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Free Flap Reconstruction Monitoring Techniques and Frequency in the Era of Restricted Resident Work Hours

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IMPORTANCE Free flap reconstruction of the head and neck is routinely performed with success rates around 94% to 99% at most institutions. Despite experience and meticulous technique, there is a small but recognized risk of partial or total flap loss in the postoperative setting. Historically, most microvascular surgeons involve resident house staff in flap monitoring protocols, and programs relied heavily on in-house resident physicians to assure timely intervention for compromised flaps. In 2003, the Accreditation Council for Graduate Medical Education mandated the reduction in the hours a resident could work within a given week. At many institutions this new era of restricted resident duty hours reshaped the protocols used for flap monitoring to adapt to a system with reduced resident labor.

OBJECTIVES To characterize various techniques and frequencies of free flap monitoring by nurses and resident physicians; and to determine if adapted resident monitoring frequency is associated with flap compromise and outcome.

DESIGN, SETTING, AND PARTICIPANTS This multi-institutional retrospective review included patients undergoing free flap reconstruction to the head and/or neck between January 2005 and January 2015. Consecutive patients were included from different academic institutions or tertiary referral centers to reflect evolving practices.

MAIN OUTCOMES AND MEASURES Technique, frequency, and personnel for flap monitoring; flap complications; and flap success.

RESULTS Overall, 1085 patients (343 women [32%] and 742 men [78%]) from 9 institutions were included. Most patients were placed in the intensive care unit postoperatively (n = 790 [73%]), while the remaining were placed in intermediate care (n = 201 [19%]) or in the surgical ward (n = 94 [7%]). Nurses monitored flaps every hour (q1h) for all patients. Frequency of resident monitoring varied, with 635 patients monitored every 4 hours (q4h), 146 monitored every 8 hours (q8h), and 304 monitored every 12 hours (q12h). Monitoring techniques included physical examination (n = 949 [87%]), handheld external Doppler sonography (n = 739 [68%]), implanted Doppler sonography (n = 333 [31%]), and needle stick (n = 349 [32%]); 105 patients (10%) demonstrated flap compromise, prompting return to the operating room in 96 patients. Of these 96 patients, 46 had complete flap salvage, 22 had partial loss, and 37 had complete loss. The frequency of resident flap checks did not affect the total flap loss rate (q4h, 25 patients [4%]; q8h, 8 patients [6%]; and q12h, 8 patients [3%]). Flap salvage rates for compromised flaps were not statistically different.

CONCLUSIONS AND RELEVANCE Academic centers rely primarily on q1h flap checks by intensive care unit nurses using physical examination and Doppler sonography. Reduced resident monitoring frequency did not alter flap salvage nor flap outcome. These findings suggest that institutions may successfully monitor free flaps with decreased resident burden.

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Free flap reconstruction of the head and neck is routinely performed with success rates around 94% to 99% at most institutions.[1] Despite experience and meticulous technique, there is a small but recognized risk of partial or total flap loss in the postoperative setting. When flap compromise is noted immediately, operative intervention can frequently lead to flap salvage provided interventions are undertaken in a timely fashion. Accordingly, most surgeons have advocated some type of flap monitoring protocol to maximize recognition of early flap compromise.

Surgeons rely on physical examination to assess flap viability, by assessing color, warmth, cap refill, and turgor. However, a variety of adjunctive monitoring techniques are used with varying frequency. The most common additional monitoring methods include assessing the quality of bleeding after pinprick and use of a Doppler sonography (Doppler) signal, which may be used externally (eg, handheld pencil Doppler) or implanted at the time of surgery.

Historically, most microvascular surgeons involve resident house staff in flap monitoring protocols, with frequency as high as every hour (q1h). Accordingly, programs relied heavily on in-house resident physicians to assure timely intervention for compromised flaps. In 2003, the Accreditation Council for Graduate Medical Education mandated the reduction in the hours a resident could work within a given week to 80 hours. At many institutions this new era of restricted resident duty hours reshaped the protocols used for flap monitoring to adapt to a system with reduced resident labor. Programs adapted in a variety of ways by altering the frequency of flap monitoring, changing the venue (intensive care unit [ICU] vs non-ICU), relying on ancillary nonresident staff, and also relying increasingly on new technology for flap checks.[2]

The focus of this study was to characterize the methods and frequency of head and neck flap monitoring and to evaluate if the adapted frequency and methods of flap monitoring had an impact on recognition of flap compromise and ultimate flap survival.

Key Points

Question In the era of reduced resident duty hours, is reduced frequency of resident-performed flap monitoring associated with head and neck free flap compromise or salvage during the postoperative period?

Findings In this multi-institutional retrospective review of 1085 patients from 9 centers, there was no difference in flap salvage or outcome when frequency of resident flap monitoring varied between every 4 to every 12 hours.

Meaning Institutions may monitor head and neck free flaps with decreased resident burden while maintaining good flap outcomes.

Materials

Participants

A retrospective review of all patients undergoing free tissue transfer to the head and neck during the period between January 2005 and January 2015 was conducted at 9 academic medical centers. Participating centers were Northwestern University, University of Kansas, University of Texas MD Anderson Cancer Center, Medical University of South Carolina, Oregon Health Sciences University, Henry Ford Medical Group, Ohio State University, Washington University, and Johns Hopkins University. Institutional review board approval was granted at each participating center. Data collection was limited to no more than 200 patients per institution to garner a representative variation in flap monitoring practices. Institutions contributed either 1 or 2 cohorts of 100 consecutive patients and were permitted to include such groups of consecutive patients from any time in the study period. Patients lacking at least 1 month of follow-up from time of surgery or those with missing data were excluded. Flap monitoring techniques, setting, and frequency were at the discretion of the treating surgeon.

Data Collection

Patient, disease, and treatment-related factors were collected and compiled into a master database. Demographic factors including preoperative laboratory values, comorbidities, tobacco status, and history of radiation or chemotherapy were recorded. Flap monitoring factors included physical examination, needle stick, and use of Doppler (either handheld or implanted). Monitoring setting was categorized as ICU, stepdown or intermediate care setting, and surgical ward. Institutions reported frequency of flap monitoring by either the nurse or the resident physician during the most intensive or critical period after flap surgery, which was generally the immediate 48 to 72 hours after surgery. Use of flap-directed pharmacotherapy was captured including antiplatelet agents, subcutaneous heparin, and intravenous heparin. Presence and timing of flap compromise was recorded, as was return to the operating room for flap distress and outcome of the flap at the conclusion of reoperation. Flap compromise was determined by surgical team notes where it was felt the flap would have significant risk of failure without intervention based on the cumulative information and personnel available. Ultimate flap outcome was categorized as flap success, partial flap failure, and total flap failure measured at 1 month from time of surgery. If a patient experienced an attempted flap salvage, their subsequent flap monitoring was not part of this study as a separate monitoring event. Accordingly, if patients did receive more stringent monitoring after flap compromise, such secondary monitoring did not contribute to this study. Patients were stratified according to frequency of resident-performed flap checks to assess association of monitoring frequency and flap outcomes.

Statistical Analysis

Demographic information is summarized in **Table 1**. Associations between categorical factors and flap failures were performed using the χ^2 test and the Cochran Armitage trend test. The Fisher exact test was used for contingency tables when numbers in respective cells were too low and normal distribution could not be assumed. Subgroup analysis was performed looking specifically at patients who demonstrated flap

Table 1. Patient Characteristics and Association With Complete Flap Failure

Characteristic	No.(%)	Complete Flap Failure, No. (%)	Odds Ratio (95% CI)
Total	1085	41 (3.8)	Not applicable
Sex			
Female	343 (32)	18 (5.2)	
Male	742 (78)	23 (3.1)	0.58 (0.29-1.15)
Diabetes			
No	923 (85)	33 (3.6)	
Yes	162 (15)	8 (4.9)	1.40 (0.55-3.17)
Prior radiation			
No	706 (65)	20 (2.8)	
Yes	379 (35)	21 (5.5)	2.01 (1.02-3.97)
Prior chemotherapy			
No	953 (89)	34 (3.6)	
Yes	132 (11)	7 (5.3)	1.51 (0.55-3.57)
Free flap			
Radial forearm	404 (37)	7 (1.7)	0.34 (0.12-0.78)
Anterolateral thigh	297 (27)	15 (5.1)	1.56 (0.75-3.10)
Fibula	205 (19)	9 (4.4)	1.21 (0.50-2.66)
Osteocutaneous radial forearm	65 (6)	0 (0)	0.00 (0.00-1.46)
Latissimus dorsi	35 (3)	2 (5.7)	1.57 (0.18-6.53)
Rectus abdominus	32 (3)	2 (6.3)	1.73 (0.19-7.25)
Scapula	21 (2)	3 (14)	4.48 (0.81-16.3)
Other	25 (2)	3 (12)	3.66 (0.67-13.0)

compromise. This group was further divided, looking at patients that had flap compromise during the first 72 hours—the period during which flap monitoring has been shown to be most critical. Multivariable analysis was performed to analyze the combined effects of multiple independent variables (comorbidity, flap monitoring techniques, monitoring setting, pharmacotherapy, and frequency of flap monitoring) on flap compromise as well as ultimate flap outcome. Effect sizes for contingency tables larger than 2 × 2 are reported as Cramer V with each 95% CI derived from the appropriate noncentral χ^2 distribution.[3] Statistical analysis was performed using SPSS (IBM) and R software (R Foundation).[3-5]

Results

Patient Characteristics

A total of 1085 patients who underwent head and neck free tissue transfer were included in the study, with a mean age of 61 years and male to female ratio of 2:1. Descriptive patient variables and association with overall flap survival are summarized in Table 1. Roughly one-third of patients had been previously radiated, and over 40% of patients were continuing to smoke prior to free tissue transfer. The radial forearm (43%) was the most frequently used free flap followed by the anterolateral thigh (27%) and the fibula (19%). A higher proportion of flap loss was seen in the group of patients who had undergone prior irradiation, and a higher rate of failure was noted for patients who underwent a scapula or other lesser-used flap (though testing of conditional independence of these flap types did not achieve statistical significance after adjusting for multiple comparisons). Radial forearm flaps were the most commonly performed and experienced a failure rate below what would be expected given the null hypothesis of conditional independence among flap types.

Flap Monitoring and Pharmacotherapy

Flap monitoring and flap-related pharmacotherapy variables are shown in **Table 2**. More than 73% of patients were placed in the ICU postoperatively, with the remainder going to either a step-down unit (19%) or surgical ward (7%). There was no statistical difference in flap outcome based on postoperative monitoring venue. Regarding flap monitoring technique, 87% of patients were monitored by physical examination of the flap vs 13% where the actual flap was not examined as the monitoring technique. Doppler was used in 99% of patients as either handheld or implanted; 32% of patients underwent needle stick as part of the flap monitoring protocol. When examining number of means used for monitoring, 13% of patients were monitored by only 1 technique (Doppler), 53% used 2 techniques (physical examination in addition to Doppler), and 32% used 3 techniques (needle stick in addition to Doppler and physical examination). There was no association between flap monitoring techniques or number of techniques with flap outcome. Antiplatelet pharmacotherapy was used in 66% of patients, and subcutaneous administered heparin for deep vein thrombosis prophylaxis was used in 73%. Four percent of the study population received intravenous heparin; however, this was not part of the routine practice of any of the surgeons and was used in response to adversity in particular patients on a case-by-case basis. Use of medications aimed at reducing flap thrombosis did not have any beneficial association with flap

outcome. Of note, however, is that use of intravenous heparin was associated with significantly increased rate of flap failure, though likely in a subpopulation that is at higher risk of failure at the time if heparinization.

Flap Monitoring Frequency and Flap Success

Nine hundred eighty patients showed no evidence of flap compromise while 105 patients (10%) developed signs of flap compromise (**Table 3**). Nine of these patients did not return to the operating room, and 3 of these patients experienced flap failure. Of the 96 flaps that returned to the operating room for flap salvage, 85 (89%) were successfully salvaged. Durable salvage was not achieved in all such cases, as some flaps still progressed to flap loss. Overall flap success was seen in 1007 patients (93%), with partial flap loss in 37 patients (3%) and complete flap loss in 41 patients (4%). The participating institutions included a general protocol with q1h flap checks, with over 99% of patients in the current study receiving nurse flap checks at this prescribed rate. The frequency at which resident house-staff performed flap monitoring did vary between institutions and also within institutions depending on surgeon preference (Table 3). Resident monitoring was performed q4h in 635 patients, q8h in 146 patients, and q12h in the remaining 304 patients. It was also noted that monitoring regimen was essentially constant by surgeon or by institution and did not vary based on patient or flap characteristics. When stratified according to resident monitoring frequency, flap compromise was seen in 12%, 8%, and 6% of flaps monitored q4h, q8h and q12h, respectively. Overall flap success was seen in 92%, 93%, and 95% of flaps monitored q4h, q8h and q12h, respectively. There was no statistical difference in rate of flap compromise nor overall flap outcome between these 3 groups.

Subgroup analysis was performed looking specifically at flap outcomes only for those flaps that demonstrated evidence of flap compromise in the postoperative setting, presumably for those which frequency of flap monitoring is most critical. Flap outcome results for the entire group of compromised flaps (n = 105) are presented along with results of those demonstrating flap compromise in the first 72-hour period. When looking at only the flaps that experienced flap compromise based on resident monitoring schedule (q4h, q8h, and

Table 2. Incidence of Flap Monitoring Techniques and Pharmacotherapy and Association with Complete Failure

Monitoring/Pharmacotherapy	No.(%)	Complete Flap Failure, No. (%) [95% CI]
Monitoring venue		
Intensive care	790 (73)	31 (5.2) [2.7%-5.5%]
Intermediate care	201 (19)	4 (2.0) [0.5%-5.0%]
Surgical ward	94 (7)	6 (6.4) [2.4%-13.3%]
Monitoring technique		
Physical exam	949 (87)	36 (3.8) [2.7%-5.2%]
Needle stick	349 (32)	17 (4.9) [2.9%-7.7%]
Doppler, external	739 (68)	30 (4.1) [2.7%-5.7%]
Implanted doppler	333 (31)	11 (3.3) [1.7%-5.8%]
Monitoring techniques, No.		
1	157 (14)	6 (3.8) [1.4%-8.1%]
2	572 (53)	18 (3.1) [1.9%-4.9%]
3	351 (32)	16 (4.6) [2.6%-7.3%]
4	4 (1)	1 (2.5) [NA]
Pharmacotherapy		
Antiplatelet	716 (66)	28 (3.9) [2.6%-5.6%]
Subcutaneous heparin	791 (73)	31 (3.9) [2.7%-5.5%]
Intravenous heparin	40 (4)	7 (18) [7.3%-33.0%]

Abbreviation: NA, not applicable.

Table 3. Resident-Performed Flap Monitoring Frequency and Association With Flap Outcome, Flap Compromise, and Salvage Outcomes

Outcome	No. (%)			Cramer V (95% CI)
	Q4h	Q8h	Q12h	
Overall flap outcome				
Flap success	582 (92)	136 (93)	289 (95)	
Partial loss	28 (4)	2 (2)	7 (2)	
Complete loss	25 (4)	8 (6)	8 (3)	
Total	635	146	304	0.0577 (0-0.0997)
Flap compromise				
Yes	75 (12)	12 (8)	18 (6)	0.0886 (0.0463-0.1503)
No	561 (88)	134 (92)	286 (94)	
Attempted flap salvage				
Flap success	33 (44)	5 (42)	8 (44)	
Partial loss	18 (24)	2 (17)	2 (12)	
Complete loss	24 (32)	5 (42)	8 (44)	
Total	75	12	18	0.0996 (0-0.2263)
Attempted flap salvage during first 72 h				
Flap success	23 (56)	5 (55)	6 (55)	
Partial loss	8 (20)	2 (22)	1 (9)	
Complete loss	10 (24)	2 (22)	4 (36)	
Total	41	9	11	0.0978 (0-0.1921)

Abbreviations: Q4h, every 4 hours; Q8h, every 8 hours; Q12h, every 12 hours.

q12h) there were no significant differences in rates of flap salvage (44%, 42%, and 44%, respectively), partial failure (24%, 17%, and 11%, respectively), and total failure (32%, 42%, and 44%, respectively). Similarly, there were no differences in flap salvage rate within the first 72 hours. There were 61 flaps that experienced flap compromise within the first 72 hours overall. Based on monitoring schedule (q4h, q8h and q12h), the flap salvage rate of these flaps was 56%, 55% and 55%; the partial flap failure rates (20%, 22%, and 9%) and total flap failure rates (24%, 22%, and 36%) within the first 72 hours were not significantly different. Multivariable analysis was performed, examining the impact of all variables on ultimate flap outcome. The only variable that was significantly associated with flap loss was the use of intravenous heparin in the postoperative setting. All other variables, including monitoring technique, setting, staff, and frequency, failed to show any statistical association with either flap salvage or with flap outcome.

Discussion

Complete free flap failure is a topic of significant interest and great debate among microvascular surgeons. While it goes without saying that both patients and surgeons are grateful that this is a rare event, it makes scientific study of the event very difficult. When flap success is sited at over 95% in the head and neck, it becomes difficult to do meaningful research on the approximate 5% of cases to better ascertain the factors that contribute to flap failure. Generally speaking, flap surgeons have strong preferences and may be dogmatic about seemingly critical maneuvers and strategies that lead to flap success. In this multi-institutional study that included 1085 free flaps, less than 4% of patients experienced total flap loss, consistent with what is reported in the literature. Given the size of the patient population, this study provides one of the largest multi-institutional populations of patients who underwent head and neck free flap reconstruction to best assess the factors and variables associated with the evolution of free flap compromise and loss.

While 41 flaps failed in this multi-institutional retrospective study, 105 were identified as having some element of flap compromise. This is important because this led to surgical exploration in 96 cases and successful viability of flap in 85 patients upon leaving the operating room (flap salvage rate of 89% with surgical exploration). The infrequency of the event of interest, specifically flap failure, makes it difficult to identify differences in the rate of this event based on flap monitoring protocol and resident monitoring frequency. Despite this limitation, there was no observed trend toward improved outcomes with more frequent resident monitoring. Furthermore, the group of patients that underwent q12h resident monitoring had the lowest rate of total flap loss (3%) compared with the more frequent flap monitoring protocols. It could be argued that there was some possible selection bias regarding flap monitoring and that surgeons may have chosen more frequent monitoring when there was some sense of impending flap compromise. In this study, however, it became clear that frequency of monitoring was a matter of protocol, largely by institution, and it did not appear that flap monitoring was being adjusted by intraoperative findings on a case-by-case basis. Thus, it remains unclear why worse overall flap outcomes were seen in the group of patients that had the highest frequency of flap monitoring. It should be stressed, however, that no conclusion can be drawn from this, because the difference in flap survival was not statistically significant nor was the sample size large enough to draw such conclusions.

Analysis of the compromised flaps showed no differences in flap outcomes based on resident flap monitoring frequency, and this remained true for the subgroup analysis of the compromised flaps identified within the first 72 hours postoperatively. Among patients who experienced compromised flaps within the first 72 hours, the risk of complete flap failure was nearly twice as great in the q12h monitoring group compared with q4h (95% CI, 0.71-4.8) and 1.6 times greater in the q12h group compared with the q8h group (95% CI, 0.38-7.0). While these increased risk estimates are not statistically significant the magnitude of the effect and the upper bound of the confidence interval do not rule out the possibility that q12h monitoring could be associated with greater likelihood of total flap failure rather than particle flap failure among patients with a compromised flap. While this may warrant closer inspection in the future, the current study suggests that more frequent resident monitoring does not lead to improved flap outcomes. While frequency of resident flap monitoring was the critical independent variable being analyzed in the current study, it must be noted that virtually all patients underwent q1h nursing flap checks in this study population. Survey responses did not quantify the duration of the immediate postoperative period, allowing for each surgeon or institution to interpret the "immediate" postoperative period. Thus, even accounting for any variations in interpretation, we can observe that hourly nursing flap checks allow for the overwhelming majority of flaps to survive. Taken a step further, hourly nursing monitoring in particular also allows a considerable amount of compromised flaps to survive. This suggests that flap monitoring in the nonacademic setting is feasible as long as the nursing staff are appropriately trained. In the academic setting, it also suggests that a nursing staff trained specifically in flap monitoring may obviate the need of sending patients to the ICU.

The majority of patients were monitored in an ICU in the immediate postoperative period (73%). While this means there were relatively few patients monitored in other locations, there was no difference in flap outcomes based on monitoring location. Arshad et al[6] performed a comparative effectiveness and cost analysis of an ICU vs non-ICU protocol in 257 patients and found increased length of stay and cost in the ICU group but no difference in flap survival rates. Panwar et al[7] conducted another study with similar findings but also demonstrated that a non-ICU protocol can be translated to a nonacademic setting. He concluded that management of the free flap patient in a protocol-driven head and neck surgical unit resulted in a less costly hospital stay, a reduced duration of admission and similar flap outcomes. Haddock et al[8] also published on the subject, reiterating the feasibility and

cost-effectiveness of performing flap monitoring in a non-ICU setting in the immediate postoperative period. It is very likely that the decision to manage a patient in a non-ICU setting is dependent on the availability within an institution of a head and neck surgical unit with the appropriately trained nursing staff to care for these patients. We believe that the skills and flap familiarity of the nursing staff is more critical than the actual venue, coupled with the frequency that nurses are able to do flap checks in each setting. We believe this study supports the notion that skilled nursing flap care is probably the critical element to safe flap monitoring, which can likely be performed in a non-ICU setting with significant cost savings. Flap-monitoring by a skilled nursing workforce in a non-ICU setting would likely optimize outcomes while minimizing unnecessary cost.

Sixty-eight percent of flaps were monitored with an external Doppler and 31% used an implantable Doppler. While not a primary objective of this study, there was a small observed difference in flap failure with the external Doppler (4.1%) compared with the implantable Doppler (3.3%). This difference was not statistically significant, and given the wide range of the confidence interval, neither of these techniques were found to be superior in this study. There are mixed findings and opinions in the literature with regards to the use of the implantable Doppler. Wax et al[9] reported 1142 patients undergoing free flap reconstruction using an arterial implantable Doppler and 74 patients with an arterial and venous implantable Doppler. He reported a 97.6% overall flap survival rate with the implantable Doppler, a lower overall revision rate of 6.7%, and more pedicles requiring intraoperative revision (11.0%). Schmulder et al[10] conducted a retrospective review of free flap monitoring comparing the venous implantable Doppler vs clinical assessment (without external Doppler); 473 flaps (188 head and neck flaps) were included in this study. There was significantly improved flap survival (94.6% vs 84%) and shorter mean time until discovery of flap compromise with the Doppler group. Ho et al[11] similarly compared free flap outcomes with the use of an implantable Doppler (89% artery, 9% vein, 2% both) vs clinical assessment (n = 75). There was a 7.0% failure rate with the implantable Doppler and 1.0% with clinical assessment.[11] Flap salvage rates were equivalent.

There are a number of different technological advancements (the implantable Doppler included) that are available for free flap monitoring that are beyond the scope of this publication. Some authors suggest that these new technologies are superior to traditional clinical assessment.[12] However, others argue that ultimately the decision to explore a flap pedicle is a clinical decision that should be based on the overall clinical appearance of the flap. The dilemma remains when a flap appears healthy and the signal from the Doppler is poor, which may be secondary to malfunction of the implantable Doppler or impending flap compromise. On the other end of the spectrum, Lin[13] argues that he would always explore a flap that appears clinically compromised even if the signal from a Doppler remains strong.

Postoperative pharmacotherapy is a highly debated topic for microvascular surgeons, with a variety of practices that are widely espoused. Over time, there seems to be a trend away from complex pharmacotherapy regimens. This study confirms there remains some variation in use of antiplatelet agents and subcutaneous heparin, though no apparent association with flap outcome was demonstrated in this study. While there was a negative association noted between intravenous heparin and flap outcome, it must be underscored that this is not believed to be a cause and effect relationship. None of the centers use intravenous heparin as a routine postoperative flap medication. Accordingly, this was only used on 4% of the study population in a biased fashion, presumably due to some other harbinger of flap distress. It is possible that intravenous heparin may be useful in this small group of likely distressed flaps, though the current study does not specifically address this. Regarding subcutaneous heparin, it should be noted that only 73% of patients were treated with this medication. Beyond its potential use for flap protection, one might expect this would be a routine medication on all such patients for deep vein thrombosis prophylaxis. Given most such patients have advanced malignancy, undergo lengthy open surgery, and may have limb immobilization postoperatively, all are likely at modest to high risk for deep vein thrombosis. This may represent an area for improvement regarding clinical practice, or an area for focused study on a more current study population.

In a survey of otolaryngologists performing head and neck microvascular reconstruction conducted by Spiegel,[14] the simplest postoperative monitoring protocol was associated with the highest rate of flap success (99%) and lowest rate of return to the operating room for a complication, 1%. There is no consensus within the microvascular reconstructive community with regards to the ideal methodology of flap monitoring postoperatively. However, there is evidence that excellent outcomes are possible with clinical monitoring alone. When it comes to patient flap safety, this study supports the notion that a broad range of flap monitoring techniques are not associated with statistically significant or clinically meaningful differences in rates of flap success.

Controversy exists over the impact of reduced resident duty hours on patient care. Bilimoria et al[15] recently published a study reporting noninferiority of more flexible surgical resident duty hours with respect to patient safety, resident quality of life, and educational attitudes. Flap monitoring patterns in the new duty hour era did not appear to negatively impact the rate of flap failure and successful salvage of a compromised flap when compared with historic norms of flap success.[16-18] Again, it should be emphasized that patients in this study were closely monitored by nursing staff. With such measures taken, institutions in this study seem to rely less heavily on resident staff for flap monitoring without compromising flap safety and success.

Limitations

There are a several limitations to this study that must be considered when assessing the results and conclusions. As a retrospective study, all data was extracted from previously

existing medical records. Extraction of certain data can be potentially subjective and open to interpretation based on wording in the medical records. There may be some variability concerning when a flap was declared compromised based how specific the medical notes were. Causes for operative exploration can also be multifactorial and open to variable interpretation depending on what details were contained in the medical record. Another limitation relates to practice patterns of monitoring. All variables regarding flap monitoring were not randomly distributed with respect to one another. For many centers, a particular cluster of monitoring practices were coupled together. Accordingly, conclusions from this study about any single element of flap monitoring practice must be interpreted with caution.

Conclusions

Head and neck free flap monitoring remains heterogeneous with respect to technique and frequency of resident flap checks across academic institutions. However, most flaps are being monitored in the ICU setting using q1h nursing checks with an external or implantable Doppler. In the era of restricted resident duty hours, variation in frequency of resident monitoring was not associated with change in successful operative flap salvage nor with overall flap outcome. These findings may serve as a guide for institutions to successfully manage free flaps postoperatively while decreasing the burden to residents with respect to frequency of flap checks.

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