Nailfold Capillaroscopy

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Keywords: nailfold videocapillaroscopy ; microcirculation ; rheumatic disorders

1. Introduction

Skin holds the advantage of being a readily accessible tissue facilitating a non-interventional and easily repeatable approach in the study of microcirculation. Although traditionally used for several decades as a bedside aid in rheumatology for the diagnosis and monitoring of peripheral vasculopathy in connective tissue diseases [1], nailfold videocapillaroscopy (NVC) has recently emerged as a non-invasive, inexpensive, easily applicable technique for the study of peripheral microangiopathy. It is reasonable that direct visualization of human microcirculation could provide valuable information regarding vascular health at a preclinical level. Under this prism, nailfold capillaroscopic examination might emerge as an instrumental modality with a complementary role in the early detection of microvascular pathology associated not only with rheumatic disorders, but also with several other systemic diseases such as essential hypertension, pulmonary arterial hypertension, chronic renal failure and diabetes mellitus.

2. Nailfold Capillaroscopy: Description of the Method

Nailfold capillaroscopy is a non-invasive imaging technique applied to an in vivo, dynamic, two-dimensional projection of the three-dimensional capillary network of the studied organ, typically the skin [2]. NVC is applied to the finger nailfold to produce images of dermal microcirculation, which corresponds to the terminal vascular network of the systemic circulation [3]. Capillaries are the thinnest component, formed by only two layers of cells—an inner layer of endothelial cells and an outer layer of epithelial cells—and shaped into an afferent (arterial) limb, an efferent (venous) limb, and a transitional zone [4]. Nailfold capillaries were first detected in the 17th century using primeval magnifying equipment. In the 19th century, the first link between capillary abnormalities and certain medical entities was introduced based on the innovative research work of Maurice Raynaud [5]. In the 21st century, the results of numerous publications established its value as a routine clinical procedure in rheumatology, especially among patients with systemic sclerosis for whom it plays a substantial role in terms of diagnosis, prognosis, and monitoring, as described in detail elsewhere [1][2]. In addition, NVC is of outstanding importance in the differentiation between primary and secondary Raynaud's phenomenon, and the monitoring of patients with Raynaud's phenomenon as their only presenting symptom [6].

2.1. Description of NVC Technique

NVC traditionally assesses skin microcirculation within the nailfold, where the major axis of the capillaries runs parallel to the skin surface, allowing for a detailed evaluation of their morphology [7]. During the examination, the patient is in a sitting position and the hands are placed at the level of the heart. To prevent vasospasm, the patient's acclimatization to a temperature-controlled room (20–22 °C) is required [8]. Thumbs and fingers affected by either infection or recent trauma are not analyzed [9]. A drop of immersion oil is applied prior to the procedure to improve the resolution.

Nailfold capillaroscopy can be performed using either a low-magnification lens (×20) or a high-magnification lens (×200). Low-magnification lenses offer a panoramic view of the whole microvascular network. On the other hand, a videocapillaroscope not only allows for low magnification but also has the potential of providing sequential high magnifications using developed computerized systems, which enable detailed observations of separate capillaries and can subsequently analyze each capillary at different time points. Another advantage of this tool is that it consists of a probe that is moved to the finger of the patient and allows for direct contact with the nailfold, thus facilitating the study of patients with severe joint contractions [10]. Practically, NVC uses optical videocapillaroscopy equipped with a ×200

magnification probe and is simultaneously connected to image analysis software. Hence, images can be stored in a digital form, providing the potential to use them for objective comparisons among subsequent measurements. NVC may also detect blood flow at the level of the microvessels and provide information on the functional state of the microvasculature [11].

2.2. Capillaroscopic Microvascular Parameters Detected with NVC

During NVC examination, the capillaries are quantitatively and qualitatively assessed. In a qualitative assessment, an overall interpretation is acquired after documenting the visibility of the image regarding the morphology, density, and dimensions of the capillaries, as well as their architecture. A qualitative assessment is especially useful in screening for systemic sclerosis in patients with Raynaud's phenomenon based on the distinction between normal and abnormal capillaroscopic morphology [10]. A quantitative or (semi)-quantitative evaluation is based on manual automated measurements of certain parameters of each capillary per linear millimeter, including the dimensions and density. Semi-quantitation gives a score between 0 and 3 per capillaroscopic characteristic and is applied in associative and prediction investigations [10]. The main qualitative and quantitative morphological characteristics observed and documented are capillary architecture and organization; capillary morphology; capillary density (number of capillary loops per millimeter); capillary size (including enlarged and giant capillaries); microhemorrhages; avascular areas and neoangiogenesis [12][13].

2.3. Normal and Altered Capillaroscopic Patterns

In general, a preserved microvascular function is characterized by a clear visualization of architecture, that is, the absence of bleeding and exudates, as well as a preserved perfusion with an uninterrupted blood flow across the capillaries. Nailfold capillaries usually demonstrate a regular architecture, uniform shape, distribution, and diameter, and most of them show a hairpin or U-shape appearance [14]. Their limbs are parallel to each other, without crossing over or overlapping [15]. The venous limb is often greater in diameter than the arterial limb, but the venous limb/arterial limb diameter ratio does not exceed 2:1 [13]. The subpapillary venous plexus can be observed in 10–30% of healthy persons [16]. In healthy subjects, giant capillaries and avascular areas are typically absent. However, the presence of isolated abnormalities does not necessarily indicate disease [17]. A pilot study by the EULAR Study Group on Microcirculation in Rheumatic Diseases proposed a simple definition to describe the morphology of single capillaries as being normal or abnormal. The simple definitions proposed were: Definition 0—normal or non-specific (defined as hairpin, crossing, or tortuous); Definition 1—abnormal (not hairpin, not tortuous, and not crossing); Definition 2—not evaluable (whenever the rater is undecided in classifying between normal and abnormal) [18]. Although moderate reliability of this definition was obtained by raters in this study, a subsequent multicenter international study conducted during the seventh EULAR course on capillaroscopy demonstrated the excellent reliability of the optimized simple capillaroscopic definition of normal and abnormal morphologies of capillaries, even when used by rheumatologists with varying levels of expertise in capillaroscopy [19].

Abnormal alterations of capillary morphology stand in contrast to the physiologic capillary pattern. Capillary abnormalities are variable regarding certain morphological or structural characteristics, such as the size and density of capillaries [20]. Due to increasing interest in NVC, there have been considerable efforts to develop a uniform nomenclature. The most important capillary alterations and their clinical significance have been described in detail elsewhere [9][21][22].

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