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# Assessment of Tissue Viability With Blood Flow Measurements

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Microvascular blood flow determines the degree of tissue viability and healing. Determining microvascular flow has become a topic of interest and is associated not only with surgical interventions[1,2] but also in determining disease conditions affecting microvascular flow such as Raynaud phenomenon.[3] The latter is highlighted by Seok-Yang et al in their article "Three-Grade Classification of Photoplethysmography (PPG) for Evaluating the Effects of Treatment in Raynaud Phenomenon" featured in this issue of *Angiology*. Raynaud phenomenon is evident during cold temperatures and emotional stimuli that lead to vasospasm in peripheral tissue microcirculation that include, fingers, toes, nose, ear lobes, or even the tongue. This year marks the 150th anniversary of Maurice Raynaud documentation of his thesis on "De l'asphyxie locale et de la gangrène symétrique des extrémités" (local asphyxia of the extremities) where this condition was discussed following his observations of patients who's fingers turned pale and blue with subsequent development of spontaneous gangrene.

Damaged or diseased organs or tissues are routinely reconstructed and tissue engineering is rapidly becoming surgical practice.[2] However, the success of a given transplant requires adequate perfusion and early identification of flow through a construct that enables appropriate measures be taken to maintain patency in the case of insufficient perfusion. Currently used noninvasive methods of determining perfusion of the peripheral tissue, where either changes in temperature or volume can be determined using infrared thermography, laser Doppler flowmetry, capillaroscopy, ultrasonography, and PPG.[4,5] Thermography will enable in distinguishing between primary Raynaud and systemic sclerosis related to Raynaud. Photoplethysmography is a second generation of one of the earliest methods devised for measuring blood flow in the extremities, which is plethysmography (which determines changes in volume). Photoplethysmography is a promising technique and can detect a low signal more accurately than a Doppler probe. Photoplethysmography measurements prove useful in determining the degree of healing where the signals were shown to be pulsatile. A pulse oximeter, which is also a PPG that can measure oxygen saturation level ($SpO_2$), is a successful application of PPG and detects blood flow to the dermis and subcutaneous tissue.

Applications of PPG in general include assessment of venous or arterial function. Photoplethysmography uses a pulse detector, arterial stiffness from pulse wave velocity measurements, endothelial function by determining the degree of vasodilation, as a highly sensitive detector of decreased perfusion, and therefore enables early detection of stenosis before it is hemodynamically critical. The optical geometry of the probe, wave length, optical properties of the tissue of interest, and its anatomical position can influence blood flow signals.


**Figure 1.** Thermal imaging demonstrating Raynaud phenomenon of reduced finger temperature. Inset demonstrating the condition in a normal individual after exposure to cold stimuli.[6] Distal phalange regions highlighted in the image are also regions of interest for PPG where interrelation of skin temperature and blood flow oscillations can be used for assessing tissue viability and healing.

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Combination of thermography and PPG would enable a reliable assessment of tissue viability and healing (Figure 1).

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