Free Flap Monitoring

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Introduction

A flap is a unit of tissue that is transferred from one site (donor site) to another (recipient site) while maintaining its own blood supply. From the late 1980s until present, Free tissue transfer or *'Free Flap'* has become a routine procedure in reconstructive surgery.

Despite a success rate of 95%[1], it has been reported that in 5 to 25% of cases re-exploration is required due to circulatory compromise.[2] Free flaps are prone to arterial and venous occlusion due to thrombosis because their placement requires microvascular anastomoses. Many of the complications leading to flap failure are avoidable and treatable if they are detected and dealt with appropriately.[3]

Flap salvage rates remain in the region of 50%.[1] Therefore, accurate assessment of flap circulation is essential. Postoperative devices designed to augment clinical assessment could potentially lead to earlier detection of vascular occlusion and improved salvage rates.

An ideal monitoring method should be non-invasive, continuous, easily interpretable, instantaneous, reliable and reproducible. Currently, clinical observation is regarded as the '*gold standard'* method of flap monitoring,[4] supplemented where possible with adjuvant technologies. The most popular adjuvant techniques are external and implantable Doppler monitoring and Laser Doppler Flowmetry (LDF).[5-6]

Current Methods of Flap Monitoring

Near Infrared Spectroscopy

Near Infrared spectroscopy (NIRS) exploits the relative transparency of biological tissue in the NIR wavelength range (Fig. 1). NIR light is capable of penetrating tissue and can still be detected upon remission, following absorption by the primary light absorbing molecules (chromophores) in biological tissues which are oxyhaemoglobin (HbO2) and deoxyhaemoglobin (HHb). It is possible to resolve changes in HbO2 and HHb, and their sum, total haemoglobin (HbT) based on the amount of light absorption. NIRS is capable of non-invasively monitoring and differentiating between venous, arterial and total occlusion of a skin flap.[5]

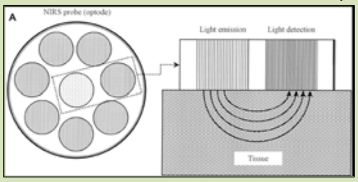

Figure 1: Near infrared light is emitted from a central optical fibre and follows an elliptical path through the tissues before it is detected by receiving fibres. [Reproduced from Scheufler *et al* 2003[12]]

Clinical Observation

Clinical assessment involves evaluation of skin colour, skin turgor, surface temperature, capillary refill time, and bleeding time following pinprick. Problems with arterial inflow are suggested when the flap is pale relative to the donor site, cool to the touch, and when capillary refill is slow or absent. Problems with venous outflow are suggested when the flap is congested, edematous, and when capillary refill is brisk and rapid. However, it is time consuming and requires specially trained staff. Subtle colour changes or inexperienced staff may lead to delayed re-exploration of threatened flaps.[3]

Quantitative Fluorescein Fluorescence

The fluorescein test involves the injection of sodium fluorescein, intravenously, dosed at 15 mg/kg for a duration of 1 minute. The dye diffuses across the capillary wall to the extracellular fluid compartment within 10–15 min but does not penetrate cells.[8] The dye binds completely to large plasma proteins and remains intravascular if normal vascular permeability is maintained. An analysis of the uptake, distribution, and clearance of dye-marked blood gives a quantitative evaluation of tissue perfusion in microsurgery. This method is minimally invasive and reliable, although it is labour intensive and carries a risk for adverse events such as allergic reactions and extravasation of fluorescein. An alternative fluorescence method involves the use of indocyanine green which has a more optimal pharmacokinetic profiles but further clinical research with this dye is required.[8]

Microdialysis

Thromboses are clearly detected by Microdialysis (MD) via a decrease in the glucose concentration in the tissue (< 2.7 mmol/l) and an increase in the lactate concentrations (> 5.7 mmol/l).[9] In some cases, MD can indicate a pathological trend in glucose and lactate concentrations hours before there are any clinical signs. A system of alarm levels has been developed for clinical staff. When alarm limits are reached, a critical evaluation of the patient can be undertaken, and the need for re-operation considered. MD analysis is a relatively simple technique and can be conducted by inexperienced staff working in institutes with a low frequency of microsurgery.[9]

Internal and Implantable Doppler Monitoring

Implantable Doppler probes are commercially available, such as the Cook–Swartz venous probem (Figure 2), first described by Swartz *et al* in 1994.[10] The absence of an audible signal may herald a failing flap. It is able to recognise vascular compromise early, although this method is both invasive and comparatively expensive.[11]

Figure 2: Cook-Swartz Doppler Flow monitoring system[11]

Laser Doppler Flowmetry

Laser Doppler Flowmetry is a non-invasive technique that measures a Doppler shift in reflected laser light, which is related to the number and velocity of moving red blood cells.[7] It can be used for buried and cutaneous free-tissue transfers, provides continuous recording and can be used to assess anastomotic patency both intra-operatively and post-operatively. It is limited to observing relatively superficial (1-2mm) cutaneous vessels which are susceptible to changes in the local environment and microvascular heterogeneity. Use of the apparatus requires experienced personnel. Although the equipment is relatively expensive, it is perceived as being cost-effective.[7]

Conclusion

Importantly, at present, there is still no one method that has proven to be more reliable than clinical assessment. One of the principal factors affecting the success rate of free-tissue transfers is the expertise of the surgeon. However, even in the most experienced hands, occasional vascular compromise is inevitable, and thus postoperative monitoring is necessary to detect and salvage failing flaps. Despite the wide range of methods available, a lack of uniformity exists in the use of monitoring devices to assess the viability of transplanted tissue.[4] Many problems such as cost-effectiveness and reliability of these methods needs to be resolved, before they can be used routinely in post-operative free flap monitoring.[6]

References: 1. Harashina T. Analysis of 200 free flaps. Br.J.Plast.Surg. 41: 33, 1988 **2.** Kubo T, et al. Management of flaps with compromised venous outflow in head and neck microsurgical reconstruction. Microsurgery. 22: 391, 2002; **3**. Chen KT, et al. Timing of presentation of the first signs of vascular compromise dictates the salvage outcome of free flap transfers. Plast.Reconstr.Surg. 120: 187, 2007. **4.** Neligan PC. Monitoring techniques for the detection of flow failure in the postoperative period. Microsurgery. 14: 162, 1993. **5**. Keller A. Noninvasive tissue oximetry for flap monitoring: an initial study. J.Reconstr.Microsurg. 23: 189, 2007. **6**. Jallali N, et al. Postoperative monitoring of free flaps in UK plastic surgery units. Microsurgery. 7: 469, 2005. **7**. Holzle F, et al. Free flap monitoring using simultaneous non-invasive laser Doppler flowmetry and tissue spectrophotometry. J.Craniomaxillofac.Surg. 34: 25, 2006. **8.** Mothes H, et al. Indocyanine-green fluorescence video angiography used clinically to evaluate tissue perfusion in microsurgery. J.Trauma. 57: 1018, 2004. **9**. Setala L, et al. Microdialysis detects postoperative perfusion failure in microvascular flaps. J.Reconstr.Microsurg. 22: 87, 2006.**10.** Swartz WM, et al. Implantable venous Doppler microvascular monitoring: laboratory investigation and clinical results. Plast.Reconstr.Surg. 93: 152, 1994. **11.** Guillemaud JP, et al. The implantable Cook-Swartz Doppler probe for postoperative monitoring in head and neck free flap reconstruction. Arch.Otolaryngol.Head.Neck.Surg. 134: 729, 2008. 12. Scheufler O, et al. Tissue oxygenation and perfusion in inferior pedicle reduction mammaplasty by near-infrared reflection spectroscopy and color-coded duplex sonography. Plast.Reconstr.Surg. 111: 1131, 2003.