General Remarks

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1 Overview of Oncoplastic Surgery

Xiao Zhou, Wei Wang, and Yue Zhou

Oncoplastic surgery is an interdisciplinary branch of oncological surgery that integrates theories and technologies in oncological surgery, plastic surgery, and microsurgery with characteristics of planned radical resection of tumors and one-stage repair and reconstruction of surgical defects on the basis of multidisciplinary treatment (MDT) of tumors [1]. As an emerging discipline, the development history of oncoplastic surgery has witnessed the progress of the plastic surgery and has experienced a combination of oncology surgery and plastic surgery, including the development and application of technologies such as microsurgery. To review the historical background for birth of this discipline, we believe that it should be traced back to the beginning of the formation and development of plastic surgery.

The plastic surgery is a branch discipline of modern surgery, and it mainly studies and treats the deformities or defects of some tissues and organs on the surface of the human body and within the human body so as to achieve the purpose of restoring their physiological functions and external morphologies. As an independent discipline of surgical specialty, the plastic surgery has a short history. In 1914, World War I led to the appearance of numerous patients with maxillofacial organ defects and limb defects, and a large number of medical staff accumulated a wealth of experience in the repair and reconstruction in the treatment of these patients, and thus, their technical levels were improved; a considerable amount of monographs on plastic surgery techniques were published in succession; thereby, the plastic surgery specialty was formed, of which, the application of free skin graft and the determination of the concept of tissue transplantation are recognized as signs of the birth of plastic surgery. On the track of development of the plastic surgery, the occurrence of a series of new technologies and new ideas played a huge role in promoting the development of this discipline [2]. In the 1960s, the microsurgical techniques were used in clinics, and then they developed rapidly and greatly contributed to the advancement of plastic surgery techniques; the complicated surgeries such as craniotomy, moving the eye socket frame and rearranging the craniofacial bone structure, and bone graft fixation had been performed in the craniofacial surgery to correct and reshape many types of severe craniofacial deformities and provide patients with an opportunity to transform the head and face and reconstruct the countenance. Skin expansion techniques were used in multiple sites on the whole body since the 1960s, which increased the flap areas and also expanded the areas of tissue defects to repair at the same time. The emergence and development of tissue engineering in the 1990s made it possible to cultivate some tissues and organs of the human body in vitro, which changed the traditional concept and pattern of trauma repair and organ reconstruction in plastic surgery [3]. The gene therapy, transplantation immunity, and computer technology had also entered the field of plastic surgery in different degrees, which promoted the

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development of plastic surgery, and made it a discipline with distinctive characteristics.

Currently, the malignant tumor has become the important cause of human death, and about 7 million people die of malignant tumors all over the world every year; the malignant tumor has become the second highest cause of death in China. The oncoplastic surgery is a product of mutual integration of oncology surgery and plastic surgery. The oncology surgery is to resect the tumor with surgical method. The surgery is still the preferred method of treatment for most of the early and earlier stage solid tumors [4]. The development of plastic surgery has laid the foundations for the birth of the oncoplastic surgery; the disfigurement, tissue and organ defects after the radical surgery in oncology surgery, and the cancer patients' desires for complete sound functions have provided the basis for the birth of the oncoplastic surgery. With the development of the tumor treatment concept, at the same time of achieving prolonged survival and even getting cured, the cancer patients also want to have intact physical forms and sound functions, so that they can adopt a positive attitude to participate in social production and social activities. Because the malignant tumors have the biological characteristics of unlimited growth and multiple metastases, the surgical method for lesion resection is still an important part of a comprehensive treatment model, which can create favorable conditions for improvement of the patient's own immune system and the body rehabilitation to achieve the purpose of improving the cure rate and prolonging survival. Common principles for radical resection of malignant tumors originated from the classic radical mastectomy invented by Halsted in 1894, which mainly include: (1) The tumor tissues are incised and exposed during surgery; (2) the en bloc resection of the original cancer and the affiliated regional lymph nodes are performed. Since the 1960s, the operators began to emphasize the intraoperative tumor-free technology with the purpose to prevent recurrence. At the moment, there was a trend that the oncology surgery was gradually distinguished from general surgery and became an independent discipline. With the rapid development of related disciplines, the oncology surgery has developed from just purely focusing on surgery into a specialty with strong technicality [5, 6]. However, the patients often have large and deep wounds after radical resection of tumors and even have concomitant exposures of blood vessels, nerves, and tendons. The radiation therapy and drug chemotherapy in the process of tumor treatment will have a negative impact on the healing of the abovementioned wounds; thus, the wound repairs for such patients are often more difficult, especially for patients with tumors in sites such as the oromaxillofacial region, chest wall, breast, and perineum where there is a higher demand for the appearance and function. It is difficult to repair this kind of wound using the general surgical method; therefore, we must learn from the plastic surgery technology to make the appearance and functions of the defect sites achieve more satisfactory recovery. The functional recovery is of great significance for reducing or eliminating the psychological burden of patients, enhancing the patient's self-confidence and improving the patient's quality of life at the same time, and it has created favorable conditions for other treatments such as postoperative radiotherapy and chemotherapy. In this context, the combination of oncology surgery and plastic surgery has become an inevitable trend of the medical development and has a broad development prospect.

In foreign countries, the combination of oncology surgery and plastic surgery can be traced back to the early nineteenth century. Dieffenbach et al. in German reshaped the patient's cheek and nose using local tissue transplantation after the removal of head and neck malignant tumor. Iginio Tansini in Italy firstly used the latissimus dorsi musculocutaneous flap to repair skin defects. In 1955, Owens used the myocutaneous flap transfer to repair the facial damage after head and neck tumor surgery [7]. Since the twentieth century, the oncology surgeons have increasingly recognized that the plastic and reconstructive surgery plays an important role in tumor resection surgery; thus, they have carried out various forms of exploration continuously. McGregor firstly used the skin flap to carry out one-stage repair of soft tissue defects after oral cancer surgery in 1963. In 1964, some scholars and medical workers believed that one-stage repair was not only necessary for tumor patients but also feasible for trauma patients, and it was listed as the preferred treatment of oral and maxillofacial defects. In 1965, Bakamjian extracted the skin flap (i.e., pedicled pectoralis major myocutaneous flap) from the front chest area to repair the defects of the oral and maxillofacial region. Thereafter, the pedicled pectoralis major myocutaneous flap became a commonly used flap in defect repair after oral and maxillofacial tumor resection. In 1977, Bakamjian and Littlewood reported that the pedicled skin flap from the cervical region was applied to repair the soft tissue defects after oral and maxillofacial tumor resection. In 1996, McGregor and Reid et al. reported that the skin flap was used to immediately repair the cheek defect after resection of squamous cell cancer. In the 1970s, the transplant techniques of the musculocutaneous flaps and the microvascularized tissue flaps gradually matured and developed and became the mainstream of defect repair after tumor resection. The massive clinical practices prove that the plastic surgery, oncology surgery, and other related disciplines are closely integrated and cooperated with each other, which have great significance for the comprehensive treatment of tumors [8–10].

In China, the plastic surgery and the surgical oncology started relatively late, and the use of skin flap for repair of partial tissue defects began in the 1970s. In 1973, Yang Dongyue firstly repaired the defect after cheek tumor resection with groin flaps using vascular anastomosis. More reasons exist for the relatively slow development of the oncoplastic surgery, of which the limitation of the technology is a more important influence factor. Before the 1970s, it was required to perform a pedicled flap procedure for all skin flap transplantations in plastic surgery, which required carrying out multiple pedicled flap transplantations and fixing the limb for a certain time; thus, the patient would be hospitalized for a long time and have more pains. The traditional transfer method limited the operation scheme design for one-stage repair and reconstruction after radical resection of many tumors. For a long time, awed by the consequences of the cancers, the cancer patients actively sought the removal of cancerous lesions in the department of surgical oncology at first, and then they would be hospitalized again into the department of plastic surgery for actively seeking repair and reconstruction of the deformities after tumor resection. Due to the lack of communication between cancer surgeons and plastic surgeons, the treatment mode that the cancer radical surgery and the reparative and reconstructive surgery were performed by stages had made many patients lose the chance of one-stage repair and reconstruction with the best effects. Because there was a lack of tissue flap techniques in the past, and the local area after tumor resection often couldn't be repaired and reconstructed, many patients with advanced cancers turned down the opportunities to undergo operative treatments; even if the radical operations were carried out with an effort, this would lead to the consequences of serious disfigurements and organ function defects due to severe local tissue defects in the patients. At present, because the plastic surgery offers a wide range of tissue repair technologies, this not only ensures the completion of radical operation and the increasing rate of local resection but also reaches the purpose of repairing the local tissue defects and reconstructing the local functions. In order to complete the tissue defect repair and functional reconstruction with high quality, it is required that the surgeons who are engaged in oncoplastic surgery have a solid knowledge and skills in cosmetic surgery. In the process of tissue repair and reconstruction, more attentions should be paid to the repair of the subunits of tissues and organs, the cosmetic repair and the tissue regeneration, and functional recovery, so as to greatly improve the quality of life of patients after surgery. Since the 1980s, the tumor resection scope has almost reached the limit the patient's body can withstand. Under this context, how to design more reasonable surgical treatment options which can improve the qualities of life of the patients at the same time of treating the diseases has become a concern of many scholars' focus. From the beginning of the 1970s, with the development of microsurgical techniques, the oncology surgeons at home and abroad constantly have absorbed the microsurgical techniques and plastic surgery techniques into their own specialties, which have opened up a new chapter of one-stage repair and reconstruction of tumors. For example, Zhang Disheng et al. have successively reported the use of pectoralis major myocutaneous flap, free forearm flap, latissimus dorsi musculocutaneous flap, and esophageal replacement with free jejunum for one-stage repair and reconstruction of the defects after head and neck surgery with microsurgical techniques. In the 1980s, Wang Hongshi firstly reported that the infrahyoid myocutaneous flaps were used successfully in one-stage repair of tongue and mouth floor defect by the oncology surgeons. In the 1990s, in order to solve the problem of venous reflux disorder occurring in the infrahyoid myocutaneous flap, Zhou Xiao reported two surgical methods such as the infrahyoid myocutaneous flap in which the venous variants were reserved and the infrahyoid myocutaneous flap in which the veins were severed and then were anastomosed. In addition, there are a large number of reports on one-stage repair and reconstruction after breast cancer radical surgery. Hence, the maturing and development of microsurgical techniques promotes the development of the entire discipline by providing necessary technical supports for the full integration of oncology surgery and plastic surgery, a guarantee for innovation in treatment programs in oncology surgery, and the birth of oncoplastic surgery.

"Necessity is the mother of invention and innovation," the necessity is also the driving force for the development of all things. In the historical process of the full integration of oncology surgery, plastic surgery, and microsurgical techniques and the emergence of a new cross discipline (oncoplastic surgery), the one-stage repair and reconstruction after radical tumor resection get rapid development in the head and neck surgery and the breast surgery. The reason can be summed up as follows:

1. After treated by the comprehensive treatment such as the operation combined with radiotherapy and chemotherapy or the radical surgical resection alone, the survival period in most of the patients with malignant tumors has been prolonged, and some patients have been cured. However, the traditional head and neck cancer surgery and breast cancer radical surgery cause serious damages to the appearance beauty, and the patients are eager to be treated by a method which cannot only cure the disease but also restore their body shapes, and thus, the patients can return back to the family and society and live on happily. Only achieving recovery in organ function and appearance beauty, the patients can have an improved quality of life after surgery, and therefore, all their physiological needs, security needs, belonging and love needs, esteem needs, and self-actualization needs can be satisfied.
2. In the past, because some oncology surgeons were not familiar with microsurgery and plastic surgery techniques, they often had no effective measures for defect repair after radical surgery; even if they had tried to perform the

surgery, the quality of life in patients was often decreased due to the serious complications after surgery. Since the 1970s, the development of microsurgery and plastic surgery techniques has provided a wealth of surgical approaches for one-stage repair and reconstruction of the defects after radical tumor surgery; hereby, the surgeons can remove the lesion focus thoroughly and do not worry about the issues of repairing the local tissue defects after lesion resection. This not only improves the 5-year survival rate of patients but also shows a higher and newer level in the aspects of reducing complications, preserving the function and improving the appearance. The radical tumor surgeries such as the head and neck tumor surgery and the breast tumor surgery plus one-stage reparative and reconstructive surgery have become one of the trends of contemporary development of oncology surgery, and this will also provide a new way of thinking for designing operation scheme for the tumors in other sites.

2 Concept and Therapeutic Range of Oncoplastic Surgery

Xiao Zhou

In the 1970s, Yang Dongyue firstly repaired the defects after cheek tumor resection using the skin flap in China, and then he applied some plastic surgery techniques into the treatments in the oncology surgery, but he did not clearly put forward the concept of oncoplastic surgery. Academician Qiu Weiliu proposed the application of microsurgical techniques in reparative and reconstructive surgery and promoted the development of oral and maxillofacial surgery in China. Zhou Xiao et al. firstly discussed in detail the relationship between the oncology surgery and other related disciplines at home and abroad from the perspectives of plastic surgery, microscopic surgery, plastic and cosmetic surgery, tissue engineering, and evidence-based medicine and put forward the concept of oncoplastic surgery: The oncoplastic surgery is a branch of the oncology surgery, and it is a surgical cross edge discipline which combines the theories and technologies of oncology surgery, plastic surgery, and microsurgery and is characterized by planned radical tumor resection plus one-stage reconstruction. The treatment scope mainly covers the repair and reconstruction of defects in the skin, mucous membrane, muscle, nerve, bone, and some organs; the surgical methods include the use of autologous, allograft, and xenograft tissues or synthetic biomaterials to repair the tissue and organ defects or deformities. When making the operation scheme, we should give full consideration to the effects of radiation therapy, chemical therapy, tumor recurrence, tumor deposit, tumor metastasis, and other relevant factors. In the treatment of malignant tumors, the radical resection of the tumors is the main aspect of the treatment, and the purpose of the implementation of reparative and reconstructive surgery is to perform defect repair and functional reconstruction on the basis of ensuring complete excision of tumor lesions in tissues and organs. The anatomic sites involved in oncoplastic surgery are more extensive. For example, the repair of head and neck defects is cross-linked with otolaryngology – head and neck surgery, oral and maxillofacial surgery, ophthalmology, and brain surgery; the repair of the defects in the breast, body, and limbs is cross-linked with breast surgery, thoracic surgery, general surgery, hand surgery, and bone surgery; the repair of the defects in the genitals is cross-linked with gynecologic oncology, gynecology, and urinary surgery. The operation scheme of one-stage repair and reconstruction after radical tumor resection should be personally designed by the oncology surgeon, which puts forward a higher requirement on the oncology surgeon. A surgeon of oncoplastic surgery must be equipped with solid basic theories and skilled operation techniques in oncology surgery, plastic surgery, microscopic surgery, and vascular surgery and should also be equipped with basic knowledges in related disciplines such as anesthesiology, radiation therapy, chemical therapy, thermatology, interventional therapy, minimally invasive surgery, laser therapy, cryotherapy, surgical nutrition, tissue engineering, ethics, and psychology. Attentions should be paid to the following aspects during the working process:

1. The operator should abide by the medical ethics, have a high degree of medical responsibility, preclude any deceptive or exaggerated behavior in the medical treatment activities, and avoid directly selecting the patients as subjects of practice in the case that the condition or opportunity is not mature.
2. The operator should be fully aware of one's own abilities and should not perform a surgery which is uncertain.
3. When the patients are admitted to hospital, attention should be paid to organizing the multidisciplinary expert consultations for intractable cases and formulating a scientific and reasonable sequential treatment program.
4. Any surgeons who are engaged in the plastic surgery must undergo strict formal training in technical operations of plastic surgery and microsurgery and try to achieve fine repair effect in the process of carrying out the oncoplastic surgery. Especially when repair and functional reconstruction of defects in subunits are carried out, it should be noted that the surgical operations conform to the surgical principle of cosmetic and plastic surgery.
5. The operator should cultivate the medical aesthetic knowledges and improve one's own aesthetic level.
6. The operator should cultivate the medical psychology knowledges and improve one's identifying and guiding abilities to help patients with psychological problems.

3 Objective and Therapeutic Principle of Oncoplastic Surgery

Xiao Zhou and Chaohui Zuo

3.1 Therapeutic Principles of the Oncology Surgery

The radical surgical treatments in oncoplastic surgery must comply with the therapeutic principles of the oncology surgery. The surgical treatments of tumors mainly refer to the surgical treatments of the malignant tumors. The malignant tumors have biological characteristics such as invasiveness and metastasis, and most malignant tumors not only show an invasive growth in local areas but also show a metastasis to the lymph nodes surrounding neoplastic foci and the distant lymph nodes. Based on the above characteristics of the tumors, in addition to following the general principles of the surgery, the surgical treatment of the tumors should also follow the basic therapeutic principles of the oncology surgery. The general therapeutic principles of the oncology surgery are summarized as three points, namely, the patient selection before surgical treatment, the determination of surgical method in the treatment, and the comprehensive treatment on the basis of individualization.

3.1.1 Selecting Appropriate Patients for Carrying Out Surgical Treatments According to the Characteristics of the Different Tumors

The surgical treatment of the tumors is closely associated with the pathological diagnosis. The pathological diagnosis can provide important results such as histological type, histological grade, and primary site as well as whether the surgical margin is safe, which are the most important evidences for surgeon to treat the patients, namely, the "gold standard" for diagnosis and treatment [11]. The clinical diagnosis and staging include the size of the primary tumor, the situation of regional lymph nodes, and the metastatic sites, which can fully reflect the basic situation of the patient, reveal the general biological characteristics of malignant tumors, and help surgeons to confirm the surgical treatment and select the surgical method.

3.1.2 Maximizing the Removal of the Tumor Tissues and Maximizing the Preservation of Normal Function of the Body and Organs

Since Halsted invented the classical radical mastectomy in 1894, the principles of two maximizations have been established and accepted by the majority of the oncology surgeons. When these two principles are in conflict with each other, the latter should be subjected to the former. However, if the removal of excessive tissues affects organ function, it is needed to reduce the extent of surgery. It should be emphasized that the preoperative evaluation is relative, and the specific surgical method is determined according to the intraoperatively explored situation for most of the oncology surgical operations. For example, whether the tumor is cleanly removed is determined according to whether there are cancer cells in the rapid intraoperative pathology report [12].

3.1.3 Fully Understanding the Limitations of Surgical Treatment and Following the Principle of Comprehensive Treatment on the Basis of Individualization

We still emphasize the general principles of cancer treatment such as early detection, early diagnosis, and early treatment; we should also follow the law of development of different tumors and rightly master the indications for the surgical treatment of tumors; we oppose the unprincipled surgical overtreatment and also don't appreciate the overly negative and conservative attitude, which make some patients who may have a chance for surgery lose the chance of surgical treatment. Today, the goal of surgical treatment of the tumors is to make tumor patients not only survive for longer period but also have a better quality of life. The treatment of tumors is not the kind of treatment based on the single discipline, and the key to improve the efficacy of tumor treatment is to advocate the comprehensive treatment based on the multidisciplinary cooperation. The comprehensive treatment program is developed primarily based on the biological characteristics and clinical stage of the tumor and the general condition of the patient. In the past, there was too much emphasis on expanding the scope of surgical resection, but it is later confirmed that it cannot improve the survival rate. With the increasing level of the surgical operation, the surgical treatments of tumors develop increasingly into the direction of individualization. At present, the therapeutic methods such as preoperative chemotherapy, radiotherapy, or chemoradiotherapy (namely, the neoadjuvant therapy) are considered for tumors at the late stage, which aims to improve the surgical resection rate, remove the occult metastases, reduce postoperative recurrence and metastasis, relieve the clinical symptoms such as pain, determine the sensitivity of the tumor to chemotherapy through downstaging treatment, and provide the basis for the choice of chemotherapy after surgery [13].

3.1.4 Following the Principle of Non-tumor Operation

In the process of diagnosis and treatment of tumors, the improper inspections or operations of the medical workers may cause the spread of tumor cells. The oncology surgery not only emphasizes the aseptic principles required in the general surgery but also follows the principles of tumor-free operation.

For each patient who needs to receive the treatment of the oncoplastic surgery, the surgical indications should be strictly controlled in accordance with the therapeutic principles of oncology surgery, and an integrated comprehensive treatment plan should be made before surgery. Of which, the treatment measures such as surgery, radiotherapy, and chemotherapy are reasonably selected; the therapeutic regimen of the radical surgery is rationally established, and the program for tissue defect repair after radical surgery is properly selected. The treatment contains the contents of the two aspects such as the tumor lesion resection and the repair and reconstruction after surgery. Harri et al. reported that the repair and reconstruction after tumor surgery has the following two goals: (1) The immediate repair and the appropriate reduction of the surgical damages during the tumor resection are beneficial to protecting the vital organs, preventing infection, preserving the necessary functions, and promoting the early rehabilitation; (2) the function and appearance will be repaired and reconstructed after tumor surgery, and the techniques for the functional reconstruction and the cosmetic and plastic surgery should be applied as far as possible. In these two objectives, the improvement of quality of life of tumor patients is the core of the treatment [14]. The oncoplastic surgery can provide technical supports for comprehensive treatments such as radical tumor resection and postoperative chemotherapy and lay the foundation for the intraoperative radical tumor resection. The oncoplastic surgery is performed mainly for head and face reconstruction, breast and chest wall reconstruction, abdominal and perineal reconstruction, limb reconstruction, etc.

3.2 The Therapeutic Principles of the Oncoplastic Surgery

The treatment of the oncoplastic surgery contains the contents of two aspects such as the tumor lesion resection and the repair and reconstruction of postoperative defects. In radical surgeries of malignant tumors, emphases are attached to the biological characteristics and occurrence law of cancers, the comprehensive treatment principle for cancers, the aseptic technique, and the tumor-free technique, and the choices of surgical indications are in full compliance with the therapeutic principles of the oncoplastic surgery. After completion of tumor resection, the plastic surgery and microsurgical techniques will be applied to repair the defects in some important sites caused by surgery, and every effort is made to restore function and appearance.

3.2.1 The Principles for the Selection of Reparative and Reconstructive Surgery

1. If the application of simple surgery can achieve the same effect, the complex plastic surgery or microsurgery will be not performed.
2. Only the donor tissues from the secondary sites can be transplanted to repair the defects in the important receptor sites.
3. It is necessary not only to ensure a good recovery of the function and appearance of the donor site but also to minimize the damages to the function and appearance of the receptor site, and it should be avoided by all means to cause secondary deformity or dysfunction in receptor sites.
4. The operation scheme of one-stage repair and reconstruction of tissues and organs is selected as far as possible.
5. The site after radical radiotherapy should not be selected as a flap donor site.

3.2.2 Surgical Classification of Repair and Reconstruction After Radical Tumor Surgery

The repair and reconstruction after radical tumor surgery can be divided into two types according to the time schedule: one-stage repair and deferred reconstruction.

1. One-stage repair, the one-stage repair has become the mainstream of oncoplastic surgery since the twenty-first century.
   (1) Its advantages include: (1) It can reduce the postoperative dysfunction and deformity at early phase, protect the wound for securing primary wound healing, create favorable conditions for the postoperative recovery of the patient, and create the conditions for undergoing other additional therapies such as radiation therapy and chemotherapy; (2) it can reduce the number of operations, reduce the occurrence of complications, and alleviate the patient's suffering and save money; (3) the radical tumor surgery is more thorough and can reduce the local recurrence rate.
   (2) Its shortcomings include: (1) The micrographic surgery is difficult, and it is required that the oncology surgeons have extensive surgical experience and expertly master the plastic surgery and microsurgical techniques; (2) after restoration, it is not convenient to directly observe and early detect the recurrent lesions in some sites, especially in the deep hidden sites.
2. Deferred reconstruction

(1) Its advantages include: (1) The surgical area is exposed after surgery in some tumor patients, and this facilitates early detection of local tumor recurrence; (2) the surgery is relatively easy.

(2) Its shortcomings include: (1) If the important tissues and organs such as large blood vessels are exposed, this can lead to serious complications after surgery; (2) if the patient receives other treatments such as radiation therapy after surgery, the difficulty of the reconstruction will be increased due to tissue damage; (3) the long-standing defect and dysfunction in tissues and organs such as the nasal defect and the language and swallowing disorders will seriously affect the physical and mental health of the patient, and this is not conducive to making them return to normal social activities.

4 Diagnosis and TNM Staging of Tumors in Oncoplastic Surgery

Chaohui Zuo and Xiao Zhou

The correct diagnosis and TNM staging of the tumor are a prerequisite for carrying out the oncoplastic surgery, and it can accurately assess the efficacy and prognosis. The tumor diagnoses include the pathological diagnosis, the diagnosis by molecular tumor markers, and the imaging diagnosis. The tumor diagnosis and TNM staging in oncology surgery are proposed by the International Union Against Cancer [15] , and the staging method which is currently widely used is also applicable to the oncoplastic surgery.

4.1 Tumor Diagnosis

The tumor diagnosis in oncoplastic surgery is a multidisciplinary comprehensive analytic process, and it is mainly dependent on the pathological diagnosis, the diagnosis by molecular tumor markers, and the imaging diagnosis.

1. The pathological diagnosis. The pathological diagnoses mainly include cytopathological diagnosis and histopathological diagnosis. The former is the diagnosis of tumor which is made based on the examinations of the exfoliocytology or the fine-needle aspiration biopsy and peripheral blood smears; the latter is the diagnosis which is made after the histological examination of the pathological sections of tumor tissues obtained by puncture, forceps biopsy, cutting, or resection. Among various kinds of tumor diagnostic techniques, the pathological diagnosis is still considered the "gold standard." However, the pathological diagnosis also has some limitations, which have a certain relationship with the specimen acquisition, the quality of section making, and the professional skill. Sometimes it is needed to draw materials repeatedly. Therefore, the conclusion of pathological diagnosis is often made after comprehensive judgment on characteristics such as clinical manifestations, surgical findings, gross morphological changes, and morphologies under light microscopy [16] .

   The diagnosis by molecular tumor markers. The tumor markers often appear along with tumors. They are produced and secreted by the tumor cells and can reflect the existence of the tumor within the body. They have the characteristics of high sensitivity and specificity. They include (1) the tumor markers belonging to enzymes, such as prostate-specific antigen (PSA), matrix metalloproteinase (MMP), and acid phosphatase (ACP); (2) the tumor markers belonging to hormones, such as human chorionic gonadotropin (HCG); (3) the tumor markers belonging to embryonic antigens, such as alpha-fetoprotein (AFP) and carcinoembryonic antigen (CEA); (4) the tumor markers belonging to glycoproteins, such as CA125 and CA199; and (5) the tumor markers belonging to receptors, such as epidermal growth factor receptor (EGFR).
2. Imaging diagnosis. The imaging diagnosis is the diagnosis which is made based on the images of human tissues or organs formed by some kinds of methods, and it plays a very important role in the early detection, diagnosis, and treatment of tumors. It relates to disciplines such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine (such as PET-CT), ultrasonic medicine, and interventional radiology, and various examinations have their own advantages and disadvantages. The ultrasound examination is a noninvasive examination, which can be used for repeatable observation and is easy to operate, but has a lack of specificity. MRI has excellent tissue resolution and can show clearly the anatomic structures and lesions, but it cannot be carried out in the patients who have cardiac pacemakers or magnetic materials within the body. As a noninvasive and safe tumor imaging technology, PET-CT can display the characteristics of tumor cells from the molecular level and provide clinicians with relevant information for the diagnosis and treatment of tumors and can also determine the recurrence and metastasis of tumors, but it is costly and can only be listed as an optional item.

4.2 Staging Diagnosis of Tumors

After determining the nature of the lesions, the staging diagnosis of the malignant tumor contributes to establishing a reasonable treatment plan and correctly assessing the efficacy and prognosis. The clinical staging should be completed before the start of treatment. TNM staging is a prerequisite for the diagnosis in oncoplastic surgery. T (tumor) refers to the primary tumor; N (node) refers to the regional lymph node metastasis; M (metastasis) refers to distant metastasis. Then the letters are followed by 0–4 numbers according to tumor size and infiltration depth to indicate the development degrees of the tumors: 1 represents small, 4 represents large, and 0 represents nothing, and the staging is decided based on these three items. If the tumor size cannot be judged in clinic, it will be represented with TX. The tumor staging includes clinical staging (cTNM) and postoperative clinicopathologic staging (pTNM), and their specific standards are negotiated and established by various professional meetings [17]. For example, the staging of the thyroid cancer is as follows: stage I stands for $T_1N_0M_0$; stage II stands for T2 or $T_3N_0M_0$; stage III stands for $T_4N_0M_0$ or any TN_1M_0; and stage IV stands for any TNM_1.

5 Application of PET-CT in Diagnosis in Oncoplastic Surgery

Yi Mo, Yi Luo, and Bo Zhou

The advances in diagnostic imaging technology have promoted the development of the oncology surgery. The statuses of the primary lesion and distant metastasis of the tumor have the very vital significance for TNM staging of the tumor and the prognosis of the patient. Making an accurate judgment on the condition and the prognosis of the tumor patient is also the basic requirement for the oncoplastic surgery. The oncoplastic surgeons must have a detailed understanding of the statuses such as the benign and malignant natures of tumors, the size of the primary lesion, the exact boundary, and the distant metastases. The existing X-ray, CT, and MRI technologies can provide the more accurate positioning information of the primary lesions and the metastases in middle and advanced stage, but they are less effective in the determination of early metastatic lesions of malignant tumors and the accurate delimitation of infiltrating tumor border. It is because that the number of these metastasized early-stage tumor cells is small and no significant changes occur in the anatomical structures, while the qualitative changes have taken place in the local histopathologic feature and metabolic status. Accurately determining the statuses of the early metastasis and infiltration of the tumor has a decisive role in the selection of surgical programs, and the research and development and application of PET-CT would better solve this problem. The first PET-CT was successfully developed by two scientists, Townsend and Nutt, and it is a milestone in the development of today’s life science and medical imaging technology. The full name of PET is positron emission tomography, and it is mainly used to display the tissue metabolic changes; the full name of CT is computed tomography, and it is mainly used to display the tissue structures. PET-CT combines the advantages of both. Furthermore, it can early detect and accurately position the tumor cells with abnormal energy metabolism. Therefore, it can provide a reliable means to assess the tumor status and make a surgical plan for the oncoplastic surgeons.

5.1 The Operating Principles and the Imaging Agents of PET-CT

5.1.1 The Operating Principles of PET-CT

The operating principles of PET-CT are that the necessary materials for human body metabolism such as glucose, protein, nucleic acid, and fatty acid are marked with short-lived radioactive nuclides to become an imaging agent. After being injected into the human body, the positive electrons emitted by the imaging agent will interact with the electrons from the adjacent tissues to produce gamma photons, then the photon signals are detected with PET scanning probe, and the signals will be transmitted into the computer for processing. The anatomical images and their corresponding physiological parameters are used to display the status of the target organ or diseased tissue, understand the function and metabolic state of the lesions, and thereby diagnose the disease. PET is a molecular imaging equipment for functional and metabolic imaging, and it can clearly display the tomographic images of the human body through the penetrative scanning of CT and provide the anatomical information of the lesions, such as location, distribution, number, size, morphology, tissue structure, and adjacent relations; hereby, the reasoning analysis for the differentiation of benignancy and malignance of the lesions is carried out. PET-CT equipment is not a simple combination of PET and CT equipments, while it is a more complete equipment which organically integrates PET and CT equipments together. PET-CT simultaneously has the functions of PET and CT. It cannot only reflect the tissue metabolism and early detect the lesions but also accurately position the lesions detected by PET and provide CT information. PET can display the pathophysiological characteristics and make it easier to discover the lesions: CT can accurately locate lesions and display structural change in the lesions. In addition to possessing the respective functions of PET and CT, the unique image fusion technology of PET-CT can simultaneously reflect pathophysiologic change and the morphological structure of the lesions, and this significantly improves the accuracy of diagnosis. Therefore, PET and CT can make their respective advantages complementary to each other.

5.1.2 The Imaging Agents of PET-CT

In addition to the use of the equipment for PET-CT examination, another important condition is the use of the positron-emitting radiopharmaceuticals which are taken as PET tracers. In recent years, the researches in this field are very active, and their clinical applications have achieved rapid development. These drugs involve multiple aspects such as perfusion, metabolism, receptors, and gene imaging. Meanwhile, a wide range of exploration and research on cell apoptosis, hypoxic tissue, cell proliferation, and enzyme activity and the multidrug resistance of tumors such as PET drugs have been conducted. Commonly used positron-emitting radiopharmaceuticals include fluorine-18 (^{18}F), carbon-11 (^{11}C), nitrogen-13 (^{13}N), and oxygen-15 (^{15}O). Currently, the most widely used tracer is ^{18}F-fluoro-deoxy-glucose (^{18}F-FDG), which plays a leading role in the oncology. Along with the constant application of new types of positron-emitting radiopharmaceuticals such as 18F-fluoro-L-thymidine (^{18}E-FLT), 18F-fluorine estradiol (^{18}F-FES), imaging agent of hypoxic cells (^{18}F-FMISO), 11C-methionine, and 11C-choline positron in the clinics, we are prompted to promote the combined application of various positron-emitting radiopharmaceuticals which can reflect different metabolic processes in the PET-CT imaging to improve the sensitivity and specificity for the early diagnoses of the tumors to achieve the purpose of early diagnosis of tumors. The carbon 11-labeled positron-emitting radiopharmaceuticals are the most important new tracers.

5.2 Characteristics of PET-CT

5.2.1 High Sensitivity

PET-CT is a kind of imaging technology which reflects the molecular metabolism. When the changes occur at the molecular level in the early stage of the disease, the morphological structure of the lesion area has not showed abnormalities. When MRI and CT examinations cannot confirm the diagnosis, PET-CT examination can detect the location of the lesion and get three-dimensional images and then conduct a quantitative analysis, thus achieving the purpose of early diagnosis. This is unmatched by other imaging examinations.

5.2.2 High Specificity

When MRI and CT examinations reveal a tumor in the organ, it is quite difficult to determine whether it is benign or malignant, but PET-CT can make a diagnosis according to the characteristics of hypermetabolism in the malignant tumor.

5.2.3 Whole Body Imaging

We can obtain the images of all areas of the whole body through carrying out PET-CT whole body imaging once.

5.2.4 Good Safety

Although the nuclides used in PET-CT have radioactivity to some extent, their retention time within the body of the subject is short due to the fact that the dose is small and the half-life is short under the dual action of physical decay and biological metabolism (2–110 min). The radiation dose in a PET-CT whole body imaging is much lower than that in the routine CT examination of a site, and thus, it is safe and reliable.

5.3 Advantages of PET-CT

With the rapid development of tumor molecular imaging, especially the emergence of PET-CT, the indications of PET-CT examination in oncology have been recognized, including the identification of benign and malignant tumors or lesions, tumor staging, follow-up and monitoring of the efficacy, detection of the primary tumors and metastases, assessment of malignant degree and clinical prognosis, and development of radiation treatment plan. Compared with PET, PET-CT has the following advantages:

5.3.1 Short Examination Time and Improved Image Resolution

The dedicated PET uses the photons emitted by radionuclides to make attenuation correction. The total body scan from the base of the skull to the upper end of the femur (including the neck, chest, abdomen, and pelvis) normally takes six to eight bed spaces, and PET and CT image fusion is more accurate, which contributes to the use of positron nuclides of short half-life. It is more comfortable and convenient for the patients, and can increase the number of daily examined patients.

5.3.2 Locating the Abnormal Space and Identifying the Tracers

CT can locate the abnormal space detected by PET, and it is easy to identify whether the tracer uptake is physiologic. Some normal tissues and organs such as the muscle, blood vessels, gastrointestinal tract, and urinary tract have different degrees of physiologic tracer uptake or accumulation. Sometimes, they are easily confused with the lesions with increased metabolic activity on the PET images. The fused PET-CT images can clearly display the anatomical site of high metabolism; thus, this not only avoids misdiagnosing the physiologic uptake as lesions but also prevents the judgment in which the high metabolic lesions are mistaken as the physiologic uptake, resulting in unnecessary missed diagnosis.

5.3.3 Improving the Accuracy of Cancer Diagnosis, Staging, and Efficacy Tracking

PET-CT can reflect the physiological or pathological changes in the human body at the molecular level and sensitively detect the metabolic abnormalities in the early stage of the disease; it can detect the early lesions and provide valuable information about the function and metabolism through qualitative and quantitative analysis. CT can accurately locate the anatomical sites of the lesions detected by PET, while PET can increase the diagnostic specificity of the suspicious lesions detected by CT; thus, the informations from both PET and CT are complementary. This can avoid or reduce the missed diagnosis of PET-negative tumors or small lesions, better monitor the response to treatment, and identify the tumor recurrence and scar lesions after treatment.

The tumor staging is an important basis for making a therapeutic regimen for the patient, and a PET-CT whole body imaging can provide information about whether the organs in whole body have tumor metastasis, which is beneficial for accurate clinical staging of multiple tumors such as lung cancer, breast cancer, colon cancer, ovarian cancer, and lymphoma. For example, in the diagnosis of lymph node metastasis, CT or MRI may detect the enlarged lymph nodes (diameter > 1 cm) as the metastasis; among them, there is no lack of enlarged lymph nodes caused by chronic inflammation; in addition, CT or MRI may misjudge the normal-sized lymph nodes which have been violated by tumor tissues as normal lymph nodes, while PET can judge whether there is metastasis according to the metabolic activity of lymph nodes, and this is more accurate than that only according to the size of the lesions.

5.3.4 Optimizing the Radiotherapy Plan for Tumor Target Area and Improving the Clinical Curative Effect of Radiotherapy

In addition to the accurate positioning of CT, the PET imaging with multiple positron-emitting radiopharmaceuticals can reflect different processes of metabolism and proliferation of tissue cells. For instance, it can reflect the information about the glucose metabolic activity in tumor tissue, the distribution of hypoxic cells, and the cellular proliferation and summarize the informations from many aspects to outline the boundaries of molecular biological target area, and thus, it can more accurately implement the conformal intensity-modulated radiation therapy (IMRT).

5.3.5 Accuracy

PET-CT helps determine the biopsy site of lesion.

5.4 Limitations of PET-CT

Although the commonly used FDG PET-CT imaging is a high-tech examination, there is also the occurrence of false positives (such as active tuberculosis, acute inflammation, active sarcoidosis, and inflammatory pseudotumor) and false negatives (such as alveolar carcinoma, well-differentiated hepatocellular carcinoma, renal clear cell carcinoma, signet ring cell carcinoma, mucinous cystadenocarcinoma, carcinoid, and well-differentiated adenocarcinoma), and the overall diagnostic accuracy rate is about 90%. Special attention should be paid to that the CT in PET-CT is mainly used for attenuation correction and localization of PET images under normal circumstances, and it is not a substitute for CT diagnosis; in order to match with PET images, the breath is not held during scanning. Under normal circumstances, only the plain scan rather than enhanced scan is performed; it is not synchronized in real time with PET scan, and there is a certain time interval. The problems in clinical application of PET-CT and the improvement measures have aroused the attentions of some scholars. Among 300 patients examined by PET-CT, Osman et al. found that after the use of CT for attenuation correction of PET images or the fusion of PET and CT images, there were six cases (2%) of positioning error, and the lesions in the liver under the right diaphragmatic dome were mistaken as the lesions in the basal segments of the right lung. The cause analysis showed that this may be caused by the difference in breathing exercises among patients during PET acquisition or CT acquisition. During the application of PET-CT, Antoch et al. found that after the use of the intravenous or oral iodinated contrast agent enhanced CT images for attenuation correction of PET images, among 30 patients, the PET images in four patients showed artifacts, which were thought to be due to the transient “projection” of the undiluted contrast agents.

6 Principles of Tumor-Free Techniques

Xiao Zhou, Feiyue Wu, and Yongyi Chen

The oncoplastic surgery operation is often divided into the primary tumor group and the donor site flap preparation group. Because the gloves, clothings, and equipments used by the surgeons in the primary tumor group may carry tumor cells, the used items such as the gloves and surgical instruments which may be contaminated with tumor cells should be promptly replaced after the completion of radical tumor surgery. The surgeons in the primary tumor group must have strict aseptic sense and tumor-free consciousness. The staffs in the primary tumor group who want to participate in the surgical operation of the flap preparation group must change their sterile surgical gowns and gloves. The surgical instruments used in primary tumor group are strictly prohibited to be used in the surgical procedure for flap preparation.

The contents of tumor-free principle of the operations in the oncology surgery are as follows:

1. Requirements for preoperative examination: The preoperative examination should be gentle, and it is needed to prevent the brutal examination and reduce the examination frequency. For example, if the patients with head and neck malignant tumors have excessive punctures and multiple biopsies, this may easily cause cancer cells to fall off [18, 19].
2. Reducing local anesthesia. The time interval between biopsy and radical surgery should be shortened. The local anesthesia in the cancer surgery should be reduced as far as possible, because the local anesthesia can increase the local pressure, and the risk of tumor cell dissemination is increased. The time interval between biopsy and radical surgery should be as short as possible, and it is advocated to carry out an intraoperative rapid frozen pathological examination. For example, for the highly suspected breast cancer, it is necessary to carry out the intraoperative rapid frozen pathological examination, and the routine pathological examination should be performed as seldom as possible.
3. The sequence of surgical exploration. Attention should be paid to the gentle movements. The exploration is carried out from far to near, and the areas around the cancer foci are explored finally.
4. Isolation. The strict isolation techniques should be adopted during surgery, and the wound surface and the incisal edge should be protected with the gauze pad. For the tumors which have invaded the tissues outside the serous membrane, they should be covered with gauzes or sterile membranes during surgery to reduce the shedding and planting of cancer cells. The electric knife or the ultrasonic knife is applied during surgery as much as possible, and the sharp dissection is performed along the level of surgical space, while less blunt dissection is performed. The electric knife or ultrasonic knife can be used to seal the small lymphatic or blood vessels to reduce the chance of intravasation of cancer cells into the vasculature. Meanwhile, it has the function of killing cancer cells. But the squeezing in blunt dissection is easy to cause the spread of cancer cells.
5. The requirements for cancer resection. The cancer tissues are not incised during surgery. When dealing with the blood vessels around the cancer, the surgeon should try to firstly ligate the veins and then ligate the arteries, which can reduce the intraoperative incidence rate of intravasation of cancer cells into the blood circulation and reduce the likelihood of metastasis by bloodstream. The lymph node dissection should be performed from far to near, and the en bloc resections of cancer foci and lymph nodes should be completed as far as possible to reduce the lymphatic metastasis of cancer cells. The scope of surgical resection is determined according to the biological characteristics of the tumor. The incisal edges should be cancer-free and have some normal tissues.
6. Rinse. After complete resection of the specimens, the surgeons and the scrub nurse should change gloves and instruments, and then the wound is rinsed with a large volume of distilled water at 42°C; meanwhile, it can also be rinsed with iodine water or chemotherapeutic drugs to reduce the possibility of survival of residual cancer cells in the wound and body cavities.

It is necessary to further develop the strict tumor-free operation procedures for all kinds of surgeries in oncoplastic surgery under the guidance of the tumor-free principle and aseptic technique principle.

7 Principles of Aseptic Techniques

Chaohui Zuo and Jianping Liang

Microorganisms commonly exist in the human body and the surrounding environment in which we live. In the process of surgery, if the effective measures are not taken, the pathogenic microorganisms can enter into the wound and cause infection either directly or through airborne droplets. The aseptic technique is an effective prevention method taken against the possible infection sources and pathways, and it includes sterilization, disinfection, aseptic operating rules, and management system. In the process of tumor surgical operation and wound management, the principles of aseptic techniques must be strictly observed [20, 21].

Sterilization refers to kill or eliminate all microorganisms on the media, and the medical equipment and surgical materials used in surgery must meet the sterilization standards. The common methods include three methods such as high-temperature sterilization, low-temperature sterilization, and ionizing radiation sterilization.

Disinfection refers to kill or eliminate the pathogenic microorganisms and other harmful microorganisms on the media, and it is applicable to disinfection for the hospital environment, object surface, skin and mucous membranes, and indoor air. The commonly used disinfectants include alcohol, iodine, peracetic acid, active chlorine, etc. The ultraviolet circulating wind air disinfector and electrostatic adsorption-type air disinfector are mainly used for the indoor air disinfection.

The medical staffs in the department of oncology surgery who will participate in the surgery should be fully prepared before surgery, and they should put on the isolation shoes and clothes, wear masks and hats, and clip off the fingernails before entering the operating room. The medical staffs with broken arm skin or purulent infection are advised not to participate in the surgery. The surgical hand-washing method includes two steps of hand-washing and disinfection. Hereinto, the seven-step hand-washing method is adopted for hand-washing, which is repeated twice for a total of

5 min; the disinfectants must acquire the health licensing certificate issued by the Ministry of Health and should be used within the validity period. Certain rules must be followed for wearing the sterile gown and gloves.

Adequate preoperative preparation should also be made for the surgical patients, and the skin in surgery area should be cleaned and shaved. Currently, the povidone-iodine disinfection is commonly used in China, and the sterilization precautions are as follows: (1) The surgical incision is generally taken as a center, and the skin around the center is scrubbed and disinfected. If the wound is infected, or the surgical areas locate in the perineum and anus, the surgical area should be scrubbed and disinfected from the outer periphery inward; (2) the skin disinfection range of the surgical area should include the area around the incision with a distance of at least 15 cm; (3) the facial and perineal skins should be disinfected using type III iodine mucocutaneous disinfectant; (4) the skin and mucous membranes should be cleaned before disinfection and then are disinfected with iodine; otherwise, it will affect the disinfection effect.

During surgery, maintaining a sterile environment in the surgical area is directly related to the effect of surgery, and therefore, it must strictly abide by the principles of aseptic technique:

1. Once the surgical staffs have washed and disinfected their hands and have worn sterile gowns and gloves, they are not allowed to get in touch with unsterilized items; the back and the areas below the waist and above the shoulders of the surgical staff should be regarded as non-aseptic area, which cannot be touched; the hands and forearms shall not hang down to the waist and below the operating table.
2. The surgical instruments and materials cannot be passed on from the behind of the surgical staffs; once the items used in surgery fall below the operating table, they cannot be picked back and used.
3. During surgery, if the gloves are damaged or have contacted an area outside the sterile field, they should be replaced immediately with new sterile gloves; the contaminated fingers should be scrubbed with 0.5% povidone-iodine or 75% alcohol wipes; if the arms have reached the non-aseptic area, the surgical staff should change his sterile gown or wear oversleeves; the drenched sheet should be covered with an aseptic towel.
4. When the surgical staffs at the same side exchange positions, they should take a step back and then turn around back to back to exchange the positions, so as to prevent contamination.
5. The incisal edges should be covered and protected with a large gauze or surgical towel, which is fixed with sutures. Only the surgical incision is exposed, and the surgical incision should be protected especially in contaminated surgery and tumor resection.
6. Before the hollow organ is incised, the surrounding tissues would be protected firstly with the dry gauzes, and then the used gauzes should be promptly removed from the abdominal cavity; the incisal area in the stomach or enteric cavity is scrubbed with the cotton balls soaked in disinfectant to prevent and reduce pollution; the instruments which have contacted the contaminated sites should be isolated for exclusive use and should not be used in the sterile area.
7. The surgical instruments and dressings should be counted before the start of surgery; the surgical area should be examined at the end of surgery. Only after the numbers of surgical instruments and dressings are checked and verified correctly, the incision can be closed to avoid that the foreign objects are left in the body cavity to lead to adverse consequences.
8. After the completion of the peritoneal suture, the incision should be flushed with normal saline; before the skin incision is sutured, the skin surrounding the incision is scrubbed with the disinfectant (e.g., 75% alcohol or 0.5% iodine).
9. The people who look over the operation cannot get too close to the surgical staff or stand too high, so as to reduce the chance of contamination.
10. During the operation, the windows should not be opened for ventilation or the electric fan should not be used, and the vents of the indoor air conditioning should not blow toward the operating table, so as to avoid stirring up dust and contaminating the air within the operating room.

In short, the medical staff in the oncology surgery department should have strong aseptic principles and tumor-free concept and strictly and consciously abide by the principle of aseptic technique and abandon all behaviors which ignore the principle of aseptic technique.

8 Anesthesia Management of Oncoplastic Surgery

Jinfeng Yang, Jingshi Liu, and Jiannan Shen

8.1 Effect of the Basic Condition of the Patient on the Anesthesia

The ages of the patients undergoing oncoplastic surgery are often relatively greater, and the nutritional statuses are poor. The patients often have concurrent diseases such as water and electrolyte disorder, acid-base disturbance, cardiac-cerebral vascular disease, endocrine disease, and chronic respiratory disease. Some patients have a long history of smoking and drinking, which largely increases the difficulty of anesthetic management and makes the incidence of intraoperative and postoperative complications increased significantly. The anesthesiologist should carry out a careful preoperative evaluation, make strict controls, and assist the surgeon to treat the primary diseases, so that the patients can undergo the surgery in the best condition [22].

8.1.1 Effect of the Surgical Site on the Anesthesia

Among the tumor patients who need to undergo plastic surgery and skin flap graft, the patients with tumors in the head and neck, oral and maxillofacial area, or craniomaxillofacial area are most commonly seen, whose surgical sites are adjacent to the respiratory tract; thus, there is a risk that the intraoperative foreign bodies, secretions, and blood are inhaled by mistake into the airway. It is required to change the head positions of these patients repeatedly during surgery, while the anesthesiologist is far away from the respiratory tract; thus, there is often the risk of the tube falling off, and this may bring a lot of inconvenience for perioperative airway management. This is also the type of surgery for which the surgeon and anesthesiologist have to communicate mostly with each other. Faced with different patients, these problems such as how to establish an airway, how to manage the airway during surgery, and how to choose the extubation time after surgery often require the anesthesiologists and surgeons to discuss repeatedly and finally reach a consensus. When the primary lesion in craniofacial area is being resected, the deep layer of the lesion is adjacent to the brain tissues, the brain tissue may be pulled in the process of separation and exposure, and the hemorrhagic secretions can penetrate into the cranial cavity and cause an increase of the intracranial pressure. Sometimes, the continuous bleeding may occur, which is difficult to estimate in practice. Therefore, the anesthesiologists should closely monitor the vital signs and always maintain a stable internal environment and timely control the intracranial pressure to prevent the occurrence of cerebral edema.

8.1.2 Effects of Surgical Scope and Time on Anesthesia

In the oncoplastic surgery operation, it is not only needed to deal with the primary lesion, but it is also needed to take the neighboring skin flap or free skin flap to repair the defect and carry out the microvascular anastomosis for the free skin flap. The operation time is long, and the operation is complicated and delicate. Sometimes, the vasospasm or even the embolism occurs after microvascular anastomosis; thus, the blood supply of the skin flap tissue cannot be fully guaranteed, and the skin flap repair needs to be carried out again, which not only brings pain to the patient but also significantly extends the length of hospital stay and increases the medical costs. Therefore, the anesthesiologist must guarantee the hemodynamic stability and the microcirculation perfusion during surgery so as to ensure a smooth flowing blood after microvascular anastomosis.

8.1.3 Intraoperative Blood Loss and Fluid Replacement

In the oncoplastic surgery operation, the blood loss would often be increased due to the great trauma and long operation time. Especially because the craniofacial tumor resection includes multiple operation steps such as osteotomy, displacement and recombination of the skull, basis cranii, eye socket, eyeball, nasal cavity, nasal sinus, and upper and lower jawbones, it is difficult to stop the bleeding before tumor resection, and more blood loss may occur in the process of tumor resection. The anesthesiologists should strengthen the monitoring and management of the blood circulation in the perioperative period, timely replenish the blood volume, and pay attention to the matching of intraoperative crystalloid fluid and colloidal fluid, thus preventing the effect of the tissue edema on the growth of skin flap.

8.2 Preoperative Evaluation and Management

8.2.1 Preoperative Examination and Treatment

1. Preoperative examination. The tumor belongs to systemic diseases. The patients are generally older, and they may have a long history of drinking and smoking and have comorbidities such as atherosclerosis, heart disease, peripheral vascular disease, and chronic obstructive pulmonary disease. The oncoplastic surgery is complicated and delicate and has a long operation time. Before the surgery, the anesthesiologist should ask for details of the history, carry out a medical examination, and discuss with the surgeons about how to complete necessary preoperative examinations. In addition to examinations such as blood routine, urine routine, liver and kidney function, lung function, blood clotting function, electrolytes, and electrocardiogram, some patients who have a special medical history should be specially treated:
   (1) Hypertension: The effect of hypertension on the whole body depends on the extent of damage of the target organ, and the surgeon should regularly monitor the blood pressure and check the functional statuses of the eye ground and other target organs.
   (2) Heart disease: The patient should be asked whether he or she has a history of angina or myocardial infarction in recent time, whether he or she has been already implanted with the coronary stent, whether he or she is taking oral antiplatelet drugs, and whether he or she has been examined with the compensatory cardiac failure and the arrhythmia with clinical significance. Table 1.1 lists some clinical predictive factors which increase the perioperative cardiovascular risk.

Table 1.1 The clinical predictive factors which increase the perioperative cardiovascular risk

Classification	Clinical predictive factors
High-risk factor	Unstable coronary syndrome
	Decompensated heart failure
	Arrhythmia with clinical significance
Median-risk factor	Patients with the past medical history of ischemic heart disease Patients with compensated heart failure or a precursor of heart failure
	Patients with the past medical history of ischemic heart disease
	Patients with diabetes mellitus (especially insulin injections)
	Patients with renal insufficiency
Low-risk factor	Old age
	Electrocardiographic abnormality
	Electrocardiogram (ECG) showed a non-sinus rhythm
	A history of stroke
	Uncontrolled hypertension

Attentions should be paid to the following issues for the heart disease patients: (1) The noninvasive heart function examination should be carried out for patients with unexplained dyspnea, heart failure with progressive dyspnea at present or in the past, previously diagnosed cardiomyopathy which is not clarified, and stable clinical symptoms. (2) The exercise stress test must be carried out before oncoplastic surgery in the patients with active heart disease and the patients with poor exercise tolerance due to possessing three clinical risk factors (the clinical risk factors refer to the previous histories of ischemic heart disease, congestive heart failure, cerebrovascular disease, diabetes, renal insufficiency); the exercise stress test can be considered for the patients with one to two clinical risk factors. (3) The cardiac ultrasound examination must be performed for the patients with valvular heart disease, hypertensive heart disease, and pulmonary heart disease to understand the opening and closing statuses of the valves, whether the myocardial motion is coordinated, whether the heart is enlarged, and whether the left ventricular ejection fraction, diastolic function, and ventricular wall motion are coordinated. (4) The patients with sinus bradycardia can have atropine tests firstly. If the patient has a heart rate of more than 90 beats/min in the atropine test, with no history of syncope, the sick sinus syndrome can be generally excluded in the patient. If the patient has a heart rate of lower than 90 beats/min in the atropine test, he or she can undergo 24 h dynamic ECG examination. If the lowest heart rate is more than 40 beats/min, the average heart rate is more than 50 beats/min, and the maximum heart rate is more than 90 beats/min, with no history of syncope, a sick sinus syndrome will not be generally considered. The cardiac electrophysiological examination can be carried out for the patients who still cannot be excluded with sick sinus syndrome by 24 h dynamic ECG examination.

(3) Respiratory diseases: The pulmonary infection patients need to undergo blood routine examination, lateral chest X-ray examination, sputum bacterial culture, drug-sensitive examination, and pulmonary function examination. The blood gas analysis may be carried out for the patients with dyspnea, and the bedside breath holding test can also be used to simply assess the lung function.

(4) Endocrine system diseases: The fasting and postprandial blood glucose level and the urine sugar level should be regularly detected in the patients with diabetes, and the free T3, free T4, and thyroid-stimulating hormone (TSH) should be detected in the patients with hyperthyroidism.

2. Preoperative treatments

   (1) Hypertension: Evaluating the effect of hypertension on the whole body is to mainly evaluate the damage statuses of the target organs, and the antihypertensive drugs must be continuously used until the morning of surgery. American College of Cardiology-American Heart Association (ACC-AHA) stated in 2009: The elective surgery can be performed for the patients with blood pressure < 180/110 mmHg and without cerebrovascular and cardiovascular symptoms, and the risk of perioperative cardiovascular complications will not be increased; the surgery should be postponed for the patients with blood pressure > 180/110 mmHg (this was also mentioned in the Guidelines for Prevention and Treatment of Hypertension in China 2010), but the statistical results of Dix and Howell showed that most physicians believe that the anesthesia and elective surgery should be postponed or canceled for the

patients with blood pressure > 160/95–100 mmHg, particularly for those patients with clinical symptoms. Therefore, it would be better for the hypertensive patients to be treated for 3–5 days before surgery, so as to prevent the postoperative cerebrovascular accident [23, 24].

(2) Heart diseases: Firstly, it should be considered to install the temporary or permanent cardiac pacemaker for the patients with confirmed symptomatic sick sinus syndrome and the patients with second-degree atrioventricular block type II and third-degree atrioventricular block, and then the surgeries are performed. The bilateral bundle branch block is mostly the right bundle branch block with left anterior fascicular block or left posterior fascicular block, and the left anterior branch can be blocked more easily; the left posterior branch is thicker, with dual blood supply. If it is blocked, this will indicate a heavier lesion. The patients with bilateral bundle branch block may have trifascicular block or develop complete atrioventricular block, and the preparation should be made to carry out cardiac pacing for these patients in perioperative period. The pacemaker should be installed for the patients with trifascicular block before surgery.

According to the guidelines of American College of Cardiology and Canadian Cardiovascular Society, the active heart diseases which require preoperative treatment are shown in Table 1.2.

The patients with cardiac dysfunction who have a significantly expanded heart should be treated preoperatively with digitalis drugs, and the potassium-sparing diuretics are applied when it is necessary and the application should be stopped on the date of operation. In the patients with unstable coronary syndrome, it is required that pentaerythritol tetranitrate (long-acting nitroglycerin) is used to expand the coronary artery, and the β-receptor blocker is used to slow the heart rate and reduce the myocardial oxygen consumption, and the tanshinone and the polarized solution can also be intravenously injected to improve myocardial ischemia. The patients for whom the drug treatments are invalid can temporarily undergo percutaneous coronary angioplasty or bare-metal stent implantation when time permits. Because the tumor surgery belongs to deadline surgery, it is not an ideal choice to carry out coronary bypass surgery or drug-eluting stent implantation before surgery. The clinically significant arrhythmias must be corrected as much as possible before surgery to avoid a serious accident. The patients with severe valvular disease are treated mainly for improvement of cardiac dysfunction and adjustment of ventricular rate in the normal range.

(3) Respiratory disease: The smoking patients should stop smoking for at least 2 weeks. The patients with acute pulmonary infections require anti-infection treatment until the symptoms such as the cough and sputum disappear, the blood routine examination is normal, and the chest X-ray shows that the lung shadows disappear, and then they can only be scheduled for the surgery. If the patients with chronic obstructive pulmonary disease have no symptoms of acute infection, they will mainly carry out the exercise of respiratory function. The nebulization which assisted expectoration is applied when

Table 1.2 The active heart diseases which require preoperative treatment

Type	Diseases
Unstable coronary syndrome	Unstable or severe angina
	Acute myocardial infarction or recently occurred myocardial infarction attack (7–30 days)
Decompensated heart failure	(New York Heart Association) The cardiac functional grading is grade IV
	Deteriorated or newly occurred heart failure
Significant arrhythmia	High-grade atrioventricular block
	Mobitz type II atrioventricular block
	Third-degree atrioventricular block
	Symptomatic ventricular arrhythmia
	Supraventricular arrhythmia of uncontrolled ventricular rate (including atrial fibrillation) (resting heart rate > 100 beats/min)
	Symptomatic bradycardia
	Newly occurred ventricular tachycardia
Severe valvular disease	Severe aortic stenosis (mean pressure across the valve > 40 mmHg, aortic valve area < 1 cm^2, or there are symptoms)
	Symptomatic mitral stenosis (exertional dyspnea, exertional syncope, or heart failure)

necessary to prevent a decrease in postoperative respiratory function.

(4) Endocrine system diseases: Before surgery, diabetes patients' fasting blood glucose level should be no more than 11.2 mmol/L, and the urine ketone test should show a negative result. For the moderately severe hyperthyroidism patients before surgery, it must be required to use the methimazole to interfere with the synthesis of thyroid hormones, use the β-receptor blocker to slow the ventricular rate down to lower than 90 beats/min, and use the compound iodine preparation to reduce the release of thyroid hormones. Furthermore, the hydrocortisone is additionally used to reduce the toxic response of the thyroid gland at 3–5 days before surgery, and a month of treatment is often needed at least to prevent the occurrence of postoperative thyroid crisis. The moderately severe hyperthyroidism patients must be supplemented with thyroid tablets before surgery, and the dose is gradually increased. Otherwise, it is prone to result in postoperative cardiopulmonary complications.

3. Surgical opportunity selection. For the patients who have an angina attack within a month and the onset of a myocardial infarction within 6 months, it is needed to postpone the elective surgery. Within 4–6 weeks after bare-metal stent implantation and within 12 months after drug-eluting stent implantation, if the dual antiplatelet therapy is prematurely stopped, this will significantly increase stent thrombosis and the risk of death or myocardial infarction, and thus, it is needed to postpone the elective surgery. The patients beyond the above time limit should stop using antiplatelet drugs for 7–15 days before undergoing the surgery.
4. Preoperative fasting and preanesthetic medication. The general anesthesia is usually performed for the patients who undergo oncoplastic surgery. The preoperative fasting time is 6–8 h for adults to prevent intraoperative vomiting, regurgitation, and aspiration. Because the oncoplastic surgical operation time is long, and the head and neck and facial surgeries are more commonly seen, the patients need to be treated preoperatively with oral anticholinergics to inhibit glandular secretion, with narcotic analgesics or sedatives to reduce the stress response in patients and with antacids to prevent the gastric mucosal damage caused by excessive gastric acid.

8.2.2 Anesthesia Plan

1. Airway management plan. The anesthesiologist should read the medical records carefully before surgery and refer to relevant imaging data to understand the scope of surgery, discuss with surgeons about the methods to establish an airway, and develop a detailed anesthesia plan. The methods to establish an airway mainly include the orotracheal intubation under rapid induction, transnasal intubation under rapid induction, awake oral or nasal intubation, and tracheotomy. If the patient has no obvious difficulty breathing before surgery, and the imaging data confirms that there is no airway obstruction, the fast-induced tracheal intubation can reduce a lot of pain in patients. The transnasal intubation is more conducive to fixation and preventing the tube from falling off due to changes in head position and is also conducive to postoperative indwelling tube to prevent possible occurrence of airway obstruction, and this ensures that the respiratory tract is unobstructed. If the patient has obvious symptoms of airway obstruction before surgery, it is supposed to carry out the awake nasal intubation guided by fiber-optic bronchoscope; if the scope of surgery involves the upper airway, for example, after reconstruction surgery of hypopharyngeal cancer and laryngeal cancer, there is still the possibility of airway obstruction, and thus, the tracheostomy tube can directly be used for ventilation.
2. Blood preparation. For the patients who have an estimated possibility of obvious and rapid blood loss, the red blood cells and plasma of the same blood type as the patient should be prepared. If the estimated blood loss exceeds 50% of the total blood volume, it should be considered to prepare the blood platelets; if the estimated blood loss exceeds 100% of the total blood volume, it is supposed to prepare the cryoprecipitate or the whole blood.
3. Psychological preparation. The tumor patients who need to undergo plastic surgery usually have larger masses, which locate most commonly in the face, mouth, and hypopharyngeal area. It is much more likely that the airway should be established firstly when the patient is awake, and then the general anesthesia is performed. The patients with tracheotomy are unable to speak for some time after surgery. Furthermore, there are some differences in color between the free skin flaps transplanted from different sites and the skins in the primary tumor sites, and this will affect the appearance. All these problems make patients face a lot of psychological pressures. The anesthesiologists should conduct detailed communications with the patients before surgery to obtain the trust of the patients and make them actively cooperate with treatments, thus preventing the occurrence of offensive behaviors in patients.
4. *Intraoperative anesthesia options and management*
   (1) Anesthesia options: The oncoplastic surgeries mainly include the tumor resection and skin flap repair for scalp cancer, eyelid tumor, lip cancer, tongue cancer, maxillofacial tumor, maxillary tumor, mandibular tumor, hypopharynx and cervical esophagus cancer, breast cancer, chest wall tumor, abdominal wall tumor, upper limb tumor, limb tumor, etc.; in addition

to the use of intraspinal anesthesia in abdominal and lower limb surgeries and the use of brachial plexus nerve block in the upper extremity surgery, it is supposed to choose general anesthesia for the surgeries in other sites of the body to ensure that the surgery is painless and safe.

(2) Induction and maintenance of the general anesthesia: It is common to carry out the total intravenous anesthesia or the intravenous inhalational anesthesia. The use of the mutual synergy between analgesics, intravenous or inhaled anesthetics, and muscle relaxants makes patients obtain the ideal anesthesia effect. In intravenous and inhaled anesthetics, it can be selected to use the midazolam and propofol for induction or the sevoflurane for induction, and the general anesthesia can be maintained with propofol target-controlled infusion or continuous infusion and the isoflurane and sevoflurane inhalation. Among the analgesics, the fentanyl, sufentanil, or remifentanil can be selected and used for induction and maintenance; among the muscle relaxants, the depolarizing muscle relaxant succinylcholine or the non-depolarizing muscle relaxants rocuronium, cisatracurium besylate, and vecuronium bromide can be selected and used for induction, and the rocuronium bromide, vecuronium bromide, atracurium, and cisatracurium besylate can be selected and used for maintenance. Since the advent of the non-depolarizing muscle relaxant rocuronium and cisatracurium besylate, the safety degree of anesthesia induction and intubation is greatly improved, while the depolarizing muscle relaxant succinylcholine with rapid onset and fast fading and with more side effects has been rarely used. Because the operation time for the tumor is very long, it is mostly advocated that the intraoperative anesthesia is maintained directly with micro pump injection or target-controlled infusion to avoid drug overdose and the occurrence of body movement in patients.

8.2.3 Anticoagulant and Antispasmodic Drugs Commonly Used in Surgery

1. Low molecular dextran. The relative molecular mass of the low molecular weight dextran is about 40 KD, and the application concentration is 10%. It has a higher permeability compared to the plasma, and its colloid osmotic pressure is two times larger than that of the albumin.
   (1) Main functions: (1) It can increase the plasma colloid osmotic pressure and can provide an effect of expanding blood volume for 6 h; (2) it can reduce blood viscosity, thereby improving microcirculation to prevent intravascular coagulation in the later period of shock; (3) it can suppress the activation of blood coagulation factor II, decrease the activities of coagulation factors I and VII, and prevent platelet adhesion and aggregation to prevent thrombosis; (4) it has a good rheological effect on leukocyte adhesion, which may be beneficial to the ischemia-reperfusion injury.
   (2) Main indications: (1) Blood loss, trauma and toxic shock, and early prevention of disseminated intravascular coagulation caused by shock; (2) thrombotic diseases such as cerebral thrombosis, angina and myocardial infarction, thrombosis obliterans, and retinal arteriovenous thrombosis; and (3) limb replantation and vascular surgery operation and the improvement of the success rate of vascular anastomosis and replantation
2. Anisodamine. Anisodamine mainly refers to the artificially synthesized 654–2. Its main role is to relieve vasospasm and improve mini circulation, and thus, it can be used to treat shock. The efficacy will be observed at 1–4 min after intravenous injection, and it is demonstrated as the face turns red and the blood circulation in nail bed is improved. 5–10 mg anisodamine is injected intravenously every time, or 10–20 mg anisodamine is added into 500 ml solution for intravenous drip.
3. Dipyridamole. Dipyridamole is an antianginal drug, and it is used to reduce platelet aggregation and inhibit thrombosis during microsurgery. After the intraoperative intravenous infusion of dipyridamole, the wound bleeding will not be easily solidified. Usage: 5–10 mg dipyridamole is added into 500 ml solution for intravenous drip.
4. Tolazoline. The tolazoline is an α-receptor blocker, and it can expand the blood vessels. Usage: 25 mg tolazoline is used for intramuscular injection, and the intramuscular injection can be performed once every 8 h after surgery.
5. Phentolamine. The phentolamine is an α-receptor blocker, and it can expand the blood vessels. Usage: 5 mg phentolamine is added into 500 ml solution for slow intravenous drip.
6. Heparin. The heparin was systemically used when the blood vessels were anastomosed in the past, but now it is rarely used. Furthermore, it only is used in exceptional circumstances by experienced physicians. The heparin has a good efficacy in preventing coagulation and improving microcirculation. Usage: The topical area is washed with diluted heparin. 50–100 U heparin is added into 200 ml of normal saline, and then the local vascular anastomotic stoma is lavaged or washed with a syringe.
7. Local anesthetics. 0.25% to 0.5% lidocaine or 0.5% to 2% procaine solution can be used to wash the anastomotic stoma, but such usage results in minimal absorption. Generally, it is available for use after being added into diluted heparin solution.

8.2.4 Application of Special Techniques in the Surgery

1. Controlled hypotension. In huge craniofacial surgery and the surgery with double skin flap graft, the controlled hypotension can be performed to reduce blood loss and maintain a clear operative field. During depressurization, attention should be paid to recovering the blood pressure to near basal level before the end of surgery to avoid the incidence of postoperative recurrent wound bleeding caused by imperfect hemostasis under hypotension.
2. Cryogenic techniques. The application of cryogenic techniques aims to reduce the metabolism of the vital organs in vivo, especially the brain, so as to reduce the oxygen consumption and thus significantly prolong the duration of tolerance to ischemia and hypoxia in the body. In the operations of oral and maxillofacial surgery and plastic surgery, the cryogenic techniques are often used in the operations with larger trauma and more bleeding as well as involving the craniocerebral region, such as the resection of huge facial neurofibroma and carotid body tumor, the craniofacial extended radical surgery, and the repair and reconstruction of complicated deformities in the cranial maxillofacial area. During the implementation of the cryogenic techniques, the degree of hypothermia should be determined based on the specific circumstances of the surgery or treatment. In most of oral and maxillofacial surgery, it is not needed to block the blood supply to the whole body or the great vessels, and the main purpose is to reduce metabolism and reduce oxygen consumption. Therefore, the mild hypothermia (30–34 °C) is more commonly used. In some special cases, when blocking the blood supply to large vessels (such as the carotid artery) or carrying out the complex craniofacial surgery, it is appropriate to decrease the body temperature to a lower level to reduce the damages caused by the cerebral compression and the cerebral ischemia-hypoxia.

8.3 Intraoperative Monitoring

The oncoplastic surgery lasts long, and the surgeons stand around the patient's head, which keeps the anesthesiologist away from the respiratory tract of the patient. Therefore, strengthening intraoperative monitoring is very important.

8.3.1 Routine Monitoring Items

ECG, noninvasive blood pressure, oxyhemoglobin saturation, and urine output are the essential monitoring items in any surgical procedures.

8.3.2 Hemodynamic Monitoring

The operators should understand timely the statuses of the hemodynamics, pulmonary circulation, and cardiac function and maintain a stable circulatory function.

1. Invasive arterial blood pressure monitoring. It can quickly reflect the blood circulation status. The catheterization of the radial artery or the dorsalis pedis artery is commonly used. The arterial pressure is converted into electrical signals through the transducer, and the result is expressed as digital numbers after computer processing. Although all stroke volumes can be displayed into blood pressure values, the arterial blood doesn't flow all the way within the whole length of the catheter during the monitoring period. Therefore, the catheter must be washed with heparin solution every once in a while to prevent blood clotting which will affect the results of blood pressure monitoring.
2. Determination of central venous pressure and pulmonary artery pressure. The relative changes in central venous pressure often indicate the change in blood circulation volume, thus providing a reference for blood and fluid transfusion. The jugular vein catheterization or subclavian vein catheterization is commonly carried out, and the femoral vein puncture can also be carried out. The femoral vein puncture can be performed in a place away from the surgical area, but it is prone to cause infection. The catheter is required to reach the level above the diaphragm (about more than 40 cm); thus, the pressure measurement can only be accurate. If the catheter only reaches the level under the diaphragm, the pressure measurement will be inaccurate due to the impact of the abdominal pressure.
3. Determination of mixed venous oxygen saturation (SvO_2). It may be considered necessary to dynamically monitor the SvO_2 (the normal values are 68% to 77%, with an average value of 75%) in some patients with moderately to severely decreased cardiopulmonary function. When SvO_2 is less than 60%, this usually indicates the increased tissue oxygen consumption or poor cardiopulmonary function. The arterial venous oxygen content difference is calculated through determination of SvO_2, and it can more accurately reflect the cardiac output. Waller et al. have pointed out that SvO_2 has a strong correlation with cardiac index, stroke volume index, and left ventricular stroke work index. When SvO_2 is decreased, and the arterial oxygen saturation and oxygen consumption are still normal, this proves that the cardiac output is also low. Therefore, it is now considered that the determination of mixed venous oxygen saturation has an important value in monitoring the serious cardiopulmonary diseases.

8.3.3 End-Tidal Carbon Dioxide Partial Pressure ($PetCO_2$) Monitoring

$PetCO_2$ must be monitored during the implementation of the oncoplastic surgery under general anesthesia, and the normal value is 4.66–6.00 kPa (35–45 mmHg). $PetCO_2$ monitoring has the following advantages: (1) Whether the endotracheal catheter is located within the trachea can be determined from end-tidal carbon dioxide waveform. (2) It can provide guidance in the setting of respiratory parameter. If $PetCO_2$ is increased higher and higher, this will indicate insufficient ventilation and carbon dioxide accumulation. On the contrary, if $PetCO_2$ is decreased lower and lower, this will indicate excessive ventilation, and it is needed to reset the parameters of the anesthesia respirator. (3) If the end-tidal carbon dioxide waveform is presented as a straight line, this usually suggests that the catheter has fallen off. (4) If $PetCO_2$ is unusually decreased, this suggests the possibility of massive blood loss.

8.3.4 Body Temperature Monitoring

The duration of oncoplastic surgery is longer, and the changes in body temperature should be continuously monitored during surgery.

8.3.5 Monitoring of Anesthesia Depth and Muscle Relaxation

During surgery, Bis or Neotrend can be used to continuously monitor the anesthesia depth, and the muscular relaxation monitor is used to continuously observe the muscle relaxation to keep the patient at an appropriate level of anesthesia and avoid that the light anesthesia may cause body movement in the patient and thus lead to the intraoperative awareness and even affect surgical operation; it should be avoided that too deep anesthesia induces delayed postoperative recovery and increases the incidence of postoperative respiratory complications.

8.3.6 Intracranial Pressure Monitoring

The intracranial pressure should be continuously monitored during the large craniofacial surgery, and the intracranial pressure can be regulated and controlled timely in a relatively safe range according to the dynamic monitoring results. A certain depth of anesthesia is maintained during surgery to avoid agitation and movement. Some methods can be used to reduce the intracranial pressure when necessary: (1) The hyperventilation is carried out. If PetCO2 is controlled between 25 and 30 mmHg, a sufficient decrease in the intracranial pressure can be achieved; (2) the right amount of mannitol or glycerin fructose is intravenously infused; (3) the adrenal cortical hormone is applied; (4) the subarachnoid catheter placement is performed to drain the cerebrospinal fluid.

8.3.7 Determinations of Blood Gas Analysis, Electrolytes, Blood Glucose, Hemoglobin, and Hematocrit

Blood gas analysis and electrolyte can be determined for avoiding hypoxia, carbon dioxide accumulation, and acid-base imbalance; the blood glucose can be determined for maintaining a stable blood sugar level and preventing the occurrence of high blood sugar or hypoglycemia; the hemoglobin (Hb) and hematocrit (Hct) can be determined for guiding the intraoperative blood transfusion and maintaining an appropriate degree of blood dilution.

8.4 Airway and Respiratory Management

8.4.1 Intubation Pathway

The oral intubation, nasal intubation, and transtracheostomy intubation are available for selection. The oral intubation is firstly preferred, and it can prevent the damage to the nasal mucosa caused by the tube. But the oral intubation is not conducive to postoperative indwelling tube. Therefore, for the patients who may have difficulty breathing after surgery, it is preferable to carry out the nasal intubation and transtracheostomy intubation.

8.4.2 Intubation Method

The intubation under intravenously induced rapid anesthesia, the awake intubation under topical anesthesia, and the intubation under inhalation anesthesia are available for selection. The tools which are used to examine the glottis include ordinary laryngoscope, video laryngoscope, rigid laryngoscope, fiber-optic laryngoscope, etc. The tools for managing the difficult airway also include laryngeal mask, esophageal-tracheal combined tube, blind tracheal intubation instrument, optical cable, thyrocricotomy devices, and percutaneous tracheostomy devices.

8.4.3 Intraoperative Respiratory Support

The endotracheal tube is properly fixed. A long extension tube and an end-expiratory carbon dioxide sensor are connected to the anesthesia respirator for mechanical ventilation. The parameters of the respirator are set according to the specific circumstances of the patient and are adjusted at any time in accordance with oxyhemoglobin saturation, end-tidal carbon dioxide partial pressure, and blood gas analysis results. The anesthesiologists should always observe the position of the tube to prevent twisting, folding, and slippage of the tube and observe the color change of the carbon dioxide absorbent, which should be replaced in time combined with the objective indicators such as end-tidal carbon dioxide partial pressure.

8.4.4 Volume Replacement and Blood Conservation

The modern view is that the volume replacement not only aims to maintain hemodynamic stability, avoid volume overload, and ensure the normal blood clotting function and renal function, more importantly, but it also aims to guarantee the tissue oxygen supply and optimize the tissue perfusion. Therefore, selecting the appropriate plasma substitute is the key for safe and effective volume replacement. The anesthesiologists should select the appropriate plasma substitutes based on the characteristics of the patient's disease, blood pressure, central venous pressure, and urine output changes to replenish the fluid volume for fluid loss and redistribution as well as the evaporation in wounds and surgical field due to the preoperative fasting, surgical trauma, and anesthesia and ensure adequate volume and microcirculation in the patient.

8.4.5 Choice of Plasma Substitutes

The ideal plasma substitute should have stable physical and chemical properties, and it can quickly supplement the blood volume, increase tissue perfusion, and have sufficient residence time in blood vessels. Meanwhile, it has no significant effects on the blood clotting function and the renal function and has no allergic reaction and tissue toxicity. It can improve oxygen supply and organ function, and it is easily metabolized and removed in the body.

Plasma substitutes can be divided into two categories according to the relative molecular mass size, namely, the crystalloid solution and the colloidal solution. The solution, in which the diameter of the solute molecule or ions is less than 1 nm, or it will not generate a light reflex phenomenon when it is penetrated through by the light beam, is called the crystalloid solution, such as normal saline, Ringer's lactate solution, invert sugar and electrolyte solution, and hypertonic saline; the solution, in which the diameter of the solute molecule or ions is greater than 1 nm, or it will generate a light reflex phenomenon when it is penetrated through by the light beam, is called the colloidal solution. The colloid is divided into three categories according to different structures: (1) proteins (gelatin), such as human serum albumin, succinylated gelatin (Gelofusine), and polygeline; (2) starches (polysaccharide), such as hydroxyethyl starch (706 plasma substitute, HES, Voluven) and dextran (70, 40); and (3) others, such as hypertonic sodium chloride hydroxyethyl starch (Holme).

The effect of expanding blood volume and the adverse reactions are compared between the plasma substitutes, and the results showed that the colloidal solution is superior to crystalloid solution. The natural colloid albumin has limited resources and is expensive and has a risk of spreading disease. In the clinic, it is only used in special circumstance such as correcting hypoalbuminemia. The gelatin solution in artificial colloid has a relatively small molecular mass and a less impact on blood clotting function, but its duration of action on expanding blood volume is shorter. At the same time, it has a higher risk for occurrence of allergic reaction. The dextran solution has a relatively large molecular mass, and the duration of its action on expanding blood volume has been extended to some extent compared with the gelatin solution, but it also has an increased impact on blood clotting function. The effect of expanding blood volume of hydroxyethyl starch is best, and the old-generation hydroxyethyl starch with higher relative molecular mass, degree of hydroxyethylation, and C2/C6 ratio has a longer duration of action on expanding blood volume, but it has a greater impact on blood coagulation and renal function; while the new-generation hydroxyethyl starch with middle molecular mass (HES, Voluven) not only retains the effectiveness of expanding blood volume of the old-generation hydroxyethyl starch, it also greatly reduces the impacts on blood coagulation and renal function. It can significantly improve visceral blood flow and oxygenation, prevent capillary leakage, reduce capillary permeability, reduce the endothelial cell activation after ischemia-reperfusion, reduce endothelial injury, and maintain the stability of endothelium, thereby reducing the inflammatory response. Its allergic reaction incidence rate is the lowest in all colloidal solution used in clinic; thus, it becomes a more ideal colloidal solution.

8.5 Blood Conservation

Blood conservation refers to carefully protecting and preserving the patient's own blood to prevent its loss, destruction, and contamination and managing and using well the precious natural resources in a planned way, thus preventing the occurrence of the transfusion transmitted diseases and complications. In addition to strictly controlling the indications for blood transfusion and avoiding unnecessary allogeneic transfusions, the blood conservation measures which can be selectively used in the perioperative period of the tumor operation include preoperative autologous blood storage and the use of erythropoietin, intraoperative acute normovolemic hemodilution, intraoperative acute hypervolemic hemodilution, use of antifibrinolytic drugs, and controlled hypotension. The anesthesiologists should make a choice based on the specific condition of the patient, the operating room facilities, and the personal experience, and two or more types of blood conservation methods can usually be used.

8.5.1 Preoperative Autologous Blood Donation and the Use of Erythropoietin

Preoperative autologous blood donation (PABD) refers to that a certain amount of autologous blood are collected several times from the patient at 2–4 weeks before surgery and then are stored, and these autologous blood will be infused back into the patient on the day of surgery to meet the need of surgical blood. In the process of preoperative blood storage, the patient can take oral iron supplements and be treated with erythropoietin to promote erythropoiesis. PABD requires that the patient is in generally good condition, with no anemia (Hb > 110 g / L, Hct > 33%) and no serious heart and lung disease. Its main advantage is that it causes no antigen-antibody reaction and is relatively safe, and it can economize the source of blood and has no infectious diseases. It is mostly suitable for patients with a rare blood type and the allergy to foreign proteins; its main drawback is that the blood may be contaminated in the process of collecting blood, and the hemolytic reaction may occur in the stored blood, and thus the length of stay of the patient is longer. Walther-Wenke et al. made a statistics on related reactions to 22,630 autologous blood transfusions in 21,553 patients which were reported in the relevant literatures and found that the incidence of sepsis was markedly lower than that in patients receiving allogeneic blood transfusion, and the incidence of blood transfusion reaction was also very low, which was about 1/4500. The main problem is that sometimes the operational errors may appear.

8.5.2 Intraoperative Acute Normovolemic Hemodilution

The acute normovolemic hemodilution (ANH) refers to the blood conservation method that the anesthesiologist collects a certain amount of blood from the artery or deep vein of the patient and stores it for a while after anesthesia induction and before the start of surgery; meanwhile, the circulating blood volume of the patient is supplemented with colloidal solution (1:2), and the diluted blood is used to maintain the function of circulation during surgery, minimize the hematocrit, and thus reduce the absolute loss amount of red blood cells in the blood; then the collected blood is reinfused into the patient before the end of surgery. ANH is simple and operable, and it costs less compared with preoperative autologous blood storage or application of recombinant erythropoietin and the intraoperative or postoperative autologous blood recovery. The collected blood is stored at room temperature in the operating room, it is less error-prone, and the blood will not be contaminated.

1. Major indications: (1) The expected amount of surgical bleeding > 800 ml, (2) the patients with rare blood type who need to undergo major surgery, (3) the patients with religious beliefs who refuse allogeneic blood infusion, and (4) polycythemia, including the polycythemia vera and the polycythemia caused by chronic hypoxia
2. Major contraindications: (1) Anemia, Hct <30%; (2) hypoalbuminemia, serum albumin <25 g/L; (3) coagulation disorders; (4) the elderly or the children; (5) increased intracranial pressure; and (6) vital organ dysfunction, such as myocardial infarction, pulmonary hypertension, respiratory insufficiency, and renal insufficiency

The acute normovolemic hemodilution is a relatively safe measure for effective blood conservation. According to some basic researches, ANH, combining with controlled hypotension, can cause hypoxia-ischemia brain injury when Hct ≤ 20%, which demonstrates as the mitochondrial degeneration in the hippocampal CA1 region, nuclear enrichment, aggregation, and nuclear membrane deformation. Furthermore, the expressions of NF-$_{\kappa}$B and tumor necrosis factor-α (TNF-α) in the cerebral cortex are increased; thus, it is recommended that ANH combined with controlled hypotension should be avoided when Hct ≤ 20%.

8.5.3 Intraoperative Acute Hypervolemic Hemodilution

The acute hypervolemic hemodilution (AHH) refers to that the patent is rapidly infused with a certain amount of crystalloid solution or colloidal solution (20–25 ml/kg) after anesthesia induction and within 25–30 min before surgery, while the autologous blood is not collected, so that the hematocrit is reduced into the physiological limits. The patient is supplemented with the same amount of colloidal solution for the intraoperative bleeding and with the same amount of crystalloid solution for the urine and evaporated water in surgical field, so that the blood volume remains in the hypervolemic state during surgery. AHH is simple and operable, and it has good timeliness and causes little damage to the blood components.

1. Major indications: (1) Complicated noncardiac surgery, such as oncoplastic surgery, esophageal cancer surgery, colon cancer surgery, hepatobiliary surgery, and orthopedic surgery; (2) the heart, lung, liver, kidney, and blood coagulation functions are normal before surgery; (3) Hct > 35% and Hb > 120 g/L; (4) the estimated blood loss is about 800 ml; (5) the patients cannot (or would not) receive allogeneic blood transfusions
2. Major contraindications: (1) Anemia (Hb <100 g/L), (2) demonstrable clinical cardiopulmonary dysfunction, (3) untreated hypertension, and (4) coagulation dysfunction

Mielke et al. observed the effects of ANH and AHH on parameters such as the intraoperative and postoperative blood loss, the proportion of allogeneic blood transfusion, postoperative hemoglobin, hematocrit, platelets, and blood clotting function and found that there are no significant differences between ANH and AHH, but the ANH is more time-consuming, and it costs more. Therefore, it is considered that the patient with about 1000 ml of estimated blood loss can be treated with AHH instead of ANH.

8.5.4 Application of Antifibrinolytic Drugs

Before resection of the primary lesion in the oncoplastic surgery, it is considered to use some antifibrinolytic drugs with short half-life to reduce the blood loss and allogeneic blood transfusion caused by the resection of the primary lesion.

1. Aprotinin. Aprotinin is natural polypeptide-serine protease inhibitor. It can inhibit plasmin, kallikrein, trypsin, and chymotrypsin and slow down the activation of the complements. It not only blocks the endogenous coagulation pathway, but it also protects the extrinsic coagulation pathway; it not only has a protective effect on platelets, but it also has a systemic anti-inflammatory effect. Therefore, it may prevent the patient from massive blood loss induced by the activation of fibrinolysis. It is noted that the patient is prone to allergic reaction when using aprotinin.
2. Hemocoagulase. The action target of hemocoagulase (sulindac) is clear, and the hemocoagulase plays an effect only on fibrinogen. It does not contain prothrombin activators and does not activate the coagulation factor VIII. Therefore, from the mechanism level, this avoids the potential risk of the blood hypercoagulable state and the thrombogenesis within the normal blood vessel wall which may occur after the use of blood clotting enzyme drugs. Pharmacokinetic studies showed that the half-life period of hemocoagulase is 2.5 h. The hemocoagulase is mainly distributed in the blood, and it can be removed quickly from the body, and thus there is no drug accumulation.

But it is not advocated that the antifibrinolytic drugs are applied after the primary lesion is resected and the bleeding is stopped, in order to avoid the effect of the blocking of the anastomosed blood vessel on the blood supply of the skin flap.

8.5.5 Controlled Hypotension

The intraoperative blood loss can be reduced through performing controlled hypotension when the primary lesion is resected.

8.6 Allogeneic Blood Transfusion

In 1998, China formally promulgated the Blood Donation Law of the People's Republic of China. In 2000, the Ministry of Health developed the Technical Specification of Clinical Transfusion, which has promoted the great progress of blood conservation and saving the usage of blood. The Hb value which is controlled as an indication for blood transfusion gradually decreases from less than or equal to 100 g/L to 80–90 g/L, and it has been decreased to 70 g/L in some operations. But no matter what kind of blood conservation measures are adopted, and no matter how the blood transfusion indication is controlled strictly, some patients undergoing oncoplastic surgery still need to receive allogeneic blood transfusion, and the anesthesiologists and the surgeons should master the following principles.

8.6.1 Implementation of Blood Component Transfusion

In order to save blood resource, it is mostly advocated that the principle of supplementing what the patient lacks should be abided by. The red blood cells can be infused to maintain a certain degree of hematocrit and carry oxygen for tissue cells to use, and the patient with blood loss of more than 20% of blood volume should be supplemented with red blood cells. The plasma is mainly infused to expand the blood volume, and the fresh frozen plasma contains some fibrinogens and blood coagulation factors. The patient with massive blood loss (more than 50% of blood volume) should be supplemented with plasma according to 10 ml/kg, and this can play a certain role in preventing secondary hyperfibrinolysis at the same time of expanding the blood volume. Because the blood platelets and cryoprecipitate must reach a certain concentration to play a better hemostatic effect, and it is more difficult to stop bleeding after large volume hemodilution, it is considered that the patient with a blood loss exceeding 50% of the blood volume should be supplemented with blood platelets according to 0.1 U/kg; the patient with a blood loss exceeding 100% of the blood volume should be supplemented with coagulation factors (i.e., cryoprecipitate) according to 0.1 U/kg, and the patient with a blood loss exceeding 100% of the blood volume had better be infused with fresh whole blood. With improvements in surgical techniques, the patients can safely pass through the perioperative period basically through blood component transfusion.

8.6.2 Paying Attention to the Warming of Banked Blood

The infusion of a lot of blood at 4 °C will cause the temperature to decrease in the patient, and sometimes it can be decreased to 34 °C, and thus this leads to a series of biochemical metabolic disorders and the inhibition of cardiac function. Therefore, the banked blood must be pre-warmed; the warming methods include that the blood is warmed by the blood warmers or the blood bag is placed into warm water at 30–40 °C.

8.6.3 Selecting the Blood Products with Shorter Storage Time

When large quantity blood transfusion is needed, it is supposed to use the blood with shorter storage time as far as possible, and the storage time is preferably within 5 days. In fact, in the banked blood which has been stored for 24 h, the activities of platelets have been basically lost; in the banked blood which has been stored for 3 weeks, from 85% up to 90% of the coagulation factors II and III have been destroyed.

8.6.4 Treatment of Transfusion-Related Complications

The blood transfusion can cause many acute and chronic phase reactions, especially the acute phase reactions; thus, the anesthesiologist should take an active prevention and treatment.

1. Acute urticaria, hypotension, and purpura. These are mostly the antigen-antibody reaction caused by allogeneic transfusion. It should be noted to strictly check blood type, control the blood transfusion speed, and follow the principle that the blood should be infused slowly at first and then faster; it is noted that the infusion tube should be rinsed clean as far as possible when the blood is replaced and the patient is intravenously injected with 5–10 mg dexamethasone before transfusion. Once the severe transfusion reactions occur, the blood infusion should be immediately stopped, and the patient is treated with corticosteroids. The patient with severe shock will be treated directly in accordance with the method for treating the anaphylactic shock, including intravenous or subcutaneous injection of adrenaline, the symptomatic and supportive treatment such as speeding up the infusion speed. The acute hemolytic reactions may lead to acute renal failure; thus, the patient should be supplemented with a lot of fresh whole blood and treated with blood purification immediately.
2. Bleeding tendency. This is a serious complication caused by massive transfusion, and it should be noted that the supplements of platelets and coagulation factors are carried out synchronously. In addition, because it is needed to consume the calcium ions in the blood clotting process, while a large number of potassium citrate in the banked blood can replace in vivo free calcium, the free calcium is reduced to affect the blood clotting and myocardial activities. It should be noted that 10–20 ml of 10% calcium gluconate or calcium chloride is used simultaneously every 1000 ml banked blood transfusion.
3. Hyperkalemia. If two to three venous pathways are developed simultaneously for massive transfusion of banked blood, this can cause acute hyperkalemia. Then it is supposed that the patient is immediately infused with the glucose and insulin to promote the potassium ions to enter into the cells, which are given according to the ratio of 1 U insulin versus 3–4 g glucose, or 10% calcium gluconate or 10–20 ml calcium chloride is infused to replace the potassium ion. The patients with severe acidosis are given simultaneously with 5% sodium bicarbonate for intravenous drip.
4. Respiratory distress syndrome. The banked blood contains tiny polymers which are composed of the fibrin network with platelets and the white blood cells, and they can clog the pulmonary capillaries, and thus causes respiratory distress syndrome. The shorter the storage time of the banked blood is, the less the formation of this substance is. 20–40 μm Millipore filters are selectively used, and they have certain preventive effect.

8.7 Application of Antibiotics

Most of oncoplastic surgeries which involve maxillofacial and oral areas are type IV operations with type II incisions, and it is needed to routinely use the broad-spectrum antibiotics during operation. The antibiotics are administered generally at 30 min before skin incision for the first time, which is repeated every 4 h, and the patient still needs to be treated additionally with anti-anaerobic bacteria drugs to prevent wound infection.

8.8 Management After Anesthesia

8.8.1 Postoperative Recovery

The vast majority of patients undergoing oncoplastic surgery can successfully regain consciousness in postanesthesia care unit (PACU) after surgery. In individual patients, since the anesthesia time is too long, the trauma is large, the basic condition is poor, or the age is too big, all of these would lead to that the anesthetics accumulate in body, the recovery is delayed, and the breathing recovery is dissatisfied; thereby, the patients need to be transferred into the intensive care unit (ICU) for continuous observation and treatment. The life-threatening phenomenon that the airway is obstructed again after extubation frequently occurs in the patients who have undergone head and neck surgery, and the anesthesiologist should pay particular attention to subtle changes in the patient's condition and strictly control the extubation indications to prevent the occurrence of accidents. The indications for extubation include:

(1) Consciousness recovery: The patient fully recovers consciousness and can answer questions (instructions) correctly.
(2) Respiratory recovery: The patient's respiration is recovered. The patient can maintain spontaneous breathing after the ventilator is deactivated; the respiratory rate is more than 10 to 12 beats/min; the oxygen saturation is maintained at around 95%; the patient has no significant

symptom of airway obstruction; the results of blood gas analysis is normal for 30 min.

(3) Reflex recovery: The laryngeal reflex, pharyngeal reflex, and muscular tension are fully recovered, and the patient can open eyes, look up, and shake hands.

For the patients who achieve the above conditions, the endotracheal extubation is performed in the presence of a surgeon and with tools to reestablish the airway. If all indicators are normal after extubation, the patient can take a sitting position, and the patient can be sent back to the ward after no symptom of airway obstruction is observed for 30 min.

8.8.2 Problems in Indwelling Endotracheal Tube

When the oncoplastic surgery involves the oral, maxillofacial, and cervical areas, the acute upper respiratory tract obstruction may occur due to muscle relaxation, glossocoma, throat or neck swelling, oozing or bleeding, and hematoma compression; the airway obstruction may occur after maxillofacial and cervical surgery due to the commonly used dressing bandage, transarticular flap, elastic fixation in bilateral zygomatic arches, and fixation with steel wire between the two jaws and the missing teeth. If the patient cannot undergo extubation after fully regaining consciousness in PACU, the patient can take the tube back to the ward and is continuously observed for 24–48 h, and the tube is retained maximally for 72 h. The tip of the steel wire flexible tube which is currently used has a small stimulation on airway wall. Under the condition of mild analgesia and sedation, the patient can generally retain the transnasal endotracheal tube for 24–48 h, and the extubation can be performed after the edema subsides. There must be a condition for carrying out tracheotomy when the extubation is performed, in order to establish the airway at any time. If the possibility that the airway will be obstructed again is very large, and there are still a lot of secretions and the edema is obvious after the tube is retained for 24–48 h, it is best to carry out the tracheotomy immediately to ensure patient safety and facilitate expectoration.

8.8.3 Postoperative Analgesia, Sedation, and Anti-vomiting

The postoperative nausea, vomiting, and restlessness may lead to a contaminated wound and damage the organs and tissues which have been repaired. The restlessness may be due to pain or intravesical catheter stimulation. The nausea and vomiting may be due to that the pharyngeal area is stimulated by the secretions or effused blood, or the stomach is stimulated by swallowed secretions or blood; the nausea and vomiting may also be the adverse reactions of the anesthetic drugs. It should be noted that the fentanyl plus a small dose of anti-inflammatory analgesics is used postoperatively in patient-controlled analgesia to alleviate the pain and also play a mild sedating effect, and this facilitates the patient to have a good rest. At the same time, the 5-HT3 receptor antagonists are routinely used to stop vomiting and prevent the occurrence of nausea and vomiting, and the secretions of the oropharyngeal cavity are cleaned timely by suction to reduce throat irritation.

8.8.4 Prevention of Complications

Statistics show that the complication rate in ICU patients after oncoplastic surgery with an average duration of 9 h reaches 57.4%; the hospital stay in patients older than 60 years is obviously prolonged, and the smokers are more prone to developing short-term complications. According to the American Society of Anesthesiologists (ASA) classification, the survival rate especially the long-term survival rate is lower in patients with grade 3–4 tumors. Another analysis on the complications of 469 cases of head and neck surgery showed that after such surgery, the cardiovascular complication rate is 12%, the respiratory complication rate is 11%, and the incidence of the heart failure is higher than that of the pneumonia. The high-risk period for cardiovascular complications is the first day after surgery, and the high-risk period for respiratory complications is the second day after surgery. The risk factors for cardiovascular complications include age, lung disease, alcoholism, and improper tumor site; the risk factors for respiratory complications include lung disease, pre-existing myocardial infarction, and higher ASA classification. Therefore, for the elderly, weak, and smoking patients after surgery, attention should be paid to preventing the occurrence of lung infections and cardiocerebral events, correcting water and electrolyte disturbances, acid-base balance disorders, and hypoproteinemia and preventing the poor blood supply to the skin flap due to that the blood is too concentrated [25].

9 Effect of Preoperative Radiotherapy on Skin Flap Graft in Oncoplastic Surgery

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The integrated treatment of the tumor refers to that the existing treatment means are used purposefully, designedly, and reasonably based on the body condition of the patient and the pathological type, invasion range, and development trend of the tumor to significantly increase the cure rate and improve the patient's quality of life. The integrated application of surgery and chemoradiotherapy brings to the malignant tumor patients a more satisfactory therapeutic effect compared with before. The integrated treatment cannot only cure the early stage tumors, but it can also protect the function and appearance; it can increase the chance of cure for patients with middle-stage tumors, expand the surgery resection rate for patients with middle-late-stage tumors, and try hard to win a better curative effect for patients with recurrent malignant tumors. The integrated treatment of the tumor needs to be completed through multidisciplinary collaboration of oncology surgery, radiation therapy, and chemotherapy.

However, the concept of integrated treatment of the tumor brings out another question to the medical experts in clinical oncology: What kind of impacts will the inevitable radioactive damages caused by radiation therapy bring on the postsurgical incision healing, the skin flap graft in oncoplastic surgery, and the repair and reconstruction of postoperative defects? This is the problem the medical workers have to study and solve; this section will make a preliminary discussion on this problem.

9.1 The Healing Process of the Normal Tissues

The tissue healing is a complex and orderly biological process of the response of tissues to trauma and repair. Theoretically, the tissue healing can be divided into three phases: the inflammatory phase, the fibrous proliferative phase, and the scar formation and reparative phase.

9.1.1 The Inflammatory Phase

The inflammatory phase starts from the tissue damage and lasts for 3–6 days under the physiological conditions. The physiological process is divided into the following stages: The damaged tissue cells release the vascular active substances to cause local vasoconstriction; at the same time, the platelets aggregate to activate the coagulation system, and the fibrinogen is converted into an insoluble fibrin network to produce blood clots to seal off the damaged blood vessels and protect the wound.

At 2–4 h after skin tissue damage occurs, the phagocytic cells begin to move into the wound and swallow the debris, foreign bodies, and microorganisms within the wound. In the early phase of inflammation, the neutrophils are seen mostly, and they secrete a variety of inflammatory mediators, namely, cytokines such as tumor necrosis factor-α and interleukin in the wound. Meanwhile, the neutrophils engulf bacteria and release the proteolytic enzymes to remove the damaged and deactivated components in extracellular matrix. After swallowing the tissue and cell debris, the phagocytic cells will be decomposed, and then the decomposed phagocytic cells together with the lysed tissues form into pus, which needs to be cleared away from the wound through changing dressings and local drainage. The accumulation of pus in the wound will also affect the healing of the wound.

The macrophages are attracted by chemotaxis-stimulating substance such as bacterial toxins and are further activated by the neutrophils, and they enter into the wound from the blood in large quantities and secrete the cytokines (such as interleukin-1, interleukin-2, tumor necrosis factor-α) which promote the inflammatory reaction and a variety of growth factors (such as basic fibroblast growth factor, epidermal growth factor, platelet-derived growth factor). These growth factors are polypeptides, and they can attract and promote cells to enter into the inside of the wound, stimulate cell proliferation, and precisely control the wound healing by means of complex interactions.

The inflammatory reaction is a complex defense reaction of the body, and its purpose is to remove or inactivate harmful substances, remove the necrotic tissue, and create favorable conditions for the subsequent proliferation. The inflammatory reaction exists in any process of wound healing and has four typical symptoms such as red, swelling, fever, and pain in suffered area.

9.1.2 The Fibrous Proliferative Phase

The fibrous proliferative phase is also known as granulomatous phase. In this phase, the angiogenesis and vascularization are the basis for the growth of granulation tissue. The granulation tissue consists of tissue connecting cells, small blood vessels, and collagen.

Under the stimulation of growth factors, the endothelial cells of the vessel wall break through the basement membrane to move into the area around the wound and form into vascular buds through cell division. The single vascular bud grows into another vascular bud, and two vascular buds are integrated and formed into vascular access and then are further integrated and formed into vascular branch, vascular net, and capillary loop. This process is also known as a process of the reconstruction of capillary vessels, and it takes 1–4 days to complete the entire process. The angiogenesis is the basis to ensure an adequate supply of oxygen and nutrition to the wound. If there is no vascular angiogenesis and reconstruction, there will be no growth of the granulation, and the wound also cannot heal.

When the neovascularization occurs, each granulation has a corresponding vascular branch and is accompanied by a large number of capillary loops. The collagens are produced initially by fibroblasts, and the fibers are formed in the cells to support the granulation tissue. The granulation tissue fills the basal layer of the wound, and it can seal the wound and is taken as the basis for epithelialization. The formation degree of granulation tissue is directly related to the extent of blood coagulation and inflammatory reaction, including the debridement process of the body under the assistance of the phagocytosis.

The fibroblasts are the main functional cells in the process of wound healing. After the trauma occurs, the fibroblasts enter into the local area to proliferate, differentiate, synthesize, and secrete the collagens. If there is hematoma, necrotic tissue, foreign body, or bacteria in the wound, the transition of the fibroblasts and the formation of new blood vessels will be delayed.

Modern researches have shown that there are fibroblasts in different stages in the wound. Their secretory activities are different, and their responses to growth factors are also different. These characteristics are extremely important for wound healing.

9.1.3 The Scar Formation and Reparative Phase

The scar formation and reparative phase is also known as maturation phase or epithelial formation phase. After the secretory activities of the fibroblasts in the wound are finished, some are turned into the stationary fibroblasts, namely, fibrocytes, and some are turned into myofibroblasts. The morphology of the myofibroblast is just like that of the smooth muscle cell, and it contains the contractile actins, which can tighten the edges of the wound and make them shrink. This process begins at 2 weeks after the injury, and the wound will continuously shrink and get smaller at a speed of 0.6–0.7 mm a day regardless of the size of the wound area.

The cells in the skin basal layer with metabolic activity have an unlimited potential in mitosis, and its physiological process is as follows: After the epidermis is damaged, the wound area is short of a large number of cells that secrete the chalones; thereby, the "epidermal chalone" level is significantly decreased in cells, and the mitotic activity is increased in the basal cells. This process initiates cell proliferation required to fill the defect. The cells migrate from the basal layer to the surface of the skin, and the repair is carried out in the linear and opposite direction to the wound edge through cell maturation, repair, and cell replacement. The formation of epithelia in the wound edges starts from where the epithelial integrity is broken, and the divided epithelial cells creep and grow to the other side through amoeba-like movement, which is similar to the activity of the unicellular organism. The wound is covered by new epithelial cells formed through mitosis and cell migration, which marks the completion of the wound healing process.

9.2 The Wound Healing of Radioactive Injury

9.2.1 The Characteristics of Wound Healing of Radioactive Injury

1. The early inflammatory reaction in the wound healing of radioactive injury is significantly inhibited, and the wound effusion is decreased, especially the leakage of leukocyte is decreased mostly. The tissue necrosis is increased, and the bleeding is extensive.
2. The growth and maturation of granulation tissue in the wound of radioactive injury are slowed down. The fibroblasts are severely damaged, and the radiation fibroblasts appear. The synthesis and secretion of the collagens in the wound are inhibited, and the wound contraction is also affected.
3. The process of the epithelial cells covering the wound of radioactive injury is lagged, and the wound healing process is delayed [26].

9.2.2 Effect of Radioactive Rays on Wound Healing

1. Diminished inflammatory reaction. The radioactive rays lead to early inflammatory reaction in wound healing, and the wound effusion is decreased, especially the leakages of monocytes and neutrophils are decreased, which is very unfavorable for the initiation and development of wound healing process and the removal of necrotic tissue. The causes for diminished inflammatory reaction may include: (1) The numbers of white blood cells and platelets are decreased in the peripheral blood of the patients with the wound of radioactive injury at the early phase; (2) the radioactive rays destroy the vascular structure in the bottom of the wound and the surrounding tissue, which leads to degeneration, necrosis, and falling off of the endothelial cells and affects the attachment of leukocytes to the vessel walls and their adhesion and emigration; (3) the tissues surrounding the wound of radioactive injury slow down the migration of leukocytes.
2. The injury of tissue cells around the wound. The lethal or sublethal damages to the tissue cells around the wound of radioactive injury, especially the poorly differentiated mesenchymal cells and fibroblasts, can cause an obstacle in the proliferation and differentiation of a variety of cell components. Rudolph et al. reported that the fibroblasts in the edges of the radiation skin ulcer were cultured in vitro, and then the ability to attach to the substrate and form colonies was significantly reduced compared with the control group, and the growth rate of the skin fibroblasts affected by radiation damage in logarithmic growth phase was reduced compared with the control group, which indicates that the proliferation ability of skin fibroblasts is low or the radioactive rays selectively eliminate the fibroblast population with stronger proliferation ability. The experimental results of Rudolph et al. confirmed the direct damage effect of the radioactive rays on fibroblasts, including reducing the proliferation ability of fibroblasts and delaying the appearance of myofibroblasts and finally resulting in delayed wound healing or nonunion. The result of the experiment showed that the fibroblasts after radiation damage have a serious degeneration, and the large and abnormal radioactive fibroblasts appear, and their proliferation and differentiation will inevitably be

affected. Gorodetsky et al. [27] also noted that the wound tension was measured at 2 weeks after the homologous fibroblasts were injected into the radioactive compound wound, and it was increased significantly compared with that in the control group. Rubin et al. considered that the damage effect of the radioactive rays on skin tissue is caused by the microvascular occlusion and tissue hypoxia.

3. The destruction of the vascular structure in the surrounding tissue. The radioactive rays destroy the vascular structure in the surrounding tissue, cause local blood circulation, and thus affect the healing process. The radioactive rays can also affect the formation of the capillary network in granulation tissues, and the reason for this is mainly related to the direct damage effect of the radioactive rays on undifferentiated mesenchymal cells, vascular endothelial cells, and smooth muscle cells.
4. Fibroblast injury. The radioactive rays cause delayed wound healing, and each development phase is lagged, of which the fibroblast injury is one of the key points. The fibroblast is one of the major repair cells, and it participates in the whole process of wound healing. Since the radioactive rays cause a sharp drop in the number of fibroblasts, structural damage, and morphological changes in fibroblasts, their proliferation abilities and the functions of secreting a variety of growth factors and type I and III collagens are weakened. The growth factors play important roles in the process of wound healing, and the abnormal expressions of a variety of growth factors in each development phase of radioactive compound trauma are the significant cause for inhibited fibroblast proliferation and weakened functions in the synthesis and secretion of collagens and extracellular matrix. In the early phase after irradiation with radioactive rays, the type I and type III collagen mRNA transcription as well as the protein synthesis and secretion are decreased, and thus the formation of granulation tissue and its transformation into normal tissue are affected. This firstly leads to reduction in the number of fibroblasts and secondly leads to reduced abilities to synthesize fibroblasts and secrete collagens.
5. The deteriorated general condition of the body. The radioactive rays deteriorate the general condition of the body, which may also be part of the reason for the delayed wound healing.

9.3 Advantages of Preoperative Radiotherapy

The preoperative radiotherapy refers to that the patient is irradiated with radioactive rays before surgery. In general, the advantages of preoperative radiotherapy are: (1) It can eliminate subclinical lesions (i.e., the small lesions which can't be detected by current imaging methods). Meanwhile, it can reduce the size of the tumor and release the adhesions; (2) it can increase the surgical resection rate, so that the patients who have been not suitable for surgery or who are inoperable can undergo surgeries; (3) it can reduce the range of surgery and better maintain the physiological and living abilities of the patients after surgery; (4) it can block the small blood vessels and lymphatic vessels around the tumor and reduce the opportunity of metastases through the blood and lymph vessels; (5) it can reduce the viabilities of tumor cells and reduce the chance of intraoperative iatrogenic spread, thereby improving the cure rate.

9.4 Study on the Underlying Mechanisms of the Effects of the Preoperative Radiation Damage on Tissue Healing

Approximately 70% of patients with tumors will receive radiotherapy at some stage in the course of disease. Therefore, most oncology surgeons may have the experience of performing the operation on the patients with a history of radiotherapy. The timing of surgery relative to the radiotherapy and the effect of radiotherapy on wound healing and postoperative complications are worth careful consideration.

The radiotherapy can cause the skin and connective tissues to produce the early and late phase reactions. The main cause for the early phase reactions is cytotoxic effect of the radioactive rays on the epithelial cells. The potential mechanisms for the late phase reactions are complex. All lamellar layers of the skin will be involved, and its main feature is the vascular injury and fibrosis. The implement of the operation in tissues which have been treated with radiotherapy can increase the postoperative complications. Therefore, it needs adequate preoperative preparation, attentive perioperative management, and precise surgical technique at the moment. It is also necessary to forewarn patients about the increased likelihood of the postoperative complications.

9.4.1 Radiotherapy-Induced Early Phase Reactions in the Skin and Connective Tissues

The early phase reactions occur in the process of radiotherapy or within a few weeks after radiotherapy. The single radiation dose is 3–8Gy. It can induce a transient skin erythema at 1–2 days after radiotherapy, and this is caused by the congestion and expansion of the blood capillaries in the top layer of the dermis. The depilation occurs at the second week after radiotherapy, and the erythema reappears at the third week and is accompanied by redness and dry or moist desquamation.

The radiotherapy-induced early phase reactions in the skin and connective tissues are mainly due to the effect of radioactive rays on the epithelial cells in dermis base layer and stratified dermal layer. The signs or symptoms of early phase skin reactions usually develop along with the treatment process, but due to the accelerated epithelial proliferation, they will begin to subside at the end of treatment after reaching a peak. In addition to the effect of the radioactive rays on the epithelial proliferation, the important changes will also occur in small blood vessels (such as capillaries, arterioles) and lymphatic system, and it is usually possible to observe the capillary dilatation and congestion, plasma leakage in the dermal papilla layer, and inflammatory cell infiltration.

9.4.2 Radiotherapy-Induced Late Phase Reactions in the Skin and Connective Tissues

The late radiation damage occurs usually at 4–6 months after radiotherapy [28]. These late changes occur in all lamellar layers of the skin, including the epidermis, dermis, and subcutaneous tissue. The epidermis atrophy is often the most significant, then the skin becomes thin, smooth, and hard and loses its elasticity, and its resistance to injury is reduced. The sweat glands, sebaceous glands, and hair follicles will usually also shrink and thus lead to dry skin and hair removal. The heavier pigmentation and telangiectasia can also be observed. After receiving high doses of radiation, the skin ulcers or necrosis may occur.

The changes in blood vessels and connective tissue play an important role in radiotherapy-induced late phase reactions in skin and connective tissues. The study is carried out from the histological level, and it is possible to observe the progressive capillary occlusion and thrombosis, while the remaining capillaries are typically dilated; thus, this leads to telangiectasia. The arterioles and small arteries show a progressive hardening and thus cause a significant stenosis and occlusion of the vessel lumen. The vascular injury may lead to inadequate tissue perfusion and oxygen supply. The study also found that the densities of the collagen fiber network and irregular elastic fibers in the irradiated sites will be greater compared with the normal skin. After receiving the high dose (60–70Gy) of radiation, the dermis and subcutaneous tissue will gradually be replaced by a very dense and inelastic fibrous tissue. It is worth attention that, although the skin and subcutaneous tissue fibrosis and its reduced blood supply may be stable at last, the reaction to stress may be the ulcer or necrosis, for example, which may occur when there is an infection or operation. Therefore, when an operation is performed in the radiation area, the late phase reactions and chronic vascular injury in the irradiated skin may disrupt the skin wound healing process and increase the risk of postoperative complications.

9.5 Effect of Preoperative Radiotherapy on Skin Flap in Oncoplastic Surgery

9.5.1 Head and Neck Tumors

Wang Zhonghe et al. in The Ninth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine have made related clinical studies on the radiotherapy resistance of the skin flap graft after resection of oral and maxillofacial tumors. Wang et al. reported that after 82 patients underwent oral and maxillofacial tumor resection, 88 tissue flaps were used for immediate repair. Sixty-eight patients (74 flaps) started to receive radiotherapy at 2–6 weeks after surgery, and the remaining 14 patients (14 flaps) had received 50–70Gy of radiotherapy within 10 years which started from 2 months before surgery. The successful rates of skin flap transplantations in the preoperative radiotherapy and postoperative radiotherapy groups were 85% and 98.6%, respectively. The incidence of acute radiation reaction of the skin flap in the postoperative radiotherapy group was significantly lower than that of the surrounding normal tissue (35.1% and 83.8%, $P < 0.01$). Follow-up was carried out for 12 to 36 months. Three patients had fibrosis changes in skin flap, and two patients had atrophic changes.

When the skin flap graft is to be carried out in patients who have received radiotherapy, full consideration should be given to the effects which may be caused by the radiotherapy. The blood vessels in receptor site may be damaged by radiotherapy, and a certain degree of barrier will happen when the revascularization is performed between tissue flap and the tissues in receptor site. Therefore, the tissue flap is prone to necrosis and poor healing. The blood circulations in receptor sites of the patients undergoing postoperative radiotherapy are normal. The radiotherapy is carried out after tissue flap heals, which will not produce significant effect on the recent healing of the tissue flap. Most scholars believe that the survival rate of tissue flap and the good healing rate in the patients undergoing preoperative radiotherapy are significantly lower than those in the patients undergoing postoperative radiotherapy.

In order to increase the successful rate and the good healing rate of the immediate reconstruction with tissue flaps in the patients undergoing preoperative radiotherapy, Wang Zhonghe proposed: When the repair with tissue flap is to be performed after the recurrent tumor or the second primary tumor is resected, the vascular anastomosis is performed as far as possible in the area outside the original radiotherapy area. The blood vessels with thicker diameters are selected for anastomosis, and the blood vessels must be strong and unobstructed after anastomosis; the length-to-width ratio of the skin flap is appropriate, and it cannot be too long and narrow; if there is fibrosis in the receptor site of the tissue flap, the tissues in the receptor site should be cut to the area with active oozing of the blood, and then the reconstructive suture can be performed. If such patients want to undergo postoperative radiotherapy, the range and the dose of preoperative radiotherapy must be taken into account to avoid the serious consequences. It should be noted that the newly repaired tissue flap has not been treated with radiation, and it also has a good tolerability to the postoperative radiotherapy. If most of the tissues in the lesion area with preoperative radiotherapy are resected together with the tumor, it is not necessary to totally exclude the postoperative radiotherapy.

9.5.2 Breast Cancer

The radiotherapy is commonly seen in the two situations before repair and reconstruction of the breast defect: (1) The patients undergo total mastectomy plus breast reconstruction when the breast cancer recurs after breast-conserving surgery plus radiotherapy; (2) the patients undergo secondary repair.

Compared with the primary autologous repair, the difficulty of the secondary repair after mastectomy surgery is relatively small. The delayed repair leads to postoperative exposure of some surgical areas of the tumor to facilitate early detection of cancer local recurrence. After the primary repair of breast defect, the breast contour makes it difficult to achieve the uniformity of radiotherapy dose, while the secondary repair can reduce the adverse effect of the radiotherapy on breast cosmetic effect and the effect of the breast contour on radiation dose distribution. However, the patients need to receive two operations, which will aggravate the trauma and pain. After mastectomy, the patients must bear the psychological pressure induced by breast deformity within a certain period of time. If the patients undergo postoperative radiotherapy, this will increase the difficulty of repairing the chest wall injury.

US MD Anderson Cancer Center reported the surgical complications in a group of 102 patients undergoing breast reconstruction after mastectomy and made comparisons of the incidences of early and late complications between the patients undergoing primary repair ($n = 32$) and the patients undergoing secondary repair ($n = 70$). The study found that the incidence of complications in the patients undergoing radiotherapy before secondary breast repair is significantly lower than that in patients undergoing radiotherapy after primary repair.

Disa et al. believed that the autologous tissue breast reconstruction is an ideal way for breast reconstruction in patients after undergoing chest wall radiotherapy. This is due to the fact that the autologous tissue has overcome some difficulties involved in allograft tissue reconstruction, and it is not need to perform tissue expansion. Furthermore, the autogenous healthy tissues have replaced the tissues after radiotherapy. The shape and texture of the reconstructed breast are close to those of the normal breast, and the long-term cosmetic result is good, and thus it is less likely to require surgical repair.

In the principles to be followed for selection of repair and reconstruction of defects after tumor surgery, Zhou Xiao indicated that:

1. If the simple surgery can achieve the same effect, the complex plastic surgery or microsurgery will not be performed.
2. Only the secondarily important area of the body can be taken as the donor site of the tissues used for the repair of the important receptor site.
3. It is necessary to not only consider the good recovery in function and appearance of the receptor site but also minimize the loss of function and appearance of the donor site, thereby avoiding the secondary deformity or dysfunction of the donor site.
4. The surgical plan for primary repair of tissues and organs is selected as far as possible.
5. It is inappropriate to select the area after radical radiotherapy as the donor site of skin flap.

It is required that the oncology surgeons should fully communicate with the radiation therapists before developing a therapeutic regimen and reasonably arrange the timing of reconstruction and repair combined with the radiotherapy and thus develop a comprehensive therapeutic regimen which cannot only make the patients restore near-normal function and appearance as far as possible but also ensure the effective treatment.

9.6 The Timing of the Preoperative Radiotherapy and Dose

There are still debates on preoperative or postoperative application of adjuvant radiotherapy and what kind of radiation treatment is best. But the surgeons are more willing to perform postoperative radiotherapy, because what they are worried about is that the preoperative radiotherapy will affect the wound healing and increase surgical complications, and furthermore, it may also increase the risk of tumor recurrence due to the fact that the preoperative radiotherapy narrows the scope of surgical resection.

The clinical studies have shown that the more hypoxic cells exist within the tumor entity, the less sensitive to radiotherapy the tumor is, and the worse the therapeutic effect is. The nourish blood vessels around the tumor before the implementation of preoperative radiotherapy have not been destroyed by surgery. The blood supply to the tumor bed is good, and the tumor cells contain rich oxygen, while the quantity of hypoxic cells is less. Therefore, the tumor is sensitive to radiotherapy. At this moment, the application of radiotherapy has a significant killing effect on tumor cells, and this is very beneficial to reducing the size of the whole tumor and eliminating subclinical lesions to perform organ preservation surgery for tumor patients. The analysis on 229 patients with oral cancers treated in the Cancer Hospital of Chinese Academy of Medical Sciences showed that for patients with T_1 and T_2 lesions, the 5-year survival rate in the preoperative radiotherapy group was the same as that in the simple surgical group; but for patients with T_3 and T_4 lesions, the 5-year survival rate in the preoperative radiotherapy group (40–50Gy) was 60%, and the 5-year survival rate in the simple surgical group was 29.4%. Therefore, the patients with early cancers can undergo simple surgery, but the patients with advanced cancers should be treated otherwise with preoperative radiotherapy [29].

It is not so much that the preoperative radiotherapy has no effect on surgical healing, but if the dose of preoperative radiotherapy is controlled well (i.e., 40–50Gy), this will not cause a significant effect on the surgery in practice. Tupchong compared the data of two groups, namely, the preoperative radiotherapy group (50Gy, 136 patients) and the postoperative radiotherapy group (60Gy, 141 patients), and the results showed that the surgical complication rates in the two groups were 43% and 42%, respectively, of which the serious complication rates were 18% and 14%, respectively. There was no statistically significant difference between two groups. The study of Cancer Hospital of Chinese Academy of Medical Sciences showed that 209 patients with laryngeal cancers were randomly divided into two groups. One group (91 patients) was treated with preoperative radiotherapy (40Gy), and another group (118 patients) was treated with simple surgery. The postoperative complication rate was 25.4% in the preoperative radiotherapy group and was 26.4% in the simple surgery group, and this indicates that the preoperative radiotherapy (40Gy) does not increase the surgical complication rate.

At present, another reason for the surgeons to select less preoperative radiotherapies is that the tumor after radiotherapy is ill-defined and the tumor-free resection margin cannot be guaranteed. But in order to recognize the problem on tumor boundary after radiotherapy, there exist the following two situations: One situation is that the tumor boundary is reduced by the planned preoperative radiotherapy (planned comprehensive treatment), and the surgery is performed at 2–4 weeks after radiotherapy; the other situation is that the tumor recurs after radiotherapy failure. The squamous cell carcinoma is taken as an example. In the formal situation, the boundary is reduced in the vast majority of the tumors, and the peripheral lesions of the tumor are controlled better than the central lesions; thus, the surgical border is guaranteed; while the tumor which recurs after radiotherapy failure often grows under the mucosa, its boundaries are indeed difficult to determine. In addition, the local circumstance is quite different from that before preoperative radiotherapy; thus, it is required to carry out extensive surgery rather than simply reducing the tumor boundary. These two situations should be treated differently.

Sauer et al. conducted a randomized study to determine which was better between preoperative synchronous chemoradiation and postoperative synchronous chemoradiation in the treatment of the rectal cancers (CAO/ARO-094). CAO/ARO-094 randomized controlled study included 823 patients. Through the pelvic CT scan and transrectal ultrasound examination, the patients were diagnosed with T3-T4 or N + rectal cancers without distant metastases. The ages were less than or equal to 75 years and the tumor was within 16 cm from the anus. The patients underwent no prior chemotherapy or radiotherapy. The patients received fluorouracil at a dose of 1000 mg/m^2 daily during synchronous chemoradiation, and the intravenous infusion was continuously carried out for 1–5 days. At the first week and the fifth week after the start of radiotherapy, the consolidation chemotherapy regimen was that the fluorouracil was administered at a dose of 500 mg/m^2 daily, and the intravenous infusion was continuously carried out for 1–5 days, with 4 weeks as a period, and there were a total of four periods. The radiotherapy was the whole pelvic irradiation. The total dose was 50.4Gy (1.8Gy each time, a total of 28 times), and the local supplement dose in the postoperative radiotherapy group was 5.4Gy. Finally, 799 patients were randomly divided into two groups: the preoperative chemoradiotherapy group and the postoperative chemoradiation group. The local recurrence rate was significantly reduced in the preoperative chemoradiation group (6%, 13%; $P = 0.006$); after examination by the surgeon, it was considered that a total of 194 patients needed to undergo abdominal perineal resection (the anal sphincter cannot be preserved) before surgery. The actual anal sphincter preservation rates in two groups were 39% and 19%, respectively ($P = 0.004$), and the anal sphincter preservation rate in the preoperative synchronous chemoradiation group was significantly increased. It was important that the acute and long-term side effects of the preoperative synchronous chemoradiation group were significantly lower than that of the postoperative synchronous chemoradiation group, and the incidences of anastomotic leakage, bleeding, and intestinal obstruction were not increased in the preoperative synchronous chemoradiation group. Although its delayed wound healing rate was higher than that of the postoperative synchronous chemoradiation group, the difference did not reach statistical significance.

The best timing for preoperative radiotherapy is an issue of concern to clinical oncologists, who can get tips from the abovementioned laboratory studies on the mechanism underlying the effect of radioactive damage on tissue healing. The radiotherapy given at a 3–6-week interval is safe, because early phase reaction of the radiotherapy has subsided at this moment and the late phase microvascular injury and fibrosis have not occurred. By this time, the incidence of postoperative complications caused by radiotherapy is lower, which has been verified in our long-term clinical practice.

Tu Guiyi and Xu Guozhen considered that the preoperative radiotherapy should be applied at a dose of 50Gy, and the surgery should be performed at 2–4 weeks after radiotherapy; the postoperative radiotherapy should begin within 6 weeks after surgery at a dose of 60–70Gy. The dose used for preoperative radiotherapy in the past was 40Gy. Zhang Zongmin et al. in Cancer Hospital of Chinese Academy of Medical Sciences applied the radiotherapy at a dose of 50Gy in the treatment of hypopharyngeal squamous cancer (5 weeks), and the case analysis showed that its overall treatment effect was better than that of 40Gy radiotherapy (4 weeks). Wang Zhonghe et al. advocated that preoperative radiotherapy dose should not exceed 50Gy; otherwise, the incidence of serious complications such as postoperative delayed wound healing, fistula formation, and the rupture and bleeding of carotid artery will be increased. Therefore, that the preoperative radiotherapy is applied at a dose of 50Gy (5 weeks) has basically become the consensus.

9.7 The Oncoplastic Surgery Treatment After Radical Radiotherapy

If the patients still have residual tumors after radical radiotherapy which reaches the designed radiation dose, and the residual tumors still don't disappear after 3 months of follow-up observation or recur after subsiding, the local resection or lymph node dissection can be used to save lives in clinic. At present, the radical cure dose of radiotherapy for the cancer is usually 60–75Gy in clinic. At the same time of the tumors being treated, the normal tissues can also have scarring and capillary degeneration accompanied with varying degrees of tissue necrosis due to the radiation damage. Most frequently, these injuries cannot be completely recovered to normal in several months or even years after radiotherapy. If a surgery is performed in the tissues after radical radiotherapy, the healing ability of the tissues after surgery is significantly decreased. Therefore, the oncoplastic surgical treatment after radical radiotherapy remains controversial.

With the continuous development of plastic surgery techniques, the means for repair with autologous skin flap are increasing, and this provides repair methods for some patients after radical radiotherapy. At present, the methods mostly adopted in the hospital where the author works in include reconstruction using myocutaneous flap with vascular pedicle, such as the latissimus dorsi muscle flap and double-pedicle trapezius myocutaneous flap (see Chap. 6, Defect Repair After Tongue Cancer Surgery), and free flap reconstruction, such as radial forearm flap, vastus lateralis flap, and rectus abdominis myocutaneous flap pedicled with inferior epigastric artery (see Chap. 7, Repair and Reconstruction of Oral-Maxillofacial Region Penetrating Defect).

It is still needed to carry out the comprehensive treatment after breast cancer radical surgery. The anterior chest wall skin is prone to radioactive ulcers after radiotherapy. Due to local skin and soft tissue fibrosis and poor blood supply, the ulcers are gradually enlarged and accompanied by infection and deep bone tissue exposure, and the ulcer wound cannot heal through change of dressing. The wound after ulcer resection cannot be repaired with skin graft method, while it needs to be repaired with pedicle flap graft and free grafting by vascular anastomosis. The radical radiotherapy causes the radiation damage to blood vessels within the radiation field, and other tissue injuries related to radical radiation such as endovasculitis, endometrial shedding, and vascular constriction will occur; therefore, the tissues in the field of radical radiotherapy are generally not selected as the donor site of skin flap and the blood vessels used to anastomose the free skin flap in receptor site. In order to improve the success rate of free flap, it is supposed to take the following measures:

1. The necrotic tissue is removed completely to avoid postoperative infection.
2. The free flaps with large-diameter blood vessels are selected and used, because the anastomotic stomas of the large blood vessels are not prone to thromboses.
3. The free flaps with long vascular pedicles are selected and used, and the need to carry out vein transplantation due to insufficient vascular pedicle length is avoided as far as possible.
4. The thick and large blood vessels are used as far as possible.
5. The arterial intima after radiotherapy is easy to be separated and detached from the vessel wall. Therefore, it is supposed to adopt the visualized vascular anastomosis technique.
6. Attention is paid to monitoring of blood supply after free tissue flap transplantation, and the vascular anastomosis should be performed again when necessary.

The indication and contraindication of the surgical treatment after radical radiotherapy remain to be further studied and discussed in the future.

10 Effect of Postoperative Radiotherapy on Skin Flap Graft in Oncoplastic Surgery

Bingqiang Hu, Xuping Xi, and Hui Wang

10.1 Advantages of Postoperative Radiotherapy

The postoperative radiotherapy is performed in patients with residual lesions due to incomplete resection, patients with possible existence of cancer according to the rules of tumor development, or patients with sensitive tumors and high-grade malignant tumors. The suspected residual area should be marked with metal clip during surgery to provide reference for easy positioning of postoperative radiotherapy. The postoperative radiotherapy is generally performed after surgical wound healing and physical rehabilitation. The patients with confirmed postoperative residual lesions should be treated with radical radiotherapy, which can achieve the purpose of curing or controlling the tumors and delaying tumor recurrences. The postoperative radiotherapy has great significances in increasing the local control ratio after oncoplastic surgery, especially in preventing the recurrence of tumors in patients with insufficient safe surgical margin.

Advantages of postoperative radiotherapy: The postoperative radiotherapy will not delay the operation time; the target area of radiotherapy can be more accurately formulated according to specific intraoperative findings, the situation of surgical resection, and the results of postoperative pathological examination; the target area and dose of radiotherapy can be determined according to subclinical tumor lesions within the scope of the operation, including metastatic lesions in regional lymph nodes; the known residual lesions or high-risk areas are treated with a large dose of radiotherapy, so as to effectively control the tumor.

Disadvantages of postoperative radiotherapy: The postoperative radiotherapy must be performed after wound healing; because the surgery has changed the vascular distribution of the tumor bed, the local blood supply may be affected, so that the hypoxic cells in residual lesions or subclinical lesions of tumor bed are increased; thereby, the radiotherapy effect is affected.

10.2 Study on the Underlying Mechanisms of the Effects of the Postoperative Radiation Damage on Tissue Healing

The effects of the postoperative radiation damage on tissue healing include the following aspects.

10.2.1 Changes in the Extracellular Matrix

The speed and quality of wound healing have an important relation with extracellular matrix components. The extracellular matrixes in the wound mainly are synthesized and secreted mainly by macrophages, fibroblasts, endothelial cells, and epidermal cells. The extracellular matrixes not only play connection and supporting effect on cells but also control the cell growth and differentiation, regulate the gene expression in cells, and affect the cell metabolism and movement. The content of collagen determines the wound tension strength. The main function of the elastic fibers is to determine the elasticities of tissues and wounds; in addition, the elastic fibers can also affect the stereoscopic morphology of fibroblasts.

The study of Midwood et al. showed that other studies have shown that after radiation damage, the abundant expressions of type I and II collagen and the abnormal collagen cross-link can be observed in normal tissue fibrosis, and there is a deposition of extracellular matrix components.

10.2.2 The Change of Cytokines

The phagocytic function of macrophage in the wound macrophage is decreased obviously after radiotherapy, and the cytokines such as tumor necrosis factor-α (TNF-α) and interleukin-1 (IL-1) released by macrophages are decreased. Cytokines have an important role in the wound healing process; particularly the transforming growth factor (TGF), fibroblast growth factor (FGF), platelet-derived growth factor (PDGF), and vascular endothelial growth factor (VEGF) are closely related to wound healing, while the radiotherapy may lead to changes in the cytokine levels of the local wound, thus affecting wound healing.

The transforming growth factor-β (TGF-β) is a multifunctional basic anti-inflammatory cytokine, and it is produced by platelets, fibroblasts, macrophages, and leukocytes. The content of TGF-β has a certain correlation with collagen synthesis, wound healing time, tension in wound healing tissue, and scar density. The TGF-β level is decreased and the collagen deposition is reduced; these are the factors that lead to wound dehiscence. All fibroblasts, endothelial cells, smooth muscle cells, and chondrocytes produce FGF. The function of FGF is to promote the proliferation of microvascular endothelial cells, thus accelerating the growth of new blood vessels. FGF plays a role through paracrine effect, which provides a necessary stimulation on early growth factor, IL-1, which plays an important role in endothelial repair. The myofibroblast is a special fibroblast, and the cytoplasm contains muscle filaments, which have systolic function, and their main role in the process of wound healing is to cause wound contraction so as to reduce the wound as soon as possible and accelerate healing; the lack of the myofibroblasts also makes it difficult to reduce the wound, thus delaying healing.

The macrophage is an important source of cytokines such as PDGF, epidermal growth factor (EGF), IL-1, prostaglandin (PG), and tumor necrosis factor (TNF); the lack of macrophages will seriously affect wound healing.

10.2.3 Traumatic Environmental Changes

The radiotherapy can cause degradation of microvascular basement membrane around the wound and increase its permeability, resulting in the loss of plasma components and the thrombosis, so that the local blood supply is poor. After further irradiation, the proliferation of endothelial cells is inhibited, and the blood vessels are further damaged, thus causing ischemia and hypoxia in the wound area and decreasing peripheral white blood cell count; therefore, the local area is prone to infection after trauma. These traumatic environmental changes are not conducive to wound healing.

10.3 Effect of Postoperative Radiotherapy on Skin Flaps in Oncoplastic Surgery

10.3.1 The Radiotherapy After Breast Reconstruction Surgery

The radiotherapy after breast reconstruction surgery is commonly performed in patients who need postoperative radiotherapy after primary repair of defects which is pathologically confirmed.

For patients who decide to undergo postoperative radiotherapy before surgery, the secondary repair can avoid delay in radiotherapy and refrain from achieving a possible imperfect cosmetic effect. Some patients who have had negative lymph nodes confirmed by preoperative clinical examination have undergone primary repair of breast defect, but it is only known after surgery that the patients need radiotherapy. Whether there is a presence of micrometastases in these patients with negative lymph nodes in the preoperative clinical examination cannot be accurately assessed during surgery, and the final pathology report is usually obtained in a few days after surgery. If the patients have undergone primary repair during surgery, and it is confirmed postoperatively that the patients need radiotherapy, there is no doubt that the patients have to face the possibility of occurrence of complications and imperfect cosmetic effects; in addition, after primary repair, the outer contour of the breast will increase the technical complexity of the radiotherapy.

Most scholars reported that the radiotherapy after primary repair causes some complications in patients. Rogers et al. reported the incidence rate of complications in patients who underwent mastectomy combined with primary autologous repair of breast defects: There were a total of 60 patients, of which 30 patients underwent postoperative radiotherapy and another 30 patients were taken as controls; the follow-up time was calculated from the start of surgery; it was 19.9 months in the radiotherapy group and was 17.4 months in the control group. The results showed that there were no significant differences in the incidence of infection, the need for skin repair, and the proportion of contralateral mastopexy between two groups, but the fat necrosis rate, the incidence of breast fibrosis (shrinkage), and the incidence of flap contracture in the radiotherapy group were higher than those in the control group, and the cosmetic result in the radiotherapy group was also inferior to that in patients who did not receive radiotherapy.

The most suitable time for breast repair after breast cancer resection is determined by whether it is needed to carry out postoperative radiotherapy. If the patients need postoperative radiotherapy, the radiotherapy after primary repair will not only greatly affect the cosmetic effect but can also lead to a higher incidence of complications. Only under the premise that the patients don't need postoperative radiotherapy can the primary repair be the best option.

10.3.2 Tolerances of a Variety of Tissue Flaps Used in Oral and Maxillofacial Repair on Postoperative Radiotherapy

The postoperative radiotherapy can increase the local tumor control rate and can't produce significant adverse effects on the cosmetic results of the repaired tissues and organs. Hidalgo and Pusic [30] retrospectively analyzed the clinical outcomes of 20 patients with mandibular tumors who underwent the primary microsurgical repair of mandibular bone and radiotherapy after mandible resection, of which 12 patients were given radiotherapy after repair surgery at a total dose of 60–65Gy. 10-year follow-up results showed that the radiotherapy did not delay the healing of the tissues in the area where the bone was incised or affect the survivability of the bone graft. Over time, the volume of free bone flap used in repair was reduced, but there was no statistically significant difference in the loss of volume in free bone flap between patients with and without radiotherapy.

Wang Zhonghe et al. reported that 82 patients who underwent repair with tissue flap after oral and maxillofacial tumor resection received 40–72Gy radiotherapy. The acute response of the tissue flap was significantly lower than that of the adjacent oral mucosa ($P < 0.01$–0.05). Two years of follow-up showed that the late side effects of the flap were rare. The results of mid- and long-term observation on oral and maxillofacial tissue flap after postoperative radiotherapy confirmed that various tissue flaps have a good tolerance on postoperative conventional radiotherapy, and the specific manifestations include: All acute radiation reactions may be dissipated and healed within 6 weeks after surgery, and the long-term follow-up showed no serious adverse consequences. This provides a reliable basis for that the patients who have undergone immediate reconstruction with tissue flap after the eradicative resection of head and neck malignant tumor safely receive the postoperative radiotherapy to improve the outcome. The tolerance of the intraoral tissue flap on the radiotherapy was superior to that of the surrounding normal mucosa within the radiation field, and the grades II, III, and IV radiotherapy reaction rates were significantly lower than those in normal mucosa ($P < 0.01$). In addition to that, the causes are related to the thicker epithelial and cuticular layers in the skin structure of the tissue flap (a better tolerance on radiotherapy) compared with the oral mucosa, but also may be associated with the protective effect of hypoxia (strong radioresistance) due to the slightly inadequate new blood supply to the tissue flap. There was no significant difference in tolerance on radiotherapy among different types of tissue flaps.

The blood circulation of the receptor site in tissue transplantation is normal in patients undergoing postoperative radiotherapy, and the radiotherapy is performed after tissue flap healing, which does not have a significant impact on the healing of the tissue flap; therefore, the tissue flap survival rate and the good healing rate in patients with preoperative radiotherapy are significantly lower than those in patients with postoperative radiotherapy.

It is not convenient to directly observe and early detect the recurrent lesions in some areas after one-stage repair and reconstruction, especially in the deeply hidden areas. Therefore, it should be noted the regular reexamination and dynamic observation are carried out for these patients, in order to detect recurrent lesions.

10.4 The Timing and Dose of Postoperative Radiotherapy

10.4.1 The Timing of Postoperative Radiotherapy

The same as the preoperative radiotherapy, the timing of postoperative radiotherapy will also affect the wound healing process. The most sensitive period to radiotherapy for the wound healing is the first 2 days of postoperative inflammation reaction period and subsequent cell proliferation period. Therefore, if the radiotherapy is performed immediately after surgery, the inflammation will be suppressed, while the neutrophils, monocytes, and macrophages are significantly decreased. In cellular proliferative phase, the quickly differentiated fibroblasts in the wound are extremely sensitive to radiation at this phase, which can lead to decreased contents of type I and III collagen fiber; therefore, it is not normally advocated that the immediate radiotherapy is performed after surgery. In the clinical application, the timing of postoperative radiotherapy is slightly delayed, which will significantly reduce the potential complications of the wound.

However, from the perspective of oncology, the postoperative residual tumor cells are in a more active growth phase, and the tumor doubling time is relatively shorter. If the radiotherapy or chemotherapy is carried out as early as possible at this time, the tumors may be more sensitive to the therapy. Therefore, the postoperative radiotherapy becomes even more important; and because the local blood supply is affected after surgery, the longer the interval time between the postoperative radiotherapy and the surgery is, the poorer the local blood supply is, and the worse the sensitivity to radiotherapy will be, which leads to reduced radiotherapy efficacy. Therefore, it is often recommended that the postoperative radiotherapy should not be performed later than 6 weeks after surgery, and the postoperative radiotherapy should better be started in patients at high risk of recurrence within 4 weeks after surgery; if the interval time between the start of postoperative radiotherapy and the day of surgery is longer, it is not conducive to controlling the residual tumor and will increase the chance of tumor recurrence.

It is surely important to establish an effective blood supply through performing vascular anastomosis for free tissue flap and receptor site during surgery, but it is also indispensable to gradually establish abundant collateral circulation (revascularization) between free tissue flap and receptor site. Zhang Chenping et al. reported that the time needed for fully establishing the tissue flap revascularization is about 3 weeks; therefore, it is safer to carry out postoperative radiotherapy at 3 weeks after surgery.

Therefore, in clinical practice, the timing of the postoperative radiotherapy can be determined specifically according to the clinical needs and the healing status of tissue flaps. If the length-to-width ratio is proper, and the vascular anastomosis is unobstructed, the postoperative radiotherapy can be started in advance at 2 weeks after surgery, which is extremely important for improving the curative effect in tumor patients among whom the tumor is cut broken during surgery, the incisal margin of the tumor margin is too close, the incisal margin is positive, or there is residual tumor. The postoperative radiotherapy should be appropriately delayed in patients with poor tissue flap healing.

10.4.2 The Dose of Postoperative Radiotherapy

The postoperative radiotherapy is applied locally in patients with advanced tumors, in whom the large lesions have been removed surgically and the surgical margins may be negative or positive. The surgical field needs to be treated with radiotherapy to strengthen the control of local or regional lesions. There are certain requirements for the time and dose of postoperative radiotherapy, and the dose is usually 60Gy; if the incisal margin is positive, and the local recurrence risk is high, the dose should be increased to 70Gy.

Wang Zhonghe made an immediate and long-term observation on the reaction of postoperative radiotherapy in

114 repair tissue flaps for oral and maxillofacial repair (4000–7200 cGy, 4–7.5 weeks), and the adjacent normal oral mucosa or skin for self-control within the radiation field was taken as self-controls. The results showed that the acute radiation reaction rate in tissue flaps (including swelling, erosions, or ulcers) was significantly lower than that in the adjacent normal tissues ($P < 0.05$), and the acute radiation reaction appeared late with a lighter degree, which could be completely subsided after radiotherapy; the long-term reaction was not common. There were no significant differences in tolerance on radiotherapy among different types of tissue flap prosthesis. Among 114 tissue flaps, 112 whole tissue flaps (98.2%) survived after radiotherapy. Conclusion: The tissue flaps for oral and maxillofacial repair have good tolerances on radiotherapy and can safely receive the whole course of postoperative radiotherapy at a conventional dose.

10.5 Measures to Reduce Radiation Damage

In view of the above characteristics of radiation damage, the radiation induced necrotic ulcers are rather intractable, and the prolonged unhealed ulcers may even have local canceration. Therefore, in the process of radiotherapy, attention should be paid to the individualization of radiation dose and the selection of radiotherapy plan; at the same time, it is particularly important to strengthen the radiological protection and the skin protection in patients with radiotherapy. In order to control, improve, or prevent radiation damage, many scholars are trying to find the methods for prevention and treatment of radiation damage.

10.5.1 Strengthen the Symptomatic Treatment

The radiation damage can cause disorders in normal metabolism of tissue cells and inhibit the regenerative capacity, which are often accompanied by severe infection and tissue necrosis. It is particularly important to strengthen local skin care and change the bandage several times to prevent local pollution. The necrotic fibrous tissues can be removed with chymotrypsin or elastase ointment, which is more conducive to infection control; the bacterial culture is carried out for infected wounds, and the sensitive antibiotics is selected for topical application or intravenous drip to promote granulation tissue growth and healing; it is supposed to strengthen symptomatic and supportive treatment, enhance nutrition, and provide immunotherapy, and the healing can be promoted by improving human body immunity.

10.5.2 Surgical Treatment

If the chronic radiation dermatitis causes repeated ulceration with obvious signs of deterioration, the efficacy of drug therapy for radiation-induced ulceration is not obvious, or in order to shorten the course of treatment and prevent the malignant transformation, the patients are often treated by surgery. The surgery aims to remove skin lesions and select different repair methods for covering the wound according to local wound conditions.

The resection range of the chronic ulcer should be large enough to have a free margin of 1 cm of the normal skin. The skin lesions around the ulcer such as atrophy, attenuation, and pigment changes are removed together with the ulcer, and thus the ideal depth is: The normal tissues with active bleeding are exposed in wound base after wound debridement. Some degenerated cartilages or bone tissues should be removed.

The different methods should be selected and used for wound repair according to the nature of the wound, the range and depth of the resection, as well as the wound base condition and location. The more common methods are skin transplantation including skin graft, local random flaps, and axial flaps and the omentum transplantation, and the good therapeutic effects can be obtained.

10.5.3 Application of High-Precision Radiotherapy to Minimize the Normal Tissue Damage

At the end of the twentieth century and the beginning of the twenty-first century, due to the rapid development of molecular biology and radiophysics and the active involvement of advanced computer technology and imaging techniques, the radiation oncology has already achieved great-leap-forward development. The high-precision radiotherapies mainly consisting of three-dimensional conformal intensity-modulated radiotherapy (IMRT) are quite different from the two-dimensional conventional radiotherapy in the past, and they can greatly improve the conformity between the shapes of the high-dose region and the target region and further reduce the treatment volume and can minimize radiation dose to normal tissues.

The three-dimensional reverse conformal IMRT plan greatly improves the conformity between the three-dimensional shapes of the high-dose region and the target region compared with conventional treatment plan, further reducing the range of the surrounding normal tissues and organs involved in the radiation field; because of the improvement of the target dose distribution and the reduced irradiation range of the normal tissues around the target, the prescription dose is further increased, and the dose of the surrounding normal tissue is decreased, thereby reducing the complications of radiotherapy. It is especially suitable for local treatment of tumors which are located in complex anatomical structures and have special shapes and multiple target points, significantly reducing the complications of preoperative and postoperative radiotherapies and thus improving the qualities of life of the patients.

10.5.4 The Use of Healing Promoting Effect of Stem Cells on Radiation Injury Impaired Wound

In recent years, with the development of stem cell engineering technology, it has been frequently reported that the stem cells are used to repair the bones, cartilages, tendons, muscles, etc. Aiming at solving the fundamental problem that the fewer repairing cells and the proliferation inhibition in local area lead to difficulty in curing the systemic or local radiation injury impaired wound, Majumdar et al. used the mesenchymal stem cells (MSCs) which have the ability to differentiate into repairing cells in the local radiation injury impaired wound. After the implantation of autologous MSCs in the local wound, a comparison was made between the wounds with transplanted MSCs and the wounds in the control group. The speed of wound healing in the MSC-implanted group was faster than that in the control group, the formation and growth of the granulation tissues were more vigorous and fresh than those in the control group, and the granulation tissues contained rich blood capillaries and fibroblasts; the content of the primary substance for synthesizing collagens, hydroxyproline, was significantly higher than that in the control group, and the formation of type I and III collagens also was increased compared with the control group, suggesting that MSCs have obvious healing promoting effect on the wound.

The MSC transplantation has an obvious healing promoting effect on the local radiation injury impaired wound. Its healing promoting effect is due to the fact that, on the one hand, the implanted MSCs or the cytokines secreted by them can promote the migration and proliferation of the inflammatory cells and repairing cells around the wound into the wound surface, initiate the repair as early as possible, and increase the number of local repairing cells; on the other hand, the local wound microenvironments may also affect the expressions of the proteins and genes in implanted MSCs, and they can induce MSCs to evolve into repairing cells and (or) secrete the extracellular matrix to participate in tissue repair; MSCs are likely to evolve into the main repairing cells, fibroblasts, to participate in tissue repair under the action of the local microenvironment of the wound. The interaction between stem cells and local wound microenvironment may affect wound healing.

10.5.5 Improvement of Local Oxygen Supply

Improving the oxygen supply to the local wound can enhance the bactericidal ability of the white blood cells and promote angiogenesis and epithelialization, which is of great benefit to the wound healing process.

The hyperbaric oxygen therapy (HBOT) can promote angiogenesis and enhance healing of tissues damaged by radiation and also has a therapeutic effect on soft tissue damages that occurred in a few months or a few years after radiotherapy. HBOT can promote blood supply to these tissues, thereby accelerating tissue healing.

10.5.6 Cytokine Therapy

The radiation-induced skin damage can significantly decrease the expressions of a variety of cytokines and their receptors, and a better curative effect has been achieved through the use of growth factors to treat radiation-induced ulceration.

After the body is damaged, the platelets will aggregate and degranulate in the local wound and release all kinds of growth factors, including PDGF, TGF-β, EGF, and insulin-like growth factor-1 (IGF-1). TGF-β1 has a positive effect in improving surgical incision healing and skin flap survival in rats after radiotherapy, and it can increase the tensile strength of the postoperative incision and promote flap survival. The systemic application of hematopoietic growth factor, interleukin-3 (IL-3), colony-stimulating factor (CSF), and interleukin-1 (IL-1) can accelerate the recovery of the function of hematopoietic system, so that the whole body condition can be improved, which is conducive to local wound healing.

Now, the externally used finished product recombinant bovine FGF basic (Beifuji) is available in the market, and it can be externally used to repair the chronic wound. Its main mechanism is to increase collagen content in the wound, thereby improving the mechanical strength for tissue repair. In short, FGF participates in the whole process of regulating the tissue repair, including regulating the inflammatory response, inducing capillary proliferation, accelerating the growth of epithelium and granulation tissue, and playing a significant role in wound healing.

Because the macrophages can produce a variety of cytokines to promote tissue healing, Zuloff-Shani studied a new method for the treatment of refractory ulcers. Under sterile conditions, the macrophages are extracted from the blood of healthy donors. In the process of preparation, the macrophages are activated in hypotonic environment to enhance their various functions in wound repair. These cells can play roles after being locally injected or directly instilled into the wounds.

11 Effect of Chemical Treatments on Biological Tissues

Wei Wang, Yi Luo, and Zhaoyan Wang

The radical surgical resections are currently the most important method for the treatments of most tumors, but they often cause serious functional defects or appearance defects at the same time of curing the tumors, which greatly affects the quality of life of patients, and therefore, more and more tumor patients ask for postoperative repair and reconstruction. Different from the patients with ordinary plastic surgery, the patients undergoing oncoplastic surgery operations often have received multiple courses of preoperative chemotherapy, and most of them will be required to receive a certain course of postoperative adjuvant chemotherapy after plastic surgery. The chemotherapy may have impacts on the aspects such as skin flap design, skin flap donor site selection, skin flap survival, and blood supply reconstruction in these patients, but there is still a lack of systematic research on this.

11.1 Preoperative Induction Chemotherapy and Postoperative Adjuvant Chemotherapy

The preoperative induction chemotherapy and postoperative adjuvant chemotherapy have put forward new challenges to the theory and technique of oncoplastic surgery. Due to the presence of the risk of tumor recurrence or metastasis, the oncoplastic surgery operations often require a certain course of preoperative induction chemotherapy. Drawing lessons from existing research results, the preoperative induction chemotherapy has the following advantages: (1) It can shrink the tumor, improve the surgical resection rate, reduce the difficulty of plastic surgery, and even avoid the need to perform plastic surgery, thus reducing the shape defects and the loss of function as much as possible; (2) it can eradicate the micrometastases, avoid the postoperative rapid proliferation of micrometastases which lurk in the body, and reduce the vitality of tumor cells, so that the tumor cells are not easy to spread during surgery; (3) it may kill the tumor cells which are sensitive to chemotherapy and eliminate the subclinical metastases, control and reduce the tumor recurrence after plastic surgery, and prolong the postoperative disease-free survival of the patients, thus indirectly ensuring the quality and efficacy of plastic surgery operations and improving the success rate and the value of the plastic surgery operations.

The postoperative chemotherapy is an important means for controlling and destroying the remaining micrometastases and has played a positive role in the prevention of local recurrence and distant metastasis. A large number of tests or studies have shown that the residual tumor cells after surgery can enter into proliferation cycle in quantity, which accelerates the tumor growth, increases the proliferation ratio, and promotes the sensitivity to chemotherapy; at the moment, the effective chemotherapy should be applied as early as possible to achieve the best therapeutic effect. Therefore, the chemotherapy after plastic surgery cannot only control the local tumor recurrence and ensure the efficacy of the plastic surgery but also is an important means for eliminating the distant metastasis, prolonging the lives of patients, and improving the qualities of life of the patients after surgery.

Different from general surgery and oncology surgery, the oncoplastic surgery has its own peculiarities. In general, the patients undergoing plastic surgery have relatively early stage tumors or some local advanced tumors which are not expected to recur within a long time after comprehensive treatment, and it is possible to implement more successful radical surgery and plastic surgery only in these patients; if the patients cannot achieve a longer survival after surgery, the repair and reconstruction also cannot be considered. For the patients with local advanced tumors, it is not difficult to receive appropriate preoperative chemotherapy, but for the patients with relatively early stage tumors, is it necessary to carry out preoperative and postoperative chemotherapy?

In another situation, the clinicians have no room for choice. Many patients have advanced disease conditions or tumor recurrences, and they have undergone multiple courses of comprehensive treatment such as radical surgery, radiotherapy, and chemotherapy before plastic surgery. For these patients with relatively late-stage tumors and the indications for plastic surgery, whether it is needed to carry out chemotherapy in the end and how to select the best time of chemotherapy need to be studied further.

For those tumors which are sensitive to chemotherapy, the preoperative chemotherapy before plastic surgery is generally beneficial; and for those tumors which are relatively insensitive to chemotherapy, in the course of preoperative chemotherapy, a few patients inevitably have disease progression or the appearance of new lesions or metastases, so that the purposes of using the preoperative chemotherapy to achieve the downstaging of the disease and make it easy to perform the surgical resection and control the metastasis are not achieved completely. Some patients with tumors which can be resected by surgery have missed the timing of surgery due to disease progression and the emergence of new metastatic lesions; it is not known whether it is beneficial to carry out preoperative chemotherapy in these patients. Should the patients who are insensitive to chemotherapy be given chemotherapy before surgery? How to predict and avoid deterioration during preoperative chemotherapy? Should the decision on whether carrying out chemotherapy be determined according to the tumor stage? These are the problems needing to be solved by the preoperative chemotherapy in oncoplastic surgery.

Along with the progress of life science and biochemistry, a lot of chemotherapy drugs with small side effects and good efficacy spring up; with the development of evidence-based medicine and the advent of joint multicenter study, more and more chemotherapy regimens are gradually becoming perfect. The use of multidisciplinary-integrated treatment mode enables us to get a new understanding on the role of chemotherapy in tumor treatment, even for some tumors which are relatively insensitive to chemotherapy; people also begin to pay attention to studies on their postoperative chemotherapies. It should be mentioned that the postoperative chemotherapies have made a great contribution to curbing the growth of tumor cells and prolonging the survival of patients. Out of fear of tumor recurrence and metastasis, the patients are often willing to receive a certain course of postoperative chemotherapy, and those with oncoplastic surgery are no exception, because even after highly successful radical surgery and plastic surgery, there may be tumor recurrence. But there are still several issues worth noting: (1) Is it needed to carry out chemotherapy after plastic surgery for patients with early stage tumors? (2) Is it needed to carry out chemotherapy after plastic surgery for patients with tumors which are insensitive to chemotherapy? (3) How to carry out the sequential chemotherapy and radiotherapy in the treatment of tumors? There is a lack of systematic-related researches on these problems, and no unified standard is available to guide the treatment standardization, all of which are expected to be further studied.

11.2 Effect of Chemotherapy on Biological Tissues

It is undoubted that the chemotherapy drugs have certain influences on biological tissues, which has also proposed new requirements to the theories and techniques of the oncoplastic surgery; for example, it is found in clinic that the blood vessels after injection of chemotherapy drugs are often damaged, which is manifested as endovasculitis, vascular occlusion, vascular stiffness, etc. Is the direct intravenous injection site still suitable for use as the skin flap donor site? What are the differences in histology and ultrastructure between the blood vessels at the non-intravenous injection sites and the blood vessels at the direct intravenous injection sites? All these problems remain to be further studied.

Even the nonneoplastic general plastic surgery also needs to have a longer time to heal the wound; the special nature of the tumor often requires that the chemotherapy is timely carried out after oncoplastic surgery to reduce tumor recurrence. For the cancer patients whose general conditions are far worse than those in healthy people, would chemotherapy have a delay the tissue repairment and wound healing process after plastic surgery? In some studies on the use of neoadjuvant chemotherapy and radical surgery, it is generally believed that the neoadjuvant chemotherapy will increase the difficulty of surgical procedure and the postoperative complications; for instance, the intraoperative blood loss is increased significantly, the difficulty in dissecting the free blood vessel is increased, the operative time is relatively prolonged, the incidence of postoperative arrhythmia is increased significantly, and the wound healing is delayed. But some studies also suggest that the neoadjuvant chemotherapy does not increase the postoperative complications and mortality, and the chemotherapy has no effect on the tissue healing in patients with oncoplastic surgery. The oncoplastic surgery often involves transplantation of various tissue flaps, multisite operation, and even allotransplantation, and it is a complex and delicate surgery. The keys to the success of oncoplastic surgery are that, in the one hand, the tumors are completely removed without recurrence; on the other hand, the growth of the repairing tissue is good, and its morphology and function are normal or similar to normal. If the tissue repair is affected by the preoperative or postoperative chemotherapy, the purpose of appearance recovery and functional reconstruction cannot be achieved through plastic surgery; in fact, it is the failure of plastic surgery. Therefore, the study on the effect of chemotherapy on tissue repair will provide the basis for oncology surgeon to design appropriate repair and reconstruction scheme and formulate reasonable chemotherapy treatment course.

At the same time of recovering the functions of the human body, the plastic surgery can cause trauma in the body and reduce the tolerance on chemotherapy in patients, so that the patients are even unable to complete the established systemic chemotherapy; if there is a concurrence of postoperative local necrosis, infection, and depigmentation in tissue flaps, it will further delay the starting time of chemotherapy and affect the dose intensity of chemotherapy. Carrying out timely and active postoperative chemotherapy in patients with tumors is often the key to cure tumor. If the delivery of chemotherapy is delayed, or the systematic chemotherapy cannot be completed, it may even cause negative effects such as tumor recurrence and shortened survival. Therefore, when the plastic surgery program is formulated, the effects of the surgery itself on postoperative chemotherapy and other comprehensive treatments should be taken into account [31–33].

11.2.1 Effect of Chemical Treatment on Skin Flap

The autologous skin flap transplantation is an effective method for repair and reconstruction. The skin flaps can be divided into the random pattern skin flap (no blood supply from direct cutaneous artery) and the axial pattern skin flap (including the well-known nutrient vessels) according to blood supply mode; they can be divided into pure skin flap, fasciocutaneous flap, and myocutaneous flap according to the tissue contained in the skin flap; they can also be divided into the pedicled skin flap and the skin flap with vascular anastomosis according to the mode of skin flap transplantation.

Currently, there are rare basic researches on skin flap and chemotherapy. Zhou Xiao et al. [34, 35] conducted a research on the effect of combined chemotherapy of cisplatin and fluorouracil on abdominal skin flap and found that there was no obvious difference in the growth of skin flap after carrying out the in situ skin flap repair at the site where the chemotherapy drug was injected directly. Wang Wei et al. conducted a research on the effect of preoperative induction chemotherapy on saphenous flaps in experimental dogs and found that there were more inflammatory cell infiltrations and thrombogeneses in direct injection site than those in non-direct injection site, but the effect of short-term chemotherapy on skin flap healing was not obvious. There is still no relevant research on whether the sites after a long-term repeated stimulation of chemotherapy drugs are suitably used as flap donor sites. Ge Zixin et al. have observed the effects of early chemotherapy after breast cancer surgery on wound healing of skin flap necrosis of the chest wall. One hundred four breast cancer patients after Halsted mastectomy were divided into the chemotherapy group (56 patients) and the control group (48 patients).The chemotherapy group was treated by the CMF regimen consisting of cyclophosphamide, methotrexate, and fluorouracil, while the control group received no chemotherapy. There were no significant differences in granulation generation time, the healing time of the dressing wound, and the time for establishing blood circulation in free skin flap between the two groups. Another report on local skin flap repair of skin ulcer caused by the chemotherapy drug leakage showed that 26 patients with chemotherapy-induced persistent skin ulcers underwent skin flap repair and achieved satisfactory results.

The study on skin flap and chemotherapy started earlier at abroad. In 1993, Vaden SL et al. carried out a study on the use of cisplatin and carboplatin in the tumor skin flap and the normal skin flap and found that there was a difference in platinum distribution between the two. However, the report mainly investigated the distribution of the platinum drugs and the establishment of research model of platinum-related skin flap from the perspective of pharmacology, failed to carry out in vivo study of the skin flap, and also didn't link it to oncoplastic surgery. The study on the application of skin flap in the repair of tumor mainly focuses on aspects of head and neck surgery and breast cancer; currently many cases are reported each year. Rapidis AD has studied 48 patients with orbital tumors, of which only 10 patients underwent surgery alone and the other 38 patients underwent radiotherapy or chemotherapy alone. In all patients, 19 underwent radical surgery combined with split-skin graft transplantation, 16 patients underwent eye socket removal and forehead flap transplantation, and 7 patients underwent maxillectomy plus repair of forehead and temporalis muscle flaps. Unfortunately, this study failed to observe the effect of chemotherapy on the growth and repair of skin flap. The same situation occurred in the relevant literatures on breast cancers and oral cancers, although all these studies mentioned that the chemotherapy or chemoradiotherapy was used before and after the implementation of plastic surgery and also put forward that the adjuvant chemotherapy could not be delayed because of plastic surgery; all studies failed to analyze the effects of chemotherapy on the risk of plastic surgery, wound healing, and skin flap survival.

11.2.2 Chemotherapy and Fascial Flap

The fascial flap refers to the tissue flap containing superficial fascia and deep fascia; since it doesn't contain the skin, the donor site won't have loss in appearance after harvesting of fascial flap, and it is the new tissue flap which has been gradually developed in recent years. The fascial flap can be divided into the pedicled fascial flap and free fascial flap according to the blood supply, simple fascial flap and composite fascial flap according to the components of the transplanted tissues, and temporal fascial flap, the fascial flap behind the ear, deltopectoral flap, and calf fascial flap according to anatomic sites.

The repair of tumor-associated scalp defect needs to use a variety of tissue flaps such as skin flap, fascial flap, and muscle flap; it also involves facial nerve repair and ectropion correction and is a relatively complex surgery. Lutz BS reported 11 patients with tumor-associated scalp defects in 2002, including eight patients after undergoing surgery and radiotherapy or with recurrent tumors after radiotherapy; the average defect area was 169.5cm^2 (30–600cm^2). This article didn't analyze the effect of chemotherapy on the surgery and didn't explain whether the adjuvant chemotherapy was performed after plastic surgery, but judging from the conclusion that all patients have achieved good cosmetic results and functional recoveries, it seems that the chemotherapy does not increase the risk of plastic surgery.

Rath T et al. have studied the defect repair after radical resection of tumors in the mouth; they used the mucous membrane to wrap the fascia which was mixed with gastrocnemius nerve transplantation and then covered it with a silicone sheet to make the mucous membrane spread within the fascia, so that the fascial flap finally complied with the requirements for transplantation. This process requires 8–10 weeks, during which the patient must receive radiotherapy or chemotherapy. Such intraoral defects repaired by reinnervation surgery can produce mucus, which is a more successful approach. Although the authors still did not observe the effect of chemotherapy on tissue flaps, the chemotherapy in this study apparently did not hamper the transplantation and survival of the tissue flap.

11.2.3 Chemotherapy and Muscle Flap

The muscle flap refers to the muscular tissue which doesn't contain skin, and it can be divided into the pedicled muscle flap and the muscle flap with blood vessel anastomosis according to the transfer mode.

There was a research on chemotherapy and muscle flap in the fifth issue of Shanxi Medical Journal in 1997. The author transplanted the pedicled temporalis muscle flap into the tumor cavity to increase local blood flow in the tumor cavity and used teniposide in the chemical treatment of brain glioma, so that the residual tumor could get a double dose of chemotherapeutic drug. The clinical observation confirmed that the efficacy was satisfactory, according to the evaluation criteria of David Barba; it was excellently effective in three cases, effective in two cases, and invalid in five cases. The patients with excellent effect were followed up for 30 months, and no tumor recurrence was observed. The study was not designed for the purpose of repair and reconstruction.

The skin invasion and lymph node metastasis of the penile cancer often cause damages to the groin and perineum, and the defects must be repaired with tissue flaps containing skins, fascias, muscles, and nutrient blood vessels. In a prospective study based on the use of CMB regimen consisting of cisplatin, methotrexate, and bleomycin as a neoadjuvant chemotherapy regimen, 15 patients with penile squamous cell carcinomas underwent tumor resection plus immediate myocutaneous flap repair after treated with CMB regimen for an average of 2.4 period and antibiotic treatment. Twenty-nine of 31 myocutaneous flaps achieved primary healing.

The neoadjuvant chemotherapy has been considered likely to increase the complications of breast cancer surgery and delay the postoperative treatment. Deutsch MF et al. carried out plastic surgery with transverse rectus abdominis myocutaneous flap (TRAM flap) in 31 patients undergoing neoadjuvant chemotherapy immediately after mastectomy and made evaluations on the surgical complications and whether the postoperative adjuvant chemotherapy was delayed. The results showed that 17 patients had postoperative complications, but the postoperative chemotherapy was delayed in only two patients; therefore, it is considered that the breast cancer patients after neoadjuvant chemotherapy can safely undergo radical surgery and plastic surgery. The study also found an interesting phenomenon: The smokers may have increased surgical complications and delayed postoperative chemotherapy. Allweis TM et al. also believed that the immediate plastic surgery after mastectomy of breast cancer will not delay the starting time of postoperative adjuvant chemotherapy.

Chang DW et al. carried out a follow-up study on 77 patients undergoing skull base reconstruction surgery after tumor resection, of whom 52 patients underwent repair with free flap, 14 patients underwent repair with temporalis muscle flap, 8 patients underwent repair with pericranium flap, and 3 patients underwent repair with other local tissue flaps. Twenty-one patients had complications, including falling off of the full skin flap in three patients, partial falling off of the skin flap in three patients, cerebrospinal fluid leakage in two patients, meningitis in two patients, abscesses in two patients, hematoma in two patients, delayed wound healing in five patients, wound infections in one patient, and cerebral vascular accident in one patient; Seventy-seven percent of the patients had a survival time of 2 years, and 58% of the patients had a survival time of 4 years. The author believes that the types of reconstructive surgery, the defect site, the dural repair mode, and whether to receive preoperative chemoradiotherapy have no effects on the occurrence of complications.

The comprehensive treatments of soft tissue tumors include artery intubation chemotherapy, tumor resection, and defect reconstruction. Sadrian R et al. carried out a retrospective analysis on some patients receiving the above treatments. All patients underwent systematic artery intubation chemotherapy before surgery, and the repair and reconstruction of the defect were carried out mostly with latissimus dorsi and rectus abdominis free flaps. Among whom, a patient still received a vascular graft and had no sign of falling off or infection of tissue flaps. The total transplantation success rate of tissue flaps was 100%. Twelve patients had good functional recovery, four patients had ordinary functional recovery, and seven patients had tumor recurrence. The average survival time after surgery was 20.6 months. These studies showed that preoperative artery intubation chemotherapy does not increase the complications of immediate tissue flap transplantation.

The free flap reconstruction and adjuvant chemotherapy after surgical resection have been used in a growing number of sarcoma patients. Peter FW carried out a study in mouse models and found that the chemotherapy and the granulocyte colony-stimulating factor (GCSF) will enhance the endothelial function of the leukocytes and thus are considered to affect the microvascular blood flow and cause flap failure. Goldschmidt D repaired the defects with serratus anterior and latissimus dorsi muscle flap in two patients after resection of stage I malignant melanoma, and the patients were treated with melphalan after surgery. In addition to moderate swelling of the tissue flaps, it was not observed that the chemotherapy had other side effects on transplanted flaps.

11.2.4 Chemotherapy and Bones

Most of domestic scholars have a positive attitude toward the preoperative neoadjuvant chemotherapy before bone tumor surgery. Fu Qin et al. selectively performed the limb-salvage surgery using metal prosthesis in 22 patients with osteosarcoma in four limbs on the basis of neoadjuvant chemotherapy and the curative effects of which were good. The Bone Tumor Research Center of The First Affiliated Hospital of Sun Yat-sen University carried out a retrospective analysis on complete clinical and follow-up data of 52 patients with bone tumor around the knee who underwent limb-salvage surgery through artificial prosthesis replacement from 1990 to 1999, including 33 patients with osteosarcoma and 19 patients with osteoclastoma; twenty-four patients were treated with preoperative chemoembolization, and 28 patients were not treated with chemoembolization at the same period. All 33 patients with osteosarcoma and 12 patients with grades II and III osteoclastoma underwent postoperative regular chemotherapy. The knee joint function was evaluated according to Enneking standard. The longest follow-up time was 118 months, and the shortest follow-up time was 12 months, with an average follow-up of 38 months. Results: Within 12 months after surgery and at the last follow-up, the function scores in the intervention group were superior to those in the nonintervention group; the early and recent complication rates and the repair rate in the intervention group were lower than those in the nonintervention group.

There are many studies on chemotherapy and bone abroad. Bertermann O et al. observed effects of the preoperative and postoperative strengthened chemotherapies on wound healing in 110 patients with lower limb osteogenic sarcoma and the chemotherapy regimen of which included bleomycin, cyclophosphamide, actinomycin D (BCD), adriamycin (ADR), and high-dose methotrexate (HD-MTX). All patients underwent en bloc resection and artificial limb surgery, and some patients received debridement and skin grafting. The antibiotics were routinely used before and after surgery, the wound healed well in 80% of patients, and no patients died of wound infection. Morello E et al. observed 13 dogs with osteosarcoma of the distal radius. These dogs without distant metastases received preoperative adjuvant chemotherapy (cisplatin plus doxorubicin) and then received the limb-salvage treatment and autologous transplantation. The average survival time and median survival time were 531 days and 324 days, respectively. The 6-month survival rate was 100%. Therefore, the author thought that it was an effective method. Gravel CA et al. [31] observed the effect of neoadjuvant chemotherapy on distraction osteogenesis technique in goat models. The results showed that whether carrying out chemotherapy or not had no significant inhibition on bone formation; therefore, it was considered that the chemotherapy was not a contraindication for limb-lengthening surgery after osteosarcoma resection. But some studies have also found that the chemotherapy indeed has some adverse effects on bones. In order to observe the effects of three kinds of commonly used chemotherapy drugs such as methotrexate, cisplatin, and doxorubicin on bone tumors in children, Van Leeuwen BL used the male Wistar rats as the study objects and found that the abovementioned three drugs reduced the intensity of the epiphysis and increased the risk of fracture. Another study suggests that the doxorubicin reduces the thickness of the growth plate, the methotrexate increases the thickness of the growth plate, and the cisplatin does not affect the thickness of the growth plate. All three chemotherapy drugs decrease the metaphysis bone trabecula in the proximal tibia, and some adverse effects are related to malnutrition caused by chemotherapy.

11.2.5 Chemotherapy and Blood Vessels

At present, most domestic studies on chemotherapy and blood vessels start from the aspects of the treatment of tumor drug extravasation and are limited to the study of chemotherapeutic phlebitis. Some abroad scholars carried out treatments and observations which lasted for 7 years in 20 patients with soft tissue sarcoma involving the limb vascular plexus, of whom six patients underwent limb perfusion treatment, four patients received systemic chemotherapy, two patients received systemic chemotherapy plus local hyperthermia, and one patient received radiotherapy; all patients underwent resection of sarcoma and invaded nerves and blood vessels, and the blood vessels were repaired by autologous or allogeneic veins; six patients underwent repair of soft tissue defects with myocutaneous flaps or skin flaps. Among 20 patients, 19 patients had successful limb salvage, and the average survival time was 30 months, and then 11 patients had distant metastases. The author believed that the preoperative combination therapy, extended resection, and vascular repair had longer-term effects of local control and limb salvage in these patients.

Valentino J observed the effect of intra-arterially administrated cisplatin on the neck arteries; the results showed that there were no differences in histology and ultrastructure between the blood vessels with and without injection of cisplatin, both of which showed intimal thickening and depositions of collagens and elastins in vascular intima. The intimal smooth muscle hyperplasia occasionally occurred, and a small number of smooth muscles had vacuolization, elastic fiber degradation, and calcinosis.

11.3 Summary

The clinical literature reports on oncological surgery have been summarized. Some studies suggest that the tumor tissue fragility after chemotherapy is increased, the difficulty to dissect the free blood vessels is increased, the surgical complications are increased, and the vascular intima damage caused by the preoperative induction chemotherapy may affect the survival of the skin flap; but others argue that the preoperative induction chemotherapy does not increase the incidence of complications after immediate tissue flap transplantation and also does not affect the recovery time after oncoplastic surgery. So far, there are rare basic researches on the effect of chemotherapy on tissues at home and abroad, when the clinical patients are taken as research objects, due to the unmanageable differences in aspects of test conditions, patient compliance, surgical procedure selection, and economical affordability; the conclusions are not always reliable. All of these are worthy of further exploration.

12 Applications of Biological Materials in Oncoplastic Surgery

Yong Zeng, Bo Zhou, and Lijian Zou

12.1 Overview of Biological Materials

The previous radical tumor surgery can achieve complete excision of the lesions; at the same time, the patients often have a damaged appearance and loss of organ function. Some radical tumor surgeries involving important sites can't be carried out because of the lack of appropriate alternative materials used to repair and even have been listed as forbidden surgeries. Therefore, a large number of cancer patients have lost the chance of surgical treatment, and some patients are also unwilling to accept radical surgery due to the low quality of life after surgery. The emergence and development of oncoplastic surgery provide new ideas and patterns for solving these problems; in particular, the progresses in biological materials science and applied technology in recent years provide a strong support for the design of operation plan in oncology surgery, the repair and reconstruction, as well as the aesthetic reproduction after surgical resection [36].

Currently, the use of tissue grafts from different sources to carry out local defect repair and aesthetic reproduction has become a more mature treatment means, and different transplantation methods have their respective advantages and disadvantages. The autologous tissue transplantation is the most commonly used treatment means in plastic surgery; even the use of autologous tissue is recognized as the "gold standard" in the field of most tissue repairs, but the acquisition of autologous tissue is limited, often leading to secondary damage in donor site; there exist some problems such as mismatching of tissue shapes, long postoperative recovery time, and poor aesthetic effect. For the patients who can't provide the required amount of tissue due to lack of tissues in donor site or are unwilling to accept donor site damage, it is needed to carry out repair using allogeneic and xenogeneic tissues or tissue substitutes [37–40].

Different from simple cosmetic and plastic surgery, the defect repair after tumor resection will make more stringent requirements for biological materials, particularly after radical resection of malignant tumor; the range of tissue defect may be larger, and some tissues surrounding the lesion have concurrent inflammation, infection, tissue degeneration, and even potential tumor cell infiltration; the patients need to be treated with systemic chemotherapy or local radiotherapy after surgery, all of which are negative factors affecting the efficacy of implanted biological materials. In turn, the implanted biological materials will also seriously affect the efficacy of local chemoradiotherapy; as an allogeneic biological material, the implant will increase the degree of local inflammation and infection. All these factors lead to a high incidence of complications after the use of biological materials to repair the defects after radical resection of malignant tumor and even eventually lead to the failure of the operation; and certain types of implanted materials may also cause interference to imageological examination after tumor surgery and affect the postoperative reexamination. Therefore, within the scope permitted by the conditions, the soft tissue and bone defects after tumor surgery should be repaired as far as possible using autologous tissues, which is still the currently preferred scheme for oncoplastic surgery; the biological materials can be used as a supplement or alternative means for oncoplastic surgeons to choose, and their indications also need to be controlled more strictly.

12.2 Classification of Biological Materials

The biomedical material is briefly called as biological material, referring to the material used in the human body or indirectly contacting with the human body; therefore, it is the general name for in vivo implant material, medical material, and prosthetic material and is a non-drug material in clinical medicine. In 1987, the International Organization for Standardization (ISO) described the definition of biological material as: It is an inanimate material which is used to contact with living tissue to reconstruct the function, including biocompatible or biodegradable material. At present, a wide variety of biological materials can be used in clinics; there are different classification methods according to different standards; under normal conditions, the classification can be carried out according to the properties, functions, sources, application sites, and use requirements of the biomedical materials. It is more common to perform classification according to the properties of biological materials [41].

12.2.1 Medical Metallic Materials

The metal materials are the biological materials earlier used in the medical field, mainly including titanium, tantalum, niobium, zirconium, stainless steel, cobalt alloys, titanium alloy, and tantalum alloy, and they are widely used in internal fixation, artificial joints, and prostheses.

12.2.2 Medical Inorganic Nonmetallic Materials

The inorganic nonmetallic materials mainly refer to a variety of biological ceramics, glass, carbon, etc., including oxide ceramics, phosphate ceramics, and bioglass. The biological ceramics can also be divided into bioinert ceramics, surface-active ceramics, and biodegradable ceramics according to their tissue reaction characteristics.

12.2.3 Medical Polymer Biological Materials

Various types of polymer biological materials develop rapidly and are gradually applied in clinics. The materials sources could be natural polymer such as polysaccharides and proteins, and synthetic polymer such as polyethylene, polytetrafluoroethylene, and polyethylene methyl methacrylate. These materials are widely used in human tissue repair and drug carrier.

12.2.4 Medical Composite Materials

The composite material refers to a new material which is made from two or more biological materials, and it can obtain more excellent material properties to make up for the shortcomings of a single material and is widely used in the replacement and repair of human tissue and organs.

12.3 Requirements for Commonly Used Biological Materials

According to different sources, the biological materials can be divided into two kinds of materials such as natural materials and synthetic materials. In order to ensure the safety and effectiveness of clinical application, there are certain requirements for biological materials from various sources.

12.3.1 Good Biocompatibility

The biological materials will not cause toxic reaction, inflammatory reaction, foreign body reaction, and allergic reaction. They have no antigenicity and carcinogenicity and are unlikely to cause thrombosis and other security issues.

12.3.2 Appropriate Intensity

The biological materials applied in repair of the force bearing parts in the human body are required to have certain intensity, tolerate a certain degree of tension and pressure, and withstand a certain load. For example, the elastic modulus of bone repair material should be close to that of the bone, have a high wear-resistant degree, and have to be resistant to aging. The requirements for the biomechanical properties of the materials used in different parts of the body are different, and the good biomechanical conditions can promote strong bonding strength at the interface between material and human body tissue.

12.3.3 Good Stability

Since the biological materials implanted into the body will have various forms of material, energy, and signal exchanges with the adjacent parts, thus it is required that the materials should have chemical stability, with no structural change after long-term implantation, and should also have good anticorrosion performance, with resistance to corrosion and abrasion and without producing soluble toxic substances.

12.3.4 Other Requirements

The requirements are that the biological materials should be nonmagnetic, conducive to processing and shaping, and easy to disinfect and sterilize.

The abovementioned are some basic requirements for biological materials proposed just from the point of view of clinical medicine and biology. Because of different characteristics of different materials, the corresponding reactions of the body are also different; even for the same material used by the same method, the reactions of the body to the materials may be different due to individual differences. The reactions of the body to the materials are closely related to the types, characteristics, surface structures, morphologies, implantation methods, implantation sites, and functional statuses of the biological materials.

12.4 The Characteristics of Commonly Used Biological Materials

With the rapid development of biological material science, there is a wide variety of biological materials which can be currently used in clinics, and different materials have different clinical use. This article will make a brief introduction on various types of materials mostly used in oncoplastic surgery and will focus on metal materials, inorganic nonmetallic materials, high molecular polymers, and biocomposite materials which are widely used in oncoplastic surgery.

12.4.1 Metal Materials

The metal materials have characteristics such as high strength, fatigue resistance, and easy processing. They are currently used in sites such as bones and teeth which need to withstand the higher loads, and the most important applications include fracture fixation plates, screws, artificial joints, and dental implants. It is important to note that the use of metallic materials in the process of repair and reconstruction of bone tissues and bone joints in oncoplastic surgery may produce un-negligible effects on local radiotherapy after surgery, different metal materials can have scattering and blocking effects on high-energy particles, so that the bone and soft tissue in front of the metal material receive an increased radiation dose, while the bone and soft tissue in the rear of the metal material receive a decreased radiation dose. Therefore, before carrying out radiotherapy on the site where the metal material is implanted, it is supposed to comprehensively consider the shape and thickness of the metal material and make corresponding adjustments to radiation dose and radiation angle. In addition, some metal materials can block the penetration of the X-ray beam, or they can be magnetized or interfere with the accuracies of imaging examination results under the strong magnetic field, which will bring effects on reexamination and treatment.

1. Medical stainless steel. The medical stainless steel is one of the earliest developed medical alloys, and it has achieved a very wide range of clinical applications due to its low prices and easy processing, such as artificial joints, fracture fixation devices, cortical and cancellous bone compression screws, skeletal traction wire, artificial vertebrae, and skull plate. After long-term implantation, the stability of the medical stainless steel will be poorer. There are large differences in density and elastic modulus between the medical stainless steel and the human hard tissue, and the mechanical compatibility between medical stainless steel and bone is poor, the metal ions dissolved from which can induce inflammatory response of the body, and its utilization rate has declined in recent years, especially the built-in products that have gradually been replaced by other better biocompatible metals or alloys.
2. Medical titanium alloys. The titanium and titanium alloy have been widely applied in clinics due to its good biocompatibilities and excellent mechanical properties. Titanium is the metal with the best biological affinity in currently known metals, and it will cause a minor tissue reaction after implanted into the body. It has a certain biological activity and the ability to bind to the bone and especially is suitable for being embedded within the bone. Its disadvantages include low hardness and poor wear resistance, and its biocompatibility and comprehensive mechanical properties can be further improved through adding other metal elements into titanium to produce the titanium alloy and implementing special surface treatment. Its clinical applications include that it can be used in productions of bone fixation devices, artificial joints, various brackets, and cranial prosthesis and it can also be used for reconstruction of jaw bone defects during oral and maxillofacial surgery.
3. Medical precious metals. The precious metals for medical use include gold, silver, platinum, and their alloys. These metals have relatively more stable chemical properties and biocompatibility, especially the alloys containing multiple metals that can improve the mechanical strength, and are mainly used for oral and maxillofacial surgery and skull repair.
4. Medical rare metal materials. Medical rare metal materials include rare metals such as tantalum, niobium, and zirconium. Such materials have good chemical stability, corrosion resistance, and biocompatibility, and they can be processed into surgical implant materials such as bone fracture plate, cranial prosthesis, and screws according to clinical use. Most of these materials are more expensive, so that their applications are limited in a certain extent.

12.4.2 Inorganic Nonmetal Materials

The inorganic nonmetal materials mainly refer to all types of biological ceramics, including hydroxyapatite, tricalcium phosphate, hydroxyapatite cement, and bioactive glass. The repairing bone tissue with bioceramic materials has a long history of clinical applications, and new materials have always been developed for clinical application. Application of these materials has become an important means for repair of bone defects and defects after benign bone tumor curettage, but the effects of local radiotherapy and systemic chemotherapy on the biological activity of these materials still need further study.

1. Hydroxyapatite. The molecular structure of hydroxyapatite (HA) is very similar to that of the human bone and tooth enamel and has a good biocompatibility. A strong chemical bond can be formed between hydroxyapatite and the human bone, but the hydroxyapatite cannot be dissolved and absorbed by the body. Synthetic HA [$Ca_{10}(PO_4)_4(OH)_2$] is the crystal structure formed by calcium and phosphate under high-temperature reaction. The ratio of calcium and phosphorus is 1.67, and its biggest feature is that its chemical composition and properties are very similar to those of the mineralized natural bone, so that it has a good osteoconduction and biocompatibility, and thus it has been widely used as a bone substitute in clinics. The osteoconduction refers to the process by which the implant materials after contacting with bone or periosteum can guide new bone regeneration in sites with the presence of osteoblasts, while the osteoinduction refers to the process by which the implant materials can also guide the new bone regeneration in the soft tissue in the absence of osteoblasts. Although the implanted hydroxyapatite structure or the scaffold composed of hydroxyapatite closely contacts with the neighboring natural bone, it is not suitable for load-bearing bone repair and also has no osteoinduction due to its high brittleness. In recent years, the hydroxyapatite has also been used as the bone induction growth factor and the biologically active carrier of osteoblasts, and it is used for promoting repair and reconstruction of damaged bone.

   HA such as porous the type and granular type is more commonly used in clinics, especially the structure of bulk porous material that is similar to that of the natural bone, and is mainly used in the nonweight-bearing area; for example, it is used for repair of bone defects in mandible, cheekbones, and orbital bone. Since pure HA material has a high brittleness, the composite material which is developed in recent years and is made from HA and other materials has the characteristics of two or more biological materials, having a wider prospect of clinical application. Common HA composite materials can be roughly divided into five types, and they are defined as follows, respectively: (1) the composite consisting of HA and biological material, such as bone morphogenetic protein (BMP), collagen, and fibrous protein; (2) the composite consisting of HA and organic biological material, such as polyester; (3) the composite consisting of HA and inorganic biological material, such as metal material; (4) the composite consisting of HA and autologous material, such as autologous bone marrow or desalinated bone; and (5) the composite consisting of HA and multiple materials.

2. Tricalcium phosphate (TCP) is a resorbable bioceramic material; after being implanted into the bone tissue, it is dissolved and absorbed by the body fluid and then is metabolized and excreted out of the body. The defect site is eventually replaced by new bone tissue, and the implanted material plays a supporting role within a period of time. TCP has a good biocompatibility and osteoconduction, whose chemical composition and microstructure are similar to those of natural bone and tooth at calcification stage, and the constitute formula is $Ca_3\ (PO_4)_2$. It can be divided into two types such as type α and type β according to the crystal structure. β-Tricalcium phosphate (β-TCP) is more commonly used in clinics; compared with the HA, its biggest advantage is that it can be absorbed and degraded by the body and has a higher strength.

   The application of TCP as a synthetic bone defect filler has a history of more than 20 years; its smaller particle diameter and cavernous interconnecting microporous structure make it have a good osteoconduction and at the same time also make it have a high degradation and absorption rate in the process of bone remodeling. The in vivo degradation and absorption of TCP can stimulate the growth of the surrounding new bone and thus can better guide new bone regeneration and play a physiological supportive role in the bone repair process. Now there are three main types of finished TCP: (1) granular TCP for filling various bone defects, (2) porous TCP, and (3) dense TCP. Its usage and indications are similar to those of HA, mostly applying to repair skull, orbital floor, and jawbone, as well as repair the bone defects after resection of benign bone tumor and tumor-like lesions.

3. Hydroxyapatite cement. The hydroxyapatite cement is also known as hydroxyapatite bone cement or calcium phosphate cement (CPC). It has a clinical application history of more than 30 years, and it is also a good bone substitute with biological activity. Compared to other bioceramic bone substitutes, it has a good plasticity; therefore, it can contact more closely with the bone. Such materials have a good osteoblastic activity while not affecting the imaging examination and being easy to obtain. The hydroxyapatite bone cement powder is generated through reaction between four-calcium phosphate and dicalcium phosphate in the presence of water, and it has a certain biological absorptivity after solidification. Compared with the hydroxyapatite ceramics, the biggest advantage of the hydroxyapatite bone cement is that it can easily be shaped into any desired forms in the surgical procedure. The disadvantage of the hydroxyapatite bone cement is that it has an osteoconduction only after contacting closely with the natural bone, and because it does not have an osteoinduction, the growth of the new bone after its implantation is often limited. To overcome this disadvantage of the bone cement, various growth factors to promote bone formation are used simultaneously, and it has been confirmed that they can accelerate collagen synthesis and bone defect healing, thereby enhancing the clinical effect of bone cement.

4. Bioactive glass. The bioactive glass was originally reported by Hench et al.; its main components include silicon dioxide, sodium oxide, calcium oxide, and phosphate. At present, such materials can be used alone or used in combination with autologous or allogeneic transplantation, being widely used to fill and repair the bone defects. The binding reaction between the natural bone and bioactive glass is the result of the interreaction between the bone and bioactive glass surface, and the hydroxyapatite surface of bioactive glass bone during a long time after implantation can be replaced by bone, whose biological activity is affected by its compositions, pH of the surrounding area after implantation, the temperature, and the glass surface treatment. The micropores of the bioactive glass also provide a scaffold for the new bone to facilitate the differentiation of blood vessels and osteoblasts. Histological studies have showed that after being implanted into the body, the bioactive glass will cause no or only a relatively minor inflammation in the surrounding tissue, and the glass fiber scaffold is absorbed more completely at 6 months after implantation. The bioactive glass is mostly used for the ear drum reconstruction, filling after bone tumor surgery, reconstruction of facial bone defect, and repair of alveolar bone defect.

12.4.3 High Molecular Polymer

Most soft tissue-filling materials belong to the polymer biological materials, and the ideal soft tissue-filling materials need to have excellent biological properties, such as the stability in aqueous solution, the chemical resistance in the surroundings, easiness of shaping, and no toxicity. Today, all kinds of polymer biological materials have some shortcomings more or less; for example, they have different degrees of degradation in the physiological environment, and the long-term implanted materials have poor in vivo stability, tissue toxic reaction, and potential carcinogenicity. The polymer biological materials which are more commonly used in clinic include silicone, polymethyl methacrylate, polytetrafluoroethylene, high-density polyethylene, polylactic acid, polyglycolic acid, polyester, nylon, polyvinyl fluoride, polyacrylonitrile, etc.

1. Silicone. Silicone (silica gel) has a repeating unit structure wherein the skeleton is constituted by the monomers consisting of silicons and oxygens, and the branched chain is composed of methyl, phenyl, and vinyl. Silicone has characteristics such as high stability, good biocompatibility, no toxicity, and insoluble in body fluids. Although it is considered as an ideal in vivo implant, it will still cause some foreign body reactions, such as the formation of fibrous capsule. The silicone viscosity is determined by its degree of polymerization. The short-chain molecule polymer is in a liquid state, while the long-chain molecules turn into jellylike substance after polymerization, and the highly cross-linked polymer chains have a rubberlike appearance.

   Polyvinyl alcohol/poly(acrylamide-co-acrylic acid) hydrogel has been used for injection filling in the breast and face in the 1960s and 1970s of the twentieth century, with increasing reports of serious complications, such as inflammatory reaction, injection site induration, discoloration, tissue ulceration, migration in the tissue, and granuloma formation; the US Food and Drug Administration (FDA) has listed it as one of the materials which are prohibited for use. Currently, the elastic solid silicone with a higher degree of polymerization is more commonly used in clinic, which can be made into tissue expanders, breast implants containing saline water or semisolid silicone, and orthopedic prosthesis used for filling the soft tissue in the skull, jaw, cheekbones, nose, and chest, and can also be used for joint replacement and tendon reconstruction.

   The most common complications after implantation of silicone prosthesis include the formation of fibrous capsule and the capsule contracture, especially in the process of breast aesthetic surgery and reconstruction; there may be the occurrence of the shape change and induration in the implant site. The surface treatment for silicone prosthesis can reduce the capsular contracture, but the effect has still not been proved conclusively. The use of the silicone prosthesis in joint reconstruction can cause synovitis. Once the synovitis occurs, it is often needed to perform surgery to remove the prosthesis.
2. High-density polyethylene. This product is also known as porous high-density polyethylene, and the trade name is MEDPOR (Porex Surgical Inc., USA). It has a nearly 20-year history of surgical application, and different shapes and thickness of materials are available for surgical repair of different purposes. Its porous structure contributes to implant vascularization, thereby reducing the formation of fibrous capsule and the rejection reaction.

   In 1993, Romano et al. firstly reported the use of polyethylene (PE) materials for repair of facial fractures, which can be made into the right shape according to the needs of surgery, while not preventing the growth of the soft tissue after implantation, and it generally does not cause the rejection reaction; in addition to that, it is necessary to remove the implant because of the infection. Dougherty and Wellisz observed in vivo differences between animal models after implantation of porous PE material and silicone prosthesis; at 1 week after implantation, it can be found that a fibrous capsule is formed around the silicone prosthesis, while the growth of blood vessels and soft tissue will appear in the surrounding area of the PE prosthesis; the recent research by Jordan et al. has found that the microvascular growth is observed at 12 weeks after implantation of porous PE prosthesis into the human body, and these findings suggest that PE material is an ideal material for synthesizing prosthesis. The clinical application of PE is also more widespread; for example, PE can be used in all repairs of defects in the head and facial areas such as the cheek, orbital arch, orbital floor, upper and lower jaw, cheekbones, temporal region, and aural region. Lupi et al. have achieved fairly good results in the use of PE materials to repair the orbital bone damage and reconstruct the orbit after tumor surgery. The research by Ram et al. has shown that PE prosthesis is an ideal material for repairing a wide range of orbital defects. Although PE implants can achieve more excellent repairing efficacy in clinics, their related complications also need to cause enough attention. Some studies suggest that PE materials have a higher infection rate compared with other implanted prostheses; therefore, it is needed to pay attention to strict sterilization in the process of clinical application. The aseptic principle should be strictly abided during surgery, and the antibiotics must be used systemically after surgery. In addition, PE materials cannot be used in the stress concentration area; otherwise, it may cause wear and tear, thus resulting in chronic inflammative reaction of the tissues.
3. Polytetrafluoroethylene. The polytetrafluoroethylene (PTFE) has characteristics such as stable chemical properties and biological activity, no antigenicity, suitableness for high-temperature and high-pressure sterilization, and easy shaping, and it is an ideal biological implant material. Due to its smaller compression and tension, its application in bone repair is limited, but it is widely used for filling the soft tissue. The product Gore-Tex which is more commonly used in clinic is an expanded polytetrafluoroethylene polymer sheet, with a high purity, no hypersusceptibility

and immunological activity, small foreign body reaction, and low incidence of inflammation. It can be used to make suture lines and artificial blood vessels and can also be used for soft tissue augmentation.

4. Polymethyl methacrylate. The polymethyl methacrylate is an acrylic polymer mainly used for bone fixation, craniofacial bone substitute, joint replacement, and chest wall repair. It has good biocompatibility, easiness of shaping during surgery, higher density, and good X-ray penetration. The reaction of the body shows a low foreign body reaction against the implanted polymethyl methacrylate, may have fibrous tissue encapsulation, and have a risk of concurrence of infection and leakage after long-term implantation. The recently developed hard tissue replacement (HTR) is a poly(methyl methacrylate) composite, which is porous and rich in anion, and can stimulate bone growth.
5. Biodegradable materials. The biodegradable materials include purified extracts of natural materials and synthetic biodegradable materials, such as collagen, chitin, cellulose, and polylactose. After these materials are implanted into the body, they can be degraded biologically and absorbed and then are metabolized and excreted out of the body. Its applications include (1) tissue engineering scaffolds, (2) bone fixation materials, (3) surgical suture lines, and (4) soft tissue filling.

12.4.4 Biocomposites

The biocomposite is a medical material consisting of two or more different biological materials. Since the conventional single kind of medical material has the advantages in one aspect but has some shortcomings in other aspects, the new materials constituted by materials with different properties not only have the properties of constituent materials but also achieve the new properties which are not possessed by one-component material; therefore, the multicomponent composite materials have the widest development prospect in the field of medical materials.

The composite materials are divided into three categories according to the types of matrix materials, namely, metal matrix composite, inorganic nonmetallic matrix composite, and polymer matrix composite.

1. Metal matrix composite. The metal matrix composite has a unique set of properties, such as excellent metal wear resistance, corrosion resistance, and biocompatibility. Its categories include titanium matrix ceramic composite materials and magnesium alloy matrix composite biological materials, and they are used extensively for hard tissue replacement and repair in surgical implant materials.
2. Inorganic nonmetallic matrix composites. The inorganic nonmetallic matrix composites mainly use the oxide ceramics, bioactive glass, hydroxyapatite, and calcium phosphate as the matrix; it is added to other reinforcement materials to improve or adjust the performance of the raw material. Its categories include:
   (1) Inert inorganic nonmetallic and active inorganic nonmetal composite materials such as zirconia (ZrO2)-HA composites, carbon fiber-TCP composites, carbon nanotube-HA composites, and nano-silicon carbide (SiC)-HA composites
   (2) Active inorganic nonmetal and active inorganic nonmetal composite materials such as bioactive ceramics-bioactive ceramic composites and bioactive ceramics-bioglass composite
   (3) Metal and inorganic nonmetallic composite materials such as various types of alloys-HA composites
3. Polymer matrix composites. The more widely used polymer matrix composites mainly include three kinds of polymer-based composite materials such as inert inorganic nonmetallic-polymer composites, active inorganic nonmetallic-polymer composites, and polymer composites-polymer composites. All kinds of materials have their unique biological characteristics, the biocompatibility and mechanical characteristics of the product have been significantly improved through integration of materials, and they are widely used to repair and replace the bone tissue and soft tissue.

12.5 Clinical Application of Biological Materials in Oncoplastic Surgery

The use of autologous tissue to repair defects in the process of repair and reconstruction of tissues and organs in oncoplastic surgery will still face many problems, such as limited donor site, secondary damage, postoperative secondary plastic surgery, and chronic pain, although inactivated allogeneic tissue transplantation can partly solve these problems, but may cause adverse effects such as infectious disease and rejection reaction. Further developments of biological materials and tissue engineering offer more options for oncoplastic surgeons. Against the operation situation of different tumor patients, all factors are considered to develop an individualized rehabilitation plan and further improve the qualities of life of patients on the basis of ensuring the effectiveness of tumor treatment, which is also the general guidelines for oncoplastic surgery. In recent years, great achievements have been made in the use of biological materials and tissue engineering technology in the fields of bone and cartilage defect repair after tumor surgery, joint replacement, artificial blood vessels, and soft tissue reconstruction, so that the surgical treatment of tumors has reached a higher level. Here are some examples of clinical application of used biological materials in oncoplastic surgery and its new progresses [42–45].

12.5.1 Defect Repair After Bone Tumor Surgery

The bones support the body and mainly play roles in sports, for support and protection. The bone tumor surgery often causes severe appearance deformity or motor dysfunction, and the qualities of life of patients are greatly affected. The excellent results have been achieved in the use of the autologous bone grafts to repair the small defects, but a wider range of defects must be repaired with biological materials. Good bone repair materials are required to have the following characteristics: (1) having a good biocompatibility; (2) not affecting the imaging examination results of the body; (3) being easily molded according to the characteristics of the defect sites; (4) having osteoconduction, the speed of biodegradation and absorption is matched with the speed of bone substitution; and (5) being readily available.

The biological materials have a widespread application particularly after the removal of benign bone tumors. The benign bone tumors refer to the abnormal bone neoplasms with slow growth and no metastasis, and a few benign tumors (e.g., osteoclastoma) potentially have malignant characteristics. According to the definition formulated by World Health Organization (WHO), the benign bone tumors can be divided into tumors originated, respectively, from the bone, cartilage, connective tissue, and blood vessels according to the histological origins of the tissues. Once the benign bone tumors are definitely diagnosed, they need to be removed by curettage, and the remaining bone defect site can be repaired by using a variety of biological materials, such as hydroxyapatite (HA), β-tricalcium phosphate (β-TCP), and TCP composites consisting of HA and α-BCP. Various types of bone cements with excellent biocompatibility, osteoconductive properties, and sufficient mechanical strength have become the most promising materials for repairing the defects after curettage of benign bone tumor.

So far, the repair of defects after resection of malignant bone tumors in maxillofacial area, load-bearing area, or areas surrounding the movable joints is the surgery which is still quite challenging, such as repair and reconstruction of function and appearance after radical surgeries for primary or nonprimary malignant tumors in cranial and maxillofacial area and the primary or secondary malignant tumors in the hip. The appearances of the patients may be affected greatly after surgery due to the complex anatomy and the large surgical difficulty; there may exist a postoperative need for withstanding the greater stress and the wear and tear; the use of biological materials in these sites for repair or reconstruction often results in poor postoperative efficacy due to worse postoperative healing and more complications. Therefore, the performers are required to have a comprehensive and in-depth understanding of the performances of all kinds of biological materials, so as to increase the success rate of surgery and practically improve the qualities of life of patients after surgery.

The materials for repair of defects after cranial and maxillofacial tumor surgery have a wide range of varieties, including autologous bone, bone cement, polybutylene methyl, titanium stent, polyethylene, and various composite materials. Various types of materials have their own characteristics, but also inevitably have some disadvantages; for example, the poly(methyl methacrylate) can release heat to lead to degeneration and necrosis of local cells during the application process; although the titanium stent has a good biocompatibility, its small deformation range and easiness to compress the tissue eventually result in the exposure of the titanium plate; all kinds of bioceramics have good biocompatibility and mechanical strength, but it is difficult to mold them according to the specific circumstances during surgery. The conventional repair method only uses the scaffold-like materials. The recent progress in tissue engineering leads to innovation in repair of craniofacial defects. Warnke et al. [43] made the titanium metal cage by means of computer-aided design and filled the recombinant human bone morphogenetic protein (rBMP-7) within the titanium metal cage, which was embedded into the latissimus dorsi during primary surgery and then was transferred to repair the mandibular defects in the maxillofacial area after good vascularization was completed, and the good results were achieved. Hernandez et al. used the titanium metal stent in combination with rBMP-7 and autologous bone marrow transplantation to induce new bone formation to repair the defects after resection of adamantoblastoma in mandibular angle, which also obtained good results. In these cases, the application of autologous tissue, biological materials, tissue engineering techniques, and growth factor-induced osteogenesis in combination with the application of vascular surgical techniques and computer-aided design and other technologies has showed a broad prospect for the clinical application of biological materials and tissue engineering. In addition to all types of metal and composite materials, the bone resected during tumor surgery after appropriate treatment can also be used as biological material scaffold for in situ repair of bone defects. The high-pressure steam method can completely inactivate the tumor cells in bone tumors and retain the good bone scaffold. This method does not cause the donor site defect, and the bone scaffold has good biocompatibility and exact match with the donor site defect in shape; therefore, in theory it will not cause local tumor recurrence. However, the tumor cells in the bone are inactivated, and at the same time the bone scaffold has also lost the osteoinduction. Von Wilmowsky et al. conducted a prospective study on the use of autologous bone marrow-derived cells which are implanted and amplified in the inactivated bone to repair bone defect, and it was found the inactivated bone where bone marrow cells were implanted and amplified had excellent osteoinduction. In addition, the platelet-rich plasma and bone morphogenetic protein had certain effects in promoting the osteogenesis characteristics of the inactivated bone.

The radical surgery for the malignant tumor of the hip joint has a high disability rate; the repair of pelvic bone and hip joint is one of the major challenges in oncoplastic surgery. The repair and reconstruction of pelvic bone and hip joint have higher complication rate and failure rate, and the nature of the pelvic tumor, the invasion range, and the occurrence site are still the most important factors to determine the surgical difficulty. The classic repair method for the hip joints such as Harrington repair method can better reconstruct the support and movement functions of the hip joints by the use of bone cement and metal screws to fix the artificial acetabulum on the healthy hip after tumor resection. The improvements of this method including the combined use of inactivated allogeneic bone and artificial hip joint reconstruction are also successful, which is suitable for most patients with pelvic tumors including children, but it still has a higher incidence of complications such as infection, bone nonunion, and postoperative fracture, and it is not recommended to be used for patients requiring postoperative radiotherapy.

12.5.2 The Cartilage Reconstruction After Tumor Surgery

The cartilages can be divided into three types such as hyaline cartilage, elastic cartilage, and fibrous cartilage. Of which, the hyaline cartilage covers the articular surface to play a buffer effect, while it can also provide the bone support for the pharynx, trachea, nose wing, and nasal septum; the elastic cartilage is located in sites which are pliable and soft, such as the outer ear, epiglottis, and pharynx, and plays a supporting role. The cartilage itself has no vascular structure, surviving only based on the nutrition in the surrounding tissue fluid, whose regenerative capacity is extremely weak, and therefore, the reconstruction of cartilage structure is also one of the difficulties in oncoplastic surgery. Especially for the trachea reconstruction after throat tumor surgery, it is not only needed to reconstruct the support function of the trachea but also needed to resolve the problems such as the tracheal intima regeneration and the prevention of postoperative contracture, so that such surgery is very challenging.

Reconstruction of the trachea needs to meet at least the following two conditions: (1) The respiratory tract has the dynamic cartilage structure; (2) the respiratory tract is covered by mucous membrane. This type of structure in the trachea is unique, and thus it is difficult to obtain the composite tissue possessing these two kinds of structures at the same time in other sites of the body, which makes it very difficult to repair and reconstruct the trachea. Although some progresses have been made in the researches on repair and reconstruction of tracheal cartilage and mucous membranes in recent years, many researches still remain in the preliminary experimental research stage. For example, in animal experiment, Delaere et al. used and transferred the autogenous ear cartilage and oral mucosa graft after pre-vascularization into the pharyngeal area to repair the trachea defect, and the initial success had been achieved. This method has a certain clinical value, but it also has some more serious disadvantages, because the vascularization process of the cartilage is very slow and is not suitable for mucosal graft, the cartilage vascularization and the tracheal intima reconstruction take a long time, and the success rate is low. Given the limitations of the use of autologous cartilage graft for tracheal reconstruction, people began to explore the use of biological materials to reconstruct the trachea, such as titanium stent, MEDPOR, hydroxyapatite, and the tissue engineering tracheal stent for planting the mucosal cells. All these materials can recover the appearance and the support function of the trachea better in the experimental process, but their common problem is that the tracheal intima reconstruction is not ideal. For smaller defects, the process of mucosal coverage in the inner wall of the prosthesis can be better completed through the crawl of the normal mucosa tissues, while for a wide range of defects, it is difficult to complete the repair through the crawl of mucous membrane, and the most important reason is the low vascularization degree of the inner surface of the stent. In animal experiments, Janssen et al. implemented the mucous membrane transplantation using the porous titanium stent and then buried them under the skin to carry out pre-vascularization for the repair of the tracheal defects, which achieved success, suggesting that the porous stent has a very important significance for the survival of mucous membrane in the inner wall of the trachea.

12.5.3 Soft Tissue Reconstruction After Tumor Surgery

Depending on whether directly contacting with the blood circulatory system, the biological materials for soft tissue repair can be divided into the biological materials which contact with the blood flow and the biological materials which don't contact with the blood flow. The former include artificial blood vessels, and the latter include breast prosthesis.

The artificial blood vessels can be used to repair and replace the diseased artery or vein. The vascular substitutes made of synthetic materials are widely used in clinics, so that the surgical range of oncology surgery also has been broadened continuously. For example, some tumors involving large blood vessels have almost been the restricted surgery zone before the appearance of suitable vascular replacement materials, but with the development of materials science, the artificial blood vessels have been widely applied; therefore, these surgeries can be generally carried out, and the good postoperative results have been achieved. At present, most artificial blood vessels are made with polymer materials by means of knitting; there are also some experimental studies on the human umbilical vein and bovine carotid artery which have been chemically treated. After the large arteries are replaced with artificial materials, the long-term effects are good, but after the artificial blood vessels are used for some arteries with slow blood flow or veins, the effects are poor, whose causes include thrombosis in the vascular lumen in the healing process, the lack of vascular endothelial cells in the intima, and hemodynamic disorders, and these are urgent problems to be solved in the field of artificial blood vessel.

The breast reconstruction after breast cancer radical surgery needs to achieve at least two objectives, namely, to restore the shape of the breast and restore the texture of the breast. Similar to other tissue reconstructions, the breast can be repaired selectively using the autologous tissue or prosthesis, and both methods can achieve satisfactory reconstruction results, because the autologous tissue reconstruction can achieve better long-term results and thus get the recognition of plastic surgeons. However, not all patients are suitable for autologous tissue reconstruction, such as some patients with more slender shape or patients with excessive fat, as well as patients with diabetes, and the autologous tissue breast reconstruction will inevitably cause donor site defect and affect the appearance. The prosthetic breast reconstruction also has been widely used due to its advantages such as simple operation, short operation process, small trauma, good postoperative aesthetic effect, and no donor site defect.

The breast prosthesis usually consists of two or three main parts: silicone outer capsule and filling material within the capsule, and some prostheses also have valves used for injection of filler material. The silicone outer capsule has a certain strength and plays a barrier effect, and the surface after special treatment may also improve tissue reaction of the body after implantation of the prosthesis; the filling materials within the capsule are mostly liquid or gel-like materials, such as liquid silicone and saline water. Previous prosthetic breast reconstruction is generally divided into two steps: The dilator is placed under the pectoralis major muscle during the primary surgery. After being injected with water for some time, the dilator is removed during two-stage surgery, and then the appropriate size of silicone prosthesis is implanted to reconstruct the breast. In recent years, with the extensive development of nipple-, areola-, and skin-sparing radical mastectomy, the surgical method of immediate breast reconstruction by which the silicone prosthesis is implanted during the primary stage after the removal of glandular tissue began to increase year by year. But breast reconstruction by implanting silicone prosthesis has its inherent drawbacks, and enough attention should be paid to possible postoperative complications. The complications of the prosthetic breast reconstruction generally can be divided into short-term complication and long-term complication. The complications which may occur within a relatively short time after surgery include infection, hematoma, seroma, dilator exposure, and skin flap necrosis. Once the prosthesis is exposed and the serious infection appears, the prosthesis must be removed, the second-stage reconstruction infection will be considered after the infection is completely controlled, and the recovery is achieved for 3–6 months. All long-term complications of the prosthetic breast reconstruction include fibrous capsule formation and contracture, prosthesis displacement, deformation, hardening, leakage, and chronic pain which will seriously affect the qualities of life of the patients, of which the incidence of fibrous capsule formation and contracture is higher, especially for some patients requiring postoperative radiotherapy or with a history of preoperative radiotherapy, and its incidence reaches from 38% up to 60%. The measures to prevent capsular contracture include improving the prosthetic material and surface treatment processes; for example, the silicone outer capsule with better biocompatibility is selected and used, and the grind arenaceous processing for its outer surface is carried out. The acellular allogenic dermis combined with prosthetic breast reconstruction is applied in recent years. This method cannot only reconstruct the natural shape of the breast but also reduce the displacement of the prosthesis and the fibrous capsule formation and contracture, thus achieving a better long-term effect.

12.6 Conclusion

The abovementioned examples are only the application of some biological materials and technology in oncoplastic surgery, which also include some experimental researches or progresses with forward-looking significance. The effects of innovative materials and technology on oncoplastic surgery are undoubtedly significant and far-reaching, while the related doctors and researchers are required to pay close attention to new progresses in all kinds of new materials and technologies. It is still needed to conduct in-depth basic and clinical researches on the interaction between radiotherapy, chemotherapy, and biological materials and its mechanism, and the relevant research results will guide us to further select the appropriate biological materials to be used in tumor patients [46].

13 Exploration on Oncoplastic Surgery and Mode of Comprehensive and Sequential Treatment

Wei Wang, Zhaoyan Wang, and Xiao Zhou

The clinical oncology is in a period of multidisciplinary cooperation of surgery, radiotherapy, and chemotherapy during which the best treatment plan is summarized by means of evidence-based medicine, and multiple tumor treatment centers are required to collaborate to complete the study of the best treatment plan. In recent years, there are great progresses in prevention, diagnosis, and treatment concept of the tumors; attaching great importance to the comprehensive treatment of the tumor and emphasizing the standardization of diagnosis and treatment and the individualization of treatment have become a trend recognized in the academic world.

13.1 Paying Attention to the Comprehensive Treatment Is the Basic Principle of the Clinical Oncology

In the treatment of malignant tumors, various existing treatments have their own advantages, but at the same time, they also have some disadvantages. It is very difficult to cure the advanced malignant tumors using a method, which often requires a comprehensive application of multiple treatment means. The comprehensive treatment is to develop the best treatment plan through comprehensively using the treatment means such as surgery, radiotherapy, and chemotherapy properly and in a planned way according to the body conditions of patients, tumor histological types and subtypes, scopes of tumor invasion (staging), and development trends, whose purpose is to improve the cure rate and substantially improve the qualities of life of patients. The malignant tumors are a kind of diseases whose clinical manifestations are very heterogeneous, and each patient's response to treatment is not exactly the same, and therefore, it is needed to carefully discuss the specific issues: what kind of comprehensive treatment plan is needed by each patient and how to select the sequential therapeutic scheme, namely, how to determine the order of priority and the best time of the therapeutic measures such as surgery, radiotherapy, and chemotherapy.

The existing effective means for tumor treatment are roughly divided into the following categories.

13.1.1 Surgical Treatment

The surgical treatments of tumors are divided into radical surgery, palliative surgery, prophylactic surgery, and reconstruction surgery. The surgical treatment is a kind of local treatment; it occupies an extremely important role in the comprehensive treatment of the tumor and is now the preferred method for the treatments of most solid tumors. Some early or localized malignant tumors can be cured by the surgery alone. Due to the biological characteristics of easy recurrence and metastasis of the tumors, the purpose of completely curing the most advanced malignant tumors with surgical indications cannot be achieved by the surgery alone, and it is necessary to apply methods such as preoperative or postoperative radiotherapy, chemotherapy, and biological therapy to assist in the treatment.

13.1.2 Radiotherapy

The tumor radiotherapies are divided into radical radiotherapy and palliative radiotherapy and are one of the important means of comprehensive tumor treatment. For some tumors which grow in vital organs or near vital organs and cannot undergo radical surgery, but are sensitive to radiation, the radiotherapy can be used alone to achieve the purpose of cure. However, the same as the surgery, the radiotherapy is a local treatment method, which is often restricted by the following factors in the course of treatment:

1. Limited by radiation tolerance dose of normal tissue and organ around the tumor, the radiation dose for the treatment of tumor cannot be increased indefinitely.
2. The epithelial-originated tumors show a moderate sensitivity to radiation or a radiation resistance; even in the radiosensitive tumor tissues, there also exist some tumor cells such as hypoxic cells which resist the radiation.
3. The radiotherapy can treat the local tumors, but cannot cure the multiple tumor lesions which spread to the whole body, and therefore, the radiotherapy must be used in combination with other treatments such as surgery and chemotherapy.

13.1.3 Chemotherapy

The chemotherapies are divided into radical chemotherapy, palliative chemotherapy, neoadjuvant chemotherapy, and adjuvant chemotherapy. Unlike surgery and radiotherapy, the chemotherapy belongs to the systemic therapy, focusing on the control of systemic metastasis and proliferation of the tumors. The chemotherapy can radically treat a few tumors in the blood and lymphatic and reproductive systems which are highly sensitive to chemotherapy, and most malignant tumors cannot be radically treated with chemotherapy alone. For the tumor patients who have undergone or will undergo surgery or radiotherapy, the chemotherapy can control or kill the possible micrometastases and residual lesions and reduce the primary lesion, which help to improve the efficacy of the surgery and (or) the radiation and delay or control the recurrence and metastasis of the tumor, thereby improving the qualities of life of tumor patients and prolonging the survival period.

13.1.4 Biotherapy

The biotherapy refers to a therapeutic method that the biological reactions of the body are regulated through the body's defense mechanisms and the action of biological agents, thereby inhibiting or eliminating the tumor growth. It includes therapeutic applications of any biological substances or biological agents such as cytokines, monoclonal or polyclonal antibodies and their cross-linked products, immunocompetent cells, tumor vaccines, and gene therapy. Thanks to the rapid development of modern molecular biology and genetic engineering techniques, the biotherapy has become a new way to treat tumors and has good development prospect, which may lead to a revolutionary breakthrough in tumor treatment.

13.1.5 Other Treatments

The interventional therapy, Chinese medicine treatment, thermal therapy, microwave therapy, ultrasound therapy, and laser therapy are important parts of the comprehensive treatment of the tumor. From the therapeutic point of view, both the surgery and radiotherapy are local treatments that can eradicate some tumors. The chemotherapy belongs to the systemic therapy, focusing on the control of the local lesion and systemic metastasis, emphasizing the treatment method of multiple courses and sufficient doses. Only the integrated use of various means can achieve the best therapeutic effect, improving the long-term survival and the quality of life of the patients.

13.2 Advances in Molecular Biology Make the Individualized Treatment of the Tumor Become a Trend

Since the 1970s, the results of researches on the human genome and the disease genome provide the platform for accelerating the development of personalized cancer research. In particular, the basic researches such as cancer genomics, pharmacogenomics, RNA genomics, and proteomics expand into clinical practice, so that the treatment mode of traditional experience is gradually shifted to the individual treatment mode based on the background of the genetic information. The molecular diagnosis and molecular-targeted therapy of the tumors and the gradually popularization and application of chip technology in the process of tumor diagnosis and treatment indicate that the era of individualized diagnosis and treatment of the tumor is coming. A growing number of research reports have confirmed that the expression levels of gene and protein detected in biological samples from tumor patients can predict the drug therapeutic effect and evaluate the prognosis, guiding the clinical individualized treatment, thereby enhancing the efficacy, reducing the adverse reactions, and promoting the rational use of medical resources.

Currently some progresses have been made in the individualized treatment of tumor; for example, EGFR-targeted monoclonal antibody therapy is used to treat head and neck squamous cell carcinoma; the high expression of excision repair cross-complementing gene 1 (ERCC1) indicates the reduced sensitivity to platinum; the high expression of thymidylate synthase (TS) indicates the reduced efficacy of pemetrexed; the ribonucleotide reductase subunit M1 (RRM1) is negatively correlated with gemcitabine sensitivity; the class III β-tubulin is negatively correlated with paclitaxel sensitivity. It is generally recognized that there are hundreds of thousands of human proteins, while the corresponding gene number is less, and the extremely complicated accidental events will occur in the process of gene transcription regulation, posttranscriptional modification, and protein expression. So far, it has been confirmed in clinic that there are still rare indicators of response-related genes of important anticancer agents. The reactivity of the drug is rarely determined by single factor and is often effectively regulated by multiple determinative factors. Therefore, we should observe that the results of relevant clinical researches do not show a consistency with laboratory findings, and there is still a long way to guide the individualized treatment of the tumor according to the genetic background information.

13.3 Exploration on the Oncoplastic Surgery and the Sequential Treatment Mode of Comprehensive Tumor Treatment

The oncoplastic surgery involves the treatments and repairs of body surface tumors, head and neck tumors, breast tumors, thoracic and abdominal tumors, bone and soft tissue tumors, and genitourinary tumors. In the process of treatment, the oncoplastic surgeons need to cooperate mutually with doctors in oncological surgery department, radiotherapy department, medical oncology department, and rehabilitation department. The oncoplastic surgery aims not only at radically curing the tumor through more reconstruction means but also at restoring the functions and appearances of human tissues and organs and maximally extending the progression-free survival and overall survival of patients.

The ultimate purpose of the oncoplastic surgery is to radically cure the tumor, preserve the function, carry out the repair and reconstruction, and prevent the recurrence, and the comprehensive treatment measures such as surgery, radiotherapy, and chemotherapy are implemented for this purpose. There is still a lack of the basis for reasonably arranging the order of comprehensive treatments and its treatment process; although some achievements have been made in sequence treatments of some tumors (such as breast cancer), there are still many issues to be resolved. Different from the patients with ordinary plastic surgery, the patients undergoing oncoplastic surgery operations often have received multiple courses of preoperative chemotherapy or radiotherapy. The chemoradiotherapy may have impacts on the aspects such as skin flap design, skin flap donor site selection, skin flap survival, and blood supply reconstruction in these patients. In particular, currently there is a lack of systematic in-depth study on whether the direct injection site of chemotherapy drugs is still suitable for use as donor site of skin flap. The plastic surgery can cause trauma in the body and reduce the tolerance to chemotherapy in patients, so that the patients are even unable to complete the established systemic treatment; if there is a concurrence of postoperative infection and tissue flap necrosis, this will further delay the starting time of chemoradiotherapy and affect the dose intensity of chemoradiotherapy. Carrying out timely and active postoperative chemoradiotherapy in patients with tumors is often the key to cure the tumors. If the delivery of chemotherapy is delayed, or the systematic chemotherapy cannot be completed, this may even cause negative effects such as tumor recurrence and shortened survival. Therefore, when formulating the plastic surgery program, we should take into account the effects of the surgery itself on postoperative chemotherapy and other comprehensive treatments.

The modes of comprehensive treatment in oncoplastic surgery are varied, and different modes should be adopted according to different tumors, different stages, and different individual conditions. The establishments of the modes must undergo a rigorous clinical research, and the continuous improvement on the basis of evidence-based medicine is carried out.

For example, the tumor resection plus one-stage and (or) second-stage plastic repair may be considered for patients with tumors in early stage or in a relatively limited site, and postoperative radiotherapy, chemotherapy, and biological therapy are appropriately considered according to the postoperative pathological findings. The patients with tumors located in important sites are not suitable to undergo radical surgery; when the patients are sensitive to radiotherapy and the clinical studies have proven that the radiotherapy and surgical treatment have the same radical effect, it may be considered firstly to carry out radiotherapy, and the patients with better efficacy can undergo radical radiotherapy; the patients who are insensitive to radiotherapy are promptly treated by surgery and chemotherapy. The preoperative radiotherapy and/or chemotherapy may be considered for the patients with advanced local tumors or large tumors who are not suitable to undergo immediate surgery, and then the comprehensive treatment including radical resection, plastic repair, and postoperative chemoradiotherapy is implemented according to the changes of the tumor.

It should be noted that the sequential treatment is not to do simple addition or patchwork, and it is needed to emphasize the individualized treatment. Different patients have different types of diseases and different tumor staging and classification; even the patients with the same disease, pathological pattern, and staging will have differences in age, mental condition, and other aspects of tumor cell heterogeneity; therefore, the oncologists should design the individualized treatment plan according to specific patient's age, gender identity, psychological characteristics, treatment tolerance, and the desired quality of life and combined with the general condition of the patient, pathological type of tumor, clinical stage, and genetic background information. During carrying out the diagnosis and treatment of tumor patients, special attention should be paid to emphasizing consultation and discussion before multidisciplinary treatment, so as to formulate a scientific and rational sequential treatment scheme.

14 Repair and Reconstruction and Aesthetic Reengineering After Tumor Resection

Zuoliang Qi, Xiao Zhou, and Xiaonan Yang

14.1 Overview

As an important branch of the plastic surgery, the oncoplastic surgery mainly studies the repair of organ and tissue defects and the reconstruction of function and appearance after tumor resection. However, the oncoplastic surgery has certain differences with the repair and reconstruction of traumas, burns, and congenital deformities and the plastic and aesthetic surgery, of which a relatively important difference is the need to face the problems of tumor spread and recurrence and the effects of chemoradiotherapy on tissue healing and postoperative aesthetic effect. Large tissue defects will often be caused after surgical resections of some tumors located on the body surface, which seriously affect the appearance and organ function of the patient. At the same time of repairing the wound, the surgeons should not only consider the recovery of function and appearance but also consider the subsequent treatment of tumors and the postoperative quality of life of the patients. In recent years, with the continuous improvement of medical technology and people's living standards, the simple resection has been difficult to meet people's requirements; therefore, both doctors and patients pay more and more attentions on how to more reasonably and beautifully carry out repair and reconstruction and at the same time of removing the tumors.

14.2 Classification of Tumors in the Body Surface

There are many methods for classification of tumors in the body surface, which can be divided into benign tumors, malignant tumors and borderline tumors according to their pathological features, the tumors originated from epithelia and the tumors originated from mesenchymal tissue according to the histological origin, and tumors in facial region, tumors in body trunk, and tumors in limbs according to the different sites. The most commonly used classification method is adopted in this section; namely, the tumors in the body surface are divided into benign tumors, malignant tumors, and borderline tumors according to their pathological features.

The common benign tumors in the body surface include pigment nevus, hemangioma, lymphangioma, neurofibromas and neurofibromatosis, skin fibroma, lipoma, xanthoma, wart and sebaceous cyst, epidermoid cyst, and dermoid cyst. Common malignant tumors in the body surface include malignant melanoma, squamous cell carcinoma, and basal cell carcinoma. Some pigmented nevi have biological behaviors which are in a state between benign and malignant tumors and have a tendency of malignant transformation and are called the borderline lesions.

14.2.1 Common Benign Tumors in the Body Surface

1. Pigmented nevus is the most common benign tumor in the body surface. It usually consists of pigment nevus cells, and it is black due to the fact that the nevus cells contain melanin granules. At present, it is mainly considered that the pigmented nevus originates from the epidermal melanocytes. It can be divided into junctional nevus, intradermal nevus, and compound nevus according to its intradermal status.
2. Hemangioma. The hemangioma mostly appears in the head, face, and neck. It mainly consists of blood vessels which are expanded and proliferated or the clearance and sinus cavity which are filled with blood and have inner walls covered with endothelial cells, and the interval and support structures are constituted by fibrous tissue and adipose tissue. According to the clinical features, the hemangioma can be divided into capillary hemangioma, cavernous hemangioma, and racemose hemangioma.
3. Lymphangioma. The lymphangioma is a benign lymphatic hyperplasia, which consists of expanded lymphatic vessels with endothelial cell proliferation and the connective tissues. According to the pathological structure, lymphangioma fall into three types: capillary lymphangioma, cavernous hemolymphangioma and cystic lymphangioma.
4. Neurofibroma and neurofibromatosis. The neurofibroma is a benign tumor which originates from Schwann cells and perineurial cell in nerve fibers or peripheral nerve axon sheath, and it is more common in the skin tissue. The neurofibromatosis is a systemic disease with neurofibroma involving the skin, bones, central nervous system, and endocrine system.
5. Dermatofibroma. The dermatofibroma is a reactive hyperplastic lesion of the skin and is common in adults. It is more likely to appear in the places such as extremities, shoulder, and back. The lesion is mainly located in the corium layer, consisting of fibroblasts, histiocytes, and collagen fibers, and can be divided into fiber-type dermatofibroma and cell-type dermatofibroma according to their different contents.
6. Lipoma. The lipoma originates from the adipose tissue and is a common benign tumor consisting of mature adipocytes. It is mostly comprised of single or multiple flat clumps of varying sizes, and it is segmented into multiple fronds by partitions composed of fibrous tissue.
7. Xanthoma. The xanthoma is briefly called as yellow tumor, and it is a benign tumor consisting of lipid-filled tissue cells and giant cells containing foam in cytoplasm.
8. Skin cysts. The skin cysts include sebaceous cyst, dermoid cyst, and epidermoid cyst. The sebaceous cyst refers to the common cyst formed through aggregation of secretions in sebaceous gland after blocking of sebaceous glands duct and is also known as atheroma or steatoma, and it is more common in young people with their sebaceous glands secreting exuberantly. The dermoid cyst is a relatively rare cyst formed by epidermal cells; it is a congenital cyst formed in the process of embryonic development; when fused with the groove, the epidermal cells are drawn into the groove by mistake and then form into the dermoid cyst along the embryonic closure line deviating from the in situ position. It is also known as traumatic epidermal cyst, epidermal cyst, or epidermal inclusion cyst and is formed usually due to the fact that the posttraumatic foreign body pierces through the skin, and then the scurfs pass through the wound into the subcutaneous tissue and grow slowly.

14.2.2 Common Malignant Tumors in the Body Surface

1. Basal cell carcinoma. The basal cell carcinoma is also known as basal cell epithelioma. It is a low-grade malignant tumor of epidermal basal cells or skin attachment which often occurs in hairy parts of the body, and it mainly consists of interstitial-dependent pluripotent basal-like cells.

2. Squamous cell carcinoma. The squamous cell carcinoma is briefly called as squamous carcinoma and is also known as epidermoid carcinoma or prickle cell carcinoma. It is a malignant tumor originated from the epidermis or adnexal keratinocytes, and the cancer cells tend to have different levels of diversification.

3. Malignant melanoma. The malignant melanoma is a highly malignant tumor originated from skin melanoma cells. It can occur in sites such as the skin, eye, gastrointestinal tract, and reproductive system, but the cutaneous malignant melanoma is the most common.

14.3 Surgical Resection of Tumors in the Body Surface

14.3.1 The Aesthetic Requirements for Incision Design

After surgical resection of tumors in the body surface, the scars are inevitably caused in the process of wound healing.

Selecting the appropriate incision can minimize scar formation, so as to achieve a satisfactory aesthetic effect. The incision scar formation is mainly affected by the following factors: (1) the individual physical constitution of the patient, (2) the characteristics of the skin in different body parts, (3) the incision tension, (4) the incision direction, (5) other local or systemic conditions, and (6) the surgical operating technique.

If the incision designs in the same part of the body are different, the postoperative results will also be quite different, of which, the wound tension will be mostly affected; therefore, the design of the surface incision should follow the following principles:

1. Incision direction. The incision should go along the direction of skin cleavage lines or wrinkles, and the surgical incision should be parallel to the skin tension lines, namely, the direction of skin cleavage lines. The skin tension lines were first discovered by Dupuytren, and Langer described them; therefore, the skin cleavage lines are also called Langer's lines. The direction of facial wrinkles is often parallel to the skin tension lines while perpendicular to the direction of the expression muscle. Therefore, the tension of the incision going along the facial wrinkles is also smaller (Fig. 1.1).

Fig. 1.1 Selected incision directions for lumpectomies in different parts of the face

2. Incision position. The incision is designedly placed in the hidden place as far as possible; thus, the postoperative scar can be well hidden. For example, the incision of the breast lump resection is placed in inframammary fold, beside the areola or armpit, and thus the postoperative scar is difficult to be found.
3. Incision shape. The incision shape also has an important impact on the postoperative appearance. The incision which can be drawn close and sutured is generally designed into the shape of long spindle, so as to avoid the formation of "cat ear" during suturing which affects the appearance.
4. Avoid the formation of linear incision across the joint. When the incision needs to cross the joint, it should be designed into Z-shape to avoid the formation of linear incision, in order to prevent the postoperative scar contracture which affects the joint function.

14.3.2 Resection Scope

For benign tumors in the body surface, such as pigmented nevus with a larger area, the fusiform excision can be first performed in a small area, and then the fractional resection will be performed every 3–6 months until the lesion is excised completely. For borderline tumors such as junctional nevus, the tumor excision should be completed at one time to avoid the canceration of the residual tumor due to surgical stimulation. The extended resection should be performed for malignant tumors in the body surface, and even the regional lymph node dissection may be carried out. The resection scopes are different according to different malignant degrees of the tumors. For example, the resection scope of the basal cell carcinoma with a low degree of malignancy is required to exceed 1.0–1.5 cm of normal tissue, and the resection depth should reach the deep fascia; the resection scope of skin squamous cell carcinoma should be limited to the area around the lesions at 0.5–2.0 cm within the normal tissue and the depth which can guarantee the extensive resection is appropriate; the melanoma with a high degree of malignancy and without lymph node metastasis should be resected to an area at 1.5–3.0 cm around the lesions, and the depth should reach to the deep fascia, while the malignant melanoma of the extremities often requires amputation.

14.3.3 Suture Method

The suture technique is another important factor in relation to the postoperative aesthetic effect. The subtle stitching and the good alignment of the tissues can effectively reduce the formation of postoperative incision scar. According to different needle inserting methods, the suture methods can be divided into simple interrupted suture, vertical mattress suture, horizontal mattress suture, continuous subcutaneous suture, half-buried horizontal mattress suture, continuous suture, skin stapling suture, and application of incision adhesive (Fig. 1.2).

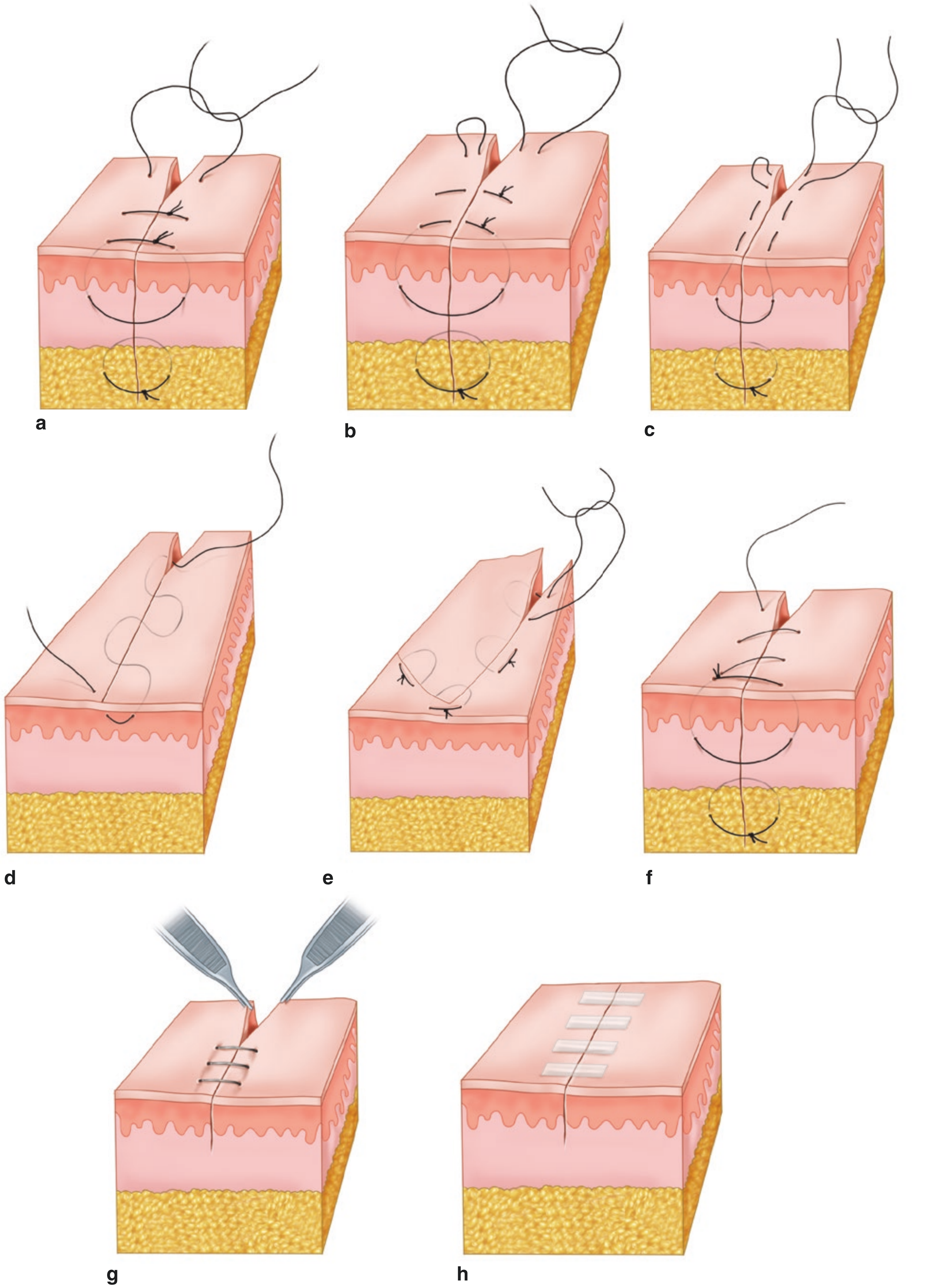

Fig. 1.2 Different surgical incision suture methods. (**a**) Simple interrupted suture. (**b**) Vertical mattress suture. (**c**) Horizontal mattress suture. (**d**) Continuous subcutaneous suture. (**e**) Half-buried horizontal mattress suture. (**f**) Continuous suture. (**g**) Skin stapling suture. (**h**) Application of incision adhesive

1. Simple interrupted suture. The simple interrupted suture is the most commonly used suture method in plastic surgery. The key point of the suture is that the needle should be inserted into the skin at a certain angle, so that the sutured tissue width in the base of the incisal margins is greater than the width between the needle entrance point and the needle exit point. The cross section of the sutured tissue generally has a trapezoid-like shape with narrow top and wide bottom, so that the incision after tying the knots is slightly valgus. The needle inserting depths should be the same on both sides of the incision to prevent the incisal margin varus. The needle distance is generally 5–7 mm, and the distance between the needle entrance point and the incisal margin is generally 3–5 mm, but it should be adjusted according to the tension at the suture site and the silk thread thickness.
2. Vertical mattress suture. The vertical mattress suture is most commonly used for incisions requiring skin edge eversion and incisions which cannot be sutured close with simple interrupted suture. It should be noted that if the stitches are not taken out early for vertical mattress suture, the obvious scars will remain.
3. Horizontal mattress suture. The horizontal mattress suture is commonly used for circumstances requiring skin edge eversion, especially for thicker smooth places (such as the foot and the palm side of the hand).
4. Subcutaneous suture. The subcutaneous suture may also be divided into continuous subcutaneous suture and intermittent subcutaneous suture. In the process of continuous subcutaneous suture, it should be noted that the needle is made to go horizontally through the dermis, and it is needed to ensure that both sides of the incision is sutured at the same level, which can make wound closed smoothly. Subcutaneous suture can avoid the scars caused by suture threads left on the skin surface, but it cannot be used for incisions with a larger tension force.
5. Half-buried horizontal mattress suture. This suture method can make thread knots only in one side of the incision to ensure that no scar is formed in the other side. For example, the incision beside the areola can be selected during breast lumpectomy, and the thread knots can be made in the areola area rather than in the side of the skin, which can make the postoperative scars well hidden.
6. Continuous suture. The advantage of this suture is to save time, but the alignment accuracy of the incision with this method is inferior to that with the interrupted suture. Sometimes, the continuous suture can be combined with locking stitch suture, which can produce a certain pressure on the incisal margin and play a role in hemostasis.
7. Skin stapling suture. The use of skin stapling suture can achieve good alignment of the wounds to avoid varus, while it can also save operation time. However, the skin stapling suture is commonly used for wounds in the surface layer of the skin, and it is still needed to use the interrupted suture method to reduce tension for wounds in the deep tissues. The skin stapling suture can also be used for the incision after the stitches have just been taken out newly to strengthen protection against wound dehiscence.
8. Application of incision adhesive. The incision adhesive and the incision paste can be used for incisions without tension or for incisions using the interrupted suture in deep tissues to fully reduce tension and have good alignment.

14.4 Repair and Reconstruction After Resection of Tumors in the Body Surface and Their Aesthetic Characteristics

Some tumor surgeries often require a wide range of resection, so that the postoperative residual wound cannot be directly drawn close and sutured, or even the wound is effectively closed, the destruction of the lesions and the surgical resection lead to serious damage or deformity of the local function and appearance, which will bring a heavy psychological burden to patients, and seriously affect the qualities of life of patients. Therefore, it is required that the oncoplastic surgeons must have a careful planning in the implementation of any tumor surgeries and fully consider the postoperative reconstruction of the local function and appearance, especially the anatomical reconstruction of the surface subunits, which is expected to achieve the purpose of radically curing the tumors and restoring the function and appearance.

14.4.1 The Selection Principles for Repair and Reconstruction Method

1. Prefer simple rather than complicated. Even for the same lesion, the repair and reconstruction methods are also varied. For example, a pigmented nevus with a small area in facial area can be treated by all methods such as serial partial excision, skin graft, and skin flap graft. Therefore, we need to develop a relatively simple therapeutic regimen with a lower degree of damage under the premise of comprehensively evaluating the treatment effects and surgical risks.
2. From near area to far area. It is often necessary to repair the wounds after resections of tumors in the body surface by the transfer of autologous tissue. Compared with the distal tissues, the adjacent tissues have a similar color and texture, while the repair by transfer of local adjacent tissues avoids the need of additional surgical site and reduces the risk of surgery in different degrees, so it is the preferred tissue transplantation.
3. Personalized design. The reasonable and effective surgical methods are designed according to different ages, genders, and local tissue structures of the lesions.
4. Pay attention to both function and appearance. At the same time of focusing on appearance repair, we should take into account the functional reconstruction. For example, after nasal tumor resection, it is not only needed to restore good nasal appearance but also needed to rebuild

the airway and restore the function of the external nose; after the resection of tumors in the bottom of the feet, the transplanted tissues should not only cover and close the wound but also have wear-resistant and good pressure-bearing capabilities.

14.4.2 Wound Closure

The appropriate surgical resection and repair plan should be developed before surgery according to the size and location of the lesion and the function and appearance requirements. The smaller lesion can be resected at one time or several times, and the wound is directly drawn close and sutured; the wounds which cannot be directly drawn close and sutured can be repaired by selection of methods such as skin soft tissue expansion, skin graft, skin flap graft, fascia flap graft, and myocutaneous flap graft. Each method has its advantages and disadvantages; the oncoplastic surgeons should select one or more methods according to the specific circumstances of the operation.

1. Simple resection and fractional resection. After it is confirmed that the surgical resection is taken as the therapeutic regimen of superficial tumors, the pinch-an-inch test of the skin can be performed to understand the elasticity and tightness of local skin of the tumor before surgery. If the scope of the lesion is smaller and the skin is loose, the fusiform or rhomboid incision can be designed to resect the lesion directly; if the resection scope is larger, a single direct resection may cause local tight skin and local tissue traction, thus affecting the appearance or function. Therefore, the fractional resection can be selected and performed at intervals of 3–6 months or even longer, so that the skin can achieve the result of external expansion under mechanical traction and ultimately only a small amount of linear scars are left. The fractional resection has the following advantages: The operation method is simple, it needs no special material and equipment, the skin has small changes after repair, the displacement of tissues and organs is small, and ultimately only the linear scars are left. But the fractional resection is not suitable for the following two situations: (1) The lesion scope is too large, the skin ductility is poor, and the wound after resection is difficult to be directly closed and repaired; (2) the tumor is malignant or because the repeated surgical stimulations are not conducive to the primary diseases.
2. Skin graft. The skin graft can be divided into blade-thickness skin graft, middle-thickness skin graft, full-thickness skin graft, and the skin graft with subdermal vascular network according to the thickness of the skin graft. The blade-thickness skin graft and middle-thickness skin graft are more commonly used in oncoplastic surgery, of which the blade-thickness skin graft is easy to cut and obtain, its survival rate is high, and the healing is faster; its advantages include that it lacks the flexibility, is prone to contracture after transplantation, and is not resistant to friction, the color is deep and dark, and the appearance is poor. The elasticity and toughness of the middle-thickness skin graft are stronger than those of the blade-thickness skin graft, and the middle-thickness skin is not prone to contracture and has a good appearance, but there are scars in its donor site, the requirement for wounds on the transplanted area is relatively high, and the survival rate is inferior to that of the blade-thickness skin graft. Comparing the two, the middle-thickness skin graft can achieve better wound healing and aesthetic effect, and it is more commonly applied in oncoplastic surgery.

Due to the racial and individual differences, the color shading and circular surgical scar will often appear in the local skin after transplantation of skin grafts, and the aesthetic effect of defect repair after lesion excision is greatly reduced. Therefore, it is currently not recommended as a first choice. However, it still has an application value in some clinical cases with large area surface defects who can't tolerate major surgical trauma. The aesthetic key points for skin graft donor site selection include: (1) Select the skin grafts from the local area to distal area; namely, the skin grafts to be transplanted should be selected preferably in the area near the lesion. For example, the area behind the ear can be selected as donor site for repair of head and face defects, and the groin area can be selected as donor site for repair of trunk defects, and the inside of the upper arm can be selected as donor site for repair of limb defects, so that not only does the transplanted skin graft have similar color and texture with the local skin in donor site but also is the location of the donor site secluded. (2) Select the thick skin graft first and then thin skin graft; namely, the full-thickness skin graft which has small color change and low degree of contracture after transplantation is selected preferably, if its sources are limited, and then the middle-thickness skin graft which is relatively thin will be selected, and the blade-thickness skin graft is often used as a last resort. The skin graft transplantation (especially in the head and face) should follow the principles of segmental skin graft (Fig. 1.3) in order to achieve better repair effect.

3. Skin soft tissue expansion. Since the American plastic surgeon Radovan et al. developed the first skin soft tissue expander in 1976, the skin soft tissue expansion began to be widely used in plastic surgery. Compared with skin graft transplantation and skin flap transfer, the biggest advantage of skin soft tissue expansion is that it can provide excessive skin with texture and color similar to the area around the site to be repaired within a short time and can perfectly repair the wound and cause no secondary damage in donor site. Especially in recent years with the development of prefabricated skin flap and the progress in the technique of flap prefabrication, the random pat-

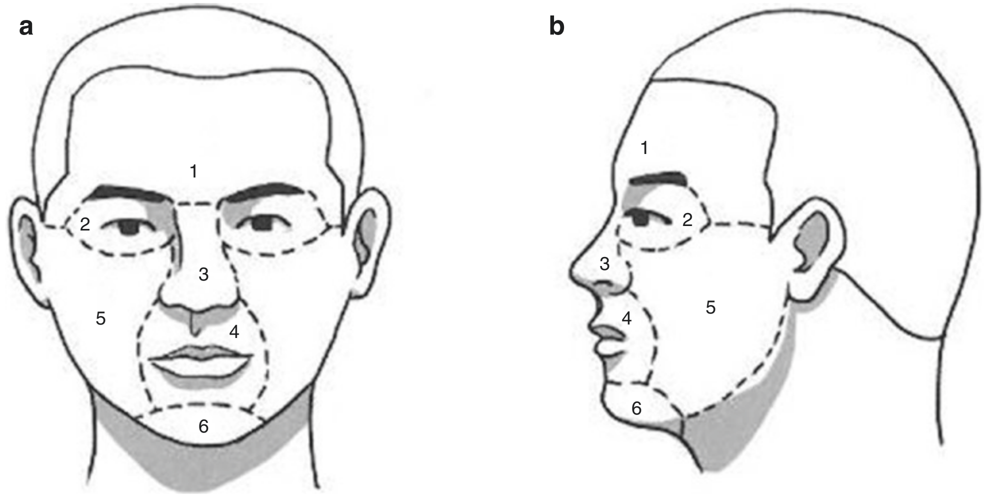

Fig. 1.3 Partition diagram of the facial area. *1*. Frontal area. *2*. Eyelid area. *3*. Nasal area. *4*. Lip area. *5*. Cheek area. *6*. Chin area. (**a**) Front view (**b**) Lateral view

tern skin flap is transformed into the axial pattern skin flap after expansion, which has greatly increased the survival rate of the skin flap and has also expanded the flexibility of skin flap design, so that the expansion technique has a wider application range in the clinical treatment. Because the skin soft tissue expansion requires a period for skin expansion, it is most commonly used for primary repair after resection of benign tumors in the body surface and the second-stage repair after radical resection and comprehensive treatment of malignant tumors. The specific application of skin soft tissue expansion is shown in Chap. 20.

4. Skin flap graft. The skin flap is composed of the skin and its attached subcutaneous tissue with blood supply. In the process of repair of skin and soft tissue defects, the free skin graft and the skin flap graft are the two kinds of methods which are most commonly used. Since the skin flap itself has a blood supply and also has a certain thickness, it has a greater application value in many areas. The skin flap is commonly used to repair the wounds with the exposure of important tissues such as bones, joints, blood vessels, and nerve trunks which cannot be directly drawn close and sutured or used in a situation without the exposure of deep tissue defects, which only aims to obtain a satisfactory therapeutic effect in appearance and function. The organ reconstruction requires the transplantation of support tissue on the basis of skin flap graft. The penetrating defects in areas such as the face, cheek, and upper jaw need to be covered by the skin flaps with a rich blood supply. The chronic ulcer wounds, especially the radiation-induced ulceration wounds, also need to be repaired by skip flap graft with blood supply flap. Therefore, the applications of skip flaps are the most basic repair means in oncoplastic surgery.

Similar to selection of the skin graft donor sites, the local skin flap near defects should be preferably selected and designed, and sewing up the incision after harvesting the skin flaps should follow the principles of the abovementioned incision design as far as possible. If the flap donor site wounds are difficult be closed at one stage, the skin soft tissue expansion can be jointly used to reduce secondary injury of the donor site. For more superficial tissue defects, the thickness of the skin flap should be trimmed at the same time of skin flap transplantation or at second stage to avoid the occurrence of bloated appearance, but it is needed to carefully protect the structures for blood supply such as accompanying vessels or subdermal vascular network.

According to their blood supply characteristics and transfer methods, the skip flaps are generally divided into two broad types: random pattern skin flap and axial pattern skin flap. The preparation and characteristics of all kinds of skip flaps and clinical indications are shown in Chap. 3 All Kinds of Commonly Used Tissue Flaps.

(1) Random pattern skin flap: The random pattern skin flap is also known as random flap. This type of skin flaps doesn't contain axial type vessels. Their blood supplies are provided by only dermal vascular network and subdermal vascular network, sometimes by subcutaneous vascular network (Fig. 1.4a). According to their transfer methods, the random pattern skin flaps can be divided into three categories such as local skin flap, ortho-position skin flap, and distant skin flap. The local skin flaps can be divided into three kinds of skin flaps including sliding skin flap, rotation skin flap, and transposition skin flap.

(2) Axial pattern skin flap. The axial pattern skin flap is also known as arterial skin flap; namely, the skin flap contains the well-known artery and accompanying venous system, and the blood vessels are used as the axis of the skin flap, so that it is parallel to the long axis of the skin flap. According to their blood supply and transfer mode, the following types are available

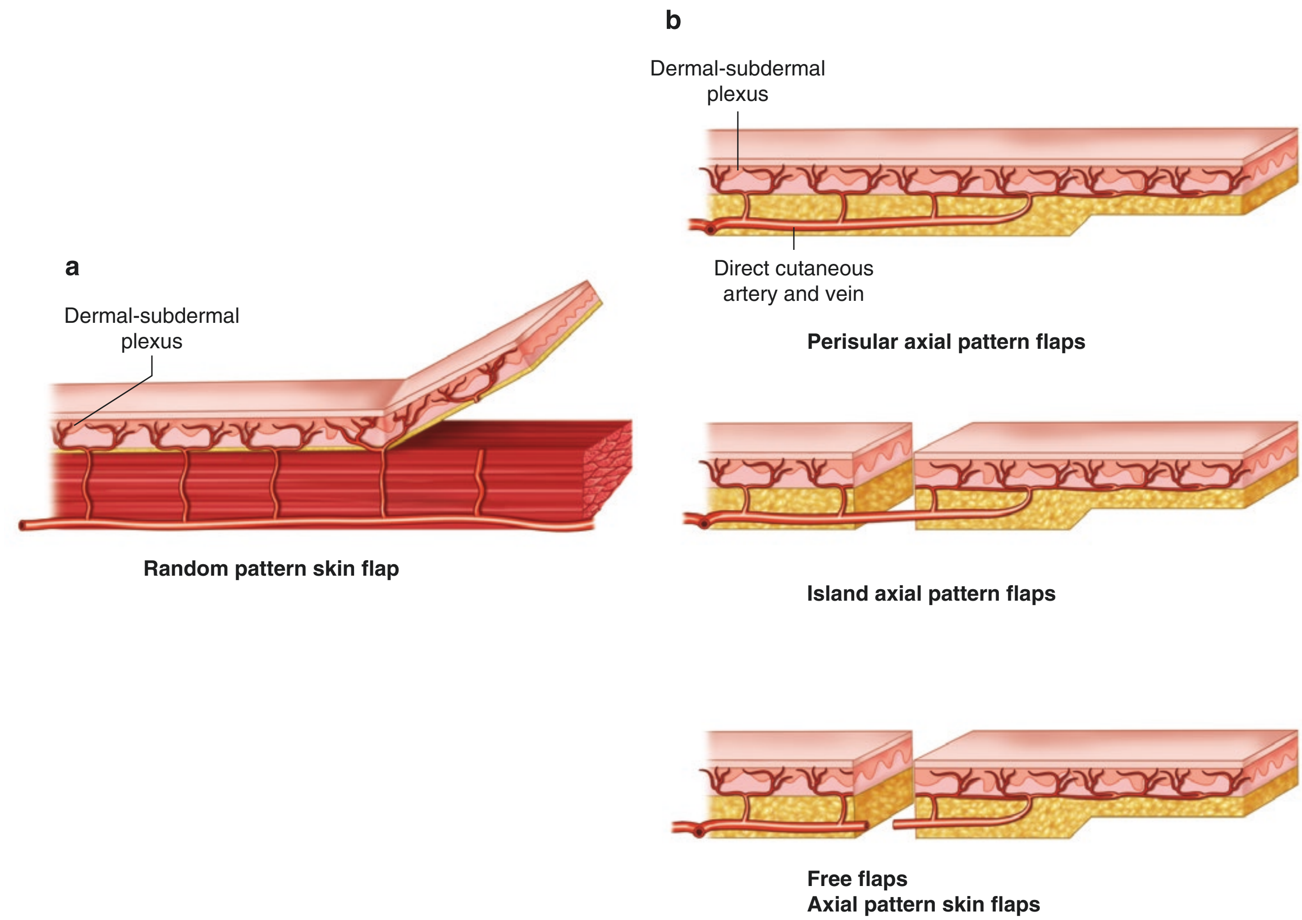

Fig. 1.4 The blood supply of the skin flap. (**a**) The blood supply of random pattern skin flap. (**b**) The blood supply of the axial pattern skin flap

for selection: arterial skin flap, island skin flap, reverse island skin flap, free skin flap, tandem skin flap, parallel skin flap, vascularized skin flap, and venous skin flap (Fig. 1.4b). Of which the free axial pattern skin flap needs to be prepared using microsurgical techniques, and the specific operations and requirements are detailed in Chap. 2 Microsurgical Techniques.

5. Fascial flap transplantation. The fascial flap transplantation is a new type of tissue flap transplantation developed on the basis of the fascia skin flap transplantation. Its main advantages are that the fascial flap has rich blood supply, the donor site can keep the skin, the appearance of the skin flap donor site is not affected, the fascial flap is thinner, and the receptive site will not be bloated with good function and appearance; its main disadvantage is that the defect area still needs skin grafting for wound closure. The surgical methods can be divided into two categories such as pedicled fascial flap transplantation and free fascial flap transplantation according to their transplantation methods. The preparation and characteristics of all kinds of fascial flaps are introduced in detail in Chap. 2 All Kinds of Commonly Used Tissue Flaps.
6. Myocutaneous flap transplantation. The myocutaneous flap is a composite tissue flap; namely, a piece of muscle or part of the muscle of the body with its superficial subcutaneous tissue and skin is harvested and transplanted. The myocutaneous flap has a rich blood supply and a strong resistance to infection, and it is suitably used for repair of larger wound defects because of its large volume and relatively great thickness. The myocutaneous flap with blood vessels and nerves can be used for functional reconstruction of local muscles due to its retention of muscle contraction function. According to its blood supply and transfer method, the myocutaneous flap can be divided into three categories such as pedicled myocutaneous flap, island myocutaneous flap, and free musculocutaneous flap with vascular anastomosis. The preparation and application of various myocutaneous flaps will not be repeatedly presented here.

14.4.3 Functional Reconstruction

The radical resection of tumors in the body surface cannot only lead to serious defect or deformity in the local appearance but also is more likely to directly affect the organ function. The direct invasion of the tumors or the extended resection may lead to the injuries of the local bone, joints, muscles, nerves, and blood vessels, and the functional reconstructions of these important tissues are also the constituent parts in the process of aesthetic reconstruction of organs.

1. Bone and cartilage transplantation. After extended resection of some bone tumors, the local appearance and support function of the bone can be reconstructed through autologous or allogeneic bone and cartilage transplantation to achieve the purpose of restoring the aesthetic appearance and support function.
   (1) Cartilage transplantation: The cartilage can be divided into three types such as hyaline cartilage, elastic cartilage, and fibrous cartilage. The hyaline cartilages are mostly located on the joint surfaces and form into bony supports in the pharynx, trachea, nose wing, and nasal septum; the elastic cartilages are mostly located in soft sites with supporting role, such as the external ear, epiglottis, and pharynx. The hyaline cartilage and elastic cartilage are usually used for transplantation or used in sites requiring reconstruction in plastic surgery, such as auricular and tracheal reconstructions. There is no vascular structure inside the cartilage, and its cellular metabolic function is poor, but the cartilage can survive after transplantation through absorbing the nutrition in the surrounding tissues, and it will be integrated with the surrounding tissue to form into fibrous or fibrous bone healing about 2 months later. The commonly used donor sites of cartilage include the auricle, costicartilage, and nasal septum cartilage.
   (2) Autogenous bone transplantation: The bone defects can be repaired to reconstruct the appearance or support function through bone transplantation. The bone block without vascular pedicle can establish blood circulation to receptor site and survive within a period of time after transplantation, and it usually takes several months to reconstruct the blood supply to the dense bone after transplantation, while it is observed that the blood vessels grow into the cancellous bone at 2–3 days after transplantation. The most commonly used donor sites of autogenous bone transplantation including the ilium and ribs, fibula, tibia, and tabula externa ossis cranii can also be used as a bone graft material. The bone graft with vascular pedicle is also known as the bone flap graft, and because it has blood supply from inherent blood vessels, it can be combined with muscle and skin to form into composite tissue flap to repair the complex defects.
   (3) Allogeneic bone transplantation: The allogeneic bone transplantation after the removal of antigen can be used to repair a wide range of bone defects, and the transplanted allogeneic bone can be taken as a scaffold for mesenchymal stem cells and osteoblast to adhere and proliferate to form into new bones, which eventually replace the allogeneic bone through crawling and substituting method.
2. Muscle transplantation. The muscle transplantation generally refers to the transplantation of skeletal muscle and can be used to reconstruct the contraction function of local muscles. The muscle transplantation can be divided into three types according to its blood supply and transplantation mode: free muscle transplantation, pedicled muscle transplantation, and muscle transplantation with vascular and neural anastomosis. Of which, the free muscle transplantation has no inherent blood supply within the transplanted muscle, and it can easily lead to the fibrosis and infected necrosis of the transplanted muscle and thus is rarely used. The pedicled muscle transplantation and the muscle transplantation with vascular and neural anastomosis are more commonly used; since the blood supply and nerves of the muscles are retained, the transplanted muscles have good contraction function, so that the movement function of the defect site can be reconstructed. Except for reconstruction of local movement function, the muscle flap can also be used for filling and repair of local defects, which has significant anti-inflammatory functions due to the rich blood supply.
3. Blood vessel transplantation. If the vascular defect length is more than 1–2 cm, and the broken blood vessel can't be directly sutured after the distance between two broken ends is shortened, it is needed to carry out the blood vessel transplantation. Under normal circumstances, both arterial and venous defects are suitably repaired with autologous veins from the body surface. The more commonly selected donor blood vessels include cephalic vein, basilic vein and its tributaries, dorsal venous networks of hand and foot, great and small saphenous veins, their tributaries, etc. In addition to bypass transplantation, the methods of blood vessel transplantation include T-shaped transplantation, Y-shaped transplantation, and patch transplantation (Fig. 1.5).
4. Nerve transplantation. The tumor invasion or surgical resection leads to peripheral nerve involvement or defect, and thus the local movement disorder and abnormal sensation occur due to loss of innervation; if the nerve defect is more than 2–3 cm, it can be repaired with nerve transplantation.

In order to achieve the optimum efficiency of nerve repair, the tension-free repair of the defects after the removal of the affected nerve segment should be performed at one stage as far as possible. In the presence of tension, the anastomosis with shortening the distance between the two broken ends of

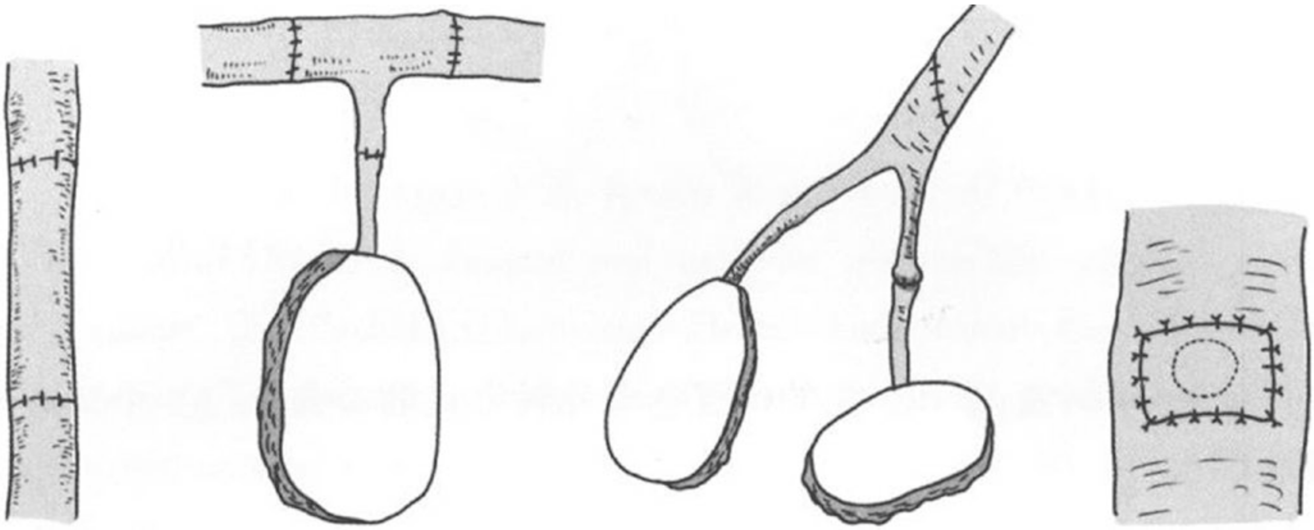

Fig. 1.5 Methods of blood vessel transplantation. (**a**) Bypass transplantation. (**b**) T-shaped transplantation. (**c**) Y-shaped transplantation. (**d**) Patch transplantation

the nerve should be avoided. At this time, it is suitable to use the free nerve transplantation in end-to-end anastomosis for repair of the nerve defects, so as to ensure a tension-free anastomosis. In addition, when repairing the nerve defects, we shall also be careful about the difference between sensory nerves and motor nerves to ensure that the corresponding nerve ends can be correctly anastomosed as far as possible. When the anatomical structure of the nerve bundle is not clear, it can also be repaired through anastomosing the membranes of nerve bundle, and finally the postoperative movement and sensory exercises are used to improve the efficacy of repair.

In the nerve transplantation, the sural nerve is most commonly selected as the donor site. The sural nerve in adults can provide a nerve segment of up to 30–40 cm, and the communicating branch of the sural nerve can also provide a nerve segment of 10 to 20 cm when a greater amount of nerve transplantation is needed. A new nerve transplantation occurs in recent years, which is called nerve implantation, including motor nerve implantation and sensory nerve implantation. The motor nerve implantation is to implant the adjacent motor nerve branch into the muscles without innervation to restore their motor function, and it has been proved that the new motor endplate can be regenerated. The sensory nerve implantation is to implant the sensory nerve into the skin without innervation and the skin flaps with poor sensory function to restore the sensation of local skin or skin flap.

5. Application of various types of biological materials. The application of biological materials in the oncoplastic surgery is detailedly shown in the twelfth section of this chapter.

In summary, the aesthetic reconstruction after radical resection of superficial tumors should include two very important parts such as functional reconstruction and appearance reconstruction; the oncoplastic surgeons need to flexibly use the various repair methods under the guidance of principles for aesthetic plastic surgery, comprehensively considering the special requirements of tumor treatment, and do their utmost to restore the function and appearance of the surgical area, thus improving the qualities of life of tumor patients.

14.4.4 Regenerative Medicine and Aesthetic Reconstruction

It has long been noted that some of the lower animals such as salamanders and geckos can completely regenerate the defect within a short period after the body tissue or organ is injured, and the appearance and function of the tissue can be fully restored to pre-injury status. The extraordinary regenerative abilities of the lower animals deeply attract the attention of researchers. Some tissues in higher mammals also show the amazing regenerative abilities; for example, the human liver after partial hepatectomy can still recover to normal volume relying on the repair and regeneration of the remaining liver cells. Therefore, can the tissue and organ defects of the body surface caused by the trauma or tumor surgery be repaired through tissue regeneration? The proposed concepts of regenerative medicine and related researches attempt to answer this question [47–49].

The regenerative medicine refers to the science of studying the development of the body under normal conditions, the structural features and functions of the tissues, and the mechanism of tissue repair and regeneration after trauma, finding effective treatment methods on this basis, promoting the body's self-repair and regeneration or reconstructing new tissues and organs, and ultimately improving or restoring the structure and function of the damaged tissues and organs. The regeneration and repair of the tissues are the goals pursued relentlessly by the life sciences. In theory, the regeneration and repair of the tissues are highly matched with the original defect sites not only in cellular components and tissue structures but also in function and appearance, so as to achieve the best efficacy of repair, which is also the ultimate goal of the reconstruction of function and aesthetic appearance. In recent years, the research progresses in the fields of tissue engineering (see Chap. 22), and stem cells make people see the application prospects of tissue and organ reconstruction, and the repair and reconstruction research based on stem cells and tissue engineering has become a new direction in the field of plastic surgery [50–53].

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