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Microdialysis in postoperative monitoring of microvascular free flaps: Experiences with a decision algorithm

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ABSTRACT

Background: Reconstruction with free flaps has become a usual practice in maxillofacial surgery. Clinical monitoring is still the standard approach for postoperative follow-up, but can be difficult or impossible with intraorally situated or buried flaps. Microdialysis is a sampling technique that offers the possibility to monitor the metabolism of flaps continuously. It is a reliable method for early diagnosis of ischemia. **Materials and methods:** 48 microvascular free flaps applied following oral cancer resection were monitored with a microdialysis (MD) catheter, placed in the flap. Glucose, lactate, and lactate/pyruvate ratio were monitored using a bedside analyser for 5 days. 48 free flaps served as controls and were assessed (refill, flap temperature, and color) by clinical monitoring (CM).

Results: 12 flaps monitored by MD showed abnormal metabolism and underwent revision. Eight flaps were saved and four were lost within the first 5 days postoperatively. In addition, two flaps were lost at days 15 and 30 postoperatively, without previous complications. Four flaps assessed by CM developed complications, underwent revision, and were saved. In addition, five flaps were lost between the 8th and 23rd days postoperatively, without revision, due to missing previous clinical signs.

Conclusion: Postoperative monitoring of free flaps using a microdialysis decision algorithm allows early diagnosis of anastomotic complications. It is a clinically feasible and sensitive monitoring method for microvascular flaps, allowing surgical revision to be undertaken before clinical alteration takes place.

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1. Introduction

Ischemia is a common problem in microvascular free-flap reconstruction after oral and maxillofacial (OMF) tumor resection. The flaps are incorporated in the area of tumor resection, with parts of the flaps intraoral and buried. Therefore, precise clinical monitoring (CM) of capillary refill and flap color/temperature — for recognition of a failure early enough for intervention — is difficult to perform (Jyranski et al., 2006; Nielsen et al., 2011). Moreover, CM is very inconvenient for the patient due to the short intervals of approximately 30 min to 2 h for the 5 days following an operation.

Within the first 5 postoperative days there is an increased risk of ischemia and necrosis due to hematoma, thrombosis, and head

posture. Vascular compromise leads to metabolic abnormalities that can be tolerated for a limited time only (Desyatnikova et al., 2001; Fowler et al., 1999; Martin-Granizo et al., 1999). It is important to re-establish vascular patency to increase the success rate of free-flap transfer (Abdel-Galil and Mitchell, 2009a, 2009b; Holzle et al., 2010; Jyranski et al., 2006; Nielsen et al., 2011; Rojdmarm et al., 1998, 2000). Nielsen et al. described a protocol for microdialysis monitoring. Glucose and lactate are the key parameters in the technique, which is based on the Embden-Meyerhof pathway, which describes glycolysis and the active metabolism of living cells (Nielsen et al., 2011).

Postoperative monitoring of free-flap transfer is known to improve the success rate. There are different options for monitoring, including non-invasive and invasive approaches. Clinical monitoring, laser Doppler flowmetry, surface Doppler monitoring, colour Doppler sonography, and microlight-guided spectrophotometry are non-invasive monitoring methods. The non-invasive methods generate data that differ according to the individual

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performing the measurements. This lack of objective data means that individual expertise is more necessary (Abdel-Galil and Mitchell, 2009a, 2009b). In addition, using non-invasive methods requires cooperation of the patients. Invasive methods include microdialysis and other implanted monitoring devices, for example for venous Doppler monitoring and temperature, tissue pO_2 , and pH measurement (Abdel-Galil and Mitchell, 2009a, 2009b).

There is no consensus on the optimal method for increasing microvascular free-flap survival. Non-invasive methods can induce lower-quality sleep than invasive methods. Wound healing is important and supported by sleep (Egydio et al., 2011). Therefore, we opt for invasive monitoring following free-flap reconstruction. Data supporting invasive monitoring are not widely available, and are mostly generated by experimental studies. These methods are not widely used or available in daily practice. During flap monitoring, different problems arise due to the complex nature of the flap. The skin surface and color, the muscle or soft tissue, and microvascular anastomosis require different monitoring parameters and experience levels. Therefore, it is difficult to determine the ideal postoperative approach between 'wait and see' and operative revision when there are other complications to consider, such as hemorrhage.

Microdialysis was described for the first time by Bito et al. (1966) and improved some years later (Delgado et al., 1972). Animal studies have been performed to evaluate the reliability of this method (Rojdmark et al., 2000; Setala et al., 2004). Moreover, clinical data have been reported in recent publications (Holzle et al., 2010; Nielsen et al., 2011). A recently published decision algorithm for microdialysis monitoring showed positive results and seems to be an adequate guideline for the management of complications (Nielsen et al., 2011).

The aim of this study was to evaluate the success of free-flap revision in cases of postoperative complications assessed using a microdialysis monitoring algorithm, in comparison with those assessed by clinical monitoring, for reconstruction following OMF tumor resection with radial forearm, fibula, and scapular flaps.

2. Materials and methods

In total, 96 free-flap reconstructions after OMF tumor resection were performed in the Department of Oral and Maxillofacial Surgery at the Schleswig–Holstein University Hospital in Germany. Of these, 48 free-flaps were performed in the group with microdialysis monitoring (surgical procedures from November 2008 to March 2011), and 48 free-flaps with clinical monitoring served as controls (surgical procedures from November 2007 to April 2010). Written, informed consent was obtained from all patients.

The patients had primary diagnoses of carcinoma. One patient had a history of radiotherapy. Secondary diagnoses included hypertension, diabetes mellitus, cardiovascular disease, and COPD. In total, 26 patients had a history of nicotine and/or alcohol abuse.

Clinical monitoring (CM) was performed after surgery for 5 days (1st day every 30 min, 2nd day every hour, and 3rd to 5th days every 2 h). CM was carried out by experienced nursing staff. Increased or decreased capillary refill time, pale or cyanotic skin colour, low skin temperature, and edema are the clinical signs of vascular complications. The CM group consisted of 48 patients (mean age 60.5 years [range 31–88 years]; 33 males, 15 females), involving 20 radialis forearm, 17 fibula, and 11 scapula microvascular free-flaps.

The MD group consisted of 48 patients (mean age 60.5 years [31–81 years]; 30 males, 18 females), involving 30 radialis forearm, 14 fibula, and four scapula microvascular free-flaps. The data were analysed using an ISCUS microdialysis analyser (EKF Diagnostics, Magdeburg, Germany) and ICU Pilot software (Version, 2006). A CMA 106 microdialysis pump (μ Dialysis AB, Solna, Sweden) was used to perfuse CMA 60 microdialysis catheters (0.6 mm diameter; 20 kDa cuff-off) with Ringer's solution (B. Braun Melsungen AG, Melsungen, Germany) at a flow rate of 0.3 μ l/min. The microdialysis catheter was placed in the subcutaneous adipose tissue of the flap at the end of the surgery (Fig. 2). A minimum of 0.5 ml of dialysate/interstitial fluid was needed for analysis. Fig. 1 summarizes the standard monitoring with microdialysis and describes the Level 1 and Level 2 alarms.

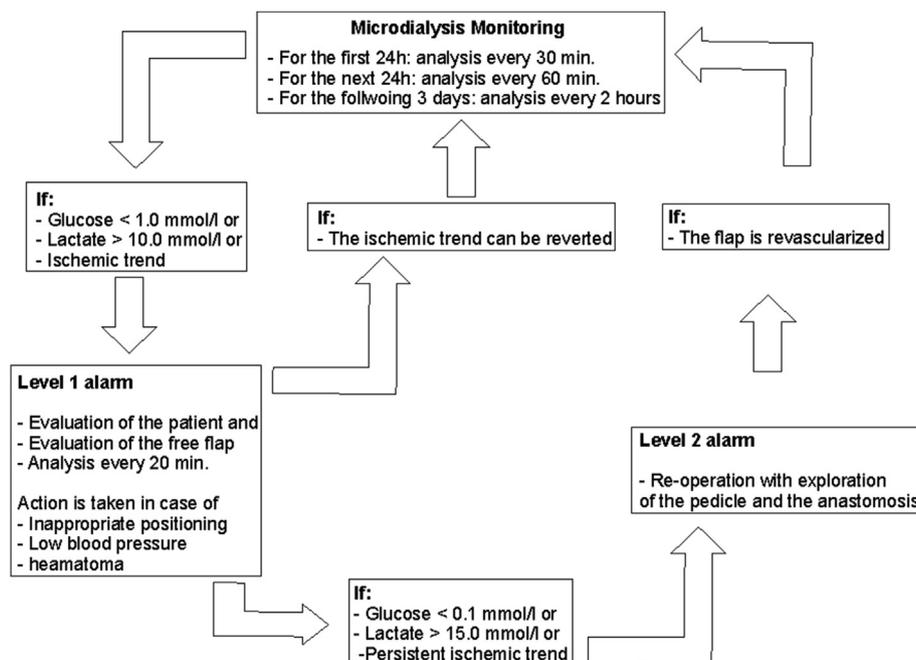


Fig. 1. The decision algorithm published by Nielsen et al (Nielsen et al., 2011). The dialysate was observed for 5 days at different intervals. The critical values for glucose, lactate, and lactate/pyruvate ratio were measured, and the decision over free flap revision was made.

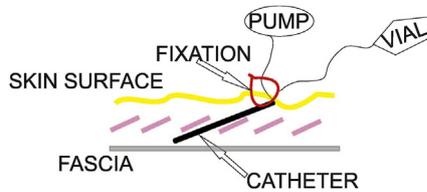


Fig. 2. The MD catheter was placed using the Seldinger technique under the surface of the skin in the soft tissue/muscle. The catheter was fixed with two sutures on the surface of the skin. The solution was pumped through the tip and collected in the vial.

3. Results

Table 1 (complications) and Table 2 (ischemic time) summarize the results for both groups: microdialysis monitoring and clinical monitoring.

Fourteen complications (29.2%) occurred in the MD monitoring group. In total, 12 revisions (25.0%) were performed, and eight flaps

Table 1

Microdialysis (MD) and clinical monitoring (CM) complications. 14 complications occurred in the MD group and nine in the CM group. All revisions in the CM group saved the flap; however, the five lost flaps showed no clinical signs of vascular compromise. Six flaps were lost in the MD group; however, two showed no clinical signs and, therefore, no revision was performed. Eight flaps out of 12 were saved with a revision.

Microdialysis			
Complication	Procedure	Outcome	Alarm
No. 01	revision	lost 5th d p.o.	Level 1 alarm
No. 02	revision	lost 5th d p.o.	Level 1 alarm
No. 03	revision	lost 5th d p.o.	Level 1 alarm
No. 04	revision	lost 5th d p.o.	Level 2 alarm
No. 05	no revision	lost 15th d p.o.	no alarm
No. 06	no revision	lost 30th d p.o.	no alarm
No. 07	revision	saved	Level 2 alarm
No. 08	revision	saved	Level 1 alarm
No. 09	revision	saved	Level 1 alarm
No. 10	revision	saved	Level 1 alarm
No. 11	revision	saved	Level 1 alarm
No. 12	revision	saved	Level 1 alarm
No. 13	revision	saved	Level 1 alarm
No. 14	revision	saved	Level 2 alarm

Clinical monitoring		
Complication	Procedure	Outcome
No. 01	no revision	lost 8th d p.o.
No. 02	no revision	lost 12th d p.o.
No. 03	no revision	lost 15th d p.o.
No. 04	no revision	lost 22nd d p.o.
No. 05	no revision	lost 23rd d p.o.
No. 06	revision	saved
No. 07	revision	saved
No. 08	revision	saved
No. 09	revision	saved

Table 2

Ischemic times for the flaps in the different groups. There was no significant difference between these times.

flap	Microdialysis	Clinical monitoring
	Time of Ischemia [hh:mm]	Time of Ischemia [hh:mm]
	mean (SD)	mean (SD)
	min – max	min – max
Radial forearm	02:02 (SD, 01:09) 00:55-05:40	02:19 (SD, 01:27) 00:45 - 05:40
Scapular	02:22 (SD, 00:56) 01:30-03:26	03:36 (SD, 01:11) 02:35-04:20
Fibular	02:56 (SD, 00:56) 00:40-03:56	01:59 (SD, 01:27) 00:55-03:26
Overall	02:24 (SD, 01:38) 00:40 - 05:40	02:19 (SD, 01:17) 00:45 - 05:40

survived (revision success rate, 66.6%; failure rate, 33.3%). However, two flaps (4.1%) without previous abnormal metabolism or revision were lost.

Nine complications (18.75%) occurred in the CM group. Four revisions (8.33%) were performed, and all flaps survived (revision success rate, 100.0%). However, five flaps (10.4%) without previous abnormal clinical signs or revision were lost.

Two cases of hemorrhage during revision were observed in the groups. The ratio of venous thrombosis to arterial thrombosis was 7:4.

4. Discussion

This study collected data from a decision algorithm for microdialysis monitoring, using the parameters of glucose, lactate, pyruvate, and lactate/pyruvate ratio. The recently published algorithm was used in a clinical trial comparing microdialysis monitoring with clinical monitoring (Nielsen et al., 2011).

The study provided data for 48 free-flap reconstructions after OMF tumor resection and monitored by microdialysis, compared with 48 free-flap reconstructions monitored by clinical examination. There is no consensus on the optimal monitoring of free-flaps, with non-invasive and invasive methods both used (Abdel-Galil and Mitchell, 2009a, 2009b). Reliable data to allow correct decisions on revision before clinical signs of vascular compromise will increase the success rate of free-flap survival. In our study, the use of the decision algorithm was as easy to manage as clinical monitoring. The microvials in the microdialysis pump were easy to remove without disturbing the patient's sleep, which would support wound healing (Egydio et al., 2011); however, there was a risk of occluding the anastomosis by head posture. The risk of catheter dislocation was reduced using suture fixation on the surface of the skin, with a minimum of two sutures. However, untrained personnel can still pull the catheter out of the free flap, resulting in reduced MD values and requiring revision of the catheter.

Non-invasive methods have a reduced risk of inflammation compared with invasive methods, which has to be considered. However, to the best of our knowledge, there are no published data for this failure that would prohibit the use of MD monitoring.

Our data did not provide the promising results reported by Nielsen et al. (2011). They reported a 17% revision rate (our data, 25%) with a success rate of 90% (our data, 66%) and an overall loss rate of 1.0% (our data, 12.5%). Potentially, correct insertion of the catheter can alter these results. There is a learning curve in the clinical use and technical practice of MD monitoring to achieve accurate results (Jyranki et al., 2006). Nonetheless, MD monitoring is able to detect ischemia in free flaps, supporting the published technique and its clinical benefit (Jyranki et al., 2006; Nielsen et al., 2011). Another benefit is that the metabolic results obtained by MD are quantified, giving the nursing staff more confidence in the

monitoring data (Jyranki et al., 2006). Compared with handheld Doppler apparatus, microvial removal from the pump and use of the microdialysis analyser are far less user dependent. However, there may be other factors that affect the success rate of free flaps that cannot be detected with MD or CM.

The secondary diagnoses among patients included hypertonia, diabetes mellitus, and cardiovascular disease. These diagnoses occur routinely in clinical practice with reduced microvasculature in the tissue. Specifically, diabetes mellitus leads to microangiopathy, with reduced soft tissue perfusion. Cardiac issues also show complications in perfusion and reduced integrity of the vessels. Therefore, peripheral microangiopathies are expected. Moreover, nicotine abuse reduces wound healing in cases of free flap reconstruction.

The limitations of the study must be considered when interpreting the results. First, the surgical reconstructions with microvascular free flaps were performed over 3 years and 5 months in one department. However, the surgery was not always performed by the same physicians. Therefore, surgical experience may have biased the results. Second, the defect and free flap sizes, as well as the physical constitution and the comorbidities of the different patients, may have also affected the survival of the flaps.

5. Conclusion

Postoperative monitoring of free flaps using a microdialysis decision algorithm allows early diagnosis of anastomotic complications. It is a clinically feasible and sensitive monitoring method for microvascular flaps, allowing surgical revision before clinical alteration takes place.

Conflicts of interest

None declared.

Ethics approval

This study was carried out according to the basic principles for ethical research in humans according to the Declaration of Helsinki.

Moreover, the University of Kiel approved the ethical petition (ethic verdict no. D444/11).

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