ASRM SCIENTIFIC PAPER PRESENTATIONS: COMPLEX NON-MICROSURGERY RECONSTRUCTION
Tuesday, January 17, 2017, 7:30am – 9:15am

107. Intraoperative Angiography for Timing of Large Pedicled Flap Division: A Novel Technique

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Introduction: Pedicled flaps based on axial blood flow are used in reconstructive surgery in a staged manner. Flaps are elevated, rotated into position and ingrowth occurs from recipient site blood vessels. After a period of weeks the flap is divided at its base and survives off retrograde inflow of the recipient site vessels. Clinical inspection is the standard of care for timing of flap division. Intraoperative angiography (IOA) is a technique that allows for immediate evaluation of tissue perfusion. This technology has been used extensively in reconstruction with free tissue transfers. We describe a novel technique using intraoperative angiography to evaluate retrograde inflow to large pedicled flaps that may optimize the timing for flap division and improve patient outcomes.

Methods: A multi-institution, retrospective, consecutive case series review was performed for all cases in which large pedicled flaps (thoracoepigastric, groin or cross leg flaps) were used for extremity reconstruction. One cohort used clinical assessment (non-IOA group) and the other used IOA to determine timing of flap division (direct visualization of retrograde tissue perfusion greater than 50% of the length of the flap was the indication for division in the IOA group). Outcome comparison included patient demographics, injury severity scores (ISS), flap type, flap necrosis and flap loss.

Results: From 2003-2016, 33 large pedicled flaps for extremity trauma were reviewed. Multivariate analysis was performed. No significant differences were found in patient demographics or outcomes by flap type. There were 11 throacoepigastric, 20 groin and 2 cross leg flaps. ISS was 6.9 points higher in the IOA group (p=0.065). Partial flap necrosis occurred in 7 patients (21%), 6 in the non-IOA group. Two complete flap losses occurred (6%), all in the non-IOA group (p=0.09)

Conclusion: Pedicled flaps based on axial blood flow are a useful technique in extremity reconstruction. Patients that have large surface area injuries or are not amenable to free flap

procedures can benefit from the staged procedure. Critical to their success is timing of flap division. The technique of pedicled flap division utilizing IOA has been described in paramedian forehead flaps, this study presents the first series in large pedicled flaps. Our data trends towards significantly decreased rates of partial and complete flap loss when IOA is used in these cases. This novel technique can assist the reconstructive surgeon in clinical decision-making and may decrease complications and reduce additional surgeries for patients requiring reconstruction of large surface area extremity injuries.

108. Freestyle Perforator Preserving Technique for the Pedicled ALT in Distant Functional Reconstructions: A Cadaveric Study and Clinical Outcomes

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Introduction

The pedicled anterolateral thigh flap (ALT) can reach defects from the mid-abdomen to the perineum and the reverse pedicled ALT can extend to the knee. The lateral femoral cutaneous nerve (LFCN) provides sensation to this well-known flap. Based off of the descending branch of the lateral femoral circumflex artery, multiple skin islands and the vastus lateralis muscle can be harvested with the flap. We present the safety, reliability and reproducibility of a freestyle perforator preserving technique of the pedicled ALT flap for defects outside the borders of the thigh.

Methods

Anatomic studies of 40 anterolateral thigh flaps were harvested in 20 cadavers. Freestyle technique with perforator preserving incision was performed to identify the perforators and isolate the flap components. The LFCN was identified all flaps. From May 2010 to May 2016, 42 patients were reconstructed using a pedicled ALT for defects outside of the thigh region. Patient age ranged from 28 to 60 years. The vascular branch to the rectus femoris muscle was ligated for elongation of the main pedicle as necessary. A tunnel was created under the proximal sartorius and rectus femoris muscles for perineal and contralateral defects. The flap was tunneled subcutaneously for lateral defects. Superdraining was performed when the reverse ALT was utilized.

Results

Twenty-two fasciocutaneous and 20 myocutaneous flaps were harvested with 60% including the LFCN. Six functional vaginal reconstructions, 3 functional penile reconstructions, and various hip, perineal and abdominal defects were successfully treated. The reverse ALT required superdraining to the greater saphenous vein in all cases. Sensate flaps regained two-point discrimination that was comparable to the contralateral thigh within an average of 6 months. The donor area was grafted in 8 (19%) patients and no major complications or flap losses were observed. Five minor wound dehiscences were treated conservatively. Mean follow up was 8 months.

Conclusion

The freestyle perforator preserving technique for pedicled ALT flap harvest with the LFCN provides reliable functional and sensate reconstruction of hip, lower abdomen, groin and perineum. Superdraining the reverse ALT is suggested to prevent flap congestion.

109. Incidence of Venous Thromboembolism and its Effects on Outcomes in Lower Extremity Salvage

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Background: Venous thromboembolism (VTE) is a major cause of morbidity and mortality following surgery. However, the impact of preoperative VTE on outcomes in lower extremity salvage is not well reported.

Purpose: This study investigates the incidence of VTE in patients requiring flap coverage of the lower extremity, the characteristics of patients with VTE in this population, and flap survival and limb salvage in the presence of preoperative VTE.

Materials and Methods: A retrospective chart review of patients with lower extremity injury requiring soft tissue reconstruction was performed at a level 1 trauma center between July 2007 and March 2015. Anticoagulation therapy or IVC filters were provided to all patients with VTE per accepted guidelines. Demographics, age, comorbidities, injury type, and preoperative data were recorded. Outcomes compared included flap complications and amputation. Data was analyzed by Fisher's exact test and unpaired t-test with $\alpha \leq 0.05$.

Results: A total of 186 patients with lower extremity injuries underwent local and free flap procedures, with 13 patients (7.0%) developing VTE during the hospitalization. 9 patients had deep vein thrombosis, 1 had a pulmonary embolism, and 3 had both. 4 VTE occurred following soft tissue reconstruction (2.2%). The average age of patients with VTE was 49 ± 14 years, compared with 39.5 ± 16 for non-VTE patients ($p = 0.04$). Patients with VTE were more likely to have chronic hypertension than patients without VTE (OR = 3.5, CI 1.1-11.6). Additionally, orthopedic internal fixation was associated with higher odds of VTE (OR = 10.3, CI 1.6-68.2). The limb salvage rate in the patients with preoperative VTE (n=9) was 100%. The rate of any flap complications (flap revision, flap necrosis, fat necrosis, dehiscence, hematoma or flap loss) was similar in patients with or without preoperative VTE (22.2% in the VTE group versus 14.1% in the non-VTE group, $p = 0.63$).

Conclusion: Lower extremity salvage patients experiencing VTE were more likely to be older, hypertensive, and to have undergone orthopedic internal fixation. Overall, the rate of VTE in this population was 7.0%, while the rate of VTE occurring after flap reconstruction was just 2.2%. Finally, this study suggests that VTE in a lower extremity does not increase the risk of amputation or flap complications despite a hypercoagulable state. Thus, it may be safe to perform flap coverage on lower extremity salvage patients with preoperative VTE when following accepted standards of care for VTE management.

110. Symptomatic Deep Venous Thrombosis Following Lower Extremity Flap Harvest: Lessons Learned From A Single Instituion Experience

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Background: Postsurgical venous thromboembolism (VTE) remains a leading cause of hospital morbidity and data to support VTE prophylaxis guidelines in lower extremity flap surgery are currently lacking. The purpose of this study was to identify the incidence of symptomatic VTE in patients undergoing harvest of lower extremity flaps who received standard chemoprophylaxis while hospitalized to identify factors which could change postoperative prophylaxis guidelines.

Methods: Sixty-two consecutive patients undergoing unilateral lower extremity flap harvest from June 2011 to December 2015 were retrospectively evaluated for the development of VTE. Each patient had a flap harvested from the lower extremity and inset into another part of the body and not the ipsilateral leg/foot/ankle. All patients with symptomatic leg pain received bilateral ultrasonographic evaluation for VTE formation. McNemar's test and conditional logistic regression was used to compare the incidence of VTE in the donor site leg to that in the contralateral leg, which served as an internal control. We then stratified by sub-groups chosen *a priori*, grouping patients by risk of VTE (from calculated Caprini score) and type of flap

Results: All patients had unilateral flap harvest by the senior author. There were 29 male and 33 female patients with mean age of 52 (SD 13.4). The average body mass index (BMI) was 25 (SD 7.2) and 20% were considered obese. Sixty-seven percent had neoadjuvant chemotherapy and 74% had neoadjuvant radiation therapy. Mean follow-up was 112 days (SD 93).

Sixty-nine percent of patients underwent flap reconstruction for a primary oncologic defect, with the majority of patients (58%) undergoing anterolateral thigh (ALT) harvest followed by gracilis flap (40%) and sartorius flap harvest (2%).

Seven patients developed VTEs in either leg (11.29%), for a total of 9 episodes of VTE. Of these, 4 were on the donor site (57.14%), 1 was on the contralateral leg (14.29%), and 2 were bilateral (28.57%). There was a 4 times increased odds for the formation of donor-site VTE when compared with contralateral lower extremity VTE (9.68% vs 4.84%, respectively). However, a McNemar's test showed no evidence for this association being statistically significant (paired OR: 4; 95% Confidence Interval [CI]: 0.40-196.99; p=0.180). The only statistically significant predictor of VTE was Caprini score (p=0.006).

Conclusions: The rate of symptomatic VTE may be higher than previously appreciated for plastic surgical procedures involving the lower extremity. Routine screening surveillance or extended prophylaxis in high-risk patients may be warranted.

111. Bridging the Gap: A 20-year Experience with Vein Grafts for Free Flap Reconstruction, the Odds for Success

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PURPOSE

Successful free tissue transfer requires tension-free microvascular anastomoses. Vein grafts are utilized when this cannot be obtained. This increases microsurgical complexity and chance of vessel thrombosis. Previous studies on vein grafts are limited to low numbers, making it difficult to draw conclusions on efficacy. We report a 20-year experience with a variety of vein graft types for an array of reconstructions.

METHODS

A retrospective chart review was performed for all patients who underwent vein grafts in free flap reconstruction from 1995 to 2015. Information on patient and flap characteristics, as well as returns to the operating room and flap loss were analyzed.

RESULTS

Seventy-two free flap reconstructions requiring vein grafts were performed. The majority were performed in the initial operation (82%) and of those, the majority were planned (71%). Reconstruction was most often in the perineal (49%) and head and neck (38%) regions. The most common indication for a vein graft was to increase pedicle length (61%). The vein graft types utilized are summarized in Figure 1. Of the initial cases, 22% returned to the operating room for flap concerns. Overall, there were 5 (7%) total and 5 (7%) partial flap losses.

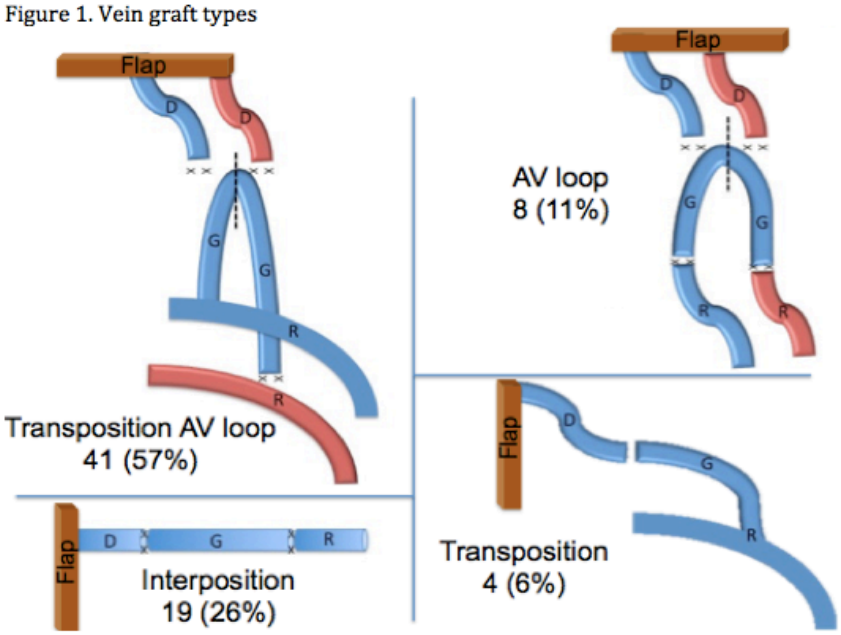
On univariate analysis, unplanned vein grafts in the initial operation were significantly associated with take-backs. Additional factors significantly associated with flap take-back and loss were: use of interpositional grafts, grafts used as arterial conduits, and reconstruction location (Tables 1 & 2). Performing an unplanned vein graft was significantly associated with using an interpositional graft ($p<0.001$).

On subgroup analysis excluding interpostional grafts: unplanned grafts, arterial conduits, and reconstruction location were no longer associated with flap take-backs or loss (Table 3). Among the 5 flap losses from non-interpositional grafts, all vein grafts had been performed in the initial surgery and not for salvage. All total flap losses involved interpositional grafts, except one: a venous transposition arterovenous loop in which the patient suffered a deep venous thrombosis, which affected both graft vessels.

CONCLUSIONS

When a surgery necessitates a vein graft, transpositions and AV loops have greater success than interpositions independent of planning, whether performed in an initial or salvage operation, conduit type, and reconstruction location. These graft types should be considered over interpositions when possible.

Figure 1. Vein graft types



Vein graft types. Interposition vein graft used for either artery or vein. Transposition vein graft used for vein. Transposition AV loop and AV loops used for artery and vein. D = donor vessel; R = recipient vessel; G = vein graft; Dashed line denotes eventual division of loop intraoperatively; XX denotes a vascular anastamosis

Table 1. Variables relation to flap take-back in initial surgeries (n=59)

	Take-back*	P value**
Planning		
Vein graft planned (n=42)	5 (12%)	0.006
Vein graft unplanned (n=17)	8 (47%)	
Vein graft type		
Interpositional (n=7)	5 (71%)	0.005
AV loop (n=8)	2 (25%)	
Transposition (n=3)	1 (33%)	
Transposition AV loop (n=41)	5 (12%)	
Reason for vein graft		
Flap issue (n=44)	9 (20%)	0.865
Recipient issue (n=11)	3 (27%)	
Vessel issue (n=4)	1 (25%)	
Conduit type		
Artery (n=2)	2 (100%)	<0.001
Vein (n=7)	4 (57%)	
Both (n=50)	7 (14%)	
Reconstruction location		
GU/Perineum (n=37)	4 (11%)	0.011
Head & Neck (n=17)	6 (35%)	
Lower extremity (n=4)	2 (50%)	
Hand (n=1)	1 (100%)	

* Only initial surgeries

** Fisher's exact

Table 2. Variables relation to flap loss (n=72)

	Flap loss*	P value**
Timing		
Initial (n=59)	6 (10%)	0.074
Salvage (n=13)	4 (31%)	
Planning* **		
Vein graft planned (n=42)	2 (5%)	0.052
Vein graft unplanned (n=17)	4 (24%)	
Vein graft type		
Interpositional (n=19)	7 (37%)	0.010
AV loop (n=8)	1 (12%)	
Transposition (n=4)	0	
Transposition AV loop (n=41)	2 (5%)	
Reason for vein graft		
Flap issue (n=44)	4 (9%)	0.129
Recipient issue (n=11)	1 (9%)	
Vessel issue (n=17)	5 (29%)	
Conduit type		
Artery (n=4)	3 (75%)	<0.001
Vein (n=18)	8 (44%)	
Both (n=50)	5 (10%)	
Reconstruction location		
GU/Perineum (n=37)	2 (5%)	0.027
Head & Neck (n=27)	5 (19%)	
Lower extremity (n=5)	1 (20%)	
Breast (n=2)	1 (50%)	
Hand (n=1)	1 (100%)	

* Total and partial
** Fisher's exact
*** Only initial surgeries

Table 3a. Variables relation with take-backs, interpositional grafts excluded (n=52)

	Take-back*	P Value**
Planning		
Vein graft planned (n=42)	5 (12%)	0.171
Vein graft not planned (n=10)	3 (30%)	
Conduit type		
Artery (n=0)	0	0.401
Vein (n=3)	1 (33%)	
Both (n=49)	7 (14%)	
Reconstruction location		
GU/Perineum (n=37)	4 (11%)	0.118
Head & Neck (n=11)	2 (18%)	
Lower extremity (n=4)	2 (50%)	

* Only initial surgeries
** Fisher's exact

Table 3b. Variables relation with flap loss, interpositional grafts excluded (n=53)

	Flap loss*	P Value**
Planning* **		
Vein graft planned (n=42)	2 (5%)	1.000
Vein graft not planned (n=10)	0	
Timing		
Initial (n=52)	3 (6%)	1.000
Salvage (n=1)	0	
Conduit type		
Artery (n=0)	0	1.000
Vein (n=4)	0	
Both (n=49)	3 (6%)	
Reconstruction location		
GU/Perineum (n=37)	2 (5%)	0.327
Head & Neck (n=12)	0	
Lower extremity (n=4)	1 (25%)	

* Total and partial
** Fisher's exact
*** Only initial surgeries

112. Lower Extremity Free Tissue Transfer in the Setting of Thrombophilia: A Prospective Comparison of Perioperative Anticoagulation Protocols

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PURPOSE: Subclinical thrombophilia contributes to delayed thrombotic complications and nonsalvageability after free tissue transfer (FTT). Currently, however, there is no consensus regarding the optimal management of perioperative anticoagulation in these patients. We present our experience with lower extremity FTT in thrombophilic patients and compare outcomes for systemic versus subcutaneous anticoagulation protocols.

METHODS: Between 2012 and 2016, 53 patients with documented thrombophilia underwent 53 free flaps for nontraumatic, lower extremity reconstruction. Patients were stratified into 2 main cohorts based on a preoperative risk assessment and intraoperative findings to receive either subcutaneous or systemic heparinization (Fig. 1). Beginning day 0, patients were administered daily aspirin (325 mg) and either (1) subcutaneous heparin (5,000 units every 8 hours), (2a) fixed-rate subtherapeutic heparin infusion (500 units/hr), or (2b) titrated therapeutic heparin infusion (PTT 50-60). Patients were immediately converted to titrated heparinization in the setting of any microvascular thrombotic event (Fig. 2). In the absence of postoperative complications, patients were transitioned to subcutaneous heparin on day 5 and continued on this regimen for a period of 3 weeks. Demographic data, reconstructive outcomes, and complications were prospectively compared.

RESULTS: Twenty-eight patients were treated with aspirin/subcutaneous heparin, whereas 25 patients received aspirin/systemic heparinization with either fixed rate (n=10) or titrated (n=15) heparin infusion. While overall rates of flap loss (11% vs. 12%, p=0.91) and postoperative thrombosis (16% vs. 12%, p=0.67) were similar between subcutaneous and systemic cohorts, sentinel postoperative thrombotic events were more common among patients treated with subcutaneous heparin (11% vs. 0% p=0.08). Salvage rates following intraoperative (n=5) and postoperative (n=6) thromboses were 40% and 0%, respectively (p=0.08), with intraoperative thrombotic complications being predictive for both postoperative thrombosis and ultimate flap failure ($p<0.05$). On subgroup analysis, bleeding complications (40% vs. 0% vs. 7%; $p<0.01$) and transfusion volumes (798 mL vs. 671 mL vs. 638 mL; $p<0.01$) were significantly higher among patients treated with titrated systemic heparin infusion when compared with those in both fixed-rate and subcutaneous cohorts, respectively.

CONCLUSIONS: When compared to subcutaneous administration, perioperative anticoagulation with aspirin/systemic heparin appears to provide a protective benefit against sentinel postoperative thrombotic events in thrombophilic patients who undergo lower extremity FTT. Nevertheless, flap salvage in the setting of microvascular thrombosis remains poor. Future studies should evaluate the role of preoperative anticoagulation in reducing the risk of intraoperative thrombotic complications in this high-risk population.

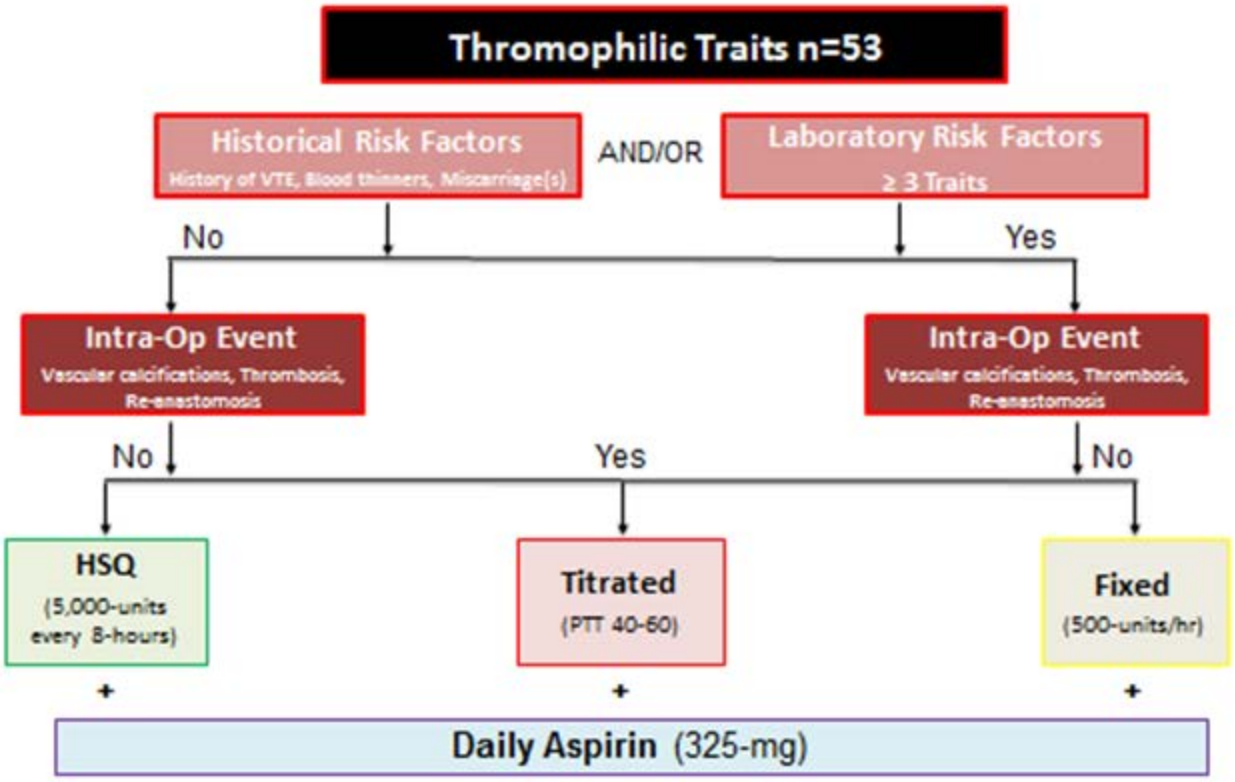

Figure 1: Perioperative anticoagulation protocol for thrombophilic patients based on preoperative and intraoperative risk stratification.

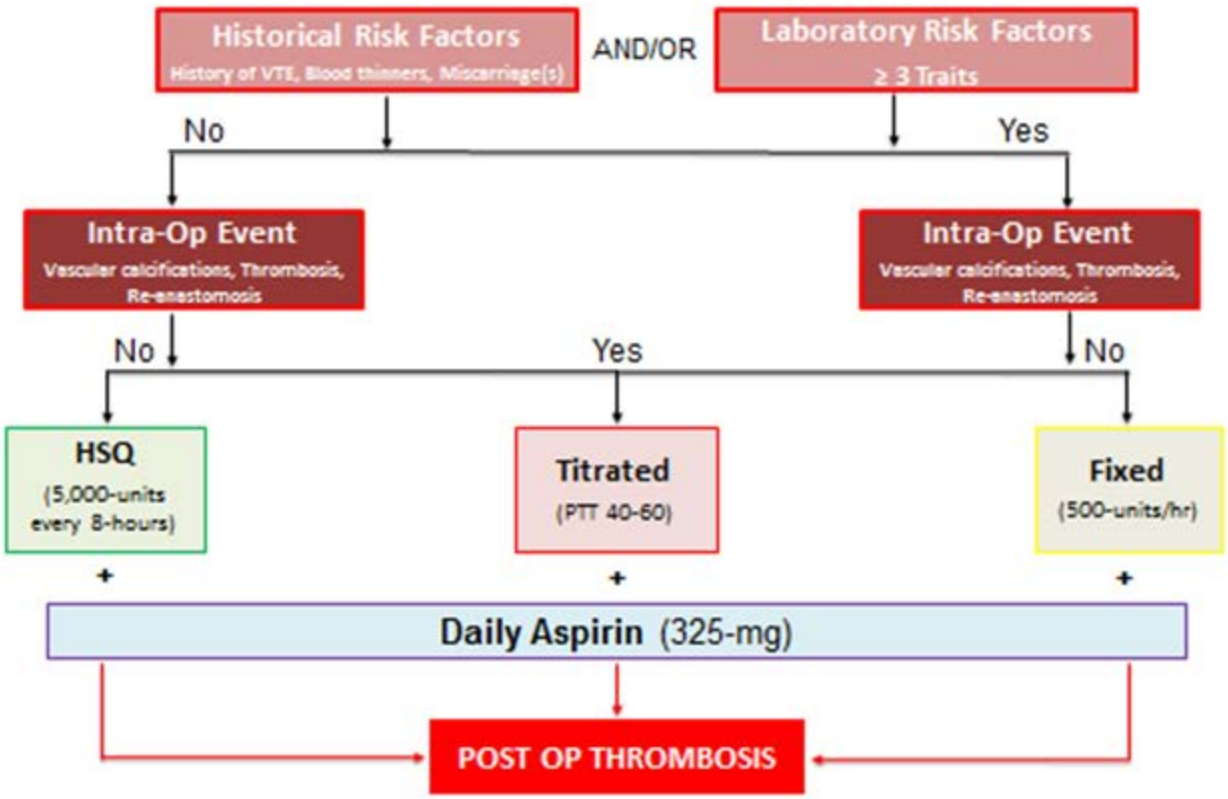

Figure 2: Adjusted protocol for perioperative anticoagulation in the setting of postoperative microvascular thrombosis. All patients are immediately converted to titrated heparin infusion.

113. Phrenic Nerve Reconstruction for Diaphragmatic Paralysis: A Long-Term Review of 180 Patients

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Background. Diaphragmatic paralysis is a devastating neuromuscular disorder, most commonly resulting from phrenic nerve dysfunction. Although plication of the diaphragm has been the surgical treatment option most familiar to clinicians, phrenic nerve reconstruction has been demonstrated to be an effective alternative. Phrenic nerve reconstruction helps to restore functional diaphragmatic activity, something plication surgery does not achieve. Peripheral nerve regeneration and muscle strengthening occurs gradually over time; thus patients must be followed over time to illustrate the value of phrenic nerve reconstruction. The purpose of this study is to report the long-term outcomes after phrenic nerve reconstruction for diaphragmatic paralysis.

Methods. 183 patients treated with phrenic nerve reconstruction for chronic diaphragmatic paralysis were followed for a median 2.7 years. Diaphragmatic paralysis was confirmed using chest fluoroscopy, and quantified using pre and intraoperative nerve conduction studies and electromyography. Postoperative assessment parameters included: SF-36 physical functioning survey, pulmonary spirometry, chest fluoroscopy, electrodiagnostic evaluation, and a five-item questionnaire to assess specific functional issues.

Results. 134 males and 46 females with an average age of 56 years (range 10-79) were treated. Mean baseline percent predicted values for forced expiratory volume in 1 second, forced vital capacity, vital capacity, and total lung capacity, were 61%, 63%, 67% and 75%, respectively. The corresponding percent improvements in percent predicted values for the entire cohort were 11%, 6%, 9%, and 13% respectively ($p \leq 0.01$; $p \leq 0.01$; $p \leq 0.05$; $p \leq 0.01$). Among the clinical responder subset demonstrating neuromuscular recovery, the percent improvements were 18%, 11%, 10%, and 17% respectively ($p \leq 0.001$; $p \leq 0.05$; $p \leq 0.05$; $p \leq 0.01$). Mean preoperative SF-36 physical functioning survey scores were 39%, and patients demonstrated an improvement to 65% following surgery ($p \leq 0.0001$). Nerve conduction latency improved by an average 23% ($p \leq 0.005$), and there was a corresponding 125% increase in diaphragm motor amplitude ($p \leq 0.0001$). 89% of patients reported an overall improvement in breathing function postoperatively over time.

Conclusion. This study provides longer term follow up on 180 patients, expanding on our prior study of 68 patients undergoing phrenic nerve reconstruction. We demonstrate an incremental improvement in diaphragm motor amplitude after longer follow up. The average improvement in diaphragm motor amplitude after surgery increased from 37% at one year, to 125% after more than two years, strongly supporting the notion that muscle strengthening after peripheral nerve

regeneration occurs incrementally. This study clearly demonstrates efficacy and a functional alternative to diaphragm plication based upon results of long term follow up in a large cohort of symptomatic patients.

114. Free Flap Reconstruction in Patients with a History of Organ Transplantation

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Background: A major surgery in patients with organ transplantation and immunosuppression can be a complicated event. The purpose of this study was to evaluate the safety and outcomes of free flap reconstruction in such a population.

Methods: A retrospective review of all free flap cases in patients with a history of organ transplantation between 2001 and 2015 was performed.

Results: A total of 57 patients were identified. There were 37 male and 20 female patients with a mean age of 56.67±15.27 years. Transplantation included kidney 14, liver 4, lungs 6, stem cell 19, bone marrow 7, heart 4, corneal 2, pancreatic and renal transplant 1. All patients had been receiving life-long immunosuppression with a variety of medications. Surgical defects included head and neck 46, breast 6, trunk 1 and extremities 4. Type of free flaps included anterolateral thigh 24, latissimus 9, forearm 9, fibula 7, TRAM 7, lateral arm 1, supraclavicular 1. All patients were managed by a multidisciplinary team perioperatively consisting of critical care, the surgical team, and the medical/transplant team. There was no 30-day mortality. Vessel thrombosis occurred in 5 patients (8.8%) and 3 patients lost their flaps (5.3%). Other surgical complications included partial flap necrosis 4, poor wound healing 3, infection 2, hematoma and seroma 5. Renal insufficiency occurred in 2 patients. No other medical complications were seen. Average length of stay was 10.34±8.54 days.

Conclusion: Good outcomes can be achieved with meticulous multidisciplinary care for immunosuppressed patients undergoing major free flap surgery.

115. Simulation Training for Microvascular Anastomosis

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Simulation Training for Microvascular Anastomosis

Introduction

Proficiency-based training is a paradigm in which trainees engage in deliberate practice until achieving performance goals based on expert performance. Proficiency-based training has been demonstrated to be superior to traditional training methods such as practicing for a specified period of time or a specified number of repetitions. The purpose of this study was to develop and evaluate a proficiency-based training curriculum for microvascular anastomosis using synthetic tissues.

Methods

Two plastic surgery residency programs supplied 4 faculty members (experts) and 10 residents for this study. In Phase 1, faculty identified a 2mm diameter synthetic blood vessel. A subjective scoring rubric to assess skills and an objective testing apparatus to assess vessel patency (leakage and stenosis) were created and validated. Each expert performed 5 anastomoses. Proficiency benchmarks for completion time, leakage, and flow-through amount were derived from the trimmed mean of these 20 trials.

Curriculum effectiveness was examined in Phase 2. All residents performed a pretest anastomosis on the simulation model. Seven residents were assigned to train to the proficiency goals using the simulation model and 3 residents were assigned to “traditional” intraoperative training. When the training period ended, all residents completed a posttest trial on the simulation model. Pretest and posttest trials were video recorded, de-identified, and graded by blinded experts. Performances were assessed on a 5-point Likert scale for 9 metrics (needle loading, instrument manipulation, suture placement, knot quality, total rubric score) and objectively assessed for 5 metrics (time, broken sutures, stitches placed, flow-through, leakage). Data were analyzed with t-test and two one-sided tests for statistical equivalence.

Results

Experts completed the exercise significantly faster ($p=.002$), broke significantly fewer sutures ($p=.042$), and had significantly less leakage ($p=.006$) as compared to residents’ pretest performances, demonstrating construct validity.

Simulation-trained residents significantly improved skills from pretest to posttest for 10 of the 14 metrics. Intraoperatively-trained residents did not improve significantly on any of the metrics.

Posttest scores for the simulation-trained residents were statistically equivalent to experts’ scores in terms of time and leakage, but not flow-through. Posttest scores for the intraoperatively-trained residents were only statistically equivalent to experts for time.

Simulation-trained residents significantly outperformed intraoperative-trained residents on 6 of the 14 metrics.

Conclusion

Residents improved microvascular anastomosis skills on the majority of metrics by engaging in simulation-based training. The curriculum successfully benefited residents above what was observed with residents who trained intraoperatively. The inanimate model may be preferred to animate tissues.

116. Donor Site Scar Preference in Trauma Patients Requiring Free Flap Reconstruction

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Study Purpose

The size of a traumatic defect dictates the free flap selected. Despite a variety of soft tissue free flap options, surgeons frequently harvest from donor sites with which they are most comfortable, without necessarily determining the patients preferred site. The goal of this study was to determine free flap donor site scar location preference as it relates to the size of the defect being reconstructed.

Methodology

Survey participants were asked to envision they were in a trauma that resulted in a range of wounds requiring free tissue transfer. They were presented with a selection of common donor site scars produced from harvesting small (<5cm in greatest dimension), medium (5-15cm) and large (>15cm) free flaps. They were instructed to rank the donor sites in order of preference and score them on a visual analogue scale from 1 (worst) to 10 (best). Data was analyzed with SPSS using Students t-test and Wilcoxon rank-sum to compare variables with p-value <0.05.

Results

250 participants (mean age 28.4, female 62.8%) completed the survey. For small reconstructions the participants significantly preferred donor site scars on the upper thigh (6.6+/-0.32), inner thigh (6.5+/-0.33), and back (6.5+/-0.32) compared to the lower abdomen (4.8+/-0.36), upper arm (4.4+/-0.30) and forearm (4.2+/-0.33). For medium size reconstructions, the mid back (6.1+/-0.29), upper back (5.9+/-0.33), lateral back (6.3+/-0.30), hip (5.9+/-0.31), and upper thigh (6.0+/-0.32) were significantly preferred over the lower abdomen (4.6+/-0.92), and anterior thigh (4.5+/-0.34). For small and medium reconstructions the midline abdominal scar scored significantly worse then all other donor sites (3.2+/-0.32, 3.0+/-0.31). For large reconstructions the preferred donor site was the back (6.3+/-0.34) compared to the thigh (5.0+/-0.37) and lower abdomen (4.6+/-0.39). Males scored scars on the back, upper thigh, leg, upper arm, and forearm significantly higher than females, while scoring scars on the lower abdomen significantly lower than females.

Conclusion

All participants preferred the back (Lat. dorsi), thigh (TUG/PAP) and hip scar (SCIP/SCIA) locations perhaps relating to the ability to conceal these scars under clothing. Males scored extremity scars higher than female participants suggesting these areas are less aesthetically concerning. Males scored lower abdominal scars significantly lower than females, which may due to the this scar being more common in females (obstetrical/gynecological surgery) and/or that males place higher value on the aesthetics of the abdomen. If multiple flaps sites could be harvested, providing options to trauma patients undergoing free tissue transfer may result in increased satisfaction.

117. Long Term Functionality of Patients with Open Tibial Fractures Requiring Soft Tissue Reconstruction: A Systematic Review of the Contemporary Literature

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PURPOSE:

Restoration of a functional limb is the ultimate determinant of successful limb salvage surgery following devastating limb injury, and yet quantitative functional outcomes following lower extremity reconstruction remain scarcely reported. This study systematically reviews functional outcomes in patients who have undergone vascularized soft tissue reconstruction for open tibial fractures and critically analyzes the success of functional limb salvage.

METHOD:

A PRISMA compliant systematic review was conducted to identify studies reporting functional outcomes after treatment of open tibial fractures requiring soft tissue reconstruction. The Pubmed, Embase, and Google Scholar databases were queried resulting in 276 articles. Titles and abstracts were reviewed by 2 independent reviewers. Studies meeting inclusion criteria: >18 years old, >10 patients, >1 year follow up, and functional outcome reporting were included. Studies >10 years old or not reporting functional outcomes were excluded. Study outcomes were reviewed and recorded including flap survival, rate of osseous union, complications, limb function, quality of life, return to work, and pain.

RESULTS:

Six studies met inclusion and exclusion criteria, reporting 258 patients with open tibial fractures (Mean age 42, 80% male). The average rate of osseous union was 92% with aggregate flap survival rate of 91%. Reoperation or revision was performed in 21% of patients, while 9% underwent amputation due to complications including flap loss, infection, nonunion and failure of limb salvage treatment. At >1 year follow up, the rate of return to work was 65.7% while 13% needed walking aids. Anterior knee pain and ankle and joint stiffness were commonly reported. In one study, there was no major difference in functional outcomes, disability and complications measured by Sickness Impact Profile (SIP) between limb salvage (SAL) and primary amputation (AMP). At 2 years, however, SAL patients (61%) had significantly greater walking speed than the AMP group. Quality of life (physical, psychosocial) was assessed differently among studies (E.g. SIP, Quick Disabilities of the Arm, Shoulder and Hand Outcome Measure) and could not be appropriately pooled.

CONCLUSION:

While high rates of flap survival and osseous union have been reported in the literature, open tibial fractures requiring soft tissue reconstruction are still a major source of morbidity with only 65.7% patients able to return to work at >1 year follow up and chronic pain as a common consequence. Importantly, non-uniform and underreported functional outcomes in the literature highlight the need for standardized functional outcomes and quality of life reporting.

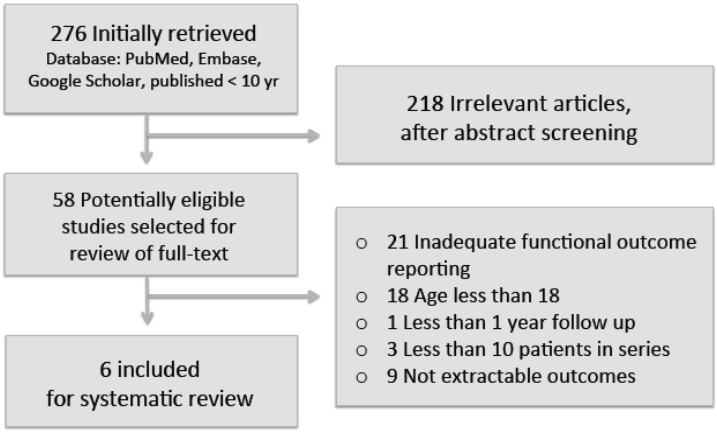

Figure 1. PRISMA study flow diagram

118. Pediatric Hepatic Artery Microvascular Anastomosis in Living Donor Liver Transplantation: 74 Consecutive Cases by a Single Surgeon

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Introduction: Living donor liver transplantation (LDLT) is an effective strategy of sourcing fresh segmental allograft for pediatric patients with liver failure when suitable donor organs are scarce. Early LDLT experience demonstrated high rates of hepatic artery thrombosis (HAT), a devastating complication associated with graft loss and up to 50% mortality. The application of microsurgical technique for hepatic artery anastomosis in LDLT has shown consistently lower rates of hepatic artery complications and is being adopted around the world. The indications, technique, challenges, and outcomes of one of the largest single surgeon experiences in pediatric LDLT microvascular hepatic artery anastomosis are presented.

Materials & Methods: A 14-year retrospective review was undertaken of all children at our institution who underwent LDLT with hepatic artery anastomosis by a single microsurgeon with the aid of an operating microscope. Data was collected on patient demographics, etiology of liver failure, graft donor, vessel calibre, vessel anastomosis, arterial complications, and long term follow up. The objective was to determine the incidence of HAT and overall outcome of pediatric LDLT following single surgeon microsurgical hepatic artery anastomosis.

Results: Between 2000 and 2014, 74 children (34 male, 37 female) underwent LDLT with microvascular hepatic artery anastomosis by a single surgeon. The commonest etiologies for liver failure were biliary atresia (n=46), inherited metabolic disorders (n=7), and neoplastic disease (n=6). Segmental living donor allografts were procured from 58 related donors (77%), 9 unrelated donors (12%), and 7 unknown donors (11%). The left lateral segment of the donor liver was transplanted in 54 cases (72%). A total of 82 end to end hepatic artery anastomoses were completed under operating microscope. Mean diameters of donor and recipient vessels were 2.0 mm and 1.9 mm, respectively. Hepatic artery complications occurred in 3 cases (4%), including a vessel thrombosis identified intra-operatively and repaired without consequence; a kinked vessel visualized on CT angiogram 3 days after surgery that was re-anastomosed without consequence; and a vessel thrombosis with systemic hypercoagulation 2 days after surgery that resulted in graft loss and patient death. At mean follow up 6.5 years post-transplantation, overall patient survival rate was 96% with 3 deaths due to small bowel obstruction, recurrent liver failure, and systemic hypercoagulation.

Conclusions: Microvascular hepatic artery anastomosis in pediatric patients undergoing LDLT is associated with a low hepatic artery complication rate and excellent long term liver graft function. Collaboration between microsurgeons and transplant surgeons can significantly reduce technical complications and optimize patient outcomes.

119. Thrombotic Effects of Branch Ligation in Rat Model

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Introduction

Vessel ligation is a basic surgical technique, but its influence on thrombus development in small vessels has yet to be clarified. In this study, the effect of branch ligation was evaluated in the artery and the vein in rats.

Materials and Methods

In 36 groin regions of 18 rats, the epigastric artery and the epigastric vein, along with the femoral artery and the femoral artery from which the epigastric vessels were given off, were dissected and their diameters were measured. Eighteen rats were divided into 3 groups of 6 rats each. In every rat, vessels in one side was left intact after dissection as the control. In group A, the epigastric artery and vein were ligated at a point 10 mm apart from the takeoff point in one side. In group B, the epigastric artery and vein were ligated at a point 5 mm apart from the takeoff point in one side. In group C, the epigastric artery and vein were ligated at the takeoff point in one side. The vessels were re-explored 10 days after the procedure, and thrombus development was observed under operative microscope.

Results

The average diameter of the epigastric artery and the femoral artery was 0.5 mm and 1.2 mm, respectively. The average diameter of the epigastric artery and the femoral artery was 0.8 mm and 1.4 mm, respectively.

No arterial thrombosis was seen in all rats. No venous thrombosis was seen in all control veins. In all vein-ligated rats in group A and B, thrombus development was seen to obstruct the region between the ligation point and the takeoff point. In 5 vein-ligated rats in group C, thrombus development began from the ligation point to the femoral vein, occluding the femoral vein. In 1 vein-ligated rat in group C, thrombus development began from the ligation point to the takeoff point, but did not reach the femoral vein.

Conclusions

Presumably due to the high velocity of the blood flow, the arteries were not affected by ligation of the branches. Although further studies are necessary in human vessels, and the diameter discrepancy between the main vessel and its branch must be considered, the results of this study may suggest that it is not safe to ligate branches of vein close to its takeoff. In addition, due to the high percentage of thrombus development, venous anastomosis should be avoided in the proximity of ligated branches.

120. Virtual Reality Simulation in Microsurgery: A necessary Tool for Skills Training and Microsurgical Teaching

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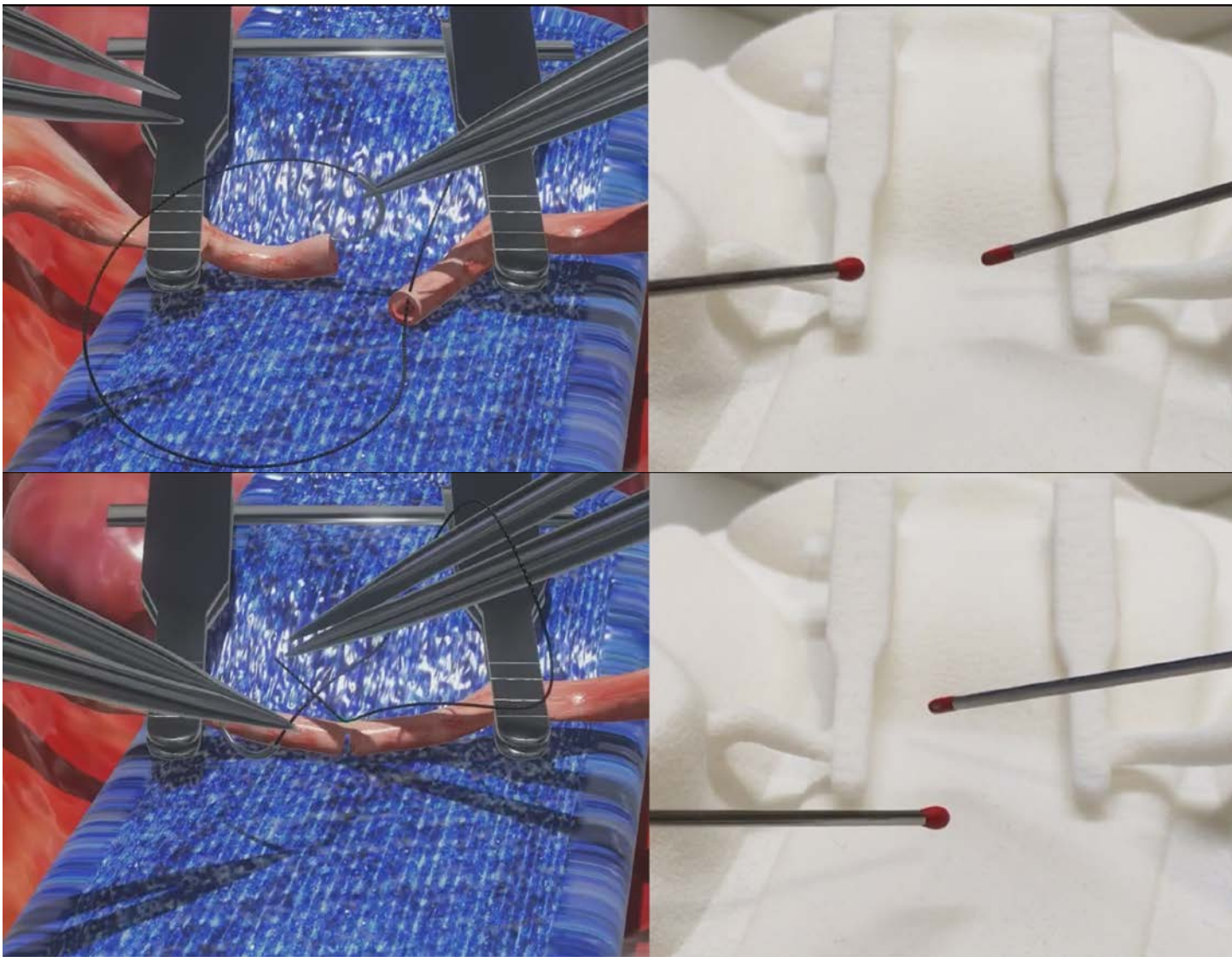
Introduction: Microsurgery has become an inevitable backbone in reconstructive surgery. The necessary repetition frequency of special microsurgical skills, however, lies in tension between continuous economization of surgical procedures and interferes with animal welfare legislation, the time factor, and the efficiency of available training models. Full-simulation has successfully found its way into laparoscopic surgery training and ophthalmic surgery training (Eyesi Surgical, VRmagic), which has been well established as an international standard training tool, e.g. across the USA and Germany. Integration of microsurgical skills training into a full-simulation device is promising to overcome all above-mentioned obstacles and interferences.

Material and Methods: A privat-public partnership was established as the basis for further development. Hardware and software solutions including training modules as well as input-units and instrument features were addressed. Abstract skills modules for binocular microscope training were adapted. Basic and specific scenarios have been defined. Medical and microsurgical attributions of simulation sequences have been performed repetitively. Input devices based on reference designs of premium instruments (S&T, Switzerland) have been developed. The presentation summarizes major steps of development, gives an overview of the current status of the project, including video sequences, and provides a baseline for the discussion of requirements by the international microsurgical society at the ASRM meeting.

Results: The current version of the full-simulator prototype includes an example scenario with a vascular anastomosis fixed in an approximator device for end-to-end anastomosis (Fig 1). Both the suture and the vessel can be manipulated with virtual instruments, guided by the input devices, while viewing the virtual scene through stereoscopic microscope oculars (Fig 1,2). Movement skills can be trained and evaluated both in an abstract and real scenario module. Skills training includes approach and handling of the vessel and completion of an anastomosis. Advantages and pitfalls of full-simulation of a microsurgical vascular anastomosis and exercising in the virtual reality are demonstrated.

Discussion: The computer-based microsurgery simulator can mimic specific aspects of microsurgical training through abstract and clinically-oriented exercises and thus provides microsurgical skills training. Further steps will include addition of more scenarios (vein vs. artery, nerve, lympahtics), end-to-side anastostomis, different vessel diameters and vessel characteristics (e.g. plaques, wall dissection). In addition, a trainer module will be integrated (scoring, registration of unnecessary movements, tissue injury, time). After finalization of the prototype, a multicenter residency training validation study will be approached to approve the feasibility of the full-simulator compared to „traditional“ training methods.



121. Beyond the Final Frontier: A Tissue-Engineered Perfusable Skin Flap

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Introduction: The major obstacle to the creation of “off the shelf” tissue engineered flaps has been the inability to fabricate constructs with an inherent hierarchical vascular network that can be microsurgically anastomosed to the host vasculature. Herein, we fabricate a pre-vascularized full-thickness cellularized skin equivalent containing a three-dimensional vascularized network of interconnected macro and microchannels lined with vascular cells, within a collagen neodermis containing encapsulated fibroblasts and pericytes, and an epidermis comprised of human keratinocytes capable of providing whole tissue perfusion.

Methods: Pluronic F127 was the sacrificial material used for network preparation: 1.5 mm diameter “U” shaped macrofibers and 100-500 µm-interwoven microfibers were heat extruded and then embedded within Type I collagen into which CFP-tagged human placental pericytes (HPLP-CFP) and human foreskin fibroblasts (HFF1) at a density of 1x10^6 cells/mL, respectively had been encapsulated. Following pluronic sacrifice, channels were intraluminally seeded with 5x10^6 cells/mL RFP-tagged human aortic smooth muscle cells (HASMC-RFP) and 5x10^6 cells/mL GFP-tagged human umbilical vein endothelial cells (HUVEC-GFP). The construct was then topically seeded with 1x10^6 cells/mL human epidermal keratinocytes (HEK). Constructs were incubated for 14 and 28 days and subsequently live flaps were analyzed using multiphoton microscopy (MPM) or fixed and processed for histology. Flaps were constructed with a decellularized vessel conduit which served as the site for microsurgical anastomosis to rat femoral artery and vein and subsequently perfused, *in vivo.*

Results: MPM imaging demonstrated a hierarchical vascular network containing macro (>1mm) and confluent microvessels (<400uM) lined by endothelial and smooth muscle cells, supported by perivascular pericytes, all in appropriate microanatomic arrangement. Neodermal HFF1 proliferated throughout the observation period and the HEK neoepidermis formed a covering epithelium along the superficial aspect of the construct. MPM demonstrated angiogenic sprouting from the nascent vascular network into neovessel like structures. Skin flaps were successfully anastomosed and perfused in nude rats.

Conclusion: We have successfully fabricated and microsurgically anastomosed the first ever tissue-engineered pre-vascularized full thickness skin flap, which recapitulates the inherent hierarchical vasculature found within skin and is suitable to provide whole tissue perfusion. We provide the platform for an on-demand, geometrically tunable tissue engineered skin equivalent with an anastomosable vascular pedicle and perfusable microvascular network. These tissue engineered constructs have the potential to transform reconstructive surgical practice by eliminating the consequences of donor site morbidity and enabling rationally designed, patient specific flaps for each unique wound environment and anatomic location.

158. Determination of Reinnervation by Motor, Sensory, and Mixed Nerves in Regenerative Peripheral Nerve Interfaces (RPNIs)

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Abstract:

INTRODUCTION: We developed a Regenerative Peripheral Nerve Interface (RPNI) with the ultimate goal of providing amputees with motor control of and meaningful sensory feedback from their prosthetic limbs. RPNIs are constructed within the residual limb by securing a free muscle graft to enclose the end of a residual nerve fascicle. Conceptually, CNS motor commands will travel to their corresponding motor nerves, into the RPNI, to an electrode implanted on the RPNI surface, and to the prosthetic limb to elicit coordinated movements. Our previous rat studies have led to proof of RPNI long-term function and high signal to noise ratio with no adverse biological effects. However, characterization of different types of RPNIs has not yet been evaluated.

MATERIALS AND METHODS: Twenty-four rats were divided into four groups: 1) motor RPNI (femoral nerve, n=6), 2) sensory RPNI (sural nerve, n=6), 3) mixed nerve RPNI (peroneal nerve, n=6), and 4) control (n=6). The control group was divided into two sub-groups: A) positive control (surgical naïve animal, left leg), B) negative control (common peroneal nerve transected and not repaired, right leg). All groups were evaluated 3 months after recovery surgery. Nerve conduction velocities and CMAPs were recorded for all groups. A 5-mm nerve segment proximal to the RPNI was harvested for histomorphometry. All RPNI constructs were harvested and processed via Immuno-Enabled Three-Dimensional Imaging of Solvent-Cleared Organs (IDISCO) for visualization of nerve fibers within the RPNI constructs.

RESULTS: All RPNIs were well-vascularized 3 months after recovery surgery. Electrical stimulation reliably elicited compound muscle action potentials (CMAPs) in all RPNIs, and the mixed nerve RPNI group had the greatest CMAPs. All RPNIs appeared healthy 3 months after recovery surgery but all were smaller than when implanted. The mixed nerve RPNI had the largest terminal weight. IDISCO revealed the 3-dimensional patterns of RPNI axonal regeneration.

CONCLUSIONS: Motor, sensory, and mixed nerve RPNIs displayed robust neural regeneration. Results from this study will enable us to further evaluate electrode-biological interfaces, and help us develop future prostheses with the ability to respond to both motor and sensory neural signals.

FIGURES:

Figure 1: Fluorescent labeling of neurofilament-M in a sensory nerve RPNI validates use of IDISCO for visualizing peripheral nerves in muscle tissue. Robust innervation of tissue by nerves of varying size. Further IDISCO experiments are currently in progress.