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Reconstructive

Intraoperative Identification of Perforator Spasm and Decreased Pulsation Using Video-capillaroscopy during Free Flap Harvest

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Summary: Temporary or prolonged vascular spasm can be appreciated when perivascular dissection is performed for microvascular reconstruction. Due to a lack of reliable assessment modalities, the resolution of spasm at the periphery of perforators cannot be determined by naked eyes or surgical loupes. To address this conundrum, we aimed to observe the state of perforator vessel spasm after flap elevation using video-capillaroscopy. Between November 2021 and February 2022, seven free flaps were evaluated with video-capillaroscopy to determine the incidence of vasospasm in less than 1 mm–diameter perforators. The type of perforator spasm after flap elevation was divided into six types according to the video-capillaroscopy findings: type A, no spasm/decreased pulsation (S/DP); type B, S/DP with recovery within 5 minutes; type C, S/DP requiring papaverine hydrochloride spraying and hot water treatment (PHS+HWT) resulting in recovery within 5 minutes; type D, S/DP requiring PHS+HWT resulting in recovery within 10 minutes; type E, S/DP requiring PHS+HWT resulting in recovery within 15 minutes; and type F, S/DP with no recovery of pulsation even after PHS+HWT. Twenty-five perforators were evaluated, 3.57 perforators (range, 3–4) per flap. Using our classification for perforator vessel spasms on video-capillaroscopy, observations of five perforating branches were classified as type A, seven as type B, six as type C, five as type D, and two as type E. No type F spasm was observed. With video-capillaroscopy it is possible to confirm if blood flow deterioration occurs even in areas that are difficult to determine macroscopically. Video-capillaroscopy, a noninvasive imaging modality, is a useful alternative for the intraoperative evaluation of perforator flow and spasm. *(Plast Reconstr Surg Glob Open 2022;10:e4613; doi: 10.1097/GOX.0000000000004613; Published online 3 November 2022.)*

INTRODUCTION

Temporary or prolonged vascular spasm can be appreciated during flap elevation, resulting in momentary decrease of pulsation.[1] Unless reversed, it can result in flap failure.[1] Intraoperative topical application of papaverine hydrochloride and/or warm water is usually sufficient to restore physiologic blood flow.[1] Nevertheless, conventional assessment methods (eg, macroscopic observation, loupe, or palpation) are inadequate to accurately evaluate spasm of perforators' small peripheral branches and determine resolution of spasm.

We have achieved real-time flap monitoring by directly visualizing flap skin capillary microcirculation in previous studies.[2–4] The purpose of this study was to use the new generation video-capillaroscopy to evaluate the incidence of vasospasm, characterize blood flow through perforators, and assess the pulsation of terminal branches during flap elevation.

METHODS

This study was approved by our institutional review board (#241, UMIN000041092). Between November 2021

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and February 2022, seven free flaps harvested for head and neck reconstruction were evaluated with video-capillaroscopy (Bscan-ZD, GOKO Imaging Devices Co., Ltd., Japan). We excluded patients with previous diagnosis of coagulopathy or medical history of vascular malformations. We extracted data on the patients' demographics and medical history, location of primary lesion, oncologic staging, number and size of perforators, and type of vasospasm. Perforators were evaluated with video-capillaroscopy at a skin temperature of greater than 36°C after flap harvest, before transecting the pedicle. (**See figure, Supplemental Digital Content,** which shows the observation point of vessels was the adipose tissue of flaps, adjacent to the flap's fascia. **http://links.lww.com/PRSGO/C205**.) The observation point of vessels was the adipose tissue of flaps, adjacent to the flap's fascia (**See Video [online],** which demonstrates our classification to categorize spasm into types A, B, C, D, E, and F, as reported in the article and video-capillaroscopy findings before and after resolution of spasm). Spasm/decreased pulsation (S/DP) was defined as transient/permanent cessation of pulse when compared with the pedicle vessels or as lack of observable sinus rhythm pulsation.

The visual field of video-capillaroscopy was about 175× and 620×, 1.2 million pixels, and 1 mm in depth from the surface. S/DP of perforators was classified as follows: No S/DP (type A); S/DP with recovery within 5 minutes (type B); S/DP requiring papaverine hydrochloride spraying (4 mg/ml) and hot water treatment (PHS+HWT) resulting in recovery within 5 minutes (type C); S/DP requiring PHS+HWT resulting in recovery within 10 minutes (type D); S/DP requiring PHS+HWT resulting in recovery within 15 minutes (type E); and S/DP with no recovery of pulsation even after PHS+HWT (type F). Fluid warming systems were used to maintain the saline solution at 42°C, while 0.5 ml of PHS was applied when S/DP was identified.

RESULTS

Four male and three female patients underwent microvascular reconstruction of head and neck defects. The average age of patients was 66.57 ± 9.16 years. Two rectus abdominis myocutaneous (28.6%) and five anterolateral-vastus lateralis (ALT) flaps (71.4%) were evaluated with video-capillaroscopy. No major complications occurred. Data on the location of the primary lesion, oncologic management, and medical history are reported in Table 1. Twenty-five perforators were evaluated, 3.57 perforators per flap (range, 3–4). Using our classification for S/DP on video-capillaroscopy, observations of five perforating branches were classified as type A, seven as type B, six as type C, five as type D, and two as type E. No type F S/DP was observed. Direct visualization of transient S/DP was seen in 92.85% of perforator vessels with a diameter of 1 mm or less, while S/DP was seen in 63.6% of perforators with a diameter greater than 1 mm ($P = 0.07$).

Real-time movement of red blood cells in adipose tissue and pulsation could be observed in the perforator's branches with a minimum diameter of 0.01 mm (Fig. 1A). The absence/presence of pulsation made it possible to determine the alignment of the artery and vein. Enhancement of sinus rhythm pulsation was observed after resolution of S/DP in vessels with type B, type C, and type E video-capillaroscopy observations (Fig. 1B).

Takeaways

Question: Is it possible to use video-capillaroscopy to evaluate the incidence of vasospasm, characterize blood flow through perforators, and assess the pulsation of terminal branches during flap elevation?

Findings: Seven free flaps were evaluated with video-capillaroscopy, and we could determine the incidence of vasospasm in less than 1 mm–diameter perforators during flap elevation. We classified the type of perforator spasm after flap elevation with video-capillaroscopy into six types according to the time for resolution.

Meaning: It is possible to confirm real-time blood flow deterioration of flaps with video-capillaroscopy in areas that are difficult to evaluate with microscope.

DISCUSSION

The incidence of vasospasm during microvascular reconstruction has been reported to be between 5% and 10%.[1] Intraoperative vasospasm is unpredictable; nonetheless, papaverine has been shown to provide some degree of prevention against it and to improve micro-anastomosis patency.[5,6] Previous studies have shown the utility of flowmeter, indocyanine green-angiography, spectrophotometry, and laser-Doppler flowmetry to depict fluctuations of blood flow.[7] Nevertheless, these modalities provide indirect measurements of perfusion and vessel caliber such as flow, contrast intensity, and oxygen saturation.[7] Furthermore, these methods have the limitation that they cannot accurately evaluate the degree of vasospasm of very small vessels (<0.5 mm).[8,9] Contrariwise, video-capillaroscopy allows direct real-time assessment of blood flow through vessels of 0.01 mm or larger, extending its application to the most peripheral branches of perforators.[2,3]

Video-capillaroscopy allows evaluation of red blood cell flow and pulse of thin perforators in a selective way, offering the possibility of assessing the microcirculation proximally, where the perforator pierces the fascia, or distally along the whole extension of the skin paddle. This feature is of special consideration in cases of subclinical vasospasm.[10] Therefore, flap areas recalcitrant to intraoperative antispasmodic therapy can be selectively excised, anticipating future wound-related complications

With video-capillaroscopy, we intraoperatively evaluated that all selected perforators for the skin paddle had resolution of spasm. Otherwise, these zones could be particularly affected during warm ischemia, and suboptimal blood flow after reperfusion secondary to unidentified persistent spasm could further affect survival of these flap segments. Additionally, with video-capillaroscopy, we can selectively clamp perforators and assess the microcirculation of flaps to identify main tributaries for optimal

Table 1. Demographic, Medical, and Oncologic Information of Patients in Whom Flap Transfer and Video-capillaroscopy Was Performed

Patient	Sex	Age (y)	Cancer	TNM	Stage	Surgery	Neoadjuvant Therapy	Comorbidities	Medical History	Flap Type	Perforators Evaluated	<0.5 mm [Size mm]	0.5–1 mm [Size mm]	>1.0 mm [Size mm]	MPD-RBC*
1	F	70	R/ Buccal mucosa	cT4aN1M0	IVa	Left buccal skin and mucosa resection + RAMC Flap -> R/ mRND -> ALT for fistula closure	CCRT X2 66Gy radiation	DM	PS0 KPS100	ALT	4	0	1 [0.7]	3 [1.2, 1.5, 1.4]	0.02
2	M	54	Oropharynx + tongue	cT3N0M0	III	R/ Hemiglossectomy + Oropharyngectomy + R/ SND (I–III)	N/A	N/A	Smoking: 20 × 36 years, wine 300 ml×34 years PS0 KPS100	ALT	4	1 [0.4]	2 [0.8, 0.9]	1 [1.5]	0.001
3	M	75	R/ Tongue	cT4N0M0	IVA	R/ Hemiglossectomy + R/ SND + TPL	N/A	CVA	Smoking 20 × 35years, wine180 ml×40years	RAMC	3	0	1 [0.8]	2 [1.3, 1.6]	0.003
4	M	76	R/ Tongue	cT3N0M0	III	R/ Hemiglossectomy + R/ SND	N/A	DM (HbA1c 6.4%), HTN, AMI, CKD	Smoking 20 × 40years, wine 180 ml×50years PS0 KPS100	ALT	4	1 [0.3]	3 [0.9, 0.8, 0.8]	0	0.05
5	M	62	Oropharynx + tongue	cTaN2M0	IVA	Total Glossectomy + B/L mRND (R/, I-III; L/, I–V)	DCF x2 CBDCA x3 RT 66Gy	N/A	smoking: 10 × 42 years, 375 ml of wine/d ×42 years PS0 KPS100	RAMC	3	0	0	3 [1.2, 1.5, 1.8]	0.02
6	F	56	L/ Tongue	cT2N0M0	II	L/ Hemiglossectomy + L/ SND	N/A	N/A	no history	ALT	3	1 [0.4]	2 [0.9, 0.8]	0	0.006
7	F	73	L/ Tongue	cT3N0M0	III	L/ Hemiglossectomy + L/ SND	N/A	DM, HTN, AF, HT	PS1 KPS80	ALT	4	0	2 [0.6, 0.7]	2 [1.4, 1.8]	0.004

->, next surgery; AF, atrial fibrillation; ALT, anterolateral thigh; B/L, bilateral; CCRT, Concurrent chemoradiation; CBDCA, Carboplatin; CVA, cerebrovascular accident; DCF, Docetaxel, Cisplatin, and 5-fluorouracil; DM, diabetes mellitus; HT, hypothyroidism; HTN, hypertension; L/, left; KPS, Karnofsky Performance Status; mRND, modified radical node dissection; N/A, not applicable; PS, performance status; SND, selective lymph node dissection; RAMC, rectus abdominis myocutaneous; R/ right; RT, radiotherapy.

*MPD-RBC, minimal perforator diameter to assess red blood cell movement on video-capillaroscopy.

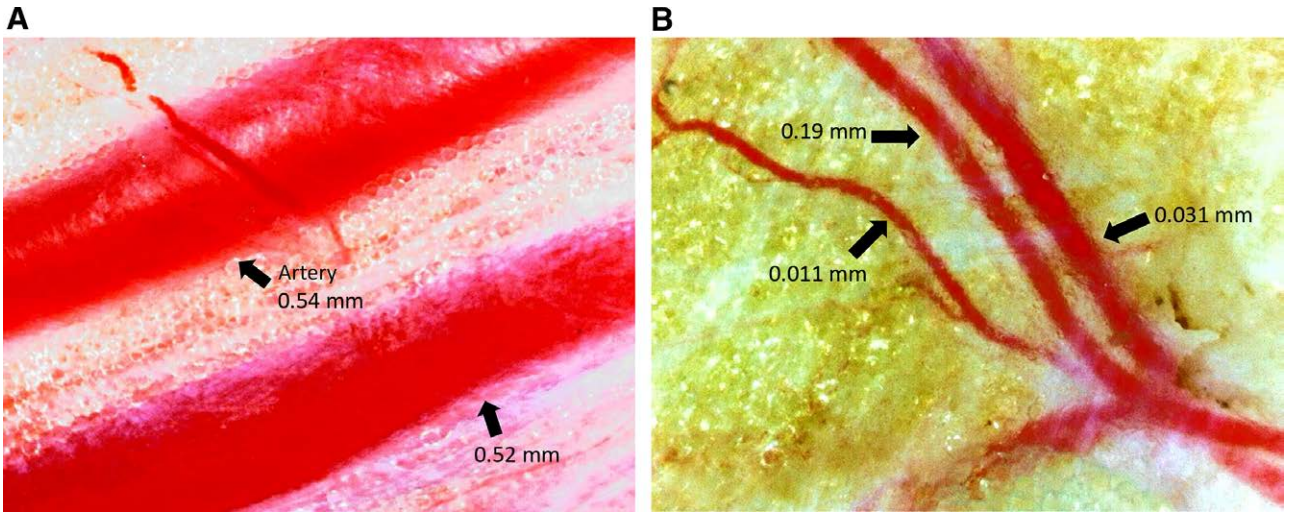

Fig. 1. Intraoperative real-time evaluation of vessel spasm with video-capillaroscopy. A, Perforator at the junction of fascia. It was possible to differentiate between arteries and veins by the presence or absence of pulsation. B, Diameter of the perforator branches in adipose tissue. The movement of the red blood cells could be observed.

perfusion. This feature may aid in the decision-making to select which perforator is best as the main axis of fasciocutaneous components.

As a limitation, when video-capillaroscopy is performed in large vessels (>0.5 mm), the volume of RBCs passing through the lumen causes the entire area to appear red and the movement of the RBCs is difficult to detect. Additionally, the external validity of these outcomes is restricted, as spasm determination has a qualitative character and the appropriate utilization of this technology has a learning curve as it happens with other technologies.

CONCLUSIONS

Since more than half of the perforators showed signs of temporary S/DP to varying degrees, it is imperative that blood flow from perforating vessels is stable with resolution of S/DP before transecting the pedicle and subsequent anastomosis. Video-capillaroscopy, a noninvasive imaging modality, is a useful alternative for intraoperative evaluation of perforator flow and pulse for safe flap transfer.

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