

Extracorporeal Free Flap Perfusion in Case of Prolonged Ischemia Time

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Summary: In free flap surgery, a clinically established concept still has to be found for the reduction of ischemia-related cell damage in the case of prolonged ischemia. Although promising results using extracorporeal free flap perfusion in the laboratory have been published in the past, until now this concept has not yet paved its way into clinical routine. This might be due to the complexity of perfusion systems and a lack of standardized tools. Here, we want to present the results of the first extracorporeal free flap perfusion in a clinical setting using a simple approach without the application of a complex perfusion machinery. (*Plast Reconstr Surg Glob Open* 2016;4:e682; doi: 10.1097/GOX.0000000000000672; Published online 20 April 2016.)

Free flap surgery or replantation of amputated body parts is always critically time sensitive, as ischemia-related cell damage propagates until the anastomosis of the artery and vein is completed. This is particularly true in cases of free flap transplantation containing muscle tissue that is highly susceptible to oxygen deficiency. Irreversible muscle cell damage under ischemic conditions starts after 3 hours and is almost complete after 6 hours.^{1–3} In contrast to, eg, organ transplantation, for free flap surgery, there is no established concept in clinical routine to reduce ischemia-related cell damage besides performing the operation as quickly as possible. In most cases, the timeframe between the disconnection of the flap and its reanastomosis is large enough for a successful transplantation. Nevertheless, in cases of inadvertently occurring prob-

lems during surgery, eg, defective recipient vessels or intraoperative deterioration of the patient, ischemic time of free muscle flaps can become critical very quickly as muscle tissue is extremely sensitive toward it. This is particularly true in cases of amputated body parts, as there is always a prolonged time of ischemia until the patient is admitted to the hospital and surgery has commenced. Based on our experimental data with perfusion of muscle tissue and data from the literature,^{4–9} we would like to introduce a new simple approach of free flap preservation that is feasible in daily clinical routine. This concept distinguishes itself from others because there is no need of any complex perfusion machinery or expensive perfusion solutions and one does not need detailed knowledge about extracorporeal perfusion to use it.

In the presented case, a multimorbid patient required a surgical debridement at the trunk and reconstruction with latissimus dorsi free flap transfer in a single-stage approach. Between flap harvest, surgical debridement, and flap anastomosis, the patient had to be repositioned because of the location of the defect and the vascular access for free flap surgery. It was assumed that this procedure necessarily causes a longer period of flap ischemia than usual during microsurgical free flap transplantation. Thus, a critical time span might be reached, which we aimed to avoid. Based on our excellent results regarding ex-

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tracorporeal free flap perfusion in laboratory scale experiments,⁴⁻⁸ an extracorporeal perfusion of the flap to reduce ischemia-related cell damage until re-anastomosis was performed in the clinical scenario for the first time.

PATIENT AND PERFUSION SET UP

A 51-year-old patient suffered from an ulcerating relapsing metastasis of an oesophageal adenocarcinoma at the right lateral thoracic wall at the former trocar site. It had unfortunately been inoculated during the pull-out maneuver of the esophageal specimen during minimally invasive surgery. Multiple metastases had been excised over time, and the patient had received a chemo- and repeated radiation therapy (50 Gray). Due to the extent of the metastasis, resection of the infected ulcer within the irradiated area down to the pleura became necessary in this palliative situation to improve the patient's quality of life. According to the resulting extended full-thickness thoracic wall defect, a subsequent free flap reconstruction was indispensable. During the previous resections, the ipsilateral latissimus dorsi muscle had been resected and was not available as a pedicled flap. Adjacent tissue was not applicable because of the heavily irradiated trunk. Therefore, an arteriovenous loop using the basilic vein (with its distal end connected to the axillary artery) was established by the vascular surgeon in advance to allow for free flap transfer of the contralateral latissimus dorsi. Thus, an intraoperative repositioning of the patient from right to left position was necessary, which extended the total time of the surgery between completion of flap harvest and replantation. The reconstructive operation started with the patient in a right lateral position, and a free myocutaneous latissimus dorsi flap from the left side was harvested.

After dissection, the flap received a continuous extracorporeal perfusion under sterile conditions with a heparinized crystalloid solution (Jonosteril, Fresenius Kabi Deutschland; 5000IE heparine per 500 mL Jonosteril), naturally saturated with ambient oxygen.⁶ The arterial branch of the muscle flap was attached to a cannula, connected to an infusion bag containing the crystalloid solution at a height of 1 m (Fig. 1). Perfusion rate was maintained between 10 and 12 mL/min. To assess edema formation, the flap was placed on a digital scale. The venous branch also was cannulated to determine oxygen consumption of the flap using quenching sensors (sensor type: PSt3 FTC, Transmitter: OXY4-mini, Presens Precision Sensing GmbH, Regensburg, Germany). Both cannulas were fixed using vessel loops bound to itself to minimize the risk of vascular damage (Fig. 2). The perfusion was performed one-way without recirculation of the perfusate. After positioning of the patient

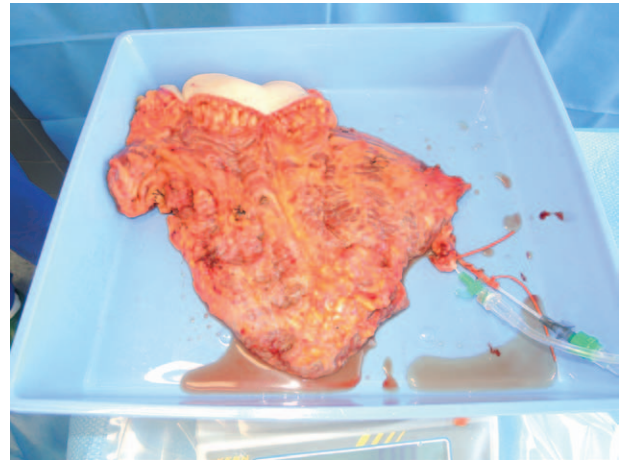


Fig. 1. Myocutaneous latissimus dorsi flap, artery and vein cannulated (fixed with vessels loops). Flap placed sterile on a sterile scale.



Fig. 2. Vessel loop fixed with itself.

in left lateral position, the flap was anastomosed to the arterial and venous branch of the arteriovenous loop after dissecting it at its lowest point. After surgical debridement, the flap was set in place and partially covered with split skin grafting.

RESULTS

Extracorporeal flap perfusion could be performed successfully without any adverse effects being observed. Only a slight weight gain over an extracorporeal perfusion time of 49 minutes of 14.7% was recorded, interpreted as increased intravascular volume and edema formation. As the perfusion bag was placed 1 m above the flap, the resulting perfusion pressure was 73.5 mm Hg. The muscle consumed 69.3% ($\pm 4.3\%$) of the supplied oxygen solved in the perfusate during the perfusion period. Partial pressure of oxygen was measured at the venous branch (Fig. 3). The transplantation of the flap was uneventful; no total or partial flap necrosis could be ob-

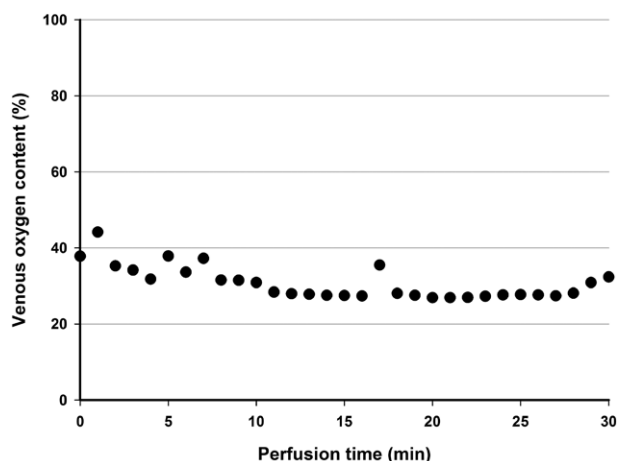


Fig. 3. Venous oxygen concentration in % of the arterial oxygen supply. Electrolyte solution applied on arterial side was saturated with oxygen by ambient air. On the venous side, after removing intravascular blood residue, the oxygen measurement was started. The oxygen concentration leaving the venous branch of the branch ranged from 26.9% to 44.15% with a mean value of 30.7% ($\pm 4.3\%$). Based on the oxygen concentration not reaching 0%, the muscle did not extract all the oxygen of the perfusate and was assumed to be adequately supplied with oxygen.

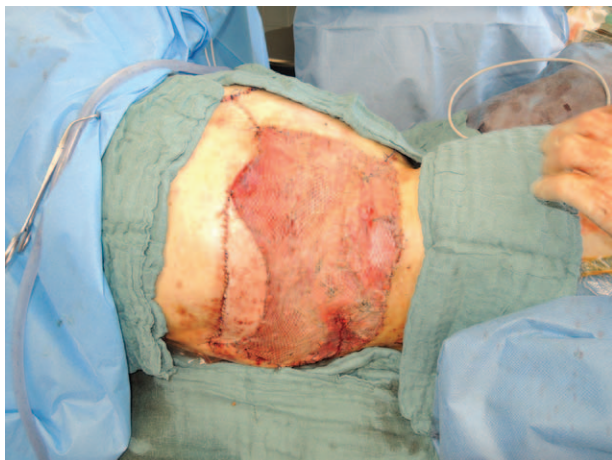


Fig. 4. After inset of the flap and additional split skin grafting of the muscular part of the flap.

served (Fig. 4). Total ex vivo time of the muscle was 80 minutes, which was lower than initially expected.

DISCUSSION

Free flap surgery in plastic reconstructive surgery is a well-established reconstructive tool despite the drawback of insufficient local recipient vessels facilitated by means of arteriovenous loops.^{10–14} In this particular case, the challenge was to perform a free flap transfer without sufficient local recipient vessels and an anticipated prolonged time of ischemia due to intraoperative repositioning of the patient during the muscle's isch-

emic time; this is particularly crucial because of the limited ischemia tolerance of a muscle flap. Although the expected time of the ischemia was not as long as expected, still being in the lower range of the critical ischemic time of muscle tissue, the feasibility of a one-way extracorporeal perfusion could be demonstrated exemplarily for the first time in a clinical scenario. The risk of an ischemia-related flap loss could be reduced successfully by means of continuous extracorporeal flap perfusion using a heparinized crystalloid solution. According to our data from previous experiments^{4–8} and due to the presented results, the tissue's oxygen demand can be met sufficiently with this simple approach using a one-way perfusion system, without the need of a complex set up using, eg, pumps, artificial oxygen carriers, or dialysis machines. In clinical daily routine, the cannulization of the vein and the oxygen measurement is dispensable. What remains is simply an infusion bag connected to the arterial branch of the flap. To our knowledge, this is the first description of an extracorporeal flap perfusion in case of free flap transplantation besides experimental and animal testing. The additional effort of extracorporeal perfusion seems to be justified in cases of free flap surgery with a prolonged ischemia time and major amputations, which come with a distinctly shorter ischemia tolerance, in comparison to, eg, finger amputations. Beyond that, it might be considered whether the presented treatment in general is superior to the clinical daily routine of tissue transplantation, cold ischemia, as it is also executed in studies in the case of organ transplantation.^{15–17}

The principles outlined in the Declaration of Helsinki have been followed.

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