ORIGINAL RESEARCH

The Effect of Regional Anaesthesia on Free Flap Survival in Lower Extremity Reconstructions

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Abstract

Background: The effect of different modalities of anaesthesia in microvascular free flap surgery has been a topic of ongoing debate. Comparative data to study the effect of general anaesthesia and regional anaesthesia in the form of peripheral nerve blocks (PNBs) on lower extremity free flap survival is lacking to date. This study aims to elucidate the effect of regional anaesthesia on flap survival in lower extremity free flap reconstructions.

Methods: A retrospective cohort study of all patients who underwent free vascularised flap reconstruction of the lower extremities between 2012 and 2021 at the Amsterdam University Medical Centre (UMC), The Netherlands, and between 2019 and 2021 at the Radboud UMC, Nijmegen, The Netherlands. In this cohort, we analysed partial and total flap failures.

Results: In this cohort, 87 patients received a total of 102 microvascular free flap reconstructions of the lower extremity. In 20.5% of these operations, patients received a supplemental PNB. Total flap failure was 23.8% in the regional anaesthesia group compared to 21% in the group with general anaesthesia only ($p = 0.779$). Operation time was longer for patients with regional anaesthesia ($p = 0.057$). Length of stay was on average 2 days shorter for patients with supplemental regional anaesthesia ($p = 0.716$).

Discussion: This is the largest cohort comparing flap survival in patients receiving general anaesthesia to general anaesthesia with a PNB in lower extremity reconstructions to date. We cannot attribute a significant beneficial or detrimental effect of regional anaesthesia to flap survival. High failure rates stress the need for future studies.

Keywords: Flap survival, Free flaps, Lower extremity, Peripheral nerve block, Regional anaesthesia.

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Introduction

Microsurgical free flaps can be key for lower limb salvage after complex soft tissue damage.[1] In recent decades, there has been an evolution in patient care and microsurgical techniques to minimize complications and improve free flap survival.[2–4] Lower extremities however, remain among the most challenging recipient sites anatomically, with success rates being reported as low as 80%.[4–6] One potential success-determining factor is the modality of anaesthesia due to its continuous influence on perioperative perfusion and haemodynamic stability and, by extension the viability of a free flap.[7,8] The physiological changes when administering general anaesthetics during microvascular free flap surgery have been thoroughly investigated to facilitate what is considered to be an optimal environment for free tissue transfer.[9]

Some studies have reported on the potentially positive effect of regional anaesthesia (Fig. 1) as a supplement to general anaesthesia perioperatively, reporting benefits for both postoperative pain management and hospital stay.[10–13] Moreover, it is postulated that the perioperative sympathectomy effects of regional anaesthesia decrease the risks of anastomotic thrombosis and microvascular collapse.[8,13] The effect of supplemental regional anaesthesia on flap survival in lower extremities remains inconclusive having only been addressed in a few studies to date often with conflicting findings.[7,8,10–16] The use of peripheral nerve blocks (PNBs) has increased over time to avoid opioid consumption in managing perioperative pain, underscoring the importance of the topic of this study.[13,17] The aim of the current retrospective cohort study is to study the effect of PNBs on lower extremity free flaps.

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Methods

Patient Selection

This was a retrospective cohort study. Approval for data retrieval was obtained from the local medical ethics committee (reference number W21_140 No. 21.155). All patients aged 12 years or older who underwent a lower extremity microvascular flap reconstruction between 2012 and 2021 at the 'Amsterdam University Medical Centre', The Netherlands, and between 2019 and 2021 at the 'Radboud University Medical Center', The Netherlands were included in this study. The patients' demographics, medical history

Fig. 1: A patient in the cohort following a lower extremity reconstruction with a supplemental perioperative popliteal block

and data on reconstructive treatment were collected. Defects of the lower extremity were divided into the following three segments: 'Knee', 'lower leg', and 'foot and ankle' defects. The 'lower leg' was defined as every defect starting under the tibia plateau to the distal part of the tibia and fibula.

Outcome Measurements

The primary study outcome was flap survival, with failure expressed as either total or partial failure. Data on anaesthesia included whether patients received only general anaesthesia or general anaesthesia supplemented by a PNB as either a single shot or a continuous infusion with a catheter. The secondary outcomes were other complications, operation duration and length of hospital stay. The operation duration refers to the time spent transferring the free flap, excluding time spent placing the PNB.

Microsurgical Technique and Monitoring

In our cohort, CT angiography was performed prior to surgery. The preferred anastomosis was an end-to-side anastomosis on either the posterior tibial, anterior tibial or peroneal artery. In cases of traumatic dissection or a need for a revision of the anastomosis, an end-to-end anastomosis was performed. The preferred technique for venous anastomosis was an end-to-end anastomosis with a coupler device. These patients did not receive prolonged anticoagulants other than a single prophylactic dose of low molecular weight heparin. Clinical monitoring was performed every hour during the first 24 hours postoperatively, every 2 hours on postoperative day 2, every 3 hours on day 3, every 4 hours on day 4 and 3 times a day from then onward. In cases of trauma or infection, a multistage treatment strategy was undertaken which comprised of an immediate debridement (and external fixation if needed) followed by a reconstruction within a few days.

Anaesthesia

Anaesthetic management varied considerably between patients. Induction of anaesthesia was generally achieved by an intravenous dose of either sufentanil or fentanyl, followed by a bolus of propofol or thiopental adjusted to the age, weight and sex of the patient. Muscle relaxation was achieved by either rocuronium or suxamethonium. Maintenance of anaesthesia was achieved with either propofol or sevoflurane. The PNBs were either a single shot or catheter techniques and these were performed pre- or postoperatively at the discretion of the attending anaesthesiologist. A wide variety of nerve blocks were performed including femoral, popliteal and sciatic nerve blocks.

Different solutions of local anaesthetics were used for the PNBs. Bupivacaine, levobupivacaine and ropivacaine in varying concentrations were used in accordance with the preference of the attending anaesthesiologist. This heterogeneity in techniques and the local anaesthetic solutions used precluded any meaningful statistical analysis of the association of these techniques in relation to flap outcomes.

Statistical Analysis

Univariate analyses were performed using Chi-squared or Fisher's exact tests for categorical variables and two-tailed independent *t*-tests for continuous variables. Two-sided *p*-values below 0.05 were considered statistically significant. Univariate analyses were performed using a statistical package for the social sciences (SPSS) (SPSS for Windows, Version 26.0; SPSS, Inc., Chicago, Illinois, USA).

Results

Patient Characteristics

In this cohort, 87 patients received a total of 102 microvascular free flap reconstructions of the lower extremity. Patient characteristics sorted according to the type of anaesthesia are displayed in Table 1. This cohort consisted of 64 males and 23 females, with a mean age of 50.24 years (range 15–89 years). The mean length of follow-up was 151.16 days (range 7–659 days) after surgery. In 79.4% of operations (or 78.2% of patients) general anaesthesia alone was used, and the remaining population received supplemental regional anaesthesia in the form of a perioperative PNB. Comparing these two groups, there were no significant differences in risk factors such as smoking, and BMI or comorbidities such as diabetes and hypertension. The most common indication for surgery was acute trauma with loss of tissue (46.1% of operations), followed by an infection (43.1% of operations). There was a 9.8% constituent of reconstructions after oncological resections done of the total number of operations. In one patient the indication was a chronic wound caused by neuropathy. The perioperative details, including the different free flaps used, are listed in Table 2. The gracilis flap was the most commonly used free flap in both groups and overall (42.2% of all operations).

Anaesthesia

Out of 102 operations, 87 operations were primary reconstructions, 14 were secondary free flaps following the failure of the first and one was a tertiary reconstruction following two failures. A total of 21 operations across 19 patients were supplemented with some form of additional regional anaesthesia. Nine operations made use of a single shot injection (8.8%), all of which were primary reconstructions. A continuous peripheral regional anaesthetic was used for a total of twelve times (11.7%, mean duration 9.7 days) of which ten were primary reconstructions and two secondary reconstructions. The most common locations for a PNB were at the popliteal nerve or the femoral nerve. Overall, six patients received the PNB preoperatively, four postoperatively and 11 both pre- and postoperatively. The trend of PNB use in our cohort shows a general increase over the years as 50% of PNBs were done between 2020 and 2021. No anaesthesia-related complications were reported.

Table 1: Patient characteristics

	GA + RA	*GA only*		
	21 operations in 19 patients	*81 operations in 68 patients*	*102 operations in 87 patients*	
Male/female	11/10	63/18	74/28	
Mean age (years)	46.3 (SD: 17.1)	51.3 (SD: 16.2)	50.24 (SD: 16.4)	$p = 0.212^t$
Risk factors				
Mean BMI	25.72 (SD: 6.5)	26.23 (SD: 5.4)	26.13 (SD: 5.6)	$p = 0.748^t$
Smoker	4	33	37	$p = 0.07^x$ (*df* 1)
Comorbidities				
Diabetes	4	6	10	$p = 0.125^x$ (*df* 1)
Hypertension	5	15	20	$p = 0.643^x$ (*df* 1)
Cardiopulmonary	2	3	5	$p = 0.292^x$ (*df* 1)
Free flap indication				$p = 0.083^x$ (*df* 3)
Trauma	7	40	47	
Infection	12	32	44	
Oncology	1	9	10	
Chronic wound	–	1	1	

BMI, body mass index; *df*, degrees of freedom; GA, general anaesthesia; RA, regional anaesthesia; SD, standard deviation; ^{t}*t*-test; ^{x}Chi-squared test

Table 2: Perioperative details

	GA + RA	*GA only*	*Total*	
Type of flap				$p = 0.423^x$ (*df* 11)
Gracilis	13	30	43	
Anterior lateral thigh	3	30	33	
Latissimus dorsi	3	5	8	
Rectus abdominis	0	4	4	
Vastus lateralis	1	2	3	
Fibula	1	1	2	
Parascapular	0	2	2	
FRFF	0	2	2	
DIEP	0	2	2	
MSAP	0	1	1	
Rectus femoris	0	1	1	
Crista	0	1	1	
Anaesthesia				
No block			81	
Single shot			9	
Catheter			12	
Mean operating time (minutes)		426.1 (SD: 168.9)	357.2 (SD: 138.6)	$p = 0.057^t$
Mean hospitalization (days)		24.1 (SD: 21.4)	26.2 (SD: 24.7)	$p = 0.716^t$
Mean follow-up (days)		117.9 (SD: 105)	160.1 (SD: 171.1)	$p = 0.336^t$

BMI, body mass index; *df*, degrees of freedom; DIEP, deep inferior epigastric perforator; FRFF, free radial forearm flap; GA, general anaesthesia; MSAP, medial sural artery perforator; RA, regional anaesthesia; SD, standard deviation; ^{t}*t*-test; ^{x}Chi-squared test

Flap Failure

Complete and partial flap failures arranged according to the modality of anaesthesia have been summarized in Table 3. In 102 reconstructions there were 22 total failures (21.6%) and 12 partial failures (11.7%). Across reconstructions, with only general anaesthesia 21% failed totally, vs 23.8% in patients with a PNB. These values represented no statistically significant difference ($p = 0.779$). Of the 87 primary microvascular free flap reconstructions, 17 flaps failed totally (19.5%). Twelve of the 68 primary reconstructions performed under only general anaesthesia (17.6%), and 5 out of the 19 primary reconstructions performed with supplemental regional anaesthesia (26.3%) failed. These values were not statistically different ($p = 0.40$). A second free flap reconstruction was opted for in 14 out of 17 cases following total failure (82.4%). The success

Table 3: Outcome of reconstructions sorted by type of anaesthesia

	Failure				
	Partial	*Complete*	*Total*	*Success*	*Total*
Primary reconstruction					
No block	8	12	20	48	68
Single shot	1	1	2	7	9
Catheter	2	4	6	4	10
Total					87
	$p = 0.757^x$	$p = 0.199^x$			
Secondary reconstruction					
No block	1	5	6	6	12
Single shot	–	–	–	–	–
Catheter	–	–	–	2	2
Total					14
	$p = 0.672^x$	$p = 0.255^x$			
Tertiary reconstruction					
No block	–	–	–	1	1
Total	12	22	34	68	102

[x]*p*-values: Comparing the partial and total failure rates separately of reconstructions under only general anaesthesia and general anaesthesia with supplemental anaesthesia.

rate of a second free flap after primary failure was 64.3%. Of these 14 patients, 12 had only general anaesthesia of which five failed (41.7%). Two patients received a PNB (both in the form of continuous infusions), both of which were successful. Failure in secondary reconstructions with regional anaesthesia was not statistically different to those without ($p = 0.255$). The singular tertiary reconstruction without a PNB was successful. A total of ten failures resulted in amputation of the lower extremity (9.8% of the operations overall). Partial failure was recorded in 14.3% of reconstructions using a PNB. Reconstructions with a single shot PNB failed once (11%), whereas in reconstructions using continuous infusion PNBs failed in 33% of cases ($p = 0.454$).

Secondary Outcomes

The group with a supplemental PNB had a longer average operating time compared to the group with only general anaesthesia (426 minutes vs 357 minutes, $p = 0.057$). The average length of hospitalization was two days shorter with supplemental regional anaesthesia, though not statistically significant ($p = 0.716$). Postoperative complications other than flap failure included wound dehiscence (16.7%), infection (24.5%), osteomyelitis (8.8%), haematoma (5.9%) and non-union (16.7%); all of which were not significantly different between the two groups.

Discussion

The current study has the largest cohort to date reporting on lower extremity free flap failure in patients with PNBs vs those with only general anaesthetic. The lower extremities are well known as a challenging reconstruction site, exhibiting higher complication and failure rates than other recipient sites.[4,18–21] Although high, the overall total failure rate of 21.6% is similar to the reported failure rates across the literature for lower extremity free flaps.[18,22,23] It emphasizes the complexity of lower extremity microvascular free flap reconstructions where a multidisciplinary approach is needed. Subsequent reconstructions after primary flap failure have been shown inherently to possess a lower chance of success.[24] Our cohort demonstrates this as the failure rate increases from 19.5 to 35.7% between a primary and a secondary reconstruction, emphasizing the importance of a successful primary reconstruction when possible.

Patients with additional regional anaesthesia demonstrated an overall higher, though statistically insignificant, total failure rate (23.8%) compared to patients with general anaesthesia alone (21%). The difference was most pronounced in the patients undergoing a primary reconstruction, namely 26.3% for the PNB group and 17.6% for general anaesthesia alone. Although the difference in failure of 2.8% in the overall cohort of 102 operations and even 8.7% in the cohort of 87 patients with a primary reconstruction was not statistically significant, it is clinically relevant to the patient and specialist. This emphasizes the need for additional research, especially since one of the few other available studies by Weisberger et al., conducted on upper and lower extremity reconstructions, displayed a similar tendency of (non-significant) increased complications in regional anaesthesia patients compared to general anaesthesia alone.[15] A study by Jayaram et al. on the use of spinal and epidural anaesthesia in lower extremity reconstructions also concluded that regional anaesthesia was a risk factor for flap failure.[7] Details on the review of the available literature are summarized in Table 4.

Anaesthesia is an integral part of free flap surgery, the intricacies of which are still being improved to ensure optimal flap survival. Publications describing free flap transfer with spinal blocks are rare.[7] The ability to control the body's haemodynamics intraoperatively as well as optimizing pain management has been associated with better outcomes and fewer flap complications.[10–12] The decrease of pain both peri- and postoperatively has the physiological benefit of decreasing stress reactions and vasospasms, which could protect the free flap pedicle.[8] Despite these potential benefits, what could explain these high failure rates in our cohort? Our results showed a longer operating time in patients with a supplemental PNB. A more complicated or time-consuming reconstruction may lead to the surgeon or anaesthesiologist opting for the supplementation with regional anaesthesia more readily to improve perioperative pain but may also result in a more complicated postoperative course. Although the baseline characteristics were comparable, our cohort was too heterogeneous to explore patient factors that influence the need for supplemental anaesthesia as well as the effect on flap failure. One theory behind the increase in flap failure in the PNB cases is the shunting of blood flow away from the free flap due to the sympathetic blockade and a consequent so-called 'steal phenomenon'.[1,11,14] In our cohort, the addition of regional anaesthesia did not display the protective sympatholytic effects which would have resulted in better flap perfusion and fewer microvascular complications. Due to the sample sizes, the heterogeneity of blocks and their different physiological effects, it is not possible to suggest the occurrence of a 'steal phenomenon' in this group.

This study cohort considers regional anaesthesia in the form of a PNB whereas other available studies focus predominantly on epidural anaesthesia. A recent randomized controlled trial (RCT) demonstrated the beneficial effect of epidurals on arterial blood flow velocity in lower extremity reconstructions,[16] where the vasodilative effect of the sympathetic blockade was postulated to trigger fewer vasospasms at the anastomosis.[1,12] These results were in line with those of a previous study[12] and were echoed by Habib

Table 4: Review of papers to date exploring forms of regional anaesthesia and free flap survival

Author(s) (year of publication)	*Number of total patients*	*Number of RA patients*	*Modality of RA*	*Anatomical region*	*Conclusion regarding flap survival*	*Significant results**
Jayaram et al.[7]	165	50	Spinal and/or epidural anaesthesia	Extremities and head/neck	Higher flap failure in the RA group	Yes
Strecker et al.[8]	20	20	Epidural anaesthesia	Lower extremity	Epidurals are safe and effective in free flap transfer; No comparison group	–
Habib et al.[10]	36	18	Paravertebral block, CI	Maxillofacial defects	Fewer flap complications in the RA group Flap survival is no difference	Yes No
Lou et al.[11]	99	53	Epidural anaesthesia	Breast	No difference in free flap outcome	No
Scott et al.[12]	35	26	Epidural anaesthesia	Lower extremity	Lower complications, and higher flap survival in the RA group	–
Ruan et al.[13]	35	29	Femoral, popliteal and sciatic PNB, CI	Lower extremity	Fewer flap complications in RA group	No
Erni et al.[14]	28	21	Epidural anaesthesia	Lower extremity	Decreased microcirculatory blood flow of free flaps with epidurals	Yes
Weisberger et al.[15]	106	53	Epidural/spinal/PNB	Extremities	Similar complication and failure rates (high in RA but not significantly), regional anaesthesia a safe alternative	No
Park et al.[16]	49	25	Epidural anaesthesia	Lower extremity	Increased arterial maximal flow velocity in epidural patients No difference in flap outcomes/complication	Yes No

*Other values may be significant in these papers. For clarity, only the *p*-values and conclusions specifically pertaining to flap survival have been summarized in this table; the significance test was not conducted; CI, continuous infusion; RA, regional anaesthesia

et al., who experienced fewer vasospasms with a paravertebral block in combination with general anaesthesia as well as better flap survival in patients undergoing maxillofacial free flaps.[10] Conversely, one study comparing lower extremity free flap patients demonstrated significantly lower microcirculatory blood flow in patients with general anaesthesia and supplemental epidural anaesthesia compared to patients with general anaesthesia alone.[14]

The main limitation of this study was the heterogeneity and the small group sizes. Although the size of our cohort is large compared to previous studies, it may lack the power to reach statistical significance. Another limitation was the retrospective nature and therefore inability to investigate postoperative pain management prospectively as this is named as one of the main benefits of regional anaesthesia.[11] The hospitalization time was shorter (although statistically not significant) for patients with regional anaesthesia; this may reflect superior pain management which optimizes the time to patient discharge.[13] Future research should focus on the relationship between free flap survival and pain management with a single shot and continuous infusions of regional anaesthesia in a prospective setup and ideally an RCT.

Conclusion

This study contributes clinically relevant data to an understudied topic whereby more insight is gained into the application of PNBs in lower extremity free flap reconstructions. Flap survival is paramount and in this cohort, we did not find a significant beneficial or detrimental effect of a PNB to flap survival.

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