Effect of operative time on complications associated with free flap reconstruction of the head and neck

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Abstract

Objective: To evaluate whether prolonged operative time is negatively associated with post-operative complications and length of stay in patients undergoing microvascular free flap reconstruction for complex head and neck defects. Methods: 342 consecutive patients undergoing microvascular reconstruction for head and neck defects between 2017-2019 at a single institution were evaluated. Operative outcomes and operative time were compared whilst controlling for patient and treatment related factors. Results: Mean operative time was 551 minutes and length of stay was 16.2 days. An 11% increase in the risk of a post-operative complication was observed for every additional hour of operative time (OR 1.11, 95%CI 1.03 – 1.21, p=0.011) after adjusting for patient and treatment factors. A cut-off of 9 hours yielded a 92% increase in complications on either side of this (OR 1.92, 95%CI 1.18 – 3.13, p=0.009). Increased operative time was also associated with increased length of stay and return to theatres, but not medical complications. Conclusion: Prolonged operative time is significantly associated with increase surgical complications, length of stay and return to theatres when performing microvascular reconstructive surgery for head and neck defects. Keywords : free flap, microsurgery, operative time, length of hospital stay, complication rate, head and neck surgery Key points : 1. This study analyzed a contemporary cohort over a relatively short period where outcomes can reliably be recorded and verified 2. This is the first Australian study that demonstrated operative time as it relates to surgical technique, comparing pedicled and free flaps and also stratified by flap type, oncological resection, or comorbidity 3. Operations more than 9 hours duration were associated with an 89% increase in the odds of developing a surgical complication 4. Prolonged operative time was also significantly associated with length of stay and return to theatres 5. Future studies are needed to investigate associations with each component of operative time element separately in a multi institutional design

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Conclusion : Prolonged operative time is significantly associated with increase surgical complications, length of stay and return to theatres when performing microvascular reconstructive surgery for head and neck defects.

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Key points

1. This study analyzed a contemporary cohort over a relatively short period where outcomes can reliably be recorded and verified
2. This is the first Australian study that demonstrated operative time as it relates to surgical technique, comparing pedicled and free flaps and also stratified by flap type, oncological resection, or comorbidity
3. Operations more than 9 hours duration were associated with an 89% increase in the odds of developing a surgical complication
4. Prolonged operative time was also significantly associated with length of stay and return to theatres
5. Future studies are needed to investigate associations with each component of operative time element separately in a multi-institutional design

Introduction

Microsurgery is routinely applied in the reconstruction of defects in the head and neck region to functionally and aesthetically rehabilitate patients.[1,2] Due to the complexity of these procedures, there is considerable interest in factors associated with postoperative complications and how operative morbidity can be minimised.[3-7] Longer operative times have been associated with increased surgical morbidity in many surgical fields.[7,8] In head and neck surgery, studies have demonstrated an association between longer operative time and septic shock, surgical site infection, wound dehiscence, blood loss, pneumonia and thromboembolic events.[9] Prolonged operative time has also been shown to be an independent risk factor for free flap failure, risk for reoperation, and increased length of stay.[10] Many of these risks remain, even after controlling for patient characteristics and procedure complexity.[9] From a health care utilization perspective, longer procedures have been related to increase cost of care and hinder practice productivity.[11]

Most studies have demonstrated operative time as it relates to surgical technique, comparing pedicled and free flaps, but have not stratified by flap type, oncological resection, or comorbidity. Determinants of operative time are highly surgeon and institution dependent, thus is unlikely that cut-offs derived from one institution can be universally applied and will vary between high and low volume units. In addition, advances in surgical technique and team-based approaches have decreased operative times for head and neck surgery.[12,13]Therefore, ongoing data is needed to define the effect of operation time across a range of institutions. The aim of this study is to investigate whether increased operative time is associated with adverse post-operative outcomes and length of stay in patients undergoing microsurgery reconstruction for surgical defects of the head and neck after adjusting for the effect of clinically relevant covariates.

Materials and methods

This retrospective study investigated a cohort of head and neck patients who underwent oncologic resection and free tissue transfer between January 2017 and July 2019 at a quaternary referral unit in Sydney, Australia. Following institutional ethics approval (HREC/X20-0337/LH20.074), patients were identified using the prospectively maintained Sydney Head and Neck Institute (SHNCI) database and included if they had undergone primary or secondary free flap reconstruction. Patients were excluded if operative time was not recorded. Operative time data was collected for each patient and was defined as the time interval between entering and leaving the operating room. Operative time was analyzed as a continuous variable (number of hours) and dichotomized based on the mean.

Potential confounders assessed included patient gender, age, American Society of Anesthesiologists (ASA) classification, Charlson comorbidity index (CCI), tumor site, elective tracheostomy, defect type (mucosal or cutaneous), reconstruction type defined as fasciocutaneous (soft tissue) or composite (osseo-cutaneous,

myo-osseous, myo-cutaneous), osseous resection (mandibulectomy, maxillectomy, craniectomy or temporal bone resection), prior radiotherapy or head and neck surgery.

Outcomes of interest were complication rate, return to theatre (operating room), and length of stay, defined as the number of inpatient days including the day of surgery. Complications were divided into medical and surgical. Medical complications included myocardial infarction, pneumonia, pulmonary embolism, urinary tract infection, stroke, deep vein thrombosis, sepsis, and renal insufficiency. Surgical complications included both recipient site and donor site complications, flap loss (partial or total), wound infection, wound dehiscence, orocutaneous fistula, and hematoma as well as any event necessitating return to theatre.

Statistical analysis was performed using Stata version 12.0 SE (StataCorp LP, College Station, TX, USA). Complication rates and return to theatre were analyzed using univariable and multivariable logistic regression and presented as odds ratios (OR) and confidence intervals (CI). Length of stay was analyzed as count data using a negative binomial regression. Operative time was included in all multivariable models as the intervention of interest. Covariates were selected based on statistical significance on univariable analysis, however patient age and comorbidity scale were included *a priori* . The choice of comorbidity scale (ASA or CCI) was determined by statistical significance. Continuous variables were transformed where required. A p-value < 0.05 was considered statistically significant.

Results

Patient characteristics

A total of 342 head and neck free flap reconstructions were performed between January 2017 and July 2019. There were 219 males (64.1 %) and 123 females (35.9%) with a mean age of 65.1 years (range 11–93 years). The majority of patients were ASA class III (n= 185, 57.8%) with a median CCI of 5 (range 0 – 13). There were 73 patients (21.3%) who had prior radiotherapy and 118 patients (34.4%) who had undergone prior head and neck surgery. The mean operative time was 551 minutes or 9.2 hours (SD 196.6 min) with a median operative time of 520 minutes or 8.7 hours (range 145 – 1395 min). The most common sites were oral cavity (n=161, 46.9%), skin / salivary gland (n= 129, 37.7%) and oropharynx (n=29, 8.5%). Osseous resection was performed 121 patients (35.4%) and a tracheostomy was performed in 114 patients (33.3%).

Defects were characterized as mucosal in 221 patients (64.7%) and cutaneous in 121 patients (35.3%). Most patients underwent soft tissue reconstruction only (n=218, 63.7%) with 124 patients (36.1%) undergoing a composite reconstruction. The most common flap was the anterolateral thigh (ALT) (n=135, 40%), followed by radial forearm (n=94, 27.5%), and fibula (n=48, 14.0%), with five patients undergoing a double free flap (Table 1).

Complications

In total, 144 patients (42.1%) had a post-operative complication, including 114 surgical complications (33.3%) and 30 medical complications (8.8%). There were eight flap failures (2.3%) and three patients died whilst in hospital (0.9%). A summary of all complications is provided in table 2. There was a 10% increase in the odds of developing a complication per additional hour of operative time (OR 1.10, 95%CI 1.02 – 1.17, p=0.008). When dichotomized, operations $>$ 9 hours duration were associated with an 82% increase in the odds of developing a complication compared to operations [?] 9 hours duration (OR 1.82, 95%CI 1.17-2.83, p=0.008). After adjusting for the effect of patient age, ASA status, prior radiotherapy, defect type, reconstruction and elective tracheostomy, there was a 11% increase in odds of developing a complication per additional hour of operative time (OR 1.11, 95%CI 1.03 – 1.21, p=0.011) and a 92% increase for patients undergoing operations $>$ 9 hours duration compared to [?] 9 hours duration (OR 1.92, 95%CI 1.18 – 3.13, p=0.009) (Table 3). Increasing patient age (continuous p=0.002; dichotomized [?] 75 years p=0.03) and elective tracheostomy (p=0.015) were other significant predictors of complications (Figure 1).

There was a 12% increase in the odds of developing a surgical complication per additional hour of operative time (OR 1.12, 95%CI 1.04 – 1.20, p=0.002). Operations $>$ 9 hours duration were associated with an 89% increase in the odds of developing a surgical complication compared to operations [?] 9 hours duration (OR

1.89, 95%CI 1.20-2.98, p=0.006). After adjusting for the effect of patient age, ASA status, prior radiotherapy, defect type, and reconstruction, there was a 13% increase in odds of developing a surgical complication per additional hour of operative time (OR 1.13, 95%CI 1.04 – 1.23, p=0.004) and a 101% increase in patients undergoing operations > 9 hours duration compared to operations [?] 9 hours duration (OR 2.01, 95%CI 1.23 – 3.28, p=0.005) (Table 4). Operative time was not associated with medical complications when analyzed per hour (OR 1.02, 95%CI 0.91 – 1.14, p=0.76) or when dichotomized (OR 1.38, 95%CI 0.65 – 2.97, p=0.40).

Length of stay and return to theatre

There were 61 patients (17.7%) who returned to theatre during their inpatient stay. The mean length of stay was 16.2 days (SD = 10.7 d) and the median length of stay was 13 days, range (4 – 64 d). Operative time (per hour) was a significant predictor of length of stay ($p < 0.001$) with each additional hour of operative time being associated with an estimated one additional day in hospital (95%CI 0.67 – 1.33 days). This remained significant after adjusting for the effect of patient age, ASA statis, prior radiotherapy, defect type, reconstruction, and elective tracheostomy ($p< 0.001$).

There was a 17% increase in the odds of returning to theatre per additional hour of operative time (OR 1.17, 95%CI 1.08 – 1.26, p<0.001). Operations > 9 hours duration were associated with an 124% increase in the odds of returning to theatre compared to operations [?] 9 hours duration (OR 2.24, 95%CI 1.27-3.94, p=0.005). After adjusting for the effect of patient age, ASA status, prior radiotherapy, defect type, and reconstruction, there was a 20% increase in odds of returning to theatre per additional hour of operative time (OR 1.20, 95%CI 1.09 – 1.32, p<0.001) and a 126% increase in patients undergoing operations > 9 hours duration compared to [?] 9 hours duration (OR 2.26, 95%CI 1.24 – 4.12, p=0.008) (Table 5).

Discussion

This Australian study of 342 microvascular free flap head and neck reconstructions investigated whether operative time is associated with post-operative complications and length of stay. In this patient cohort, lengthier operative times, particularly those longer than 9 hours duration, were associated with adverse outcomes including surgical complications, any complication, return to theatre and length of stay after adjusting for the effect of potential confounders such as comorbidity, patient age, tumor site, reconstruction type, and use of tracheostomy.

In our analysis, the adjusted effect of one hour of additional operative time was a 13% increase in the odds of developing a surgical complication (p=0.002), a 20% increase in the odds of returning to theatre (p<0.001), and one extra day of hospital stay (p<0.001). This equated to more than double the odds of a surgical complication for operations > 9 hours duration compared to [?] 9 hours duration (p=0.005). These findings are not unique and are supported by several studies from other countries showing that prolonged operative time is an independent risk factor for post-operative complications.[8,10,11] In fact, Serleti et al. identified a similar cut-off ([?]10 hours) as being associated with complications such as flap failure, thromboembolism, bleeding, and hematoma.[13] Eskander et al. found that each hour was associated with a 21% increase in the odds of a complication and a 24% increase in the odds of wound-healing problems.[1]However, other studies have shown dramatic variations in the critical time (cut-off) associated with adverse outcomes, ranging from 480 minutes to 920 minutes, highlighting the importance of institutional factors and the need for individual units to publish their own results.[8,11]

Unfortunately, our cohort was not large enough to analyze whether operative time predicted free flap failure. However, two national database studies have shown that this is the case, including Ishimaru et al.[14] who analyzed 2846 patients from the Japanese national database and Sanati-Mehrizy et al.[15] who analyzed 2013 patients from the American College National Surgical Quality Improvement Program database. The association between operative time and surgical morbidity is robust across multiple specialties. This is well demonstrated in a meta-analysis by Cheng et al. that found a statistical association in 80% of the 66 studies they included.[16] Whilst the critical time-threshold varied between studies (e.g. 2, 4, 6 hours), it is remarkable that pooled adjusted risk of complications consistently doubled in all specialties, and each additional hour was associated with a 21% increase in complication rate ($p < 0.001$), similar to our results.

Determining the true independent effect of operative time is almost impossible because it is dependent on multiple confounding factors, including case complexity, surgeon experience and technique, institutional factors such as operating room staff and protocols, prior treatment (surgery or radiotherapy), and intraoperative problems, which inevitably lengthen the operation and increase the likelihood of postoperative complications. Some of these factors cannot be modulated, however, head and neck microvascular reconstructions are typically long operations, where many components can be made more efficient. These include anaesthetic preparation time, surgical planning, equipment preparation, team communication and multi-tasking, and concurrent flap harvest with tumour ablation, as well as innovations in harvest and anastomotic techniques, such as advanced sealing technology and venous coupler use.[8,11,12,17] In our institution we routinely performing concurrent flap harvest where possible and is likely to have the greatest impact on the duration of surgery. Several approaches make this option viable in a greater proportion of cases. Firstly, the ALT is the most common soft tissue flap in this cohort. This flap has the advantage of being able to harvest a larger portion of tissue than that anticipated to be necessary without substantially increasing the donor site morbidity. Secondly, we frequently use virtual surgical planning for osseous flap reconstruction. This allows the defect to be defined prior to surgery and has been shown in several studies to reduce operative time.[18,19] Finally, we perform operative tracheostomies at the end of the operation and avoid elective tracheostomy use when it is felt safe to do so by both the ablative and reconstructive surgeon. Tracheostomy not only lengthens the procedure but was associated with double the odds of a complication in this series (Figure 1). Chaukar et al. found that both tracheostomy and longer operative time were independent predictors of wound complications after head and neck surgery, suggesting contamination of the wound with tracheal secretions as a likely mechanism.[20]

A prolonged operative time often indicates longer free flap ischemic time and tissue damage due to anoxic injuries. Moreover, the risk of reperfusion injury and the incidence of no flow phenomenon increase with longer ischemic time.[21,22] Alternatively, increased operative time could be a proxy for procedure complexity, associated anaesthesia risks, or intraoperative complications.[23]Designing a study to control for these metrics is challenging as there are no validated measures of procedure complexity in head and neck oncology or reconstruction.

Limitations

This study is limited by its retrospective design, inability to account for confounding variables not available in the patient's medical record, such as intra-operative decision-making, that may have affected both operative time and complication rate. Whilst the sample size of this study is relatively small, we have analyzed a contemporary cohort over a relatively short period where outcomes can reliably be recorded and verified. The heterogeneity of ablative and reconstructive surgeons from multiple specialties, contribution and experience of trainee surgeons, and flap selection introduces bias into this study but also accurately reflects the unique characteristics of our institution. Increased operative time within this cohort is likely to be a surrogate for multiple factors, including but not limited to patient complexity and concurrent procedures performed which increase both time and complications, such as tracheostomy and osseo-integrated implant placement. Our study did not investigate how specific components (e.g. anesthesia time, resection time, flap harvest time, in-setting time, and ischemia time) affected overall time. This may be important as flap ischemia time is likely to be a better predictor of flap outcome.[27-29] Given that surgical interventions may impact each component of operative time differently, future studies should investigate associations with each time element separately in a multi institutional design to aid the generalizability of findings.

Conclusion

Head and neck cancer surgeries are complex operations with a high risk of surgical and medical complications. Longer operative time is significantly associated with surgical complications, length of stay and risk of return to theatre among patients undergoing head and neck free flap reconstruction.

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