligence considering medical science and expertise and is therefore improper …" [2]. Pursued malpractice cases are rare, with most cases staying unveiled or not being reported. This is the same for all medical fields including surgical mistakes in head and neck oncology.

However, much more important than simple figures about errors in head and neck oncology is the knowledge of causing mechanisms. A mistake and patient harm is commonly an addition of multiple mistakes e.g. external influences, misjudgments etc. during a surgical procedure. This is pictured in Reason's *Swiss Cheese Model* [1]. In general impairment occurs, when "Swiss cheese holes" meaning multiple defects in safety barriers fatally engage (Figure 1).
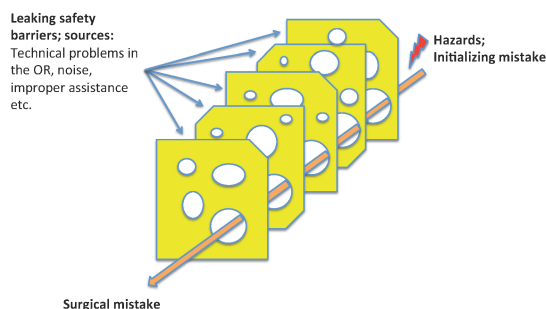

Figure 1: Swiss cheese model (by Reason)

Preoperative check lists, patient IDs, checks of technical devices in the operating room and a time out before surgery are implemented in many institutions and are simple and successful tools to reduce surgical risks. During surgeries, disturbing elements such as beepers, phones, music, repetitive use of OR doors or improper communications in the OR might cause lack of concentration of the involved surgical personnel and lead to mistakes. Although McFadzean and Bennett elucidated the interrelation of talkative surgeons and the surgical speed in their humorous study, they did not analyze surgical mistakes [3]. Instead, these can be minimized easily. Finally, a reduced hierarchy among the personnel in the OR supports active thinking, handling and interfering with more self-

confidence among surgical assistance, being an important element in the prevention of malpractice. As in cockpits of airplanes, the assistant represents the co-pilot with responsibilities, always being aware of possible risks and ready to help the surgeon (pilot) to prevent from mistakes and patient harm.

3 Preoperative planning

A thorough planning and comprehensive diagnostics are necessary before therapeutic decisions for head and neck cancer patients. Misjudgment at this stage can already lead to errors. This requires the correct use of diagnostic tools and the interpretation of the results with the support of the medical fields being involved, such as anesthesia, internal medicine, radiology etc.

Moreover, physical as well as psychological aspects of the patient have to be taken into consideration, and it hast to be assured, that the patient not only is in adequate medical and general condition for a surgical procedure, but has also been stated all therapeutic options given including possible risks and side effects.

3.1 Endoscopy, histology

Endoscopy of oral cavity, pharynx, larynx, esophagus and bronchi to analyze and biopsy tumors of the upper aerodigestive tract as well as to detect possible second malignancies is an established procedure for many decades [4]. However, the panendoscopy also includes possible risks for the oncologic surgeon. The ability of reclining a patient's head and the opening and position of the jaw enables the surgeon to preoperatively judge the suitability of the planned procedure. In some patients an adequate positioning of rigid endoscopes might not be possible and a surgery would not result in a gain of knowledge and should therefore be avoided. During endoscopy, caution for dental protection and the volatile mucosa should be taken care off. Good visualization should be accompanied by limited force while careful forwarding the scopes. In particular patients with carcinoma of the esophagus or lower aspects of the pharynx are at risk to suffer iatrogenic perforations [5], as are patients with stenosis or changed anatomy, e.g. after previous radiotherapy or surgical procedures [6]. The use of flexible scopes causes a somewhat lower rate of complications, with a generally reduced perforation rate depending on the surgeons expertise [7]. After inset of a rigid endoscope, the position of the light source should be checked and covered with a wet sponge in case of contact with the facial skin of the patient to prevent lesions caused by pressure or heat of the light source.

Moreover the biopsy and histologic work-up of head and neck cancers can be a source for mistakes. For that not only enough tissue material should be taken but the biopsy should be taken in the area of non-necrotic tumor growth. Otherwise it can result in misjudgment of the

pathologist, necessity of a further biopsy and therefore unnecessarily prolonged diagnosis.

The surgeon also has to consider the consequence of the biopsies taken. To have a general diagnosis, a single biopsy is generally sufficient. The exact extention of an upper aerodigestive tract cancer however might be of high relevance for the surgical and therapeutic planning and for the functional outcome after a surgical procedure. Therefore additional biopsies in case of suspicion might be relevant in areas such as e.g. arytenoid cartilage, interarytenoid space, base of tongue etc. whereas other additional biopsies might be avoidable to reduce additional costs. Also an endoscopic procedure should commonly be performed or assisted by an experienced oncologic surgeon.

In case of a patients with carcinoma of unknown primary and negative FDG_PET CT, a panendoscopy with tonsillectomy, nasopharyngeal and base of tongue biopsy or resection is carried out. That way small primaries can often be detected that have not been visualized endoscopically [8]. In case no primary can be found, the lymph node is biopsied. Since many years the significance of open node biopsies, a complete node resection or fine needle aspiration (FNA) procedures are discussed. In this manuscript, no general judgment, but possible sources of mistakes for the different procedures will be presented. For FNAs, the performing institution should have an experienced cytologist, otherwise the percentage of misdiagnosis might be unacceptable, which is also demonstrated in significantly differing results of various studies [9], [10]. The use of ultrasound improves the diagnostic safety and is recommended for FNAs [11]. However, there still is a relatively high rate of false-positive or false-negative results, which can cause fatal misdiagnosis or diagnostic delay. Cytology is particular challenging for some specific tumors such as lymphoma and the cell material via FNA might not be sufficient [12].

In case of the necessity for a node biopsy, a complete node resection should be preferred. Iatrogenic extracapsular spread of a metastasis is caused by the surgeon if partial resection of a node is performed. That way possible spilling of tumor cells in the wound can occur followed by the necessity of a more radical procedure in the neck after diagnosis and even reduced prognosis of survival for the affected patients [13]. Other retrospective studies however show no difference in overall survival in these cases presuming consequent treatment after diagnosis [14].

3.2 Staging, imaging

Imaging techniques are not topic of this review, however the correct use of imaging techniques as well as the interpretation has strong influence on the therapy, surgical decision and planning and will therefore be discussed. Ultrasound is todays gold standard for the diagnosis of **lymph nodes in the neck**. Specificity and sensitivity has shown to be higher than in CT and PET-CT [15]. High resolution, options for doppler function and the additional

option for onset FNA highlight the utility of ultrasound in the diagnostics of neck nodes [16]. However, limitations are given for retropharyngeal nodes, for which CT and MRI are the preferred imaging techniques [17] . This has to be considered in case of carcinoma of the pharynx and involvement of the pharyngeal back wall, in which 9–50% retropharyngeal metastases are reported in the literature and these nodes might also stay undetected during neck dissection unless preoperatively identified and mapped [17]. FDG-PET is of low relevance for the diagnosis of occult metastases with sensitivities of 50% and does not reduce the necessity of an elective neck dissection [18]. Depending on problem definition and tumor localization CT/PET-CT as well as MRI are the diagnostic tools for the preoperative evaluation of primary tumors of the head and neck. Though some small tumors might not need further imaging but the endoscopic view, in case there is no expected consequence after additional imaging. A sufficient imaging however enables a thorough preoperative evaluation of a tumor and supports a save resection as well as judgment of the necessity of a possible reconstructive procedure. The PET-CT is of relevance rather in the case of recurrences than in primaries with detection of e.g. distant metastasis and further involvement of the tumor. Using the PET-CT cancer involvement >8 mm can be detected [19] though smaller lesions might be missed. The **oral cavity** can generally be well detected via physical examination, however questions might arise concerning the depth of the tumor growth and possible mandible invasion, both aspects being of high importance for the surgical planning. Depth of invasion and medullary bone infiltration are best pictured via MRI [20]. Especially tumor depth within the tongue can be ideally marked using the MRI and can also well be correlated with pathologic results [21], [22]. Cortical bone invasion can best be illustrated using CT with sensitivity and specificity of 100% and 97% respectively [20]. However, dental material might cause relevant artefacts and can cause significant limitations in the imaging of oral cavity cancers.

For **oropharyngeal cancers** we have the same general criteria as shown above. In addition, the MRI has advantages in the imaging of the pterygopalatine fossa, involvement of the deep cervical fascia and prevertebral musculature as well as perineural tumor spread [23], [24].

In the evaluation of primaries of the **larynx and hypopharynx** a possible deep tumor invasion and the proximity to the neck vessels and other structures and an infiltration of the laryngeal skeleton is of relevance. Involvement of the laryngeal skeleton is either a reconstructive challenge or affords the complete resection of the larynx. Both of which has to be thoroughly decided and planned before surgery and is supported not only by endoscopy but also by the right imaging technique [25]. Also a submucosal spread, which might not be detected during endoscopy alone, can be unveiled using MRI and/or CT imaging [26]. Involvement of the **neck vessels** like the jugular vein or the carotid can be imaged via CT or MRI with high resolution [27]. Todays duplex ultrasound can be as well used as precise and simple tools for this interrogation. The
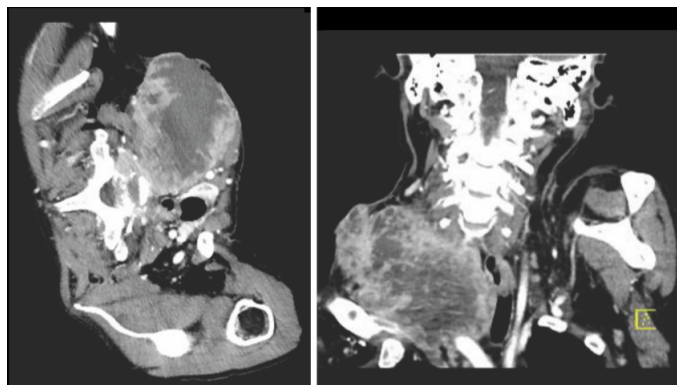
Figure 2: Inoperable situation of a hypopharyngeal metastasized cancer

proof of such infiltration is of consequence for the evaluation and the planning of a surgical procedure and helps preoperatively to outline risks and to avoid complications [28]. This topic will be focused again in 4.6.

The significance of imaging techniques concerning the involvement of the laryngeal skeleton is depending on different aspects, especially the localization of the tumor and the parts involved, e.g. since specificity and sensitivity in particular of the MRI for infiltration of the cricoid, the arytenoids and the thyroid cartilage can be significantly divergent [26]. But also the imaging of the submucosal spread can lead to misjudgment. The preepiglottic fat, being of relevance especially for direct involvement or lymphatic spread of supraglottic cancers can well be detected using CT and MRI with sensitivities of 100% and specificity of 93% and 84–90% respectively [26], [29]. The paraglottic space has high sensitivities of 93–95% for CT and MRI, however only specificities between 50–76% with a high rate of misinterpretation of infectious reactions and a chance of overestimation of tumor involvement preoperatively. On the other hand cancer spread in the paraglottic space might be hidden clinically and CT/MRI can add important information for the surgeon preoperatively and have impact on the surgical strategy [26]. Carcinoma of the piriform sinus can generally be detected well with CT as well as MRI with advantages for the MRI for carcinoma of the postcricoid area and hypopharyngeal cancers with origin at the posterior wall with possible spread towards deep fascia, esophagus and ororpharynx. Many studies describe limitations for the primary radiochemotherapy after tumor invasion of the laryngeal skeleton, for which the identification of such is important and influences the decision making process towards surgery [30]. To clarify this CT has a high sensitivity and a high predictive value [26]. Instead MRI has only a specificity of 89% and a low predictive value (10%) in the detection of cartilage invasion [31]. Other authors report specificities for invasion of the thyroid cartilage of 56%, the cricoid of 87% and for the arytenoid of 95% [26]. On the other hand, the MRI seems to be suitable to evaluate the tumor invasion within the laryngeal cartilage [32]. Overall the high resolution CT seems the preferred imaging tool in most cases with possible skeleton involvement of the larynx.

3.3 Patient selection

Successful surgery as with other therapies correlates significantly with the selection of patients and their general health status. In some cases proper patient selection appears more difficult for surgeons than surgery itself. Therefore it is important to carefully filter patients that are not candidates for a surgical procedure especially in complex cases. Figure 2 shows an obviously inoperable case with infiltration of squamous cell carcinoma involving the carotid artery and the spine.

Tumor staging and involvement of the anatomical structures plays a role in the decision for surgery. So do the general health condition of the patient as well as the individual surgical skills and options given. Co-morbidities tremendously influence post-surgical outcomes via complication rates, quality of life, postoperative functions and patient survival [33]. Studies showed that co-morbidities in head and neck cancer patients have even more impact on patients outcome than for other cancer entities [34]. Even validated by influencing factors such as age, sex and tumor staging, co-morbidities in head and neck cancer patients have a significant negative influence on patient prognosis [35]. Among those are coronary heart disease, obstructive pulmonary disorders, hypertonia, kidney and liver disorders, malnutrition, secondary tumors, psychological disorders and alcohol abuse.

As mentioned above, cancer infiltration can be another limiting factor for surgical procedures and preoperative misjudgment leads to incomplete resections, higher morbidity rates and risk for complications. Despite a wide range of surgical options in the era of reconstructive surgery, infiltration of the common or internal trunk of the carotid artery and infiltration of the skull base are at least limiting factors. Even in case of a general operative option in these cases the rate of post-OP complications is higher and the survival rate poor. In these settings one has to make decisions considering all data in individual case. Thomas et al. tried to create a model to predict morbidities for head and neck cancer patients [36]. Based on their data preliminary radiation therapy, high blood pressure and in particular prolonged surgery time were predicting factors for higher morbidity. The impact of radiation therapy on the tissue is well known for head and neck surgeons. In irradiated patients postoperative effects

can be skin necrosis, fistula formation and other signs of diminished wound healing.

Risk factors for the development of head and neck carcinoma and for arterial sclerosis are somewhat similar, which causes a high correlated occurrence of both. Although reason for a higher morbidity by arterial sclerosis is somewhat unclear, a reduced microcirculation is thought to be a factor for postoperative wound healing problems.

Longer surgical and anesthesia time is a proven risk factor for a higher morbidity as demonstrated in many studies. Sterile conditions decline as surgery time is prolonged, concentration of the surgical team is reduced and clearly general condition is somewhat diminished.

Overall it is important to carefully judge preoperative comorbidities and to consider no surgical procedure. However in several cases surgery might be the sole curative option. Then as in salvage surgery risk factors have to be minimized hazarding the consequences.

3.4 Nutrition

The nutritional status of head and neck cancer patient becomes of increasing relevance. In PubMed the yearly outcome of publications on the topic were 8 in the 1970s rising up to an average of 73 manuscripts per year since 2000.

50% of patients with head and neck cancer suffer from malnutrition at time of diagnosis. Again malnutrition is strongly associated with prognosis of these patients [37]. Such malnutrition can be even intensified during therapy and a nutritional improvement of the patients is of importance to reduce complication rates during surgery or other therapeutic procedures. In general oral food uptake or at least an enteral nutrition is preferred to a parenteral nutrition [38]. The general healing is improved and the rate of infections reduced [39]. In particular patients suffering from higher cancer stages profit from additional energy via food uptake to meet the requirements of their catabolic metabolism for fat and carbohydrates [40].

Oncologic patients should therefore receive early nutritional support, especially in cases of limited swallowing function. Nasogastric feeding tubes can be stigmatizing and are not a permanent solution. Percutaneous endoscopic gastrostomies (PEG) are a valuable option for early support of cancer patients for nutrition and medication even in patients with significant functional limitations.

PEG tubes have a low complication rate and can be placed during diagnostic endoscopy if indicated. As such they improve the nutritional status and the pre-condition of the patients before therapy [41], [42]. On the other hand the general prophylactic use of PEG tubes can support a negative influence on the swallowing function as a long term result compared to patients with partial or complete oral food uptake [43]. In this context Madhoun et al. unveiled also a high rate of prophylactic PEG tubes without latter use [44]. However other studies demonstrate the benefit of a prophylactic PEG through improved nutritional status and quality of life [45]. Despite the controversy the use of PEGs seem to be useful and should be suggested especially in patients with postoperatively expected dysphagia.

4 Surgical risks and errors

After correct and thorough diagnostics and preparation of head and neck cancer patients, surgery itself including indications for a surgical procedure is the most important source of risks and mistakes. Beside the individual surgical training and expertise, risk levels depend on requirements such as the surgical technique used and the localization of the tumor and related anatomic prerequisites. These will be discussed as follows.

4.1 Techniques

Beside conventional surgical procedures **laser surgery** has been an established technique in head and neck oncology since many decades. Not only pharyngeal and laryngeal cancers have been treated with laser surgery with oncological and functional excellent results [46], [47], [48]. Despite the exceptional advantages of these technical developments, the use of laser surgery also contains some risks that have to be addressed to provide a safe use.

First, any laser surgery demands special training and expertise to face the technical requirements of laser use. In case of the application of an endoscopic device, it has to be assured that its placement enables a good visualization of the tumor and complete resection of the tumor. Moreover, safety procedures such as protection of the personnel in the OR by laser glasses with the indicated wave length of the laser in use, cover of patients eyes and face with wet towels and warning signs on the OR doors have to be performed. To prevent accidental and dramatic burns during microscopic laser surgery, specifically covered laser tubes or alternatively a conventional tube covered with wet sponges can be used for intubation for protection [49]. Additionally, the tubes cuff should be blocked using e.g. saline solution and the percent of oxygen during ventilation leveled about 30%.

The most important general risk factors after laser surgery are swelling, bleeding and dysphagia and therefore do not differ from other surgical techniques used in the head and neck. Swelling tends to occur in particular depending on the duration of surgery or procedures in anatomic areas such as the arytenoids. Using corticoids the risk of postoperative swelling can be reduced. Tracheostomies might be necessary in selected cases only, however in critical cases, a postoperative intensive care should be provided in case no tracheostomy has been performed.

Bleeding can be an issue during surgery or postoperatively. During surgery vessels have thoroughly to be taken care off using cautery or clipping. Especially small arterial vessels can mimic hemostasis via spasm or retraction and cause unexpected postoperative bleedings. Lower energy levels of the laser can help to better identify and

cauterize vessels if needed. Since most patients do not need a tracheostomy after laser surgery and are therefore unprotected as with a blocked cannula, the risk of aspiration is higher in this patient group in case of insufficient hemostasis. In high risk patients, e.g. after extended laser resection of the base of tongue or intraoperative enhanced bleeding, a temporary tracheostomy as safety procedure might be considered. Studies identified resections of the lateral pharyngeal wall, the area ventral to the arytenoids and craniolateral to the thyroid cartilage to be of higher risk for postoperative bleedings [50].

The event of dysphagia also depends on the extent of the laser resection and localization of the tumor. Dysphagia can in particular be expected after resection of the base of tongue, of the arytenoids or involvement of nerve structures such as the glossopharyngeal nerve, pharyngeal fibers of the vagal nerve and the superior laryngeal nerve. Nasogastric feeding tubes can be placed for a few days in case of expected dysphagia. Especially after resection of the arytenoid cartilage a prolonged nutritional support via feeding tube might become necessary, which suggests the placement of a PEG, even more so in case of planned postoperative radiotherapy and anticipation of lasting dysphagia. Temporary use of feeding tubes moreover disburdens the wound area and supports healing.

Other possible but rare complications after microscopic laser surgery of the larynx can be postoperative stenosis which can occur in particular after involvement of the laryngeal skeleton [50].

Whilst the laser is especially valuable for cancer resections of the base of tongue, hypopharynx and larynx, other localizations such as tumors of the oral cavity, tonsillar fossa or palate can just as well be accessed using even more simple techniques such as conventional tools, monocautery or radiofrequency tools. Nevertheless, the tool finally used will be based on the expertise and preference of each surgeon.

Recently some groups promote the use of robotic systems (transoral robotic surgery, TORS) for cancers of the head and neck. Especially its use for resection of cancers of the ororpharynx is propagated, though the technique still somewhat still in development [51]. TORS affords a certain amount of training and expertise comparable to that needed for the use of the laser and requires costly instruments. Despite the possible advantage of three-dimensional movements of the tools, the transoral access is still limited by the size of the tools and the economic effort is high. Moreover TORS lacks haptic control, the overall surgery time is still prolonged compared to other techniques and the additional benefit compared to other excellent existing techniques such as microscopic laser surgery or conventional methods remains unclear. Other indication, having been described for TORS, such as the inset of microvascular free flaps, have to be generally questioned and can not be recommended. However there is raising experience for TORS and further developments, such as combinations with the laser, reduction of size of

the instruments used might contribute to reduce the risk in oncologic surgery [52].

4.2 Oral cavity

Maybe more than for other locations, cancers of the oral cavity are indications for a surgical procedure in most cases. Even T4b cases demonstrate comparable oncologic results as T4a tumors as long as neither the carotid artery nor the skull base were infiltrated [53]. At the same time the anatomic structures of the oral cavity are important for functions such as swallowing and articulation and surgeons need experience and reconstructive knowledge for many cases in this location to fulfill the necessary requirements.

Most cancers of the oral cavity can be treated transorally (Figure 3). Only rare cases e.g. with immobility of the jaw afford another access such as pull through maneuvers which enable good access for extended cancers of the tongue and the floor of mouth. A mandibulotomy approach, which is still sometimes used for cancers of the oral cavity or oropharyngeal cancers, should be avoided if possible to minimize morbidity. The complication rate for this approach in the literature is as high as 23.3% to 47.6% and among others includes the risk for cosmetic impairment, extruding plates, lip contracture, affected bony wound healing, abscess and osteoradionecrosis after adjuvant radiotherapy, dysfunction of the temporomanibular joint and impairment of dental closure [54], [55].

Figure 3: Transoral approach using open mouth gags and the *Stierlein* retractor

Tongue: There is no clear border between the musculature of the tongue sometimes resulting in diffuse infiltration of carcinoma of this origin. Fine nerve fibers within the muscles allow for perineural spread. Such cancer cell extension is not rarely hidden during cancer resection.

This demands not only for a subtle preoperative assessment but also a sufficient clear resection margin during surgery resulting in >0.5–1 cm in the pathologic review. Sometimes clinical testing for mobility, sensation and taste of the tongue can unveil neural affection of the hypoglossal and lingual nerve, chorda tympani and glossopharyngeal nerve. As long as the resection is restricted to the tongue, even half the tongue can be removed without significant functional impairment. However, after resection of >50% of the volume of the tongue and involvement of the floor of mouth in many cases reconstructive procedures, e.g. using radial forearm or anterolateral thigh flaps, should be recommended, to preserve mobility of the tongue and to achieve an optimized postoperative function. The likelihood of metastatic spread in tongue cancer depends on the depth of tumor invasion and does not necessarily correlate with the T-stage. In tongue cancers with invasion >4 mm a neck dissection is recommended in the literature, in cancers with less invasion additional morbidity induced by a neck dissection can be avoided [56]. Another retrospective analysis by Spiro et al. showed a correlation of patient survival with the thickness of tongue cancers but no correlation with the T-stage [57]. The pattern of lymphatic spread is variable and should be carefully considered in the planning of the neck dissection. Whereas tumors of the tip of the tongue drain into submental nodes of level Ia, cancers of the lateral tongue can metastasize into level Ib and II and rarely involve III and IV, preferably ipsilaterally. Cancers of the base of the tongue tend to also drain bilaterally and have multiple lymphatic crossings and therefore need to be treated with a bilateral neck dissection.

Alveolar ridge, retromolar trigone: In these areas the oral mucosa directly contacts the periosteum of the mandible raising the likelihood for bony invasion. Resection of parts of the bone often has to be included in the preoperative surgical planning. After surgery and adjuvant radiotherapy of this location the risk for necrosis of soft tissue, osteoradionecrosis and trismus is about 12% in the literature [58]. Again, the risk of such complications can be reduced using microvascular or pedicled reconstructive options. At the alveolar ridge tumor invasion of the neck of teeth has to be paid attention to. This enlarges the risk for tumor invasion of medullary bone and involvement of the inferior alveolar nerve with perineural spread, which might be undetected in preoperative imaging but has to be considered for the surgical planning. In the case of medullary invasion a segmental resection of bone becomes necessary. In case of infiltration just of periostium or cortical bone a wedge resection might be sufficient and has shown to be an oncologic safe procedure [59], [60]. For the prevention of iatrogenic fractures, 1 cm of bone width has to be preserved [61]. Resections of segments of the anterior mandible including the symphysis demand a reconstruction with a microvascular free flap. Patients without dentures, with reduced general status and with affecting co-morbidities a microvascular procedure might imply an inacceptable risk. Instead of a reconstruction of the bone, which would ideally be performed,

these patients can alternatively be treated with a soft tissue reconstruction with or without preservation of mandibular continuity using titan plates [54]. Extrusion of titan plates especially after adjuvant therapy is between 7–14% and a high volume soft tissue coverage of the plate is necessary [62], [63] if no bone is implanted.

The lymphatic drainage of the retromolar region follows primarily to the jugulodigastric nodes. Metastatic spread into level IV and V was shown in 21% of patients with carcinoma of the alveolar ridge and clinically N+ neck status [64]. The general risk of positive neck nodes in these tumors is 25% and even occult metastases are found in 15% of the neck specimen.

Floor of mouth: Loss of significant floor of mouth tissue is accompanied by a loss of movement of the tongue and asks for a reconstructive planning, e.g. with a radial forearm transplant with strict watertight closure to prevent fistula formation in this area.

Attention has to be paid for the lingual nerve, that courses around Wharton's duct and these structures can be preserved especially during resections of small cancers by duct identification and stenting. In case of partial resection the orifice of Wharton's duct can be set back in by marsupialization.

A neck dissection should generally be performed in floor of mouth cancers, with occult metastasis rates averaging 22%. Only T1 cancers had 10% occult metastases and an elective neck dissection is at least recommended for floor of mouth cancers ≥T2 [65]. Another investigation focused on the importance of neck dissection even in small cancers as a significant reduction of recurrence free survival was found in patients with T1–2 cN0 cancers and occult metastases [66]. These patients would profit from adjuvant regimens in case of detection of positive nodes. Lymphatics of the anterior floor of mouth drain ipsi- and contralateral into submental and submandibular nodes whereas lymphatics of the dorsal parts of the floor of mouth tend to drain only ipsilaterally.

Buccal mucosa: Carcinoma of this region can possibly involve the Stenon's duct, which can be identified and possibly replaced after partial resection to prevent postoperative stenosis. More extended carcinoma of the buccal region should be ideally treated with microvascular free tissue transfer to prevent contractions in this area. Buccal carcinoma has a high rate of lymphatic spread. Primary lymphatic drainage involves level II–III but level I as well, which has to be respected in the planning of a neck dissection.

Hard palate: Small palatal carcinoma can well be treated with a transoral approach. If no bony involvement is present, the bone has a good tendency to epithelialize secondarily without reconstruction. Larger defects with bony resections might result in oral incompetence and rhinophonia and have to be treated with prosthesis or reconstructive procedures.

In case of possible involvement of the great palatine nerve, the nerve should be biopsied to identify neurotropic growth away from the macroscopic borders of the tumor [54].

In general the lymphatic drainage involves levels I–III but can involve retropharyngeal nodes and might be uncovered during preoperative diagnostics, which should be considered for a possible postoperative treatment.

4.3 Oropharynx

Although some tendency away from surgery towards non-surgical treatment for patients with ororpharyngeal cancer can be seen in some head and neck cancer centers, until today there has been no data showing an improved prognosis or even function for those patients. The therapeutic decision for this patient group however depends on e.g. resectability, HPV-status, personal preference and also on the surgical options given. Respecting today's data surgery including reconstructive surgical treatment in combination with adjuvant radio(chemo)therapy seems to be the best choice to treat most of these tumors. The impact of new aspects, such as HPV-status, for therapy selection is still somewhat unclear, but should be included in the decision process. The initial therapeutic decision not just but also in this region is of tremendous importance considering the high morbidities and low survival rates for salvage surgery in this location. Gheanno et al. analyzed mortality rates of 8% and a 5-year survival rate of 24% in an analysis of 120 treated patients [67].

Based on their anatomical proximity to the retromolar region and the base of the tongue especially of cancers of the tonsillar fossa, these cancers involve similar risks as mentioned in 4.2. But ororpharyngeal cancers have further risk factors and knowledge of these can help to provide mistakes. For this it is useful to divide oropharyngeal cancers into cancers of the soft palate, tonsillar fossa, base of tongue and pharyngeal wall. General postoperative complications include damage of blood vessels such as the carotid artery and nerves (e.g. N V, VII, IX, X, XI and XII), fistula formation, trismus, aspiration, bleeding, pain and muscular dysfunction.

For most carcinoma of the oropharynx even the transoral approach is sufficient (Figure 3). Involvement of inferior oropharyngeal structures can be approached using anterior, transhyoid or lateral pharyngotomy. In many cases transoral and pharyngotomy approaches are combined. Again mandibulotomy should be avoided to prevent complications as mentioned above (see 4.2). However, basic and most important principle for the decision of an approach is a good view to ensure a safe tumor resection [68].

The **soft palate** can be generally treated well tranorally. Main problem is the expected postoperative function. Depending on tumor localization the loss of more than 1/3 of the soft palate might demand tissue reconstruction, e.g. using a radial forearm flap. The possibility of bilateral lymphatic drainage also asks to perform a bilateral procedure if a neck dissection is indicated.

Surgery of the **tonsillar fossa** and the **lateral pharyngeal** wall faces comparable problems and risks. One major aspect concerns involvement of the base of tongue, depth of invasion and the judgment for the necessity for recon-

struction. Uncovered bone and exposed deep neck vessels are indications for reconstruction not only to improve overall function but to avoid complications such as diminished wound healing, pain and fatal bleedings. Before transoral resection close study of the course of the large neck vessels is recommended preoperatively to avoid complications. In some cases an additional external approach supports minimizing this risk. Large defects should be reconstructed to avoid fistulas especially in salvage cases. T1 cNo cancers can be managed with unilateral neck dissection, but in cancers >T2 the chance for bilateral metastases is >20% and therefore bilateral neck dissection should be recommended [69].

Carcinoma of the **base of the tongue**, especially small cancers can very effectively be managed using laser surgery with low morbidity, excellent functional and oncologic results such as 84% recurrent free survival [70]. Recently other techniques like TORS have been used for base of tongue disease [71], [72], but advantage of TORS compared to e.g. laser techniques remain unclear. Cancers of the base of the tongue often have a submucosal spread and adequate resection margins are difficult to identify and ask for haptic control. Affections of the lingual artery and the hypoglossal nerve can be operative risk factors. However when infiltrated by tumor those structures cannot be preserved. In these cases, an initial neck dissection and ligation of the lingual artery in the neck helps to reduce the risk of intraoperative and postoperative bleeding. The neck in base of tongue cancers should be treated bilaterally having a cross-over lymphatic drainage and a high risk of metastases [73].

Risk factors of cancers of the dorsal pharyngeal wall can basically be compared with the other oropharyngeal locations. Besides infiltration of the deep fascia has to be considered in which a reconstruction would be necessary. Also the lymphatic drainage of these cancers can be challenging with involvement of retro- and parapharyngeal nodes as well as bilateral metastases. This has to be taken into account in the surgical as well as adjuvant regimen.

4.4 Hypopharynx

Carcinoma of the hypopharynx is generally challenging to treat, including numerous risks and has a relatively bad prognosis. Depending on size and tumor origin structures such as the larynx, the thyroid or prevertebral structures, nerves like the inferior laryngeal nerve and others can be affected by the cancer growth. In the 1970s Kirchner could show that carcinoma of the apex of the piriform sinus has generally involvement of the laryngeal skeleton and would not easily to be accessed using conservative procedures [74]. Though modern reconstructive techniques today might help to avoid highly invasive procedures such as laryngopharyngectomies. Other studies described the submucosal spread and suggested resection margins for hypopharyngeal cancers, which were highest for cancers of the inferior hypopharynx and less in lateral and then cranial cancer origins. The authors

suggested resection margins of 3, 2 and 1.5 cm respectively with even larger margins in salvage cases [75], [76]. These figures have not been proven otherwise yet, though wide margins are suggested for hypopharyngeal tumors and the necessity of reconstructive options should be revised. Small cancers of the hypopharynx can be treated well with laser surgery with excellent clinical results, though data for the use of the laser in larger tumors in this area is limited [77]. Before laser surgery of cancers of the lateral hypopharyngeal wall a previous neck dissection should be performed followed by coverage of the large neck vessels medially with e.g. a wet sponge to avoid vessel lesions that might occur using the laser.

The sensation of the hypopharyngeal mucosa is important for a regular swallowing act, with possible dysphagia after resections in that anatomic area. This can be encountered by feeding tube placements before or during surgery.

Lymph node metastases occur relatively early and often bilaterally. Only small tumors with cN0 neck status should be treated with an ipsilateral neck dissection. Tumors of the inferior aspects of the hypopharynx can spread into paratracheal nodes. Tracheostomy before surgery of the neck can possibly lead to tumor spread by these nodes resulting in parastomal recurrent disease and a high mortality rate [78] (Figure 4). Therefore placement of tracheostomy in these cases is recommended after resection of these nodes during neck dissection [79]. As in oropharyngeal cancers tumors located at the dorsal wall of the hypopharynx can again spread towards retropharyngeal nodes.

Figure 4: Parastomal metastatic recurrence of a laryngeal cancer

4.5 Larynx

The complex anatomy of the larynx predisposes this area for risks of mismanagement during surgery and possible dysfunction postoperatively.

The supraglottic region contains important structures for the swallowing function such as the epiglottis and especially the arytenoid cartilages and resection of these structures can lead to dysphagia and chances of aspiration, despite possible successful rehabilitation [80]. Elderly patients might not profit from rehabilitation and in

these cases such resections are not suitable because of the risk of lasting dysphagia and aspiration. However, small (T1–T2) cancers of the supraglottic region are successfully treated with laser surgery evaluating oncologic and functional aspects [81]. Care has to be taken during (laser) surgery in the interarytenoid region, since it might result in scarring followed by laryngeal dysfunction (Figure 5).
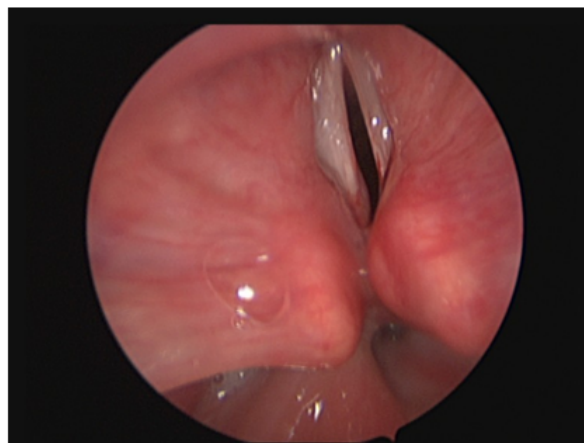

Figure 5: Scarred interarytenoid region and hypopharynx after a laser procedure (during inspiration)

Frequency of lymphatic metastases of laryngeal carcinoma is somewhat comparable with hypopharyngeal cancers demanding for an early and consequent decision to perform neck dissection in most cases.

T1 staged cancers of the larynx are commonly ideal candidates for microscopic laser surgery, as far as exposition with the endoscope is adequate. Frequently patients should be informed about a possible intraoperative change of plans, in case exposition would not be sufficient.

For documentation of the vocal cord mobility and to plan the postoperative rehabilitation of the voice a phoniatric check is advised before surgery. Today a voice rest for only a few days after surgery but early rehabilitation is recommended by most speech therapists [82].

Endoscopic resection can be performed without damage of the vocal cord or muscle. However, 20% of T1 vocal cord cancer cases show a regular movement of the cord, though having microscopic infiltration in the pathology report [83]. A resection margin of >1 mm is thought to be adequate in vocal cord cancers [84], though a complete resection in the initial surgery seems important. An analysis of 1,467 cancer cases from Göttingen demonstrated, that patients, who had to receive a second procedure because of residual cancer cells had a significant worsened prognosis compared to the primarily R0-resected group [85]. Also for most T1 cancers it can be recommended to resect small ones primarily as complete excision biopsy. Though, in case of other treatment than resection an initial sole biopsy is sufficient. Resections including the anterior commissure and the laryngeal cartilage of this area might lead to scaring and web formation. Placement of silicone placeholders for about

4 weeks can help to reduce that risk. Resection techniques used to take care of this complication is accompanied with rather unsatisfactory and unstable results. In cases of involvement of the cartilage, resections should be either performed using external approaches or endoscopically by a surgeon with high skills using the laser. This is the same for larger cancers of the endolarnyx. Subglottic cancer are often treated with laryngectomy, but in selected cases resection with partial laryngeal preservation using delicate local reconstructive techniques can be performed. This should be preoperatively considered before decision for laryngectomy is made. Of course therapeutic options other than surgery might be discussed.

Laryngectomy is a known procedure for many decades and based on the wide access and the destructive nature of the surgery does not include too many risk factors. But surgeons should be aware of some aspects in this context that might lead to mistakes and possible complications. First the incision line should be above and separate from the stoma to avoid tension and for optimized conditions for voice rehabilitation [86]. Also the superior thyroid artery does not have to be ligated routinely to preserve that vessel and others for possible future procedures including microvascular savage cases. This is generally recommendable for all surgeries in the neck. An initial complete skeletonization of the larynx helps to minimize frustration during the final laryngeal resection. Decision for the location of the pharyngotomy should be based on the tumor involvement of vallecula and/or preepiglottic fat. In case of a standard resection via pharyngotomy into the vallecula, a long spatula can be placed transorally to bring the mucosa forward for an easy, precise and small incision. Such small pharyngeal incisions help to reduce the chance for fistulas in the postoperative period. Of course pharyngeal mucosa has to be preserved as much as possible to improve postoperative swallowing function. In some cases of additional pharyngectomy reconstructive procedures to enlarge the pharyngeal lumen have to be considered, later reconstructions being much more comprehensive and include an enhanced risk for complications. Myotomy of the superior esophageal sphincter is necessary for improvement of swallowing function and later voice rehabilitation. After tension-free placement of the tracheal stump in the neck skin the correct and atraumatic placement of a voice prosthesis in case of voice rehabilitation is important to prevent later insufficiencies and fistula development. Pharyngeal closure can be done in a T-shape manner to prevent pseudovallecula formation and provide a sufficient closure [87].

Partial laryngectomy is performed depending on the tumor location and involvement. As diverse are possible complications and risk factors, though the supracricoidal laryngectomy should be mentioned. The success of this surgery among other factors such as patient intelligibility and age depends on the structures left in situ, with best postoperative swallowing function saving both arytenoid cartilages instead of only one. It is important to completely mobilize the larynx down towards the mediastinum in or-

der to lift up the cricoid and residual larynx up towards the base of the tongue as cricohyoidopexia or even towards the mentum with strong permanent sutures. Because of the tracheal shift, tracheostomy is to be the last step in this procedure.

4.6 Neck dissection

Neck dissection is a substantial part of many head and neck cancer surgeries and based on the complex anatomic structures of the neck offers many options of risks and mismanagement. Many neck specimen e.g. in elective procedures might not even contain tumor tissue, though their necessity has been demonstrated [88]. Indication for a neck dissection and the definition of the extension should closely be evaluated preoperatively. Whereas years ago neck dissections were performed most radically, today's procedures are rather selective, depending on the extension of existing metastases [89] and allow for preservation of anatomic structures in the neck. The separation into different levels and their assignment to different primary locations allowed for reduction in morbidity though preservation of oncologic safety in the past (Figure 6). Indication for neck dissection in larger head and neck cancers is given for most cases, though small T1 tumors might not afford a neck procedure [89]. Whether a neck dissection has to be performed solely ipsi- or as well contralateral is also part of the necessary preoperative therapy planning and some comments on indications are found above (4.2–4.5).

Figure 6: Selective neck dissection level II–Va with preservation of all vessel and nerve structures

Already the incision planning is of importance for the surgeon and the outline of incision lines depending on individual needs. Beside personal preferences all structures should be well accessable and the operative view appropriate to avoid mistakes. Also cosmetic aspects should be considered to avoid stigmatizing scarring as much as possible. Although the pedicled sternocleidomastoid flap with skin island is only rarely used, the incision line should ideally be on the medial aspect of the sternocleidomastoid muscle to beware the option for this flap.

Intraoperative bleeding reduces the surgeons view and surgical safety. Therefore thorough hemostasis and repetitive rinsing of the wound supports a stable visual-

ization of the neck anatomy. Postoperative bleedings usually occur in the early postoperative period and often derive from small arterial vessels or small veins going off directly from the internal jugular vein. Ligation of these vessels rather than just electrocautery helps to prevent postoperative bleeding. Extended neck dressings do not help to prevent bleedings but rather hinder early detection of such complications [90]. Providing proper wound care no additional dressings are necessary for the neck.

Chyle fistulas after lesions of the thoracic duct occur in 1–2% of cases after neck dissection of level IV or Vb and predominantly after radical neck dissections [91]. Some fistulas might be detected intraoperatively, but most fistulas appear delayed and the postoperative healing period is prolonged significantly. The risk might be minimized by generally ligating before resection of tissue parts in the area of the thoracic duct.

Today bilateral resection of the internal jugular vein is obsolete causing brain edema and high mortality. Oncologic needs are rarely present and indication for a surgical procedure should be questioned in such cases. However, a single sided radical neck dissection is often indicated. In case of additionally planned surgery of the contralateral side, this side should be operated first and if the vein is preserved as planned, radical neck dissection can be performed on the other. Otherwise, if the internal jugular vein has been accidentally damaged, it is recommended to wait up to 4 weeks until new additional venous outflows could develop before the radical neck dissection is performed contralaterally. This management leads to reduction of the mortality rate from 12% down to 3% [92]. It is also possible to preserve the external jugular vein as additional run-off and in some cases, resection of the internal jugular vein might be performed superior to the outflow of the facial vein, all this supporting venous drainage and reduces postoperative swelling of the patients.

One of the most common complications after neck dissection is damage of the accessory nerve with shoulder and arm dysfunction. To minimize this risk, attention should be paid to the accessory-cervical plexus (Figure 7), which can result in functional impairment though intact N.XI structure. Also trauma to the nerve after visualization should be minimized and the perivascular supply saved to reduce the risk of damage [93]. In case of dysfunction, physiotherapeutic rehabilitation can improve function [94].

Commonly only the mandibular branch of the facial nerve might be affected during neck dissection unless the parotid gland would be involved in the surgery. Pressure or even the use of sharp hooks in the area of the mandible and floor of mouth can damage the mandibular branch and has to be avoided. The vagal nerve can be damaged during revision cases or surgery closer to the carotid but should otherwise not be at risk. The hypoglossal nerve (0.4%) [95] and the phrenic nerve are commonly not affected as well as long as not infiltrated by tumor and surgical diligence is given. Sensitive nerve fibers such as the great auricular, located 1 cm cranial to the external jugular vein, the lingual nerve during preparation of level

I or other sensitive fibers of the cervical plexus can also be spared respecting their anatomy without e.g. impairment of access and lead to a preservation of sensitivity and improvement of the patients general condition postoperatively [96].
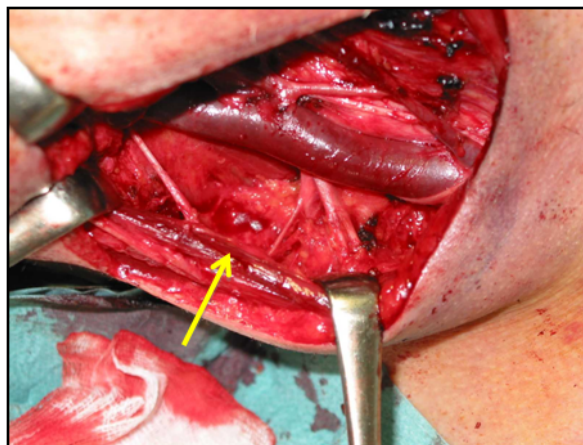

Figure 7: Level Va and accessory-cervical plexus (arrow)

A dramatic but rare complication after radical neck dissection is visual loss and just 12 cases are reported in the literature [97]. Underlying cause is an anterior or posterior ischemic optic neuropathy with assumed distension of the ophthalmic vein with compression of the orbital apex followed by reduction of perfusion of the eye bulb [98]. Further contributing factors can be arterial hypotension, hypovolemia and anemia [99].

The carotid artery implies several risks that can cause complications during a neck dissection. Often plaques formation is present in the vessels, that can get mobilized during manipulation on the carotid wall during surgery and induce neurologic complications. Much more often, manipulation on the carotid bulb causes arrhythmia and surgical preparations in this area should be announced to anesthesia. Also vessel walls should be kept moist to minimize the risk of thrombosis in these vessels.

Direct damage to the carotid wall occurs after thinning of the wall structures during resection of close metastatic disease as well as fistulas followed by direct contact of saliva to the vessel wall. Loss of adventitia and also microscopic cancer cells in the vascular wall significantly raise the chance of carotid rupture [100], [101]. Also accidental damage of the pharyngeal wall during extended neck procedures can cause fistula followed by carotid arrosion and fatal bleeding events in the early postoperative period asking for a thorough control of the pharyngeal wall structures after such radical procedures. In case of an accidental or planned pharyngotomy and an unprotected carotid artery, like in radical neck dissections, not only the sole suture of the pharyngeal mucosa but also an additional soft tissue cover using e.g. flaps is recommended to avoid arrosion and bleeding of the carotid artery (Figure 8).
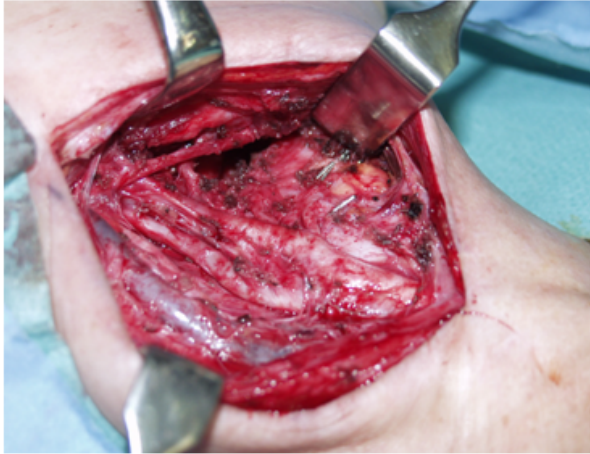
Figure 8: Modified radical neck dissection and pharyngotomy in a salvage situation. A transplant might be useful for reconstruction of the pharyngeal wall and to protect the exposed carotid artery.

In such cases of enlarged risk for carotid complications the medical staff taking care of the patient postoperatively should be informed and instructed for precautions. In the emergency case of surgical intervention, generally the carotid has to be ligated since most attempts to suture isolated defects are ineffective. In selected cases radiologic intervention might be possible to solve the problem, which in retrospective analysis could stop the bleeding though did not lead to an improved survival of the patients treated [28], [102], [103]. Detected complications after radiologic intervention were recurrent bleedings, neurologic complications and thrombosis of implanted stents.

Before surgery the knowledge of presence and position of possible metastatic nodes is mandatory. Accidentally opening of metastatic lymph nodes causing tumor cell spilling and nodes that are left in the neck both worsens the patient's prognosis and can be avoided with close awareness of the preoperative imaging. In the case of a forgotten node and detection during the early postoperative period or before adjuvant treatment, an immediate resection of such nodes is necessary to avoid a worsening of the prognosis. A solely adjuvant regimen is not sufficient in such cases.

4.7 Tracheostomy

Tracheostomy is certainly one of the most performed procedures in oncologic head and neck surgery and it is as important to know about risk factors as it is to make the right judgment on indication for tracheostomies to possibly avoid morbidities in head and neck cancer patients. Whereas tracheostomies can help to reduce the postoperative time of sedation and stay on the intensive care unit, they might also cause a higher morbidity, risk of additional complications and enlargement of costs and hospital stays [104].

The surgical procedure can be performed in different fashions with each having advantages as well as disadvantages that will not be discussed in this context and basically depend on the personal experience and preference of each surgeon. Tracheotomies without epithelialization however includes a higher risk of later tracheal stenosis and moreover can cause complications such as asphyxia during change of cannulas postoperatively in case the tracheal opening is not properly saved and the tissue collapses after removal of the cannula especially in patients with short and thick necks. In emergency cases coniotomies are performed and should be replaced by a tracheostomy as soon as possible to avoid later complications. Complication rates during or after tracheostomy vary between 5–8% though most complications are present in the early post-OP time [105], [106]. Bleedings, local infection, emphysema, tracheitis, lung infection, fistula formation, tracheal stenosis, cannula dislocation and obstruction and peristomal recurrences are reported. Again patients suffering from severe co-morbidities and patients after irradiation have a higher complication rate of about 30% [107]. As many as 1% of patients have stomal recurrences including high mortality rates [108]. As mentioned above this fatal complication can be controlled by first removing the paratracheal nodes in cancers of the inferior hypopharynx and subglottic cancers of the larynx before tracheostomy. In a retrospective analysis stoma recurrence was found in patients with N+ neck status and placement of tracheostomies before surgery of the primary and neck [108]. Postoperative bleedings commonly derive from the thyroid. In an analysis of Haspel et al. chances of bleeding is clearly reduced using thorough electrocautery compared to ligation and other rather manipulative procedures [106].

Decision for or against tracheostomy is often made at the end of surgery depending on factors such as time, risk of bleeding, chances of swelling and respiratory insufficiency as well as transplant volume in case of reconstruction. Steroids can help to minimize the risk of postoperative swelling and if no tracheostomy is performed postoperative supervision via intensive care with or without placed endotracheal tube is necessary in many cases. The decision process is not always easy however there are certain situations mostly indicating a tracheostomy (Table 1). Pulmonary dysfunction, radical neck dissection in combination with further head and neck procedures, perioperative swelling in particular after perilaryngeal surgery, rather extended cancer resections of the pharynx and supraglottic region with expected chances of aspiration or enhanced tendency of bleeding during surgery demand for tracheostomy to prevent later complications. Generally there is no clear cut off for indication and a final guideline cannot be presented. Cameron et al. tried to face the problem using a scoring system. For key factors, namely tumor location, neck dissection, reconstruction and mandibulotomy are listed to decide on the indication for tracheostomy. But despite all efforts made, no guideline can result from such attempts. Moreover the study only included oral cavity and oropharyngeal cancers leaving out hypopharyngeal and laryngeal cancers [104]. After all, the final decision for tracheostomy has to be

Table 1: Obligatory und optional indications for tracheostomy placement in head and neck cancer cases
(cm: co-morbidity; nd: neck dissection)

Situation	obligatory	optional
Risk of aspiration	x	
Risk of bleeding	x	
Severe pulmonary cm	x	
Edema	x	
Surgery time >4 h		x
Transplant		x
Radical nd		x
Bilateral nd		x

Figure 9: Skin necrosis and fistula after salvage surgery

made by the surgical team based on facts of each individual case and cannot be standardized.

4.8 Salvage surgery

Salvage surgery serves as the last therapeutic option, is particularly challenging based on the tissue impairment caused by the previous therapies and therefore is accompanied with high complication rates including fistulas and skin necrosis (Figure 9). After salvage surgery complication rates as high as >90% are described [109]. This illustrates the high potential for risks and mistakes in salvage surgery.

Early detection of recurrent disease improves the success rate of salvage surgery significantly which shows the general importance of close meshed control visits of tumor patients [110]. In case of a recurrence PET-CT offers a high sensitivity not only for the local recurrence but also detecting metastatic findings, which is important before a decision towards an elaborative salvage procedure is made [111].

Salvage surgery after primary radiochemotherapy of cancers of the larynx and hypopharynx has a very high rate of pharyngocutaneous fistula formation (appr. 75%) after primary closure of the pharynx [112]. Therefore pedicled or microvascular flaps are generally recommended for the surgical planning of those cases. Using pedicled flaps, the pectoralis major flap can be used to either support the primary closure with fresh tissue volume or to add pharyngeal lumen with a skin island being incorporated in the reconstruction. With this the risk of fistulas is clearly reduced [113]. Free tissue transfer using microvascular flaps offer an additional variability in flap selection, size and placement, however affords some institutional experience in this surgical technique with a challenging vessel and tissue impairment in salvage cases. The use of free flaps reduces the general complication rate, the risk of fistula, strictures and even the necessity of a prolonged feeding tube dependency of the patients tremendously [114], [115], [116]. However, it has to be considered that despite the use of either flap surgery salvage cases will have a higher complication rate than regular head and neck cancer surgeries [117], [118]. It is important to clarify the patient's expectations and to intensively discuss possible complications and success rates.

Survival rates after salvage surgery vary from 20–45% in oro- and hypopharyngeal cancers up to 82% in laryngeal cancers [109], [119]. Postoperative quality of life is reduced and social reintegration aggravated [109].

4.9 Pharyngocutaneous fistulas

Prevention, development and therapy of fistulas concern different fields in head and neck oncology and is discussed in each of these chapters. Generally, fistulas occur in 10–30% of cases after opening of the pharynx [120]. Risk factors are neck metastases, low levels of postoperative albumin and hemoglobin [121]. Other general factors for an impaired wound healing such as diabetes, immunosuppression and previous radiation can also have influence on fistula formation. Small fistulas can successfully be treated with conservative wound management. Another option in selected cases would be the use of a vacuum therapy, though with chances of residual cancer cells being a strict contraindication for this therapy [122]. Larger or persisting defects might need surgical closure using flaps.

4.10 Reconstructive surgery

4.10.1 Pedicled flaps

There are several options for the use of pedicled flaps in oncologic head and neck surgery and the two most common flaps will be discussed with their sources of mistakes.
The pectoralis major transplant is probably the most used flap in reconstructive head and neck oncology. Based on the broad access the harvest is relatively uncomplicated, but still some features should be mentioned in this context. First of all the arch of rotation and distance to the defect has to be simulated before harvest to provide a tension-free inset of the flap. The cutting line should not cross the blood supply of a possible deltopectoral flap in order it would be needed at a later stage and not to waste this reconstructive option. It is safest to harvest a simple muscle flap, though harvest of an included skin island might be demanded. This skin island is quite sensitive to shearing forces and suture fixation to the underlying fascia of the pectoralis muscle and as with all transplants gentle handling of the tissue during harvest is recommended to preserve the flaps blood supply. Complete flap necrosis is relatively rare and numbered 1–7% in the literature [123], but partial flap necrosis can be as high as 29% as described by Shah and coworkers [124].
The deltopectoral flap is even less complicated and its subfascial harvest easy. Dopplersonography can be used to identify the intercostal vessels. Harvest should be performed strictly subfascial to preserve the flaps blood supply within the fascia and should stop appr. 1.5 cm before the intercostal perforators enter the flap medially. Again the flap length needed to cover the defect should be measured before harvest to avoid tension. Knowledge of the flaps angiosomes helps to calculate the growing risk of partial flap necrosis at the distal end of the flap [123]. Diminished reach and flexibility is one of the restrictions of pedicled flaps and a major advantage for microvascular free tissue transfer.

4.10.2 Microvascular free tissue transfer

Even more than pedicled flaps microvascular flaps offer a large variety of reconstructive options and multiple advantages led to growing use of these flaps in head and neck oncologic surgery in the last years. Resection margins can be performed as much as needed and patients profit from improved function and appearance. The option for such transplants should be given in today's head and neck oncologic surgery. Different flaps have multiple sources to make mistakes which can be in detail found in the literature for each flap [123], [125]. In the following correct basic planning and performance of microvascular flaps will be discussed, which is important to avoid mistakes and supports the chance of success of these surgeries.
Basic precondition is an intensive and lasting training in oncologic and microvascular surgery to be able to achieve success rates >95% flap survival. Experience is known to be one of the most important factors concerning survival rates of microvascular transplants [126]. As mentioned previously the surgical time is one of the major factors in complication rate and wound healing problems. The course of the surgery not only but in particular in these microvascular reconstructions should be well planned and organized by the responsible surgeon and continuously supervised to avoid time delay. If possible, transplants which do not afford repositioning of the patient during surgery but instead allow for a 2-team procedure should be preferred. About 95% of defects can be reconstructed with radial forearm, anterolateral thigh flaps as well as fibula flaps in case bone is needed all of which allow for a 2-team approach [127].
Mistakes in the context of reconstructive surgeries with microvascular free tissue transfer can occur in planning, the surgery itself and postoperative care.
As with any other oncologic procedure general health condition, co-morbidities such as coagulopathies and the option for a longer anesthesia time should carefully be evaluated [128]. The patients age is generally no contraindication for a microvascular surgery [127], [129], although general complications can be more likely in elderly patients. Especially in perforator flaps tobacco consume forces the risk for thrombosis of the pedicle of the flap and is a risk factor for higher rates of revision surgery [130]. Abstinence from tobacco is suggested at least 2 weeks before surgery to minimize the risk of flap loss. Further important factors for best final reconstructive results are a precise planning of the flaps size and shape including an assumption of about 30% flap shrinkage after possible added radiation therapy. Among others flap selection should include optimized tissue components, size, thickness, morbidity at the harvest site as well as pedicle length and vessel diameter, both of which should fit the requirements for anastomosis with the neck vessels. Since many flaps are performed in salvage cases, the risk of thrombosis is higher because of radiation damage of the vessel walls. Minimized manipulation and

suturing from inside to outside in these vessels help to somewhat lower the risk of thrombosis.

Before microvascular anastomosis the surgeon had already operated a certain amount of time, nevertheless this last step affords a maximum of concentration. A short break before anastomosis helps the surgeon to focus again for safest performance. During the procedure the body temperature of the patient should be closely monitored to avoid vasospasm of the flap vessels and the flap might need to be warmed in case the climate in the operating room might be too cold. Arterial spasms caused by manipulation of the vessels of the pedicle might be addressed with local application of lidocain. During gentle manipulation on the anastomosed vessels, the vessel rims should be cleaned and rinsed with heparin solution. Vessel clamps of the wrong size or strength can cause trauma to the vessel walls and lead to later thrombosis. Vessels to be anastomosed ideally have the same diameter though differences in diameter of 1:2.5 can possibly be overcome using delicate suturing techniques. Further risk factor for an insufficient microvascular technique is a wrong positioning of the pedicle resulting in tension or kinking and later thrombosis. All these factors and a well performed suturing technique help to avoid revisions and improve flap survival. Although still used frequently, peri- and postoperative medication has no influence on revision frequencies or flap survival [131].

Figure 10: Skin island in the neck wound for easy flap supervision after reconstruction using a radial forearm transplant

Close monitoring of the flap postoperatively supports a rapid detection of insufficient flap perfusion. This affords a training of the supervising personnel. Little skin elements located at the course of the pedicle and planned during flap harvest integrated in the neck wound help to safely monitor the flap skin especially in case of flaps that are located in the lower parts of the upper aerodigestive tract and cannot easily be visualized. Beside clinical checks and doppler sonography other more sophisticated techniques exist though might not yet be necessary for the clinical routine [132]. Timely cognition of perfusion insufficiencies lead to a high amount of successful flap revisions and the high efforts of these complex surgeries warrant a more intense postoperative monitoring (Figure 10).

5 Wound management, antibiotics

After extended neck procedures suction drains should be placed to avoid seroma and hematoma. These can be removed as soon as daily outflow is <25 ml/d. Pressure dressing on the neck have no impact on the risk of postoperative bleedings [133].

In case of pharyngotomy during neck surgery a peri- and postoperative administration of antibiotics reduces the risk of infections. Prophylactic antibiotic therapy is most effective if given brief before and until 24 h after surgery. Longer lasting antibiotics do not reduce the risk of wound infections or fistula formation [134] but instead increase the risk for colitis and resistances [135]. Antibiotics including gram-negative and anaerobic germs are suggested [136]. Interestingly radical neck dissection are accompanied with a higher risk for postoperative wound infections to be addressed in the postoperative care [134]. Surgeries in the oral cavity have a higher risk of infection in case of initially reduced oral hygiene and thorough previous care can reduce this risk [137]. As mentioned earlier general risk factors for a higher rate of wound infections are a high tumor stage, smoking, alcohol, diabetes, previous radiation therapy, anemia and low albumin, flap surgeries, mandibulotomy, tracheostomy, blood transfusions and again a prolonged surgery time. Prevention and a close monitoring of early signs of infections can minimize wound healing insufficiencies and later consequences [138].

In case of infected wounds smear tests can be performed to identify the correct antibiotic treatment option. Together with intensive local care an expansions of the infection towards the neck vessels has to be avoided. Besides the local treatment larger defects and fistulas might have to be treated early with reconstructive options as described above. In many cases it is useful however to wait for stabilized conditions and clean wounds before surgery to optimize the chances of a successful reconstruction.

6 Histology

The goals in head and neck cancer surgery is to safely resect the cancer with clear margins and on the other hand to keep morbidity low. The judgment what is to be a clear margin is up to date incongruent [139]. It might depend on location, three dimensional extension and

kind of cancer invasion criteria. Although safe resection margins are decisive for a recurrent free tumor survival opinions on that definition are surprisingly divergent. In a US questionnaire 476 head and neck surgeons stated a resection margin of >5 mm as to be sufficient, whereas others interpreted margins >1 mm as safe as well [140]. This discrepancy can be found among head and neck surgeons world wide. Studies showed that resection margins >5 mm are appropriate in the oral cavity and somewhat in the pharynx [139]. Liao and co-workers unveiled that even >7 mm safety margins are necessary in the oral cavity to provide a good prognosis [141]. Another investigation demonstrated margins <5 mm as risk factors for local recurrence [142]. But safe margin definition is strongly dependent on tumor location in the upper aerodigestive tract. Cancers of the vocal fold for example are sufficiently resected with margins between 1–2 mm. This is not the same for trans- or supraglottic cancers however [139]. No clear statement can be made on safe margin definition in the pharynx and supraglottic space lacking data for these locations.

Even the judgment of carcinoma in situ and severe dysplasia seems divergent among surgeons [140] but evidence of severe dysplasia in resection margins should be scored as R1 resection as it is for carcinoma in situ [143].

Although frozen sections are used intraoperatively to assure clear margins, final pathology reports might unveil contrary results [140]. But later re-resections are without proof of cancer cells in many cases and faultily location of the tissue having to be resected in a second procedure can lead to misinterpretations if no further cancer is found. This might be one reason that this patient group, although clear margins in a re-resection has a worse survival and a higher rate for local recurrence compared to initially R0-resected patients [144]. This should to be taken into account in the final margin interpretation and the judgment of the necessity of adjuvant therapy.

Moreover tissue shrinkage through cutting and induced by formalin influences the assessment of margins. Already cutting mucosa leads to 20–25% tissue shrinkage compared to the clinical appearance [145]. Another 10% is added by formalin solution. Since the above margin criteria mentioned are all based on pathologic margins, surgeons might calculate about 35% more margin clinically than mentioned in the literature to achieve a safe resection [139].

7 Management after surgical mistakes

Surgical mistakes can result in considerable burdens for the patients and their relatives. Insufficient and improper communication by any medical personnel involved will even enhance this problem. In many cases the patient interest does not primarily focus on a financial compensation but an open communication about what had occurred and that such mistakes can be avoided in the future [146].

In Germany scruples of doctors to talk about mistakes and to transport an appropriate apology have no legal grounds instead it implies no admission of guilt and there is no loss of insurance safety. On the contrary such behavior will promote a positive trusting relationship between doctor and patient.

After adverse events the communication with the patient should take place as soon as possible, in a neutral atmosphere and providing time. Some hospitals have specific algorithms for this scenario and defined doctors e.g. the head of a department, who communicate the situation with the patient. This can ensure a professional and experienced communication and might be helpful in case of a disrupted relationship between a patient and a treating doctor.

Regret about the mistake and a clear statement on how the problem will be taken care of has to be clearly stated towards the harmed patient. Sometimes it might be advisable to integrate the patient relatives in the communication process. A thoroughly performed conversation results in understanding and a further objective process in most cases. In major issues involving the public again fast transparency and open communication of the facts are important to keep up a rational discussion. Lack of transparency and delay in communication on the contrary have been shown to have fatal consequences in the public and that they could have been avoided.

Refurbishment, support of the colleagues and an atmosphere of open communication about mistakes within the institution is of importance and institutional conferences about mistakes such as so called M&M (morbidity & mortality conferences) have a high learning effect for the entire staff. This again results in positive behavioral and sometimes structural changes with reduced mistakes and adverse events and therefore an improved patient treatment.

8 Conclusion

The previous chapters describe a variety of possible sources of risks, errors and mistakes starting with misinterpretation of preoperative diagnostics, faulty indications, incorrect surgical handling up to failures during the postoperative treatment. Knowledge of possible risk sources is one of the basic principles for the avoidance of mistakes. However such mistakes cannot always be obviated in the clinical routine and therefore a proper handling of possible complications, consequences for future treatments and an adequate communication process with the patient is of importance. All this will continuously influence a positive development of surgical skills and improve the future treatment not only of our oncologic patients.

Notes

Competing interests

The author declares that he has no competing interests.

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