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# RESEARCH ARTICLE

## POSTOPERATIVE MONITORING OF MICROVASCULAR FREE FLAPS

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**ABSTRACT**

***Introduction:*** Microvascular free flaps are a reconstructive option that allows the treatment of large and complex defects. Normally the loss of free flaps is due to arterial or venous compromise, that´s why adequate flap postoperative monitoring is essential and allows to identify vascular compromise, and perform a timely surgical reintervention, in order to achieve the salvage of the flap. ***Materials and methods:*** An exhaustive review of the literature was performed in different databases like PubMed and Cochrane, about the existing evidence on postoperative monitoring of microvascular free flaps. The terms "free flap" and "monitoring" were used for the search and articles written in English and Spanish were included. ***Results:*** Clinical monitoring is the Gold Standard for the detection of vascular compromise in a microvascular free flap. This method and the manual Doppler ultrasound are the methods of choice for flap monitoring. Other methods, such as the implantable Doppler, have higher flap recovery rates than the previous ones, although it is less cost-effective. ***Conclusions:*** Postoperative monitoring through clinical observation, the use of manual Doppler ultrasound, and other more complex methods such as implantable Doppler are monitoring methods that allow quick reintervention of flaps with vascular compromise, in order to avoid flap loss.

## INTRODUCTION

Microvascular free flaps are a reconstructive option that allows the treatment of large and complex defects (Perng, 2013), providing stable coverage, improving the aesthetic appearance, and restoring the functionality of the part of the body involved (Khatri, 2017). These flaps can have an approximate success rate of up to 95-97% (Perng, 2013; Bui, 2007; Nakatsuka, 2003). Despite these results, the possibility of loss is always present (Pignatti, 2012). Generally, loss of free flaps is due to arterial or venous compromise, external compression, torsion of the vascular pedicle and bruising, that´s why adequate flap postoperative monitoring is essential and allows to identify vascular compromise and perform a timely reintervention in order to achieve the salvage of the flap (Chae, 2015; Yang, 2014). It is important that both, medical and nursing staff involved in post-surgical flap monitoring, have training this area (Madattigowda, 2019). In the hands of experts, monitoring during the postoperative period saves 70-80% of compromised flaps (Al-Dam, 2014; Disa, 1999), for this reason, the monitoring technique used must be harmless to the patient and the flap, fast, reproducible, reliable, accurate, economical, useful for all types of flaps and ideally equipped with a screen that allow even inexperienced staff to identify circulatory changes in the flap (Chae, 2015).

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Most thrombosis occurs in the first 24 hours after surgery (Mirzabeigi, 2012). In this critical period, flaps should ideally be monitored every 30-60 minutes to decrease the period between vascular occlusion and reintervention, that is going to be necessary in approximately 5-25% of cases (Khatri, 2017; Chen, 2016). After 48 hours, the flap should no longer be closely monitored and it is suggested to space the time 6 hours between each evaluation (Zoccali, 2017). Beyond 72 hours, monitoring is unnecessary since only 10% of thrombosis develops after the third postoperative day, and at this time the compromised flaps are no longer in condition of salvage (Jallali, 2005). Kroll, et al. reported that the greatest complications occur because of arterial thrombosis in the first day postoperative, subsequently, venous thrombosis becomes the main cause of complication, being the only one on the third day (Kroll, 1996). Chen K, et al. described venous occlusion as the main cause of complications throughout the postoperative period during the first week (Kroll, 1996). As there is a discrepancy in the different studies regarding the main cause of flap compromise according to their postoperative evolution time, it is necessary to be aware and carry out a rigorous monitoring of both types of vascular compromise.

## METHODS

An exhaustive review of the literature was performed in different databases like PubMed and Cochrane, about the existing evidence on postoperative monitoring of microvascular free flaps.

The terms "free flap" and "monitoring" were used for the search and articles written in English and Spanish were included. For historical and technical backgrounds, reports older than 1999 were used whenever considered necessary.

# RESULTS

## CLINICAL MONITORING

The Gold Standard for free flaps monitoring at this moment is clinical observation (Perng, 2013; Khatri, 2017; Chae, 2015). This method includes the evaluation of temperature, color, turgor, size, capillary filling, and flap bleeding. All these parameters are going to stablish the adequate perfusion of the flap. One of the limitations of clinical monitoring are the inability to assess difficult access or hidden flaps (Khatri, 2017; Chae, 2015).

**Figure 1. Free flap with arterial compromise. Paleness and a decrease in temperature with respect to the surrounding skin is evident, as well as a decrease in size and turgidity**

**Figure 2. Free flap with venous compromise**

***Temperature:*** Measurement of the flap temperature can be done through touch, temperature probes, sensitive tapes, manual or infrared thermometers (Chae, 2015; Smit, 2010). Kraemer R et al. described that the reduction of the flap temperature by 3 centigrade degrees compared to the surrounding skin indicates arterial compromise, and the reduction of 1-2 centigrade degrees indicates venous compromise (Kraemer, 2011).

**Figure 3. Postoperative monitoring of a micro vascular flap using manual Doppler ultrasound**

**Figure 4. Postoperative monitoring of a micro vascular flap using manual Doppler ultrasound**

***Capillary Filling:*** Arterial occlusion is characterized by decreased or absent capillary filling, and venous occlusion by normal or even accelerated filling (Chae, 2015; Salgado, 2009). This flap characteristic can be evaluated by making sustained pressure on the tissue, which when released must give rise to a pink coloration in an approximate time between 2-3 seconds, values that indicate that the tissue is healthy and reperfused (Salgado, 2009).

***Color, Size, and Turgor:*** The color in an arterial occlusion will be pale (Figure 1), and in a venous occlusion cyanotic (Figure 2). Changes in flap size and turgor will decrease in arterial occlusion and increase in venous congestion[6]. (Figure 3).

***Bleeding:*** Bleeding should ideally be evaluated by the "pinprick test" (Khatri, 2017; Salgado, 2009), which is possible to performed through a superficial puncture with a needle on the cutaneous component of the flap close to the vascular pedicle, this in order to obtain brilliant red bleeding, that indicates flap viability. The bleeding will be decreased or absent in an arterial occlusion and anticipated in a venous occlusion (Chae, 2015). Puncture should not be done very frequently due to the damage it can cause in the flap (Salgado, 2009), as well as the damage of the subdermal venous plexus that can lead to the presence of dark blood or extensive ecchymosis of the skin that makes difficult a future assessment (Kao, 2019).

**MANUAL DOPPLER ULTRASOUND:** Manual Doppler ultrasound has a sensitivity of 89% (Hosein, 2016), and allows to effectively identify the function of the flap vessels. The vascular signal of the flap must be stablished intraoperatively and marked with a suture in the skin, to achieve adequate evaluation in the postoperative period (Jallali, 2005) (Figure 3). This is an operator-dependent technique, so its results will be linked to the expertise of the person who performs the test (Figure 4).

Over time, new technologies for monitoring free flaps have emerged, however, there is discrepancy among the authors about whether or not these technologies are superior to the clinical evaluation of flaps. The dilemma occurs when a flap looks clinically healthy, but presents Doppler abnormalities, or in the other hand when it presents clinical compromise associated with a normal Doppler. In these cases, the clinical findings will have a greater impact on the decision to explore the flap (Patel, 2017).

**OTHER MONITORING METHODS:** Implantable Doppler with 100% sensitivity (Salgado, 2009), has shown to have higher flap recovery rates than clinical monitoring, as well as lower flap failure rates (Chang, 2016). This method has become very important in microsurgical flaps where there is no cutaneous island that allows clinical monitoring (Rappoporta, 2016). This device measures venous and arterial blood flow in the pedicle. The venous signal immediately detects an obstruction in venous or arterial blood flow, and the arterial signal immediately detects an arterial obstruction, taking 3 to 4 hours to identify a venous obstruction (Chae, 2015). An advantage of this device is that it can be linked to a screen or even to mobile devices of the medical staff using internet (Sang, 2017). It should be taken into account that the approximate cost of each device is in order of US $ 3,000, additionally each SONDA/probe has a cost of US $ 250 (Rozen, 2010). Which makes this option less cost-effective in our environment than the previously exposed methods. Another option is the color Doppler, in which the vessels of the microvascular anastomoses are directly visualized, as well as the flow of the vessels in real time. However, it is not routinely used due to the need of transfer the patient to the imaging unit for the study, the requirement of a radiologist to use the device and of a surgeon to anatomically guide the location of anastomoses, conditions that are difficult to achieve in the early postoperative period of the flap, given the hourly monitoring requirements (Albert, 2014). The use of devices that induce hyperemia on the cutaneous island of the flap using negative pressure has also been described, however, they do not present better results compared to conventional clinical monitoring (Dadras, 2019). Capillary glucose measurement allows identification of flap venous compromise, despite the systemic glucose levels are high or normal. However, this method is not useful in cases of arterial occlusion. Since it's expected that capillary flap glucose decreases, the association of low bleeding of this complication makes difficult to achieve a good sample for the analysis (Mochizuki, 2019). Fluorometry monitoring performed with an indocyanine green laser is a new method to assess tissue perfusion. Although it has been used more to stablish the viability of the flap in the intraoperative period, in recent years it has been useful for postoperative monitoring of microsurgical flaps. For this method a device that includes a laser light source and a camera with optical filters is required. Although it is a method that has shown good results, many health centers still do not have the necessary devices to carry it out (Hitier, 2016). Smaller studies, with limited follow-up research, have also documented other flap monitoring methods such as continuous monitoring of tissue perfusion with photoplethysmography waves, the use of technetium-99m sestamibi scintigraphy, the perfusion-weighted magnetic resonance imaging and serial measurement of the flap using capillary glucose and lactate levels. While many of these potential options are relatively low cost and have few side effects, they all require additional research, larger trials, direct randomized comparisons, and cost analysis to determine whether or not they provide any additional benefit over the traditional monitoring techniques previously discussed (Kohlert, 2019).

## CONCLUSION

Microvascular free flaps are a reconstructive option that allows the treatment of large and complex defects. These flaps can fail in the postoperative period due to venous or arterial obstruction, so it is essential to know the signs that indicate these types of vascular compromise. Postoperative monitoring through clinical observation, the use of manual ultrasound, and other more complex methods such as implantable Doppler are methods that allows timely reintervention of flaps with vascular compromise, to avoid its loss. Knowledge of the parameters mentioned above by the staff in charge of flap monitorization is necessary to reduce the loss of flaps in the different institutions

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