Oral Oncology 94 (2019) 21–25

Contents lists available at ScienceDirect

Oral Oncology

journal homepage: www.elsevier.com/locate/oraloncology

Novel application of the Clavien-Dindo classification system and the comprehensive complications index® in microvascular free tissue transfer to the head and neck

Julian Jakob Ebner[a,*], Tarun Mehra[b], Thomas Gander[a], Paul Schumann[a], Harald Essig[a], Daniel Zweifel[a], Martin Rücker[a], Ksenjia Slankamenac[c,1], Martin Lanzer[a,1]

[a] Department of Oral and Maxillofacial Surgery, University Hospital Zurich (Head of Department Prof. Dr. Med. Dr. Med. Dent. Martin Rücker), Frauenklinikstrasse 24, CH-8091 Zurich, Switzerland
[b] Medical Office, University Hospital Zurich, Rämistrasse 100, CH-8091 Zurich, Switzerland
[c] Department of Surgery and Transplantation, University Hospital Zurich, Rämistrasse 100, CH-8091 Zurich, Switzerland

Introduction

Complications are a major cause of reduced quality of life, delayed adjuvant therapy, extended hospital stay, and hence increased health-care costs after surgery [1–11]. The type of complication varies widely according to the surgical site and procedure, but matching surgical procedures to their most common complications is possible. The Clavien-Dindo-Classification (CDC) system is a tool for the grading of complications outlined by Strasberg and Clavien in 1992 [12]. It was modified and reintroduced in 2004 by Daniel Dindo and Pierre-Alain Clavien to objectively assess, grade, and report surgical complications [13]. The CDC system grades postoperative complications according to the specific need for treatment on a scale from grade I to V. Grade I describes Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions. Allowed therapeutic regimens are: drugs such as antiemetics, antipyretics, analgetics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside. Grade II is applied if pharmacological treatment with drugs other than such allowed for grade I complications is needed, including Blood transfusions and total parenteral nutrition. Grade III is applied if any surgical intervention is required with suffix “a” for all interventions under local anaesthesia and suffix “b” for all operations under general anaesthesia. Grade IV covers all life threatening complications requiring intermediate care or intensive care management with suffix “a” equalling a single organ dysfunction and suffix “b” for multiorgan dysfunction. Grade V represents any lethal complication. If the patient suffers from a complication at the time of discharge it is further awarded the suffix “d”. Conditions unavoidable due to the nature of the main surgical Intervention are named sequelae [13]. After its publication in 2004, the CDC has been widely adopted for the assessment of individual surgical complications in general surgery and went on to be adapted for transplant surgery [13,14]. In the years 2010 to 2012 it came to be established in the field of urogenital surgery [15,16]. Since then the CDC went on to other fields of surgery and was first applied in head and neck reconstruction by Perisanidis et al. in 2012 and secondly by Monteiro et al. in 2014 [17,18]. Among the CDC‘s limitations is the inconsistency in its use and that users often report only the most severe complication since the overall burden of complications is too complex to derive from the CDC [16]. Therefore in 2013, Slankamenac et al. introduced the Comprehensive Complication Index® (CCI®) [19]. The CCI® was the first tool to allow quantification of the overall burden of postoperative complications by summarizing all postoperative complications with their respective severities on a numerical scale ranging from 0 (no complication) to 100 (death). It is based on the operation risk index, a mathematical tool to evaluate the general business climate using the opinion of different professional groups involved. To translate the calculation for surgical needs Slankamenac et al. had to gain objective ratings of complication related morbidity. This was done by having common surgical complications rated by patients and health care professionals in multiple centres. The estimated weight applied to CDC classes I through IVb ($\mathbf{wC}1 + \ldots + \mathbf{wCx}$) is then entered into this formula $CCI^{®} = \frac{\sqrt{(\mathbf{wC}1 + \ldots + \mathbf{wCx})}}{2}$ to calculate the continuous scale CCI®. Any class V complication results in the CCI® being 100 (Death). Before publication the CCI® calculation was validated externally by three centres [19,20]. For general, abdominal, and transplant surgery, both the CDC and CCI® have not only proven useful for the straightforward assessment of postoperative complications but also for improving our understanding and management of surgical complications.

Microvascular free tissue transfer to the head and neck region is a well-established procedure with an often unfavourably long hospitalization. General and specific complications vary according to surgical

* Corresponding author at: University Hospital Zurich, Department of Oral and Maxillofacial Surgery, Frauenklinikstrasse 24, CH-8091 Zürich, Switzerland.
E-mail address: JulianJakob.Ebner@usz.ch (J.J. Ebner).
[1] Contributed equally as senior (last) authors.

https://doi.org/10.1016/j.oraloncology.2019.05.005
Received 21 August 2018; Received in revised form 11 March 2019; Accepted 5 May 2019
Available online 09 May 2019
1368-8375/

site and specific anatomy. Complications after microvascular head and neck reconstruction have a significant impact on morbidity, length of hospitalization and healthcare cost [2,21]. So far no standardized tool for the documentation or classification of complications in head and neck surgery exists. The studies performed have tended to be observational, for example recording rates of arterial or venous thrombosis, flap loss and mortality.

Therefore the aim of this study was to evaluate the applicability and benefit of the CDC and CCI® for microvascular free tissue transfer to the head and neck [13,19]. While the CDC has been sparingly used in previous head and neck studies, the CCI® has not been introduced to our field so far [13,17,18,22].

Methods

Study design

All patients who underwent vascularized, free tissue transfer to the head and neck region at the University Hospital Zurich from December 2011 to December 2014 were retrospectively evaluated. Eligible patients were identified by the procedure code for microvascular free tissue transfer in our hospital clinical information system (KISIM, CISTEC AG, Hohlstrasse 283, CH-8004 Zürich, Switzerland). We additionally screened all patients receiving local flaps and non-microvascular tissue transfer for accidentally-misidentified microvascular flaps. We excluded a total of 3 patients: 1 due to insufficient data, since the patient was preoperatively admitted to the University Children's Hospital Zurich and her paper file could not be obtained; and 2 because they had previously undergone lung transplantation and underwent surgery in an already critical state while on intensive care, rendering us unable to distinguish between surgical complications, effects of the immunosuppression, the transplantation, or the underlying illness of the patients.

The patients' files were assessed for the following data: age; sex; pre-operative weight; American Society of Anaesthesiology (ASA) score; presence of malignant/benign neoplasms; pre-operative radiotherapy, chemotherapy, or both; iatrogenic or illness-related immunosuppression; pre-operative haemoglobin level; pre-operative sodium and potassium levels; pre-operative antiresorptive medication; type of surgical flap and patient side; length of hospital stay; length of intensive care treatment; length of intermediate care treatment; and transfusions of blood products [23]. Transfusions include any event during or after the Operation up to the date of discharge and were further classified into erythrocyte concentrates, thrombocyte concentrates and fresh frozen plasma. Intensive care followed by intermediate care management or in rare cases primary intermediate care management is obligatory for at least 24 h postoperatively in our hospital due to the flap monitoring and blood pressure requirements.

We primarily focused on the postoperative outcome and assessed the following parameters: number of postoperative complications and sequelae, grade of each complication according to the CDC system [12,13], the CCI® [19], rate of partial flap necrosis and flap loss, requirement and number of corrective operations, donor site defects and subsequent operations, and post-operative in-hospital death. We differentiated between partial flap necrosis (e.g. skin island necrosis of limited extent or minor dehiscence at the flap border) and flap loss to distinguish critical flap conditions requiring extensive revisional surgery from those manageable with minor surgery under local anaesthesia or completely without long term consequences for the patient.

In order to document all post-operative complications, the electronic and paper patient files were manually searched, including the documentation for intensive and intermediate care wards, as well as all examination reports and laboratory results up to the patients' discharge. Any complication found was graded according to the CDC and entered into the CCI® calculation using the assesssurgery.com CCI-Calculator® [24]. Complications caused by partial flap necrosis, flap loss, and donor site morbidity were documented and evaluated separately. Sequelae which cannot be avoided due to the nature of the operation were not included into the calculation of the CCI®. By identifying risk factors for possible complications, surgery might become more predictable and countermeasures could be applied earlier. Therefore, the generated data was to be used for further identification of risk factors for overall post-operative morbidity, complications of increased severity and partial flap necrosis or flap loss.

Statistical analysis

First, a descriptive analysis of the entire patient population was performed. We expressed the distribution of variables using means and standard deviation (SD) for normally distributed data, and medians and interquartile ranges (IQR) for non-normally distributed data. We tested the data for normality with the Kolmogorov-Smirnov test and performed quantile-quantile plots of dependent variables.

A stepwise backward regression model was used to identify independent predictors of overall morbidity (represented by the CCI®), severe complications (CDC grade IIIB or higher), and partial flap necrosis or flap loss. In the multivariate linear and logistic regression analysis we adjusted the results for possible confounders such as age, sex, underlying malignant disease and type of flap.

All results were reported as point estimates, 95% confidence intervals (CI), and p-values ($p < 0.05$ was considered significant). All statistical analyses were performed using STATA software (version 14, Stata Corp., College Station, TX).

Results

Patient characteristics

A total of 129 patients were identified. The mean age was 63.7 years (SD, 14.5) and the male-to-female ratio was 59.7–40.3%. The mean BMI index was 23.9 (SD, 4.7). Most patients had an ASA score of 2 (58.1%) or 3 (33.3%) compared to score 1 (7%) and score 4 (1.6%). In 84.5% of patients, malignant disease was the indication for treatment. In 34.1% neoadjuvant treatment had been undergone, with 19.4% having received combined radio-chemotherapy, 9.3% radiotherapy and 5.4% chemotherapy. No patient was under immunosuppression at the time of surgery and only 2 patients (1.6%) had received antiresorptive medication earlier. Mean pre-operative haemoglobin, sodium, and potassium were 130 g/l (SD, 19), 139 mmol/l (SD, 3) and 4 mmol/l (SD, 0.4) respectively. A total of 33% of patients received transfusions of blood products or erythrocyte concentrates. Only 1 patient additionally received platelet concentrates (0.8%) and 2 (1.6%) fresh frozen plasma.

The microvascular flaps raised were: 56 radial forearm flaps, 33 fibula flaps, 15 anterior lateral thigh flaps, 7 scapula flaps, 4 lateral upper arm flaps, 4 gracilis muscle flaps, 2 deep circumflex iliac artery flaps, 2 latissimus dorsi flaps, 1 ulnar forearm flap, and in 5 cases combinations of at least 1 bony flap and 1 other flap were used. A hard tissue flap was used in 36.4% of patients and soft tissue flap in 63.6%. Left-sided operations were performed in 63.6% of patients and right-sided in 36.4%.

Outcome analysis

The median hospital stay was 16 days (IQR, 13–23), compared to a median catalogue length of hospitalisation of 21.3 days (IQR 19.5–23.1) calculated accordingly to the swiss cost bearers standards (SwissDRG AG, Haslerstrasse 21, 3008 Berne, Switzerland). Intermediate care was required in 76% of patients with a median length of 1 day (IQR, 1–2) and intensive care in 93% with a median length of 2 days (IQR, 1–3). At least 1 complication occurred in 98.5% of patients according to the CDC. 104 different complications could be identified, including common findings from anaemia (101 patients), hypervolemia (76

patients), alterations in blood electrolyte levels (74 patients), hypertension (19 patients) and nausea (8 patients) to bleedings of the neck (12 patients) or the donor site (5 patients). 52 of the aforementioned complications could only be identified in 1 patient each, these range from deep vein thrombosis to catheter infection or double vision. The median number of complications per patient was 4 (25th–75th percentile, 3–5). The highest complication grade was I in 26 patients (20.2%), II in 37 (28.7%), IIIa in 26 (20.2%), IIIb in 29 (22.5%), IVa in 6 (4.7%), and IVb in 2 (1.6%). There was 1 post-operative fatality (0.8%, grade V). The most common complication (N = 107) was dysphagia, with a CDC grade of I in 89 cases. Since all cases were associated with operations of the oral cavity and pharyngeal space, this complication was considered as a sequela. The mean CCI® was 35.7 (25th–75th percentile, 24.2–45.6). Flap complications were noted in 18.6% of cases, partial flap necrosis in 8.5%, and total flap loss in 3.1%, resulting in a need for corrective surgery in 21.7% of cases. In 17.8% of patients, a donor site defect was documented, resulting in the need for corrective surgery in 7.8%.

Risk analysis

A stepwise backward regression identified two risk factors for increased overall morbidity following vascularized, free tissue transfer to the head and neck region. Patients receiving transfusions of erythrocytes had a significantly increased overall morbidity according to the CCI® [46.0 (SD, 18.2) vs. 29.2 (SD, 14.1); adjusted difference, 13.5; 95% CI, 7.0–20.0; $p < 0.001$) compared to patients that did not receive transfusions. Furthermore, patients with an ASA score > 2 had a significantly higher CCI® [41.9 (SD, 21.0) vs. 31.0 (SD, 13.9); adjusted difference 7.6; 95% CI, 1.0–14.2; $p = 0.025$].

In a second stepwise backward regression, predictive factors for more severe complications (CDC score grade IIIb and higher) were singled out. Patients receiving erythrocyte transfusions suffered from more severe complications (46.5% vs. 20.9%; adjusted relative risk, 4.1, 95% CI, 1.5–10.9; $p = 0.005$), as well as those with an ASA score higher than 2 (46.7% vs. 20.2%; adjusted relative risk, 3.2; 95% CI, 1.3–8.1; $p = 0.012$) and those that underwent neoadjuvant radio-chemotherapy (48% vs. 25%; adjusted relative risk, 3.3; 95% CI, 1.2–8.9; $p = 0.021$).

The stepwise backward regression model showed that patients with a BMI ≥ 25 had a higher rate of partial flap necrosis (26.8% vs. 12.3%; adjusted relative risk, 3.1; 95% CI, 1.1–9.1; $p = 0.038$).

Discussion

We modified the definitions of the CDC to allow them to more precisely reflect our specific field. Considering age, sex, ASA distribution, length of hospital stay and flap loss, the examined patients were similar to previous studies exploring microvascular reconstruction [25–31]. The CDC score has been proven to be valuable in assessing the severity of surgical complications for procedures in thoracoabdominal, gynaecological, urogenital and transplantation surgery [13–16,32,33]. Clavien et al. demonstrated that no specific modifications according to the specific surgical field are needed and that ratings are mostly consistent between investigators, surgeons, nurses and patients [14]. Yoon et al. found that the CDC score was the most frequently used grading system for scientific studies as well as clinical documentation in urological surgery, but is not usually integrated into the clinical workflow in urology [15,16]. In our field of head and neck surgery, Monteiro et al. tested the CDC score in hypothetical patients presented to 81 surgeons of differing training levels and found moderate to high inter-observer reliability. They considered it to be a practicable tool for complication assessment in the head and neck region while emphasizing the need for further adjustment to this field [18]. Perisanidis et al. used the CDC score in 79 patients receiving jejunal free flaps for oral cavity reconstruction and found more severe complications (65% with a CDC grade IIIa and higher) than in our study [17]. The difference is most likely related to the neoadjuvant radio-chemotherapy that their patients received since they also defined swallowing difficulties as sequelae and only considered clearly necessary tracheostomies as grade IIIb complication [17]. As shown, the CDC score is a reliable tool in grading individual complications and it prevents accidental downgrading, even if applied to the head and neck region [17]. McMahon et al. applied the CDC score to 192 patients receiving free tissue transfer to the head and neck region. In their prospective cohort study, they found 190 complications in 123 patients with 32% of patients suffering from a grade IIIa complication or higher [22]. These figures are slightly lower than what we found in the current study, both in overall numbers and grade distribution, but still comparable to major abdominal operations. In their study, data generated after discharge while visiting the outpatient department were included, while the list of complications excluded minor complications such as simple hypertension, oedema or misbalanced lab results (e.g. anaemia and electrolyte disorders) [22]. While using the CDC score to identify and grade individual complications has been well established, drawing conclusions on the overall well-being of the patient requires the CDC grades to be summarized or simplified. Previous studies have tended to report the total number of complications and their grades while implementing a cut-off to define more severe complications, usually grade IIIa or IIIb [17,22]. Clavien et al. have warned of categorizing patients solely by their highest CDC grade and using this tool to briefly describe the severity of complication [14]. They argue that complications off all grades impact the patient and even those of lower grades need to be taken into account [14]. The CCI® prevents common CDC mistakes such as presenting the single highest complication only. By summarizing all surgical complications into one figure comparability between time points and between cases becomes easier. Studies across different fields have consistently reported that the CCI® is a highly reliable tool to estimate and compare the patient's burden of surgical complications [11,19,34–36]. The aforementioned comparability further allows long term monitoring of morbidity and surgical outcome. The CCI® could for example be used to compare the morbidity after primary tumour resection and adjuvant therapy or simply to objectify the course of the patient's recovery. It also shows a strong correlation with the need for prolonged hospitalization and intensive care. However, inter-observer reliability still shows potential for improvement which is most likely due to the range of CDC interpretations shown in previous head and neck studies [17,18].

To clearly understand the similarities and differences between head and neck and general surgery, we strictly applied the original CDC definitions in close cooperation with the research team that created and developed it. We were thus able to combine the insight of both the CDC's developers and its first-line users. From our data, a strict application is still useful in assessing surgical complications and maintaining this practice in future studies can help avoid accidental down staging of complications. On the other hand adapting the CDC grades to our specific situation could help to identify the more severe complications specific to our field, which result in an actual prolongation of hospitalization, persistent disability, and higher costs. In other words, an adapted CDC would mean a more precise representation of the complication. For example, the CDC ascribes a grade of IIIa for minor wound treatment, which in our field is traditionally performed in an examination room and is more comparable to a grade I bedside wound treatment. Therefore, common treatments with little or no influence on the patients' status, hospitalization, recovery or healthcare costs are artificially exaggerated by the CDC and result in higher CCIs®.

The CCI® is a universal and easily reproducible tool to assess the overall burden of all complications (graded using the CDC) on a single patient. It has been well established in general surgery as a tool for measuring the overall impact of surgical complications, as well as a meter for regular post-operative quality of life assessments [11,35,36]. In radical gastric surgery, the CCI® has been shown to be more predictive of longer overall hospital stays than the CDC, while also

generating data allowing to monitor a patient's development or compare surgeons via their cumulative sum of complications [35]. Our patients showed a similar distribution of CDC grades and CCI® scores to those found in larger general surgery procedures [11,35,36].

Nonetheless, in addition to naming head and neck specific sequelae (e.g., dysphagia), further adjustments are recommended to appropriately apply the CDC to head and neck reconstruction. These adjustments need to mainly address the grading of complications within the CDC as well as standardizing the patient documentation and pre- as well as post-operative checkups. Starting with the latter, only documented complications can be measured, meaning pre- and post-operative checkups should include regular blood tests, vital signs, weight measurement and clinical examination. The results should be documented chronologically in one electronic patient file. By doing so, postoperative changes can be distinguished from pre-existing conditions and the risk of missing a complication is reduced, rendering the results of the CCI® more comparable. The nature of microvascular flaps, which in our specialty usually are easily accessible through the mouth or even extra-orally, leads to a lower threshold for treatment of smaller dehiscences, loosened sutures, or small fluid collections under local or even no anaesthesia in the examination room. This results in a higher rate of CDC grade III complications that would have otherwise not have been addressed or graded at a lower level. To minimize this mismatch, small procedures performed under local or no anaesthesia and in a regular examination room could be lowered to grade I or II. Since many postoperative procedures are performed in a similar bedside setting in an examination room, grade I seems appropriate. Examples of such procedures include simple wound rinsing and cleaning, seroma drainage or a single suture. Yet since other procedures are closer to the original definition of grade IIIa, but still have only a minor effect on the patient, grade II seems appropriate. This would apply to superficial abscess drainage that does not require further surgical treatment or closure, major suturing, or superficial tissue removal such as a necrosectomy. In contrast, considering our CCI® distributions being comparable to other surgical fields any changes to the grading system would have to be compared to the original CDC and CCI®.

Compared to previous studies regarding risk assessment, our study showed no novel findings. Nevertheless, a significant difference in overall morbidity was observed in patients who received erythrocyte transfusion and the data strongly suggests the presence of more risk factors. Erythrocyte transfusion also appears to be connected to an increase in the relative risk of more severe complications and partial flap necrosis. This has previously been described and erythrocyte transfusions have also been linked to an increase in unplanned hospital readmissions [37–39]. Higher ASA scores appear to be associated with higher overall morbidity and an increased relative risk of more severe complications. While this finding has been reported previously, it remains controversial and requires further examination in a randomized, prospective study [40–47]. In patients that had undergone pre-operative radio-chemotherapy the risk for more severe complications also seems to be relatively elevated, in accordance with previous findings [48–51]. Patients with a BMI of 25 or higher showed a higher relative risk for partial flap necrosis, which had previously been shown for patients undergoing breast reconstruction but has been largely ruled out for other microvascular reconstructions [52] and thus also should be investigated more thoroughly. In other studies the length of surgery and ischemia time have been described as risk factors for complications in microvascular free flaps and increased length of stay [39,53–59]. These factors could not be taken into account in this study due to a change in the documentation regimen for both times during the period examined. The length of stay reported in our study is longer than in other reports [53,57]. This is mainly due to local circumstances providing cancer patients and especially patients undergoing microvascular reconstruction with extensive stays on rehabilitation wards requiring a direct transfer from the surgical ward. Waiting time for admission into rehabilitation can be multiple weeks and the claim expires if the patient is discharged before admission into rehabilitation.

In the future, more studies into the association between the CCI® and the length of hospital stay, in-hospital costs, re-admission rate, 30 to 90-day mortality, and overall survival are warranted. Such studies will help elucidate the possible benefit of the assessment of post-operative complications after head and neck surgery using the CCI®.

Conclusions

Our study presents the first application of the CCI® to head and neck surgery as well as the first assessment of the overall burden of the post-operative course. The CCI® is a valuable tool for assessing the overall burden of surgical complications for head and neck microvascular reconstruction. However, with slight adjustments to the definitions of CDC grades, we believe that it could be further refined and adapted to this field. The considerably high rate of minor surgical procedures performed due to complications is likely to draw a distorted picture of surgical complications among our patients. A prognostic value for our patients' quality of life can also be assumed but is yet to be proven. Therefore, adjustments to the CDC should be investigated in a prospective study and compared to the existing system.

Declaration of Competing Interest

This work was by no means supported by financial aid, grants or support from outside the University Hospital Zurich and the authors report no conflict of interest.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.oraloncology.2019.05.005.

References

[1] Mason LB, Garcia AG. Hospital costs of surgical complications. Arch Surg 1984;119(9):1065–6.
[2] McAleese P, Odling-Smee W. The effect of complications on length of stay. Ann Surg 1994;220(6):740–4.
[3] Hunt CM, Camargo Jr. CA, Dominitz JA, Bute BP, Clavien PM. Effect of post-operative complications on health and employment following liver transplantation. Clin Transpl 1998;12(2):99–103.
[4] Collins TC, Daley J, Henderson WH, Khuri SF. Risk factors for prolonged length of stay after major elective surgery. Ann Surg 1999;230(2):251–9.
[5] Lang M, Niskanen M, Miettinen P, Alhava E, Takala J. Outcome and resource utilization in gastroenterological surgery. Br J Surg 2001;88(7):1006–14.
[6] Dimick JB, Chen SL, Taheri PA, Henderson WG, Khuri SF, Campbell Jr. DA. Hospital costs associated with surgical complications: a report from the private-sector National Surgical Quality Improvement Program. J Am Coll Surg 2004;199(4):531–7.
[7] Stokes ME, Ye X, Shah M, et al. Impact of bleeding-related complications and/or blood product transfusions on hospital costs in inpatient surgical patients. BMC Health Serv Res 2011;11:135.
[8] Canis M, Weiss BG, Ihler F, Hummers-Pradier E, Matthias C, Wolff HA. Quality of life in patients after resection of pT3 lateral tongue carcinoma: microvascular reconstruction versus primary closure. Head Neck 2016;38(1):89–94.
[9] Healy MA, Mullard AJ, Campbell Jr. DA, Dimick JB. Hospital and payer costs associated with surgical complications. JAMA Surg 2016;151(9):823–30.
[10] Chotai S, Sivaganesan A, Parker SL, et al. Effect of complications within 90 days on cost per quality-adjusted life year gained following elective surgery for degenerative lumbar spine disease. Neurosurgery 2017;64(CN_suppl_1):157–64.
[11] Slankamenac K, Slankamenac M, Schlegel A, et al. Impact of postoperative complications on readmission and long-term survival in patients following surgery for colorectal cancer. Int J Colorectal Dis 2017;32(6):805–11.
[12] Clavien PSJ, Strasberg S. Proposed classification of complication of surgery with examples of utility in cholecystectomy. Surgery 1992;111:518–26.
[13] Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240(2):205–13.
[14] Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250(2):187–96.
[15] Yoon PD, Chalasani V, Woo HH. Use of Clavien-Dindo classification in reporting and grading complications after urological surgical procedures: analysis of 2010 to 2012. J Urol 2013;190(4):1271–4.
[16] Mitropoulos D, Artibani W, Graefen M, et al. Reporting and grading of

complications after urologic surgical procedures: an ad hoc EAU guidelines panel assessment and recommendations. Eur Urol 2012;61(2):341–9.
[17] Perisanidis C, Herberger B, Papadogeorgakis N, et al. Complications after free flap surgery: do we need a standardized classification of surgical complications? Br J Oral Maxillofac Surg 2012;50(2):113–8.
[18] Monteiro E, Sklar MC, Eskander A, et al. Assessment of the Clavien-Dindo classification system for complications in head and neck surgery. Laryngoscope 2014;124(12):2726–31.
[19] Slankamenac K, Graf R, Barkun J, Puhan MA, Clavien PA. The comprehensive complication index: a novel continuous scale to measure surgical morbidity. Ann Surg 2013;258(1):1–7.
[20] Slankamenac K, Graf R, Puhan MA, Clavien PA. Perception of surgical complications among patients, nurses and physicians: a prospective cross-sectional survey. Patient Saf Surg 2011;5(1):30.
[21] Dassonville O, Bozec A, Chateau Y, et al. Multicenter prospective micro-costing study evaluating mandibular free-flap reconstruction. Eur Arch Otorhinolaryngol 2017;274(2):1103–11.
[22] McMahon JD, MacIver C, Smith M, et al. Postoperative complications after major head and neck surgery with free flap repair–prevalence, patterns, and determinants: a prospective cohort study. Br J Oral Maxillofac Surg 2013;51(8):689–95.
[23] American Society of Anesthesiologists. New classification of physical status. Anesthesiology 1963;24:111.
[24] http://www.assessurgery.com/about_cci-calculator/.
[25] Ishimaru M, Ono S, Suzuki S, Matsui H, Fushimi K, Yasunaga H. Risk factors for free flap failure in 2846 patients with head and neck cancer: a national database study in Japan. J Oral Maxillofac Surg 2016;74(6):1265–70.
[26] Dassonville O, Poissonnet G, Chamorey E, et al. Head and neck reconstruction with free flaps: a report on 213 cases. Eur Arch Otorhinolaryngol 2008;265(1):85–95.
[27] Lee YK, Park KY, Koo YT, et al. Analysis of multiple risk factors affecting the result of free flap transfer for necrotising soft tissue defects of the lower extremities in patients with type 2 diabetes mellitus. J Plast Reconstr Aesthet Surg 2014;67(5):624–8.
[28] Liu Z, Tian Z, Zhang C, Sun J, Zhang Z, He Y. Microvascular reconstruction in elderly oral cancer patients: does diabetes status have a predictive role in free flap complications? J Oral Maxillofac Surg 2015;73(2):357–69.
[29] Singh B, Cordeiro PG, Santamaria E, Shaha AR, Pfister DG, Shah JP. Factors associated with complications in microvascular reconstruction of head and neck defects. Plast Reconstr Surg 1999;103(2):403–11.
[30] Wong S, Melin A, Reilly D. Head and neck reconstruction. Clin Plast Surg 2017;44(4):845–56.
[31] Pohlenz P, Klatt J, Schon G, Blessmann M, Li L, Schmelzle R. Microvascular free flaps in head and neck surgery: complications and outcome of 1000 flaps. Int J Oral Maxillofac Surg 2012;41(6):739–43.
[32] Umezawa H, Nakao J, Matsutani T, Kuwahara H, Taga M, Ogawa R. Usefulness of the Clavien-Dindo classification in understanding the limitations and indications of larynx-preserving esophageal reconstruction. Plast Reconstr Surg Glob Open 2016;4(11):e1113.
[33] Panhofer P, Ferenc V, Schutz M, et al. Standardization of morbidity assessment in breast cancer surgery using the Clavien Dindo classification. Int J Surg 2014;12(4):334–9.
[34] Borchert DH, Federlein M, Muller VA, Wagenpfeil S, Eisele RM. Comprehensive complication index for NOTES procedures: results from a randomized controlled trial and comparison to published NOTES complication data. Surg Endosc 2015;29(10):2928–33.
[35] Kim TH, Suh YS, Huh YJ, et al. The comprehensive complication index (CCI) is a more sensitive complication index than the conventional Clavien-Dindo classification in radical gastric cancer surgery. Gastric Cancer 2017.
[36] Clavien PA, Vetter D, Staiger RD, et al. The Comprehensive Complication Index (CCI (R)): added value and clinical perspectives 3 years “Down the Line”. Ann Surg. 2017;265(6):1045–50.
[37] Carniol ET, Marchiano E, Brady JS, et al. Head and neck microvascular free flap reconstruction: an analysis of unplanned readmissions. Laryngoscope 2017;127(2):325–30.
[38] Lodders JN, Parmar S, Stienen NLM, et al. Incidence and types of complications after ablative oral cancer surgery with primary microvascular free flap reconstruction. Med Oral Patología Oral y Cirugia Bucal 2015:e744–50.
[39] Cannady SB, Hatten KM, Bur AM, et al. Use of free tissue transfer in head and neck cancer surgery and risk of overall and serious complication(s): an American College of surgeons-national surgical quality improvement project analysis of free tissue transfer to the head and neck. Head Neck 2017;39(4):702–7.
[40] Kruse AL, Luebbers HT, Gratz KW, Obwegeser JA. Factors influencing survival of free-flap in reconstruction for cancer of the head and neck: a literature review. Microsurgery 2010;30(3):242–8.
[41] Ehrl D, Heidekrueger PI, Ninkovic M, Broer PN. Effect of preoperative medical status on microsurgical free flap reconstructions: a matched cohort analysis of 969 cases. J Reconstr Microsurg 2018;34(3):170–5.
[42] Kastanis G, Topalidou A, Alpantaki K, Rosiadis M, Balalis K. Is the ASA score in geriatric hip fractures a predictive factor for complications and readmission? Scientifica (Cairo) 2016;2016:7096245.
[43] Lavelle EA, Cheney R, Lavelle WF. Mortality prediction in a vertebral compression fracture population: the ASA physical status score versus the Charlson comorbidity index. Int J Spine Surg 2015;9:63.
[44] Prause G, Offner A, Ratzenhofer-Komenda B, Vicenzi M, Smolle J, Smolle-Juttner F. Comparison of two preoperative indices to predict perioperative mortality in non-cardiac thoracic surgery. Eur J Cardiothorac Surg 1997;11(4):670–5.
[45] Prause G, Ratzenhofer-Comenda B, Pierer G, Smolle-Juttner F, Glanzer H, Smolle J. Can ASA grade or Goldman's cardiac risk index predict peri-operative mortality? A study of 16,227 patients. Anaesthesia 1997;52(3):203–6.
[46] Wolters U, Wolf T, Stutzer H, Schroder T. ASA classification and perioperative variables as predictors of postoperative outcome. Br J Anaesth 1996;77(2):217–22.
[47] Patel RS, McCluskey SA, Goldstein DP, et al. Clinicopathologic and therapeutic risk factors for perioperative complications and prolonged hospital stay in free flap reconstruction of the head and neck. Head Neck 2010;32(10):1345–53.
[48] Klug C, Berzaczy D, Reinbacher H, et al. Influence of previous radiotherapy on free tissue transfer in the head and neck region: evaluation of 455 cases. Laryngoscope 2006;116(7):1162–7.
[49] Schultze-Mosgau S, Grabenbauer GG, Radespiel-Troger M, et al. Vascularization in the transition area between free grafted soft tissues and pre-irradiated graft bed tissues following preoperative radiotherapy in the head and neck region. Head Neck 2002;24(1):42–51.
[50] Benatar MJ, Dassonville O, Chamorey E, et al. Impact of preoperative radiotherapy on head and neck free flap reconstruction: a report on 429 cases. J Plast Reconstr Aesthet Surg 2013;66(4):478–82.
[51] Bourget A, Chang JT, Wu DB, Chang CJ, Wei FC. Free flap reconstruction in the head and neck region following radiotherapy: a cohort study identifying negative outcome predictors. Plast Reconstr Surg 2011;127(5):1901–8.
[52] Shin JY, Roh SG, Lee NH, Yang KM. Is obesity a predisposing factor for free flap failure and complications? Comparison between breast and nonbreast reconstruction: Systematic review and meta-analysis. Medicine (Baltimore) 2016;95(26):e4072.
[53] Eskander A, Kang SY, Tweel B, et al. Quality indicators: measurement and predictors in head and neck cancer free flap patients. Otolaryngol Head Neck Surg 2018;158(2):265–72.
[54] Iamaguchi RB, Takemura RL, Silva GB, et al. Peri-operative risk factors for complications of free flaps in traumatic wounds – a cross-sectional study. Int Orthop 2018;42(5):1149–56.
[55] Wu H, Liu F, Ji F, Guo M, Wang Y, Cao M. Identification of independent risk factors for complications: a retrospective analysis of 163 fibular free flaps for mandibulofacial reconstruction. J Oral Maxillofac Surg 2018;76(7):1571–7.
[56] Brady JS, Desai SV, Crippen MM, et al. Association of anesthesia duration with complications after microvascular reconstruction of the head and neck. JAMA Facial Plast Surg 2018;20(3):188–95.
[57] Thomas WW, Brant J, Chen J, et al. Clinical factors associated with reoperation and prolonged length of stay in free tissue transfer to oncologic head and neck defects. JAMA Facial Plast Surg 2018;20(2):154–9.
[58] Suominen S, Asko-Seljavaara S. Free flap failures. Microsurgery 1995;16(6):396–9.
[59] Pattani KM, Byrne P, Boahene K, Richmon J. What makes a good flap go bad? A critical analysis of the literature of intraoperative factors related to free flap failure. Laryngoscope 2010;120(4):717–23.