Analysis of Outcome and Complications in 400 Cases of Microvascular Head and Neck Reconstruction

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Objective: To determine the incidence and causes of perioperative complications in patients who undergo microvascular free flap procedures for reconstruction of the head and neck.

Setting: Academic tertiary care medical center.

Patients and Methods: A total of 400 consecutive microvascular free flap procedures were performed for reconstruction of the head and neck, with 95% of the defects arising after the treatment of malignancies. Flap donor sites included radial forearm (n=183), fibula (n=145), rectus abdominis (n=38), subscapular system (n=28), iliac crest (n=5), and a jejunal flap. Patient-related characteristics (age; sex; diagnosis; comorbidity level; tumor stage; defect site; primary vs secondary reconstruction; and history of surgery, radiation therapy, or chemotherapy) and the incidence of perioperative complications were recorded prospectively over a 7-year period.

Results: The perioperative mortality was 1.3%. Overall, perioperative complications occurred in 36.1% of all cases. Free flaps proved to be extremely reliable, with a 0.8% incidence of free flap failure and a 3% incidence of partial flap necrosis. Perioperative medical complications occurred in 20.5% of cases, with pulmonary, cardiac, and infectious complications predominating. Multivariate statistical analysis showed significant relationships between the incidence of perioperative complications and preoperative comorbidity level as indicated by American Society of Anesthesiologists (ASA) status ($P = .02$).

Conclusions: The present study confirms that free flaps are extremely reliable in achieving successful reconstruction of the head and neck. The incidence of perioperative complications is related to preoperative comorbidity level.

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Free tissue transfers have become the preferred reconstructive technique at many oncology centers to repair complex defects of the head and neck. Current experience demonstrates that microvascular free tissue transfer frequently allows for reliable, single stage, and immediate reconstruction in this patient population.[1] However, because the use of these flaps permits advanced tumors to be more aggressively treated by surgery in a patient population with a high prevalence of coexisting illnesses, complications are not uncommon.

The aim of this study was to assess the incidence and causes of complications in patients undergoing microvascular free flap reconstruction for surgical defects of the head and neck. We identified the variables that influence both medical and reconstructive complications by analyzing a series of 400 consecutive free flap reconstructions performed over a 7-year period at a single academic center. To our knowledge, the present report comprises the largest detailed analysis of complications associated with microvascular head and neck reconstruction to date.

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METHODS

A single senior surgeon (K.E.B.) performed 400 free flap procedures in 388 patients (253 men and 135 women, ranging in age from 19 to 90 years) between 1995 and 2002 for reconstruction of wounds in the head and neck region. Of the 388 patients, 376 received 1 free flap, 1 received 2 simultaneous free flaps for reconstruction of a substantial through-and-through oromandibular defect, and 11 received 2 sequential flaps to treat recurrent cancer (7 cases) or cases of reconstructive failure (4 cases). Ninety-five percent of the defects arose as a result of the treatment of malignant neoplasms of the head and neck region; 37% of the reconstructions were done in patients with a medical history of high-dose external beam radiation therapy to the reconstruction site; 5% of the free flaps were used to reconstruct traumatic or congenital defects or defects from excision of benign neoplasms of the head and neck; and 85% of the defects involved the oral cavity and/or oropharynx, while 8% involved the skull base or midface and 7% were defects of the pharyngoesophageal segment.

Since the patents in the present series were treated at teaching hospitals, most of the flap harvests, flap insettings, and microvascular anastomoses were performed by residents and fellows in otolaryngology–head and neck surgery acting as first assistant surgeons, although all such activities were directly supervised by one of the authors (K.E.B.). All patients were anticoagulated using intraoperative topical irrigation of the donor and recipient vessels using heparinized saline solution and postoperative systemic aspirin, 81 mg/d for 7 days, unless contraindicated by heparin or aspirin allergies. Postoperative flap monitoring was done using transcutaneous Doppler stethoscope detection of the flap's arterial pulse and visual inspection of the flap's skin paddle, in cases for which the skin paddle was accessible. Routine flap monitoring was done on an hourly basis equal to the postoperative day number by the nursing staff, on a twice-a-day basis by the house staff physicians, and on a daily basis by the attending physicians.

The free flaps selected for reconstruction are listed below.

Flap Donor Site	No. Performed
Radial forearm flap	183
Fibula flap	145
Rectus abdominis flap	38
Subscapular system flap	28
Iliac crest flap	5
Jejunal flap	1

Cervical recipient blood vessels were used for free flap perfusion in all cases. Only 1 case required use of an interposition saphenous vein graft. This was a jejunal free flap used for total esophageal reconstruction in a patient with complications arising after treatment of a congenital tracheoesophageal fistula. In this patient, branches of the thyrocervical trunk were not available owing to previous surgical procedures, and a vein graft was needed to lengthen the arterial pedicle to reach a recipient vessel arising from the external carotid artery.

Data were recorded prospectively using a personal computer–based database. Patient characteristics that were analyzed included age; sex; comorbidity level according to the American Society of Anesthesiology (ASA) status; pathologic diagnosis; history of radiation therapy, surgery, neck dissection, or chemotherapy; tumor T stage; tumor N stage; malignant vs benign pathology; defect classification (oral/oropharyngeal, pharyngoesophageal, or skull base/midface defects); and free flap type. The main outcome measures were complications occurring within 30 days of surgery. Complications were further subcategorized as reconstructive complications or medical complications. Reconstructive complications were defined as those having a direct impact on the flap donor site wound or on the flap recipient site wound. Medical complications were categorized by affected organ system, which are listed in **Table 1**.

Statistical analysis was done using SPSS statistical software (SPSS for Windows Version 11.0.1; SPSS Inc, Chicago, Ill). Univariate statistical analysis was performed using the χ^2 and 2-tailed *t* test methods. Of those factors showing statistical significance on univariate analysis, multivariate analysis using logistical regression was then undertaken. $P<.05$ was considered statistically significant.

RESULTS

The perioperative mortality was 1.3% (5 of 399 surgical procedures performed). One patient died 10 days after undergoing iliac crest flap oromandibular reconstruction. He experienced an intraoperative tension pneumothorax that resulted in a severe anoxic brain injury. Two additional patients died during their initial period of hospitalization, with one experiencing liver failure and the other, myocardial infarction. Two patients died shortly after hospital discharge, during the 30-day perioperative period. One death was attributed to a pulmonary embolism, while the other was attributed to a tracheotomy tube mucous plug, which occurred in the patient who had been transferred to a nursing home.

Table 1. Perioperative Medical Complications in 399 Surgical Procedures

Medical Complication	No. (%) of Occurrences
Respiratory	40 (10.0)
Cardiac	31 (7.8)
Infectious	30 (7.5)
Gastrointestinal	16 (4.0)
Hematological	15 (3.8)
Neurological	6 (1.5)
Psychiatric	6 (1.5)
Genitourinary	4 (1.0)
Vascular	4 (1.0)
Integumentary	4 (1.0)
Endocrine	3 (0.8)
Perioperative death	5 (1.3)

Seven cases required urgent surgical reexploration for clinical evidence of vascular flap compromise. Two cases of venous anastomotic thrombosis, which occurred on postoperative days 2 and 4, and 1 case of arterial anastomotic thrombosis, which occurred on postoperative day 1, were not successfully salvaged despite reexploration and thrombolytic therapy. One case of arterial insufficiency was corrected on postoperative day 4, when a microarterial anastomosis created under excessive tension ruptured after a change in head position. One case of venous congestion was corrected on postoperative day 5 by draining a cervical hematoma, which arose after heparin anticoagulation was initiated during the workup for a suspected pulmonary embolism. Another case of flap venous congestion was corrected on postoperative day 2 by draining a neck hematoma that resulted from an unrecognized laceration of an anterior jugular vein. An additional case of venous congestion caused by neck drain compression of the flap's venous pedicle was corrected on postoperative day 4 by drain repositioning. Overall, the rate of successful salvage of ischemic free flaps by urgent surgical reexploration was 57% (4 of 7 cases). The overall rate of free flap failure due to microvascular thrombosis was 0.8% (3 of 400 cases).

Perioperative complications occurred in 144 (36.1%) of 399 surgical procedures. Reconstructive complications occurred in 76 (19.0%) of 399 surgical procedures, while medical complications occurred in 82 of 399 surgical procedures (20.6%). Specific medical and reconstructive complications are listed in Table 1 and **Table 2**, respectively. Among the medical complications, respiratory, cardiac, and infectious complications predominated, with the incidence of all other types of medical complications being less than 5%. The 2 most common medical

Table 2. Perioperative Reconstructive Complications in 400 Free Flap Procedures

Reconstructive Complication	No. (%) of Occurrences
Delayed healing of flap donor site wound	23 (5.8)
Necrosis of native facial or neck skin	13 (3.3)
Partial free flap necrosis	12 (3.0)
Wound infection	11 (2.8)
Salivary fistula	11 (2.8)
Cervical hematoma	9 (2.3)
Total free flap necrosis (flap failure)	3 (0.8)
Hardware extrusion	1 (0.3)

Table 3. Recent Series of Microvascular Head and Neck Reconstruction

Source	No. of Flaps	Flap Survival, %	Radial Forearm, Fibula, and Rectus Abdominis Flaps, % Total Cases Performed
Present series	400	99.3	91.5
Chalian et al,[3] 2001	156	99.4	91.7
Disa et al,[4] 2001	728	98.6	81.2

complications were pulmonary edema and supraventricular tachycardia. The most common reconstructive complication related to delayed healing of the flap donor site. This was frequently secondary to partial skin graft failure at the donor sites of radial forearm and fibula flaps.

Univariate statistical analysis showed a statistically significant relationship between the incidence of perioperative complications and the risk factor of ASA status (χ^2=18.31; P=.001). The incidence of perioperative reconstructive complications was associated with the risk factors of ASA status (χ^2=10.37; P=.04), previous surgery (χ^2=10.03; P=.02), defect type (χ^2=7.96; P=.02), and flap type (χ^2=18; P=.03). The incidence of perioperative medical complications was associated with the risk factors of ASA status (χ^2=16.70; P=.002), age (2-tailed *t* test; P=.03), and flap type (χ^2=15.77; P=.008). Other risk factors analyzed, including patient sex, pathologic diagnosis, history of radiation therapy, history of previous neck dissection, history of chemotherapy, T stage, N stage, and malignant vs benign pathology, had no demonstrable significant impact on the incidence of overall complications, reconstructive complications, or medical complications.

Multivariate analysis using linear logistical regression showed that previous surgery (P=.002) was the only significant risk factor of perioperative reconstructive complications. Patient age (P=.002) and ASA status (P=.04) were significant risk factors of medical complications after multivariate analysis.

COMMENT

Surgical treatment of patients with head and neck cancer was revolutionized during the 1970s with the development and clinical application of microvascular free flaps and pedicled myocutaneous flaps for head and neck reconstruction. Although free flaps were clinically used for head and neck reconstruction several years earlier than pedicled pectoralis major, trapezius, and latissimus dorsi myocutaneous flaps, free flaps remained in infrequent use for head and neck reconstruction during the next 10 to 15 years, largely owing to a perceived unreliability of this reconstructive technique, which relies on the successful creation of small blood vessel vascular anastomoses.[2] Questions regarding the reliability of microvascular free tissue transfers have largely been put to rest, since several recent clinical series of free flap reconstruction of the head and neck have documented that the incidence of perioperative free flap failure is as low as 1%.[3,4] The results of 3 large clinical series of microvascular head and neck reconstruction that have been recently published are summarized in **Table 3**, confirming their high degree of reliability.

A characteristic shared by these series and summarized in Table 3 is that radial forearm, fibula, and rectus abdominis flaps comprised most of those used for reconstruction of a wide variety of oral cavity, pharyngoesophageal, skull base, and facial defects. These commonly used free flaps share certain attributes that likely account for their high reliability. Radial forearm, fibula, and rectus flaps all have long vascular pedicles containing large caliber blood vessels. Microvascular anastomoses are much less prone to thrombosis when they have an external diameter that exceeds 1 mm,[5] and all of the flaps used in this series contained nutrient blood vessels with diameters that usually exceeded 2 mm. In addition, the use of free flaps that contain long vascular pedicles usually preludes the need to perform vein grafts. Jones et al[6] reported a statistically significant increased risk of perioperative free flap failure when interposition vein grafts were required in a series of 305 free flaps used for head and neck reconstruction. Likewise, the group at M. D. Anderson, Houston Tex, reported a statistically significant association between vein grafts and free flap failures in a series of 308 cases of head and neck reconstruction and in a larger combined series of 854 cases of breast or head and neck reconstruction.[7,8] Khouri et al[9] analyzed a multi-institutional experience with 493 free flaps and noted an increased incidence of flap thrombosis in cases that needed vein grafts. In the present series, heavily reliance on a few free flap donor sites that offered long vascular pedicles meant that a vein graft only had to be used in 1 of 400 cases. Vein grafts were unnecessary even in cases of microvascular flap reconstruction in patients with a medical history of prior neck dissection, despite the need to use recipient blood vessels within the contralateral neck within a substantial number of these cases.[10] Heavy reliance on flaps with long vascular pedicles containing large-caliber blood vessels was probably the most important single factor to account for the 99% success rate achieved in this series.

Previous series have reported other factors that may be associated with an increased risk of free flap failure in patients undergoing head and neck reconstruction. In analyzing 250 free flaps, O'Brien et al[11] reported an increased risk of flap failure in patients undergoing jaw reconstruction compared with reconstruction of other defects in the head and neck. In the present series, a similar phenomenon was observed. The incidence of free flap failure in 162 cases of vascularized bone-containing free flaps was 1.9% compared with no flap failures in 238 soft tissue flaps ($\chi^2=4.44$; $P<.05$). In our series, the 2% incidence of fibula flap failure proved to be statistically higher than the 0% incidence of flap failure seen with all other types of free flaps ($\chi^2=5.38$; $P<.03$). Other factors that have previously been reported to be associated with an increased risk of free flap failure include preoperative weight loss, involvement of more than 1 operating surgeon, cigarette smoking history,[12] flap diameter greater than 4 cm, operative time longer than 11 hours,[13] reconstruction of an irradiated wound, the use of skin-grafted muscle flaps,[9] and the use of nitrate or bronchodilator pharmacotherapy.[14]

The present series showed a statistically significant relationship between the incidence of perioperative reconstructive complications and the risk factors of ASA status ($\chi^2=10.37$; $P=.04$), previous surgery ($\chi^2=10.03$; $P=.02$), defect type ($\chi^2=7.96$; $P=.002$), and flap type ($\chi^2=18$; $P=.03$). However, after multivariate analysis, only previous surgery remained a significant risk factor for reconstructive complications. This is similar to the study by Schusterman et al,[7] who reported a significantly increased risk of free flap failure in patients with a history of surgery. This increased complication rate may reflect the complexity of reconstruction because of scarring and fibrosis secondary to prior surgery.

It is striking to note the high incidence of primary wound healing in the head and neck in patients who undergo free flap reconstruction. In the present series, the incidence of complications indicative of delayed flap recipient wound healing was very low. There was a 3% incidence of partial free flap necrosis and a 2.8% incidence of salivary fistula formation. Other series of microvascular head and neck reconstruction have reported similar results.[15] This is in contrast to previously published series of head and neck reconstruction using pedicled myocutaneous flaps. While the incidence of total flap necrosis in pedicled myocutaneous flaps is similar to that reported in recent series of microvascular flap reconstruction, the incidence of partial flap necrosis is consistently higher for regional flaps than that reported for free flaps. Partial flap necrosis frequently leads to delayed wound healing, including salivary fistula formation. Mehta et al[16] reported a 25% incidence of partial flap necrosis in a series of 220 pectoralis major myocutaneous flaps used for oral cavity reconstruction. Shah et al[17] reported a 29% incidence of partial flap necrosis in a series of 211 pectoralis major myocutaneous flaps used for head and neck reconstruction, while Schusterman et al[18] reported significant partial flap necrosis in 14% of pectoralis major myocutaneous flaps used for intraoral soft tissue reconstruction. Ferri et al[19] reported a 14% incidence of salivary fistula formation in a series of 85 pectoralis major myocutaneous flaps used for head and neck reconstruction.

Despite the high reliability of free flaps, pedicled regional flaps are still used about twice as frequently as free flaps for head and neck reconstruction in academic otolaryngology programs in the United States. In a survey of otolaryngology residents graduating in 1997, 85 respondents reported exposure to 1637 pedicled flap and 870 free flap procedures.[20] This phenomenon is likely secondary to a variety of factors, including persisting misconceptions regarding free flap reliability and a lack of surgeons with training in microvascular surgery in some centers. Additionally, concerns regarding the potential for development of perioperative medical complications after lengthy surgery may also contribute to a reluctance to consider the use of free flaps.

Patient comorbidity has frequently been reported to be a risk factor for medical complications after microvascular reconstruction. Shestak et al[21] reported an increased incidence of perioperative complications in patients undergoing microvascular head and neck reconstruction when the ASA status was class III or higher. Serletti et al[22] also reported a significant relationship between ASA status and the incidence of medical complications in a similar patient population. In the present series, statistical analysis showed that ASA status was the only significant predictor of overall perioperative complications after microvascular head and neck reconstruction, and multivariate analysis showed that perioperative medical complications were associated with the risk factors of ASA status ($P=.04$) and patient age ($P=.002$).

Our findings are very similar to those reported by Singh et al,[15] who noted a significant correlation between comorbidity level and the incidence of complications among a group of 200 patients undergoing microvascular head and neck reconstruction. Singh et al[15] also noted that age older than 70 years was associated with increasing complication severity. A major difference between the methodology of the present study and the previous work by Singh et al[15] relates to the method of comorbidity classification selected for patient stratification. The present study used the ASA system, which is a comorbidity index that is commonly used by anesthesiologists to preoperatively to evaluate patients with regard to their general state of health and the severity of underlying diseases. Specific criteria are used to define each class: class I denotes a healthy patient; class II describes a patient with mild systemic disease; class III describes a patient with severe systemic disease with definite functional limitations; class IV describes a patient with severe systemic disease that is a constant threat to life; and class V describes a patient who is not expected to survive for more than 24 hours, regardless of operative intervention. Other studies have reported that the ASA system of comorbidity classification lacks adequate specificity and reproducibility to be useful for patient stratification in major head and neck surgery.[23,24] Singh et al[15] advocated using the more complex Charlson comorbidity index, whereby advanced Charlson grade was the only significant predictor of complications occurring after microvascular head and neck reconstruction in their study. In our series, in which the data were compiled prospectively and which, to our knowledge, is the largest detailed analysis of complications associated with microvascular head and neck reconstruction to date, ASA status proved to be useful to identify patients at risk for perioperative and medical complications. We believe that rarely used and complicated comorbidity scales such as the Charlson index, while useful as research tools, may add an unnecessary degree of complexity to the clinical evaluation of patients who are being evaluated for microsurgical reconstruction compared with the widely used and simple ASA index.

It is interesting to note that in our series, age remained a statistically significant predictor of medical complications after multivariate analysis. This has been observed in few other studies. As previously noted, Singh et al[15] reported that age older than 70 years was associated with increasing complication severity. In reviewing their experience with 241 microvascular head and neck reconstructions, Haughey et al[12] found a significant relationship between the incidence of major medical complications and patient age older than 55 years. In contrast, many other investigators have concluded that age should not be considered when deciding whether a patient is an acceptable candidate to undergo free flap reconstruction.[21,22,25-27] The preponderance of the medical literature and the present series suggest that comorbidity is likely the most important factor in determining the risk of perioperative complications. However, our data indicate that age is also a valid indicator of the risk of perioperative medical complications.

CONCLUSIONS

Microvascular flap reconstruction has proven to be very reliable for repair of defects in the head and neck, resulting in a low incidence of free flap failure and a high incidence of primary wound healing. In the present series, significant perioperative complications occurred in about a third of the cases. Careful preoperative assessment, with particular attention paid to the ASA status, history of surgery, and patient age, can help to identify patients who are at high-risk to experience perioperative complications. While we do not advocate withholding reconstruction in patients identified to be at high risk, attention to these risk factors may result in a lower incidence of complications, since some of the most common complications seen in patients who undergo microvascular head and neck reconstruction may be preventable. Based on our present analysis, we have modified some of our perioperative protocols in patients categorized as ASA class III or higher and those older than 80 years in an attempt to lower the incidence on medical complications. To lessen the risk of pulmonary edema, we limit intraoperative fluid replacement using crystalloid and more commonly use postoperative diuretics in this patient population. We also advocate starting many high-risk patients on β-blocker therapy prior to surgery to lessen the risk of supraventricular tachycardia, unless contraindicated by preexisting conditions such as diabetes, glaucoma, asthma, bradycardia, or hypotension. Knowledge and identification of the risk factors revealed in this study may make it possible to reduce the incidence of perioperative complications after microvascular head and neck reconstruction.

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