Journal of Plastic, Reconstructive & Aesthetic Surgery (2016) 69, 1382–1388

ELSEVIER

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Cracking the perfusion code?: Laser-assisted Indocyanine Green angiography and combined laser Doppler spectrophotometry for intraoperative evaluation of tissue perfusion in autologous breast reconstruction with DIEP or ms-TRAM flaps☆

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Received 21 January 2016; accepted 5 July 2016

KEYWORDS
Fluorescence angiography;
Laser Doppler spectrophotometry;
Breast reconstruction;
DIEP;
TRAM

Summary The aim of this prospective study was to assess the correlation of flap perfusion analysis based on laser-assisted Indocyanine Green (ICG) angiography with combined laser Doppler spectrophotometry in autologous breast reconstruction using free DIEP/ms-TRAM flaps.

Between February 2014 and July 2015, 35 free DIEP/ms-TRAM flaps were included in this study. Besides the clinical evaluation of flaps, intraoperative perfusion dynamics were assessed by means of laser-assisted ICG angiography and post-capillary oxygen saturation and relative haemoglobin content (rHb) using combined laser Doppler spectrophotometry. Correlation of the aforementioned parameters was analysed, as well as the impact on flap design and post-operative complications.

Flap survival rate was 100%. There were no partial flap losses. In three cases, flap design was

☆ Part of this work was presented at the 46th Congress of the German Society of Plastic, Reconstructive and Aesthetic Surgeons 1–3 October 2015, Berlin, Germany.

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http://dx.doi.org/10.1016/j.bjps.2016.07.014

based on the angiography, contrary to clinical evaluation and spectrophotometry. The final decision on the inclusion of flap areas was based on the angiographic perfusion pattern. Angiography and spectrophotometry showed a correlation in most of the cases regarding tissue perfusion, post-capillary oxygen saturation and relative haemoglobin content.

Laser-assisted ICG angiography is a useful tool for intraoperative evaluation of flap perfusion in autologous breast reconstruction with DIEP/ms-TRAM flaps, especially in decision making in cases where flap perfusion is not clearly assessable by clinical signs and exact determination of well-perfused flap margins is difficult to obtain. It provides an objective real-time analysis of flap perfusion, with high sensitivity for the detection of poorly perfused flap areas. Concerning the topographical mapping of well-perfused flap areas, laser-assisted angiography is superior to combined laser Doppler spectrophotometry.

Introduction

Today, autologous breast reconstruction after breast cancer, using free tissue transfer with abdominal tissue, is a standard operative procedure in specialised centres. Besides alloplastic reconstruction using silicone implants, free DIEP and ms-TRAM flaps are the gold standard in free autologous breast reconstruction. Methods of tissue engineering seem promising in this context, but are not as yet clinically available options.[1,2] In the past, cadaveric studies and clinical trials assessing different methods of flap perfusion analysis were conducted to better understand the anatomy of abdominal wall perfusion through the epigastric vessels and their perforators.[3–6] Besides the conventional perfusion zones based on Hartrampf and Holm, respectively, preoperative computed tomography angiography for perforator mapping has become a standard procedure.[7–10] In general, microvascular free tissue transplantation has become more reliable due to technical improvements and increasing microsurgical experience and is frequently also used today in older patients with possible comorbidities.[11,12] However, intraoperative flap evaluation and postoperative flap monitoring can currently still be challenging if there are special circumstances e.g. uncommon perforator patterns, ischaemic flap areas or change of blood flow during flap dissection.[13] Apart from subjective clinical judgement (capillary refill, colour, etc.) influenced by the surgeon's experience and the broadly used handheld Doppler, several different technologies are available for clinical use to decrease flap failure rates and optimise perioperative flap design.[14,15] Multiple studies have been performed to assess the individual advantages or disadvantages of specific technologies, but there is a lack of literature regarding direct comparison of single methods.[13,16,17] In this prospective study, we used laser-assisted angiography (SPY Elite Novadaq Technologies Inc., Toronto, Canada) with Indocyanine Green (PULSION Medical Systems, Feldkirchen, Germany) and combined laser Doppler spectrophotometry (CLDS) in addition to the clinical evaluation in order to compare the aforementioned methods in terms of benefits, intraoperative decision making and its value in routine operative use.

Patients and methods

The study adhered to the ethical principles of the Declaration of Helsinki (21 CFR Part 50) and the International Conference on Harmonisation of Good Clinical Practice guideline. The protocol was approved by the institutional Review Board (registration number 85_13 B), and written informed consent was obtained from all patients before any study-related procedures were performed. Thirty-two patients were included in this prospective study. Exclusion criteria were solely based on contraindications for the application of Indocyanine Green, e.g. iodine allergy, autonomous adenoma of thyroid gland, hyperthyroidism or severe renal failure. For perforator mapping, computed tomography angiography (CTA) was performed on all patients prior to surgery.

All operations were performed by two teams, with one team harvesting the DIEP or ms-TRAM flap and the other team preparing the recipient vessels, with the internal mammary vessels being chosen for this purpose. Besides the clinical evaluation of the flaps, intraoperative perfusion dynamics were assessed using laser-assisted angiography with Indocyanine Green and CLDS to determine post-capillary oxygen saturation and relative haemoglobin content. The measurements were performed after dissection of the complete abdominal tissue and the donor vessel in four standardised areas: ipsilateral medial, ipsilateral lateral, contralateral medial and contralateral lateral (Figure 1). For this purpose, blood pressure was stabilised on the same level for all patients by the anaesthesiologist (systolic blood pressure values between 110 and 130 mmHg). For clinical evaluation, capillary refill and tissue colour were recorded in the aforementioned areas by the surgeon (Figure 1). At each measurement, four values for skin colour (0 = no refill, 1 = pale, 2 = pink, 3 = livid) and three values for capillary refill (1 = <1s, 2 = 1–2s, 3 = >2s) were recorded by the single surgeon. For CLDS, the Oxygen to see device (O2C, LEA Medizintechnik, Gießen, Germany) was used. Relative haemoglobin content, post-capillary oxygen saturation and relative blood flow were measured. To assess tissue perfusion, we used the SPY Elite System (Novadaq Technologies Inc., Toronto, Canada)