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REVIEW

Implantable Doppler in monitoring free flaps: A cost-effectiveness analysis based on a systematic review of the literature

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Summary
Objective: The purpose of this paper is to evaluate the efficacy and cost-effectiveness of the implantable Doppler system based on the analysis of the available scientific literature and clinical and cost data available in our hospital. The results of this system are compared to those of conventional free flap monitoring methods.
Materials and methods: The literature published between 1991 and 2011 was systematically reviewed. All available cost data were collected and several simulations were performed. A retrospective assessment of the efficacy of conventional methods in our hospital was also conducted.
Results and conclusion: The implantable Doppler system is more effective than the conventional methods used to monitor free flap perfusion. The mean flap salvage rate with the implantable Doppler was 21 percentage points higher (81.4 vs. 60.4). The excess cost compared to conventional methods was about CAD 120 per patient (about EUR 94). However, this excess cost can be compensated or even reversed, depending on the initial flap salvage rate in the health facility and the type of free flap (buried vs. non-buried).

Introduction

Progress in the field of free flaps has been achieved in parallel with research concerning the optimal monitoring device. Although clinical monitoring (colour, temperature, capillary refill, pin prick, etc.) is still the gold standard (conventional monitoring), this method is highly dependent on the clinical experience of the healthcare personnel and can sometimes be difficult to implement effectively. Two types of

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postoperative vascular problems can be observed after free flap reconstruction surgery: arterial or venous. Venous occlusion is the more frequent of these two types of problems and is detected later. Delayed detection of venous thrombosis is a serious problem, as it increases the risk of failure of free flap salvage due to the ''non-reflux'' phenomenon [1]. It has therefore become very important to develop an inexpensive, effective, rapid, and easy to use method of free flap perfusion monitoring applicable to buried and non-buried flaps. The monitoring method most closely corresponding to these criteria appears to be the implantable Doppler. Although other alternative monitoring methods will also be discussed, this study therefore essentially focuses on this technology compared to conventional monitoring methods.

Objective

The purpose of this evaluation is to determine whether use of implantable Doppler constitutes a valuable alternative to the current methods of clinical monitoring of free flap perfusion. This study assessed two endpoints: efficacy and cost.

Situation in our institution

The current mode of monitoring of free flap perfusion in our institution consists of either clinical examination of colour, temperature and capillary refill of the flap, or pin prick of the flap, when the flap is accessible, or the use of percutaneous external Doppler for buried flaps. Note that external Doppler is used as a complement to clinical examination and that it can sometimes be difficult to distinguish the flap pedicle from adjacent vessels. Flap monitoring is performed hourly for the first 24 h then every 2 h for the following 24 h and finally every 4 h for the following 7 days.

Over a 4-year period, from September 2006 to November 2010, 68 cases of head and neck free flaps were performed in our teaching hospital. Four of these 68 free flaps presented compromised perfusion (one case of vein occlusion and three cases of artery occlusion). Two of the four cases of compromised perfusion were salvaged by revision of the free flap anastomosis, corresponding to a salvage rate of 50% and a success rate (including salvage) of 95.5% (i.e. a total of three failures, including one case of intraoperative failure not related to compromised flap perfusion).

Compared to the monitoring methods currently used in our establishment, use of implantable Doppler would be considered by healthcare personnel to be more reliable to ensure effective flap monitoring. Compared to pin prick, implantable Doppler would also have the advantage of not submitting the patient to a long and uncomfortable examination.

Description of the implantable Doppler technology

Implantable Doppler is a minimally invasive technique, allowing direct and easy tissue perfusion monitoring. This technique was introduced by Swartz et al. [2] in the context of microsurgical reconstructions. The system is composed of an implantable 20 MHz ultrasound probe, mounted on a silicone cuff that can be rolled around the arterial or venous pedicle and which is connected to a portable monitor [3]. Various methods have been described to attach the cuff around the vessel, including microclips [4], sutures [5] and fibrin sealant [6], and each method provides good results. The tension exerted on the vessel by the silicone cuff is important, as an excessively tight cuff can cause obstruction to blood flow, while an excessively loose cuff can lead to false-positive results. The ultrasound probe is connected to a thin lead that is brought out through the wound. This lead is then connected to the monitor at the patient's bedside. The probe is released from the silicone cuff by pulling on the lead 5 to 10 days after the operation, when decided by the surgeon. The electrode is designed to separate from the cuff when a tension of 50 g is applied. In order to avoid accidental disconnection of the probe by pulling on the lead, the lead is connected to an extension cable, which is sutured to the patient and which connects the probe to the monitor.

Method

A review of the English and French scientific literature was conducted using PubMed as search engine and the keywords ''Doppler'' and ''implantable''. The reference period was between 1st January 1991 and 1st January 2011. All studies on efficacy, safety and learning curve of implantable Doppler were included. Studies conducted in non-human subjects were excluded. Studies using patient subgroups derived from a larger study were also excluded. The level of scientific proof classification scale for the studies reviewed was that proposed by Hailey et al. [7]. This scale classifies studies according to their methodological design from level 1 (highest) to level 9 (lowest).

Cost data were collected in collaboration with the department of human resources, the purchasing department, the financial department, the operating room and the recovery ward, the critical care and traumatology programme, the Sherbrooke University Physicians Society and the cost estimate provided by Cook Medical. The data collected concerned the cost of use of the various available technologies, their acquisition costs as well as the cost of free flap surgery following perfusion failure of the previous flap. Several cost simulations were performed as a function of implantable Doppler efficacy parameters.

Results

The PubMed search revealed 292 articles, including four reviews of the literature and 14 studies corresponding to our inclusion and exclusion criteria. According to the level of scientific proof classification scale of the studies identified, the highest score was 5, corresponding to studies for which the level of scientific proof was described as ''good to satisfactory''. The other studies were classified as 6 or 7, corresponding to studies for which the level of scientific proof was described as ''satisfactory''. Two studies were excluded, as they were based on population sub-samples derived from other studies [8,9].