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Original article

Microsurgery and vasospasms: Spasms' predictive factors during harvesting

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ABSTRACT

Background: Vasospasm (VS) in microsurgery is a source of surgical complications, repeat operations, stress for the patient and the surgical team, as well as increased length of stay. Various risk factors have been identified but knowledge regarding the implicated mechanism remains limited.
Hypothesis: Our objective was to determine if the harvesting conditions for microsurgical toe transfers could increase the risk of VS. Our secondary objective was to determine the correlation between VS occurrence before flap division, and the occurrence of vascular complications after completion of vascular anastomoses.
Patients and methods: Primary endpoints were the existence of locoregional anaesthesia of the lower limb, the Gilbert classification, the nature of the graft taken from the foot, the characteristics of the patients and smoking status. Our secondary endpoints were the presence of secondary VS or microsurgical failure. This series consists of 14 toe transfers over a 30-month period. Primary VS was defined as occurring prior to flap division, while secondary VS occurred after transfer.
Results: In this series, we identified 4 cases of primary VS. The average age of the operated population was 30.6 ± 11.2 years (16–58). The patients who presented with primary VS had a mean age of 35.3 ± 16.2 years (21−58), with no statistical difference with the other group ($p = 0.54$). There was a statistically significant difference between the absence of locoregional anaesthesia and the occurrence of primary VS in toe transfer ($p = 0.0008$). Microsurgical failure occurred in 1 case. This failure was linked to the presence of a primary VS. Gilbert's classification and type of graft were not predictive of VS ($p = 0.15$ and $p = 0.08$, respectively). The occurrence of secondary VS was statistically linked to the occurrence of primary VS ($p = 0.009$).
Discussion: The occurrence of VS remains unpredictable and the effectiveness of available treatments is debated in the literature. Faced with the failure of curative treatments, this study aimed to determine predictive factors for VS. The existence of secondary VS, when prolonged and non-responsive to conventional measures, can lead to anastomotic revision. Performing locoregional anaesthesia on the lower limb makes it possible to effectively combat the occurrence of VS. The absence of primary VS was correlated with an absence of secondary VS and an absence of microsurgical failure. In addition to controlling vasospasm, regional anaesthesia provides effective analgesia at the harvesting site.
Level of evidence: IV

1. Introduction

Vasospasm (VS) remain difficult to manage in microsurgery, despite six decades of experience with this entity in the microsurgical community [1,2]. Above all, it remains a diagnosis of exclusion [1]. The absence of revascularisation of a free transfer or a replanted finger fragment must initially eliminate a technical cause such as vascular injury, twisted pedicle, non-permeable suture, or kinking effect [1,3–5]. Thereafter, general causes (arterial hypotension, hypothermia, use of vasopressors, etc.) should be identified and treated [6,7]. It is only when all these causes have been eliminated that the diagnosis of vasospasm can be made.

The absence of revascularization of a free flap when releasing the tourniquet, causes an increase in operating time, even in the event of

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Table 1
Primary endpoints.

	SV+	SV−	*p*
Patient characteristics			
Sex ratio (M/F)	3/1	9/1	0.51
Mean age ± SD (min-max), years	35.3 ± 16.2 (21−58)	28.7 ± 8.9 (16−45)	0.54
Smoker (yes/no)	0/4	1/9	0.99
Loco-regional anesthesia of lower limb (yes/no)	0/4	10/0	0.0008
Gilbert classification			
I	1	7	
II	2	3	0.15
III	1	0	
Type of graft			
1st toe Wrap Around	1	5	
2nd toe Wrap Around	0	1	
Pulp of 1st toe	0	1	0.08
Ungual 2nd toe	1	0	
PIP transfer	0	3	
MTP transfer	2	0	

SV+: vascular spasms before flap division.
SV−: no vascular spasms before flap division.
PIP: proximal interphalangeal.
MTP: metacarpophalangeal.

vasospasm if the surgeon times doesn't end the operation until the spasm has ceased. It can be a source of stress for the surgical team and lead to anastomotic revision [1,8].

In our practice, releasing the tourniquet is a systematic step before flap division during partial toe transfers. This method makes it possible to identify possible leaks on the pedicle, thus formally eliminating all technical errors. Furthermore, this method aims to never divide a flap with a spasmed pedicle.

Our main objective was to determine the factors favoring the occurrence of vascular spasms during toe transfer surgery. Our secondary objective was to determine the correlation between the occurrence of vascular spasm before flap division, and the appearance of complications after making the anastomoses.

2. Materials and methods

2.1. Patients

This single-operator retrospective series is comprised of 14 toe transfers over a period of 30 months between 2019 and 2021. The average age was 30.6 ± 11.2 years (16–58), 12 men and 2 women. These free transfers from the foot were offered to physiologically adult patients following traumatic sequalae of the fingers.

2.2. Methods

In our practice, partial or total toe grafts are isolated to pedicled island flaps prior to flap division. The lower limb tourniquet is released and revascularization of the flap is expected. This method ensures the absence of vascular wounds, the ligation of all collateral vessels, and the absence of technical errors. Once the flap is prepared on the recipient site and the vascular anastomoses performed, the tourniquet is released. Then, we wait for the flap to be reloaded before considering the end of the surgical procedure.

2.3. Evaluation methods

Primary VS was defined as appearing before tapering the flap while VS occurring after completion of the anastomoses were termed secondary VS.

The occurrence of a primary or secondary VS was considered when the time to obtain a capillary pulse on the flap was greater than 15 min after release of the tourniquet, despite control of blood pressure and temperature. The patient's temperature was controlled by heating blankets on the patient's body and the proximal end of both lower limbs, combined with thick woven abdominal compresses soaked in physiological saline at 38 °C. These compresses were placed on the dorsal and plantar surfaces of the foot.

The number of primary VS was defined for this entire series according to intraoperative findings. Our primary endpoint focused on identifying a link with the characteristics of our population, being a current smoker, the Gilbert classification [9] (anatomical description of arterial variations of the first intermetatarsal space), the type of graft taken from the foot, as well as the existence of locoregional anesthesia in the lower limb. The secondary endpoints were the existence of secondary VS and the existence of microsurgical failures.

2.4. Statistical analysis

The JMP software (SAS institute) was used to produce the statistics. Quantitative parameters were provided as means and standard deviations, while qualitative parameters were provided as absolute values. A Fisher's exact test, with an alpha risk of 0.05, was used for comparison between groups.

3. Results

3.1. Epidemiological data

For this series of 14 toe transfers, we identified 4 cases of primary VS. In 10 cases, the flap did not show spasms before flap division (Table 1).

Two women underwent toe transfer surgery and primary VS was noted in only one case. In men, three cases of primary VS were identified.

The overall average age of the operated population was 30.6 ± 11.2 years (16–58). The patients who presented with primary VS had a mean age of 35.3 ± 16.2 years (21−58), and there was no statistical difference with the other group ($p = 0.54$).

A single smoking patient was found in this series and he did not exhibit a primary VS. There was a statistical link between the absence of locoregional anesthesia and the occurrence of primary VS of toe transfer ($p = 0.0008$). Microsurgical failure was found in 1 case. This failure was linked to the presence of a primary VS.

3.2. Locoregional anesthesia of the lower limb (LRA)

LRA to the lower limb was performed in 10 cases. When LRA was performed, no primary VS were identified (Table 1).

3.3. Gilbert's classification

Gilbert type I was found in 8 cases and it was linked to primary VS in only 1 case. The only type III identified was linked to primary VS (Table 1).

3.4. Graft type

Of the 6 transfers completed in accordance with Morrison's technique [10], a single case of primary VS was noted. Both metatarsophalangeal transfers underwent primary VS. The 3 proximal interphalangeal joint transfers did not present primary VS.

3.5. Secondary vascular spasms

The presence of secondary VS after completion of the transfer was found in 5 cases (Table 2). In 4 cases, they were related to primary VS of the flap. The occurrence of secondary VS was statistically linked to the

Table 2
Secondary endpoints.

	SV+	SV−	*p*	Total
Secondary SV (yes/no)	4/0	1/9	0.009	5/9
Microsurgical failure (yes/no)	1/0	0/13	0.07	1/13

SV+: vascular spasms before flap division.
SV−: no vascular spasms before flap division.
Secondary VS: vascular spasms after flap transfer and loading.

occurrence of primary VS (p = 0.009).

4. Discussion

VS remains a diagnosis of exclusion, where it is necessary to ensure the absence of technical errors and/or a flap loss of load [1,3–5]. These technical errors could be a non-permeable anastomosis, an arterial thrombosis, a suture under tension, a kinking effect, a twisted pedicle, a leaky anastomosis, a vascular wound, or a loss of load on non-ligated collaterals. Verifying for these situations, and treating them is recommended, as well as managing blood pressure and temperature control as necessary [6,7].

Despite the monitoring these parameters, the occurrence of VS is still observed [1,2]. It is in this context that vasodilators in the form of local topical agents are used. However, the results of these local agents remain highly debated in the literature [2,8,11]. Proof of their effectiveness as well as the superiority of topical treatments to each other, or to general measures or even to surgical revision, has never been provided [2,8,11].

Furthermore, it may be more logical to propose a solution that prevents VS, as opposed to seeking curative treatments which are still debated in terms of their effectiveness. In addition to this, the occurrence of VS in microsurgery remains unpredictable, as does the effectiveness of the different treatments accumulated in the therapeutic armamentarium of microsurgeons [1,2,6–8]. It is in this context that we questioned the existence of a link between primary VS and the appearance of secondary VS, as well as the factors favoring primary VS.

In this series of 14 toe samples, four primary VS were identified. Epidemiological criteria or the existence of smoking did not make it possible to identify predictive factors for primary VS, although age is a recognized risk factor for spasms [12,13]. Smoking tobacco is an identified risk factor for vasospasms however it was not identified as an implicated factor in this series [14,15].

The provision of locoregional anesthesia to the lower limb has been identified as a protective factor for the occurrence of primary VS. Anesthetic substances significantly reduce the occurrence of primary VS through a dual action at the level of the sympathetic nervous system, but also the smooth muscles of the arterial wall (tunica media) [6,16–18]. The use of anesthetic distal nerve blocks, particularly at the ankle in this setting, ensure this double action given the proximity of the vascular-nervous elements to the posterior tibial pedicle. The significant benefit of a distal anesthetic block is the lower risk neurotoxicity given the smaller volume of anesthetic substances [19].

In our experience, the time for revascularization of the pedicled island flap before division, was instantaneous or reduced to a few minutes when an LRA had been performed on the lower limb.

The type of graft does not seem to influence the appearance of primary VS. However, both metatarsophalangeal grafts spasmed. This could be explained by the more technical characteristic of these grafts, which perhaps require more traction on the pedicle. Although, it remains difficult to draw conclusions from only two cases.

In the same sense, the vascular variation of the dorsal intermetatarsal artery as per Gilbert's classification, does not seem to influence the occurrence of primary VS. It might seem logical to implicate Gilbert stage III as predisposing to primary VS. However, the low proportion of stage III identified does not allow conclusions to be drawn. When presented with this vascular arrangement, the dissection of the plantar metatarsal artery was systematically terminated at the level of the intermetatarsal ligament. This chosen method could have influenced the results observed.

Finally, it appears that the occurrence of primary VS influences the surgical outcomes. The presence of secondary VS is statistically associated to the presence of primary VS. It is specifically these secondary VS which are responsible for an increase in the operating time and therefore in the length of stay, particularly for surgeons who wish to observe the revascularization of the transfer before considering leaving the operating room and transferring the patient to the hospitalization unit.

The secondary VS, when prolonged, can lead to anastomotic revision [8]. These iterative manipulations only worsen the present VS [20]. The only microsurgical failure obtained in this series occurred following both primary VS and secondary VS, that were difficult to resolve.

Our work has certain limitations. Indeed, the results should be judiciously considered since this is a small series, thus hindering the deduction of formal conclusions. However, there was no missing data concerning our evaluation parameters, which allowed us to observe certain trends to be confirmed in larger studies. Furthermore, our results were generated from a sole particularly experienced surgeon, which should be considered in the analysis since the learning curve in microsurgery can be particularly long, even if condensed learning based on immediate repetition of the exercises helps speed up the process [21]. In addition, our data are specific to grafts taken from the foot, while spasms are not observed on the proximal or central parts of the limb [22–24].

5. Conclusion

The use of locoregional anesthesia in the lower limb seems to reduce the appearance of primary VS when taking toe transfers. Furthermore, LRA doesn't simply help limit vasospasms, but also helps diminish postoperative pain. The occurrence of secondary VS appears to be associated to the presence of primary VS.

Performing LRA on the lower limb, ideally in the form of a distal ankle block, may reduce the occurrence of primary and secondary VS.

Author contribution

Germain Pomares contributed to the study design, collection, analysis and interpretation of the data, writing the manuscript, revising the manuscript for important intellectual content, analyzing the statistical data and performing the surgeries. He approved the final version of the manuscript.

Amandine Ledoux contributed to interpretation of the data, writing the manuscript, revising the manuscript for important intellectual content. He approved the final version of the manuscript.

Thomas Jager and Christophe Duysens contributed to the revision of the manuscript and approval of the final version of the manuscript.

Alban Fouasson-Chailloux contributed the study design, analysis and interpretation of the data, writing the manuscript, revising the manuscript for important intellectual content, statistical analysis and approval of the final version of the manuscript.

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Conflicts of interest

The authors declare no conflicts of interest.

Generative AI and AI-assisted technologies statement

No artificial intelligence was used in the writing of this manuscript.

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