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Comparative Outcomes for Microvascular Free Flap Monitoring Outside the Intensive Care Unit

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Abstract

Objective. There is a trend towards nonintensive care unit (ICU) or specialty ward management of select patients. Here, we examine postoperative outcomes for patients transferred to a general ward following microvascular free flap (FF) reconstruction of the head and neck.

Study Design. Retrospective quality control study.

Setting. Single tertiary care center.

Methods. Consecutive patients who underwent FF of the head and neck before and after a change in protocol from immediate postoperative monitoring in the ICU ("Pre-protocol") to the general ward setting ("Post-protocol"). Outcomes included overall length of stay (LOS), ICU LOS, FF compromise, and postoperative complications.

Results. A total of 150 patients were included, 70 in the pre-protocol group and 80 in the post-protocol group. There were no significant differences in age, sex, comorbidities, tumor stage, or type of FF. Mean LOS decreased from 8.18 to 7.68 days ($P = .4$), and mean ICU LOS decreased significantly from 5.2 to 1.7 days ($P < .01$). There were no significant differences in postoperative or airway-related complications ($P = .6$) or FF failure rate (2.9% vs 2.6%, $P > .9$). There was a non-significant increase in ancillary consults in the post-protocol group (45% vs 33%, $P = .13$) and a significant increase in rapid response team calls, a nurse-driven safety net for abnormal vitals or mental status (19% vs 3%, $P = .003$).

Conclusion. We show the successful implementation of a protocol shifting care of FF patients from the ICU to a general ward postoperatively, suggesting management on the floor with less frequent flap monitoring is safe and conserves ICU beds. Additional teaching and familiarity with these patients may over time reduce the rapid response calls.

Keywords

free flap monitoring, head and neck, microvascular free flap

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Microvascular free flap (FF) reconstruction is a reliable option for patients with defects of the head and neck.[1,2] While there are a variety of FF monitoring options,[3] postoperative monitoring often occurs in the intensive care unit (ICU) to allow frequent monitoring, ensure FF survival, and quick return to the operating room to increase chances of survival.[4,5] There is an ongoing push to reduce healthcare utilization and increase efficiency, particularly in resource-constrained settings.[6,7] ICUs are a resource-intense environment, and decreasing length of patient stay in the ICU has the potential to reduce costs.[8,9] Further, the ICU setting is not without risks for postoperative patients and has not been shown to reduce complication rates, with comparable FF compromise despite the ability to have more frequent FF monitoring.[10,11] FF care in a general ward with standardized nurse-led monitoring remains understudied.

Here, we present postoperative comparative outcomes for patients transferred to a general ward immediately following microvascular FF reconstruction of the head and neck versus receiving care in an ICU setting.

Methods

This is a retrospective cohort study at a single tertiary care center. Institutional Review Board approval was obtained prior to proceeding. Consecutive patients who underwent microvascular FF reconstruction of the head and neck between October 2021 and November 2022 were included in the study. Demographic data, oncologic information (if

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applicable), surgical reconstruction details, and postoperative outcomes were recorded. Primary outcome was FF compromise prior to discharge, defined as persistent physical examination and/or vascular doppler changes that progressed to partial or complete tissue loss/necrosis and/or flap explant or debridement. Secondary outcomes included overall length of stay, intensive care unit length of stay, postoperative complications, and need for ancillary consultations or rapid responses.

Protocol and Cohorts

The study was divided into 2 cohorts: pre- and post-FF monitoring protocol change. In the "Pre-protocol" group, patients undergoing FFs were sent to the ICU setting immediately postoperatively, with the goal of transitioning out of the ICU to the floor or stepdown unit on postoperative Day 3. Flaps were monitored by nursing staff q1 hours for the first 24 hours, then q2 hours for the following 48 hours, then q4 hours until discharge (**Figure 1**). The "Post-protocol" group was admitted to a general surgical floor or stepdown unit immediately postoperatively unless they had a non-flap-related ICU level need (ie, ventilator or pressor requirement). FF monitoring was performed by general surgical floor nursing staff every four hours starting immediately postoperatively and continuing until discharge. Frequency of monitoring by the physician team (3 times per day) was unchanged during the study period. The same group of reconstructive surgeons performed the FF reconstructions in both groups.

Statistical Analysis

For analysis, patients were initially stratified by whether they received their operation before or after workflow change implementation. Demographic characteristics, preoperative comorbidities, and operative characteristics were compared using Wilcoxon rank sum tests, Pearson's Chi-squared tests, and Fisher's exact tests depending on the classification of the variable (continuous vs categorical). Similar statistics were used for comparing postoperative outcomes of interest. Multivariable logistic regression analysis was conducted with any complication (postoperative complications tracheostomy complications, and medical/other complications in aggregate) as the primary outcome. Postoperative complications include cellulitis/wound infections, fistulas, and free-flap failures. Tracheostomy complications included tracheostomy site bleeding, stoma breakdown, pneumonia, and other pulmonary complications. Finally, medical complications included atrial fibrillation, strokes, codes, supraventricular tachycardia, urinary tract infection, clostridium difficile infection, acute kidney infection, deep vein thrombosis, pulmonary embolism, and delirium. The multivariable model adjusted for age/sex, comorbidity index, TNM staging, tracheostomy, and finally postoperative destination, with additional sub-analysis for the postprotocol patients that were sent to the ICU immediately postoperatively. All statistical analysis was performed using R (RStudio PBC). Significance was defined as an $\alpha < 0.05$.

Results

A total of 150 consecutive patients undergoing microvascular FF of the head and neck were included in the study: 70 patients in the pre-protocol group and 80 patients in the post-protocol group. There were no significant differences between groups in age, sex, Charlson comorbidity index, tumor stage, or type of flap (**Table 1**). The mean percentage of traveler or float nurses ranged from 14% to 22% during this time.

ICU Usage

Ninety-three percent (n = 65) of patients in the pre-protocol group went to the ICU immediately postoperatively versus 11.3% (n = 9) in the post-protocol group. Reasons for immediate postoperative ICU needs in the second cohort included surgeon discretion for significant comorbidities in four patients, need for close neurologic monitoring due to craniectomy by neurosurgery in four patients, and new onset supraventricular tachycardia in one patient. The patients sent to the ICU in the post-protocol group still received q4 hour

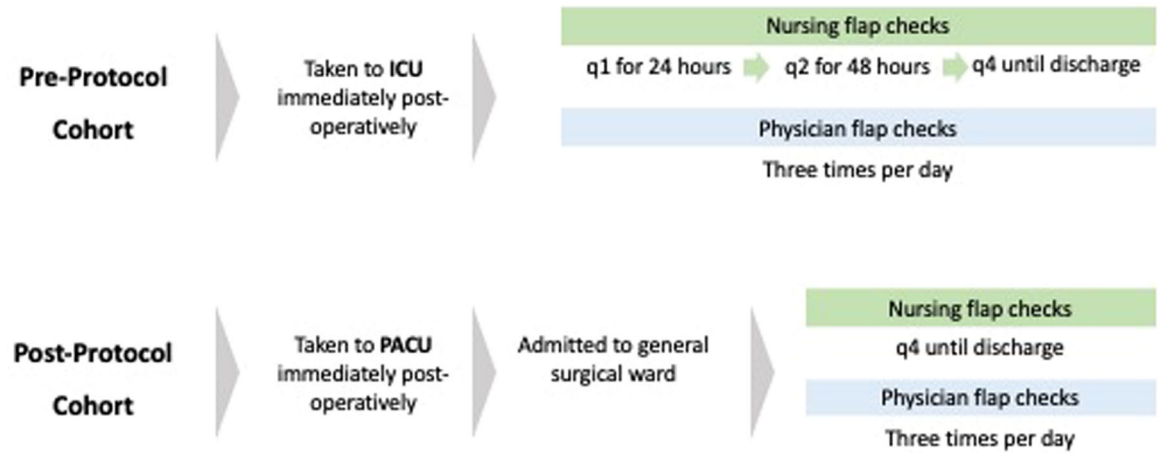

Figure 1. Schematic diagram of flap checks preprotocol and postprotocol change. ICU, Intensive care unit; PACU, Post-anesthesia care unit.

Table 1. Demographic Characteristics for Pre-protocol ("Pre") and Post-protocol ("Post") Groups

Characteristic	Pre, N = 70 N (%)	Post, N = 80 N (%)	*P* value
Age at surgery	65 (55, 75)	67 (62, 72)	.5
Sex			.3
Female	20 (29%)	29 (36%)	
Male	50 (71%)	51 (64%)	
Race			.001
Asian	0 (0%)	1 (1.3%)	
Black	7 (10%)	0 (0%)	
White	58 (83%)	78 (98%)	
More than on Race	1 (1.4%)	0 (0%)	
Unknown	3 (4.3%)	1 (1.3%)	
Other	1 (1.4%)	0 (0%)	
Charlson Comorbidity Index			.13
0	45 (64%)	42 (53%)	
1	12 (17%)	24 (30%)	
2	7 (10%)	12 (15%)	
3	3 (4.3%)	2 (2.5%)	
4	2 (2.9%)	0 (0%)	
5	1 (1.4%)	0 (0%)	
Tracheostomy			.2
No	36 (55%)	34 (44%)	
Yes	30 (45%)	43 (56%)	
T Stage			.7
1	6 (8.6%)	3 (3.8%)	
2	14 (20%)	20 (25%)	
3	12 (17%)	11 (14%)	
4	24 (34%)	30 (38%)	
N/A	14 (20%)	16 (20%)	
N Stage			.024
0	23 (33%)	41 (51%)	
1	15 (21%)	7 (8.8%)	
2	16 (23%)	9 (11%)	
3	3 (4.3%)	7 (8.8%)	
N/A	13 (19%)	16 (20%)	
M Stage			.7
0	50 (71%)	63 (79%)	
1	1 (1.4%)	1 (1.3%)	
N/A	19 (27%)	16 (20%)	

FF monitoring by nursing (rather than q1 hour monitoring as was done for the pre-protocol group). Subanalysis of the postprotocol group stratified by ICU use immediately postoperatively did not predict any complications in the multivariate model (odds ratio [OR] 0.71, 95% confidence interval [CI] 0.11-4.62).

FF Compromise

There was no significant difference in FF compromise between the cohorts (2.9% vs 2.6%, $P > .9$) (**Table 2**). In the pre-protocol cohort, there were 2 instances of FF compromise during hospitalization. One FF failed abruptly on postoperative day (POD) 11 due to arterial compromise following postoperative chyle leak, it was not salvaged. The second flap had superficial venous congestion first noted on POD3 and the majority of the flap was salvaged. Within the post-protocol cohort, there were also 2 patients with FF compromise during their initial hospitalization. One flap was due to loss of venous flow on POD7 and the other due to arterial compromise on POD10. Neither flap was able to be salvaged. Of note, all but one of the flap failures were late failures outside the window of change in FF monitoring (the first 72 hours).

Table 2. Outcomes of Interest for the Pre-protocol and Post-protocol Groups

Outcome	Pre, N = 70 N (%)	Post, N = 80 N (%)	*P* value
Hospital stay (days) (median; IQR)	6.0 (5.0, 9.0)	6.0 (5.0, 8.0)	.4
ICU stay (days) (median; IQR)	4.00 (4.00, 5.00)	0.00 (0.00, 0.00)	<.001
Any complication	43 (61%)	50 (63%)	>.9
Readmissions	16 (23%)	21 (26%)	.6
Postoperative complications	35 (50%)	43 (54%)	.6
Tracheostomy or pulmonary complications	14 (20%)	13 (16%)	.6
Other complications	10 (14%)	14 (18%)	.6
Flap compromise	2 (2.9%)	2 (2.6%)	>.9
ICU transfer	4 (6.5%)	6 (8.3%)	.8
Ancillary consults	23 (33%)	36 (45%)	.13
Rapid responses	2 (3.0%)	12 (19%)	.003

Abbreviation: IQR, interquartial range.
Other complications include new atrial fibrillation, stroke, supraventricular tachycardia, urinary tract infection, clostridium difficile, acute kidney injury, deep vein thrombosis or pulmonary embolism, or delirium

Length of Stay

The length of stay in the ICU significantly decreased between cohorts from a mean of 5.2 days (SD 4.07 days) to 1.69 days (SD 4.12, $P < .01$). Overall hospital stay decreased from mean of 8.18 days (SD 5.11 days) to 7.68 days (SD 5.52 days, $P = .4$).

Cost Analysis

Financial comparisons were done using average payer costs by acuity of hospital bed, which is primarily driven by differences in nursing labor costs. By utilizing fewer days in the ICU, the relative cost reduction was almost 50%. Patients treated in the pre-protocol were charged on average $10,197 (95% CI 8431-13,209) compared to an average of $5,297 (95% CI 4415-8830, $P < .001$) in the post-protocol group. On linear regression analysis predicting cost while adjusting for

pre- and post-protocol status and complications, patients treated post-protocol exhibited an independent reduction in cost ($b = -4469$, 95% −6993 to −1944, $P < .001$).

Postoperative Course

There was no significant difference in postoperative complications ($P = .6$) or airway-related complications ($P = .6$) between the 2 groups. There was a non-significant increase in ancillary consultations for patients in the post-protocol group (45% vs 33%, $P = .13$); acute pain management (16%), cardiology (16%), and general medicine (16%) were most often consulted. There was no difference in need for transfer from the floor to the ICU setting for pre-protocol and post-protocol cohorts (6.5% vs 8.3%, $P = .8$). There was an increase in rapid response team calls (a nurse-driven safety net for abnormal vitals or mental status) for patients in the post-protocol cohort (19% vs 3%, $P = .003$). Regression analysis did not identify an independent predictor for any postoperative complications (**Table 3**).

Table 3. Multivariate Regression Predicting Any Complications

Characteristic	OR	95% CI	*P* value
Age	1.01	0.98, 1.04	.367
Sex			
Female	-	-	
Male	0.86	0.38, 1.92	.713
Charlson Comorbidity Index			
0	-	-	
1	0.9	0.38, 2.16	.81
2	1.41	0.43, 5.06	.576
3	0.72	0.10, 6.31	.744
4	0.43	0.01, 12.5	.576
5	-	-	-
T-Stage			
1	-	-	
2	0.92	0.15, 4.93	.925
3	2.24	0.33, 14.0	.39
4	0.63	0.11, 3.05	.573
N/A	0.57	0.02, 8.50	.692
M Stage			
0	-	-	
1	1.02	0.03, 34.8	.988
N/A	3.43	0.61, 22.7	.169
N Stage			
0	-	-	
1	0.95	0.31, 2.92	.921
2	0.6	0.20, 1.74	.349
3	1.83	0.39, 10.2	.455
N/A	1.76	0.11, 55.2	.701
Tracheostomy			
No	-	-	
Yes	2	0.91, 4.49	.087
Pre vs post			
Pre-	-	-	
Post-	1.01	0.45, 2.25	.987

Abbreviations: CI, confidence interval; OR, odds ratio.

Discussion

Here, we describe the efficacy of a microvascular FF pathway relying on postoperative monitoring on a general surgical floor. Previous studies have demonstrated the potential for safe monitoring outside the ICU setting but focused on intermediate-level care or specialty-specific non-ICU wards.[12-14]

Prior papers have shown no difference in FF survival with variations in resident monitoring,[15] but little data exists regarding frequency of nurse-led monitoring, which is dependent on the type of hospital floor or unit. The frequency of monitoring on the general surgical floor by nursing staff at our institution is every 4 hours starting immediately post-operatively and continuing until discharge, and 3 times daily by the physician team. Of note, the nursing staff were not part of a specialty-specific team, and at times almost one-fifth of the staff were replaced by float or traveling nurses. Further, the pre-protocol group benefitted from being the last iteration of a well-established FF pathway, optimized over many years. The post-protocol group is the first iteration of a new pathway that did not benefit from similar optimization and still yet still demonstrated comparable outcomes. Flap monitoring by general ward nurses can be successfully implemented without change in flap survival.

FF Compromise

There was no significant difference between FF compromise in the non-ICU setting compared to those monitored in the ICU (2.9% vs 2.6%, $P = >.9$). This is in line with what has been reported in prior studies.[13,16-18] The authors recognize that this retrospective cohort study was likely not powered to detect a difference in FF failure rate. Assuming a baseline FF failure rate of 5%, a conservative estimate of the number of patients required to detect a FF failure rate of 10% in the post-protocol intervention group is 870 total patients. Two flaps failed in the pre-protocol group. One was an anterolateral thigh (ALT) FF for reconstruction of a large facial basal cell carcinoma defect that developed venous congestion, likely of a perforator, that was first identified on POD3 and partially salvaged. The other patient was a salvage total laryngectomy with chyle leak and fistula that eventually lead to arterial compromise of the latissimus dorsi FF on POD11 and could not be salvaged. Two flaps failed in the post-protocol group, 1 was a latissimus dorsi FF for reconstruction of a salvage laryngectomy with a clot in the distal vein on POD7. The second was an ALT FF for salvage oropharyngectomy with acute oropharyngeal bleed and pedicle hemorrhage on POD10. Neither flap was able to be salvaged. While FF monitoring is typically continued q4 hours until discharge, the late failures were all well outside the change in monitoring period and therefore unlikely to be related to immediate postoperative microvascular

compromise that would be identified with routine monitoring.[19] Late FF failure is increasingly recognized as a proportion of our team's FF failures and this phenomena has been described by other authors.[20]

Length of Stay

The mean length of hospital stay, while not statistically significant, decreased by half a day in the post-protocol group. Importantly, the ICU length of stay decreased significantly by over 3.5 days. Having patients spend more postoperative time on the floor rather than a critical care unit has the potential to increase the amount of teaching patients receive and allows for continuity of discharge planning with social work and case management teams. Decreased time in the ICU may also increase time spent with physical therapy in rehabilitation and avoid ICU-related deconditioning.[21]

Postoperative Course and Complications

There was no difference in overall rate of postoperative complications between groups, including airway-related complications. This is different from Chen et al. that reported increased rates of sepsis and pulmonary complications among patients monitored in the ICU.[22] There was no significant difference in number of consults to subspecialty teams between the 2 groups, although there was a 12% increase in the postprotocol group. At our institution, physician consultants do not follow patients while they are in the ICU, as all care is managed by the critical care team, and there is not a hospitalist-based co-management team once on the floor. Therefore, it is not surprising that complex postoperative patients in a general ward would generate more ancillary consults to address medical comorbidities.

There was a significant increase in rapid response calls for the post-protocol cohort. Rapid responses are a hospital-wide safety net system that allows any clinician, staff, or family member to elevate concerns regarding a change in patients' mental status or vitals and triggers evaluation by a critical care clinician. This increase is likely a direct result of moving complex head and neck patients to the ward, and represents a potential learning curve from nursing and other support staff. Most calls were related to change in mental status, change in vitals noted on the monitor, or change in pulmonary status. Importantly, there remained a low rate of patients needing to be transferred from the ward back to ICU level care after being on the floor and no difference between the 2 groups. Of those requiring transfer, the most common reasons were pulmonary and cardiac complications. On multivariate analysis, there was no predictor for complications, and the Charlson comorbidity index and type of FF did not differ significantly between the 2 groups.

Hospital Utilization

Part of the impetus for this initiative was optimizing use of scarce resources such as the intensive care unit and nursing staff at busy tertiary care center. This was further spurred on by high-volume ICU needs during the COVID era. By moving FF patients out of the ICU setting, we were able to reduce the mean number of ICU days per patient by almost 70%, and subsequent associated hospital bed-related costs by 50%. This increases bed availability for other patients with critical care needs. This was further helped by having a bed management plan for postoperative beds on a general ward, avoiding patients remaining in the ICU despite not having critical care needs due to lack of available floor beds. Utilizing fewer surgical intensive care unit rooms resulted in a 67% reduction in room costs in the postprotocol group. While a more comprehensive cost analysis is outside the scope of this study, this change has the potential to lower hospital costs and is in line with what has been reported in other studies.[17,18]

There was a decreased reliance on nurse staffing given the change to q4 hour FF monitoring. Within the general ward at our institution the nurses did not undergo formalized training, but did have access to an inpatient nurse practitioner specialized in head and neck that served as a source of informal training. Implementing this protocol change during a hospital-wide robust increase in travel or float nurses (as high as 22%) demonstrates the flexibility of monitoring and teachability of knowledge required for FF care.

Limitations

This study is limited by the retrospective nature at a single tertiary institution. The lack of direct cost data for each patient's entire hospitalization makes generalizations regarding cost savings difficult to elucidate, as our analysis does not account for re-operation or costs independently associated with complications or consultations, although this has been described in other papers.[17,18,23]

Conclusion

Head and neck FF patients can be successfully managed postoperatively in a nonspecialty specific general ward setting with no increase in postoperative complications, including FF flap failures. Additional teaching and familiarity with these patients by nursing and support staff may over time reduce the increase in rapid response calls.

Author Contributions

Madelyn N. Stevens, concept and design, data collection, analysis, manuscript creation and editing, final review; **Kavita Prasad**, data collection, presentation of research, final review; **Rahul K. Sharma**, data collection, analysis, final review; **Jean-Nicolas Gallant**, concept, analysis, final review; **Daniel R. S. Habib**, data collection, manuscript creation and editing, final review; **Alexander Langerman**, concept and design, final review; **Kyle Mannion**, concept and design, final review; **Eben Rosenthal**, concept and design, manuscript editing, final review; **Michael C. Topf**, concept and design, manuscript editing, final review; **Sarah L. Rohde**, concept and design, manuscript editing, final review.

Disclosures

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