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Monitoring in microvascular tissue transfer by measurement of oxygen partial pressure: Four years experience with 125 microsurgical transplants

René Jonas [a,*], Thomas Schaal [a], Michael Krimmel [a], Dirk Gülicher [a], Siegmar Reinert [a], Jürgen Hoffmann [a,b]

[a] Department of Oral and Maxillofacial Surgery, University Hospital Tübingen (Head: Prof. Dr. Dr. Siegmar Reinert), Osianderstraße 2-8, 72076 Tübingen, Germany
[b] Department of Oral and Maxillofacial Surgery (Head: Prof. Dr. Dr. Jürgen Hoffmann), University Hospital Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany

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ABSTRACT

In a prospective study, the characteristics and benefit of an invasive measurement of oxygen partial pressure (pO_2) with the aid of a polarographic sensor were investigated in 125 microsurgical reconstructions of the head and neck area over a period of 45 months. Measurements were performed over 96 h in eight different types of microsurgically revascularized flaps for extra- and intraoral reconstructions and were evaluated separately for each flap type.

Of 125 reconstructions the system indicated malperfusion in 18 cases. Salvage surgery was performed in 17 cases due to venous thrombosis (6 cases), arterial thrombosis (3 cases), a combination of arterial and venous thrombosis (2 cases), rheological problems (3 cases), venous insufficiency by hematoma (2 cases) and kinking of vessels (1 case). In 10 cases salvage surgery was successful, 7 flaps were lost despite salvage surgery. In all these cases, the polarographic probe indicated the necessity of salvage surgery correctly. After 96 h no malperfusion was seen. Postoperatively, a common and characteristic development of the oxygen partial pressure in different types of flaps was seen. Initially, a clear increase of pO_2 could be measured. During 96 h, a slow decrease of pO_2 was observed.

In conclusion polarographic measurement of pO_2 can be an excellent apparative supplement for the postoperative clinical control of microsurgically revascularized transplants. In buried flaps, this technique represents the only reliable method for transplant monitoring.

1. Introduction

In terms of reconstructive techniques, microvascular tissue transfer has been progressively incorporated into the purview of oral and maxillofacial surgeons during the past 20 years (Eckardt and Fokas, 2003).

Regarding physiologic and esthetic outcomes just as quality of life, refinement in microvascular free-flap reconstructive techniques of surgically created defects after oral cancer resection has enabled an increasing number of patients to be rehabilitated and has proven to be an extremely reliable method (Mücke et al., 2011; Pohlenz et al., 2007). Patients treated that way even show a trend to better 5-year survival (de Vicente et al., 2011).

According to the literature, vascular thrombosis occurs in 8–14% of the cases and is considered to be the main reason for flap failure (Kessler et al., 2012; Novakovic et al., 2009; Hoffman et al., 2012). Furthermore, a dependency of the occurrence of thrombosis on flap type and method of anastomosis could be shown (Zhang et al., 2011).

In most cases, flap losses are seen in the first three postoperative days. As only early intervention can be successful and clinical symptoms of malperfusion are not reliable or do not even exist in buried flaps, several methods of apparative flap monitoring were described. Flap monitoring should give a continuous and reliable information of tissue condition, should be very sensitive to change in flap perfusion and in addition should be easy to use and to remove.

We present a simple and reliable method to monitor the perfusion of microsurgical flaps by measurement of oxygen partial pressure (pO_2) in the flap tissue with a polarographic probe (Licox®).

2. Material and methods

2.1. The polarographic probe

Polarographic measurement of brain-oxygenation by Licox®-probes (Fig. 1) is a standard method in neurological monitoring.

* Corresponding author. Tel.: +49 7071 29 86174; fax: +49 7071 29 3481.
E-mail addresses: drjonas@kabelmail.de (R. Jonas), siegmar.reinert@med.uni-tuebingen.de (S. Reinert).

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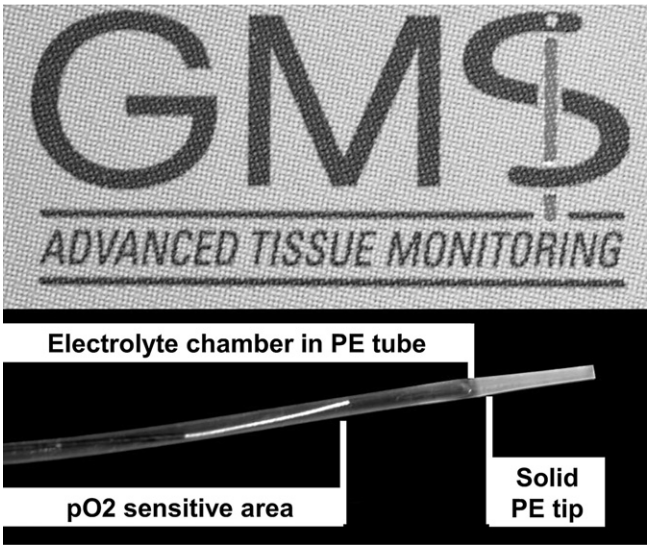

Fig. 1. Tip of Licox® polarographic pO_2 probe.

Monitoring a microvascular transplant was first mentioned in 1990 (Hjortdal et al., 1990). The electrode, surgically implanted in the flap tissue, can be left in place for several weeks and represents a pO_2-measuring field in a random tissue-sample of several mm^3. The electrochemical measurement of oxygen partial pressure is performed by reduction of molecular oxygen on the surface of a high-grade steel electrode. The chemical reaction consumes electrons and the intensity of the resulting current depends linear on the pO_2 of the surrounding tissue:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

The technical principle of the Licox®-probe is the "Clark-electrode" (Fig. 2). Anode and cathode are connected by an electrolyte solution and coated by a polyethylene tube, which is oxygen-permeable on a measuring range of 5 mm. The probe is connected to the measuring device by a cable. A computer graphs and saves the measured data. Licox®-probes are sensible for mechanical stress.

2.2. Patients and flaps

In 119 consecutive patients with 125 microvascular flaps of the past four years flap monitoring was performed at the Department of Oral and Maxillofacial Surgery, University Hospital of Tuebingen with the polarographic probe (Licox®). One patient received four flaps, three patients received two flaps.

The flaps used: fasciocutaneous radial forearm (41%) and lateral upper arm (14%), osteomuscular flaps from the iliac crest (14%), fibula (6%), scapula (2%) and parascapula (1%), perforator ALT-flaps (9%) and musculocutaneous latissimus dorsi (13%) flaps (Fig. 3). The patient population consisted of 35 women and 84 men with a mean age for women of 63.8 years and for men of 57.7 years. The mean age at time of operation was 60.5 years. The oldest patient was 87 years, the youngest 17. With the exception of seven cases (5.9%) the indication for a microvascular flap was a defect due to the resection of a malignant neoplasia (squamous cell carcinoma 78.8%, adenoid-cystic carcinoma 2.5%, ameloblastoma 2.5%, adenocarcinoma 1.7%). 98 flaps were used for intraoral reconstructions of the tongue ($n = 28$), floor of the mouth ($n = 26$), alveolar process of the lower jaw ($n = 16$), intermaxillary region ($n = 10$), corpus of the lower jaw ($n = 10$) soft palate ($n = 5$) and inner cheek ($n = 3$). Twenty-seven flaps were used for extraoral reconstructions of the face, mainly the cheek and lips (Fig. 4). 51% of the patients suffered from common systemic diseases like hypertension (31%), diabetes (11%), coronary heart disease (6%), cardiac insufficiency (5%) and COPD (4%). Of these 119 patients 47 (40%) presented a history of smoking (8%), alcohol abuse (2%) or a combination of both (30%). Average in-patient time after microvascular tissue transfer was 34 days.

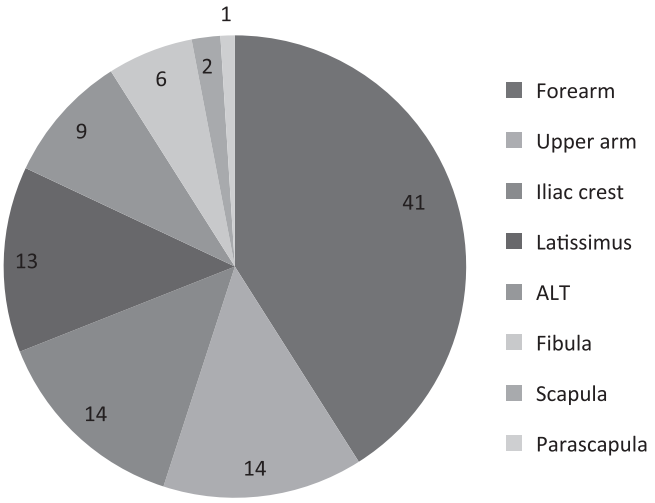

Fig. 3. Percental distribution of flap types.

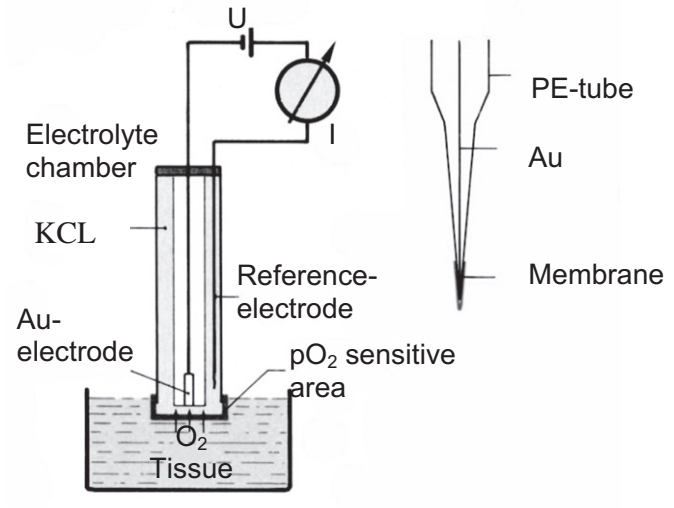

Fig. 2. Schematic setup of the Clark-electrode.

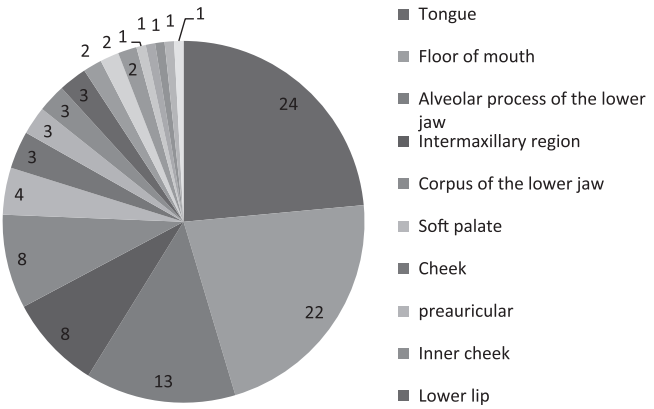

Fig. 4. Percental localization of defects.