Measurement of oxygenation in nailfold capillaries; a feasibility study in patients with systemic sclerosis and healthy controls

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Introduction

Systemic sclerosis is known to affect perfusion and is therefore likely to cause hypoxia.

The aim of this study was to determine the feasibility of measuring oxygenation at the nailfold.

This was done using adapted nailfold capillaroscopy. Capillaroscopy is a well-established technique for measuring characteristic vascular structural changes in SSc.

Method

Capillaroscopy was performed simultaneously at two wavelengths (two cameras with independent optical filters), Figure 1.

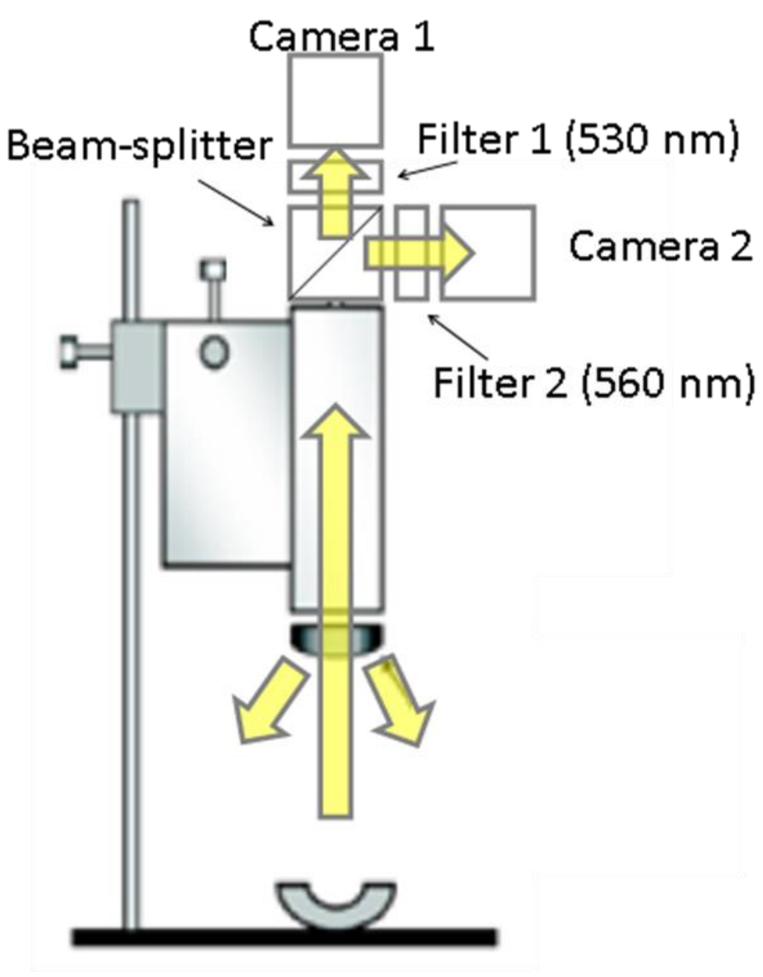

Figure 1. Schematic of microscope set-up showing the two cameras and their filters chosen to be at an isobestic point on the oxyhaemoglobin spectrum (where there is no change in light absorption with an oxygenation change i.e. allowing recording at a constant level) and the other at a point where there is significant change in light absorption intensity .

Filters were chosen to enable combined images to show changes in oxygenation. Images were single frames, rather than panoramas, allowing oxygenation measurement at single vessels only (Figure 2).

Participants underwent imaging before, during and after finger occlusion. Images were taken at baseline, 1 minute after finger occlusion (2 mins, 200 mmHg), upon release and at 1 minute after release.

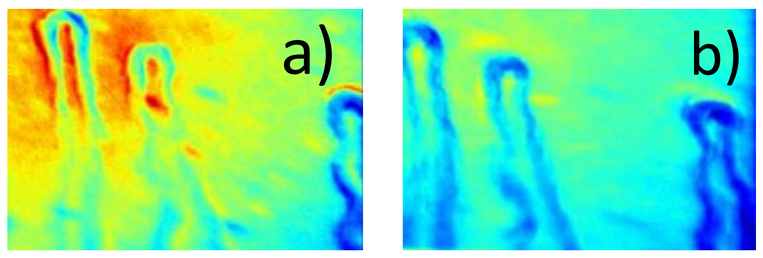

Figure 2: False colour image showing oxygenation in capillaries at (a) baseline and (b) decreased oxygenation (blue is relatively low and red high oxygenation) in the same capillaries under occlusion. Within these images one single capillary was followed.

Baseline capillary level oxygenation was compared between patients with SSc and healthy controls (HC) using a two-sample t-test with unequal variances, as were changes between time-points. The share of individuals recovering their baseline level of the outcome variable after release was compared between groups using Fisher's exact test.

Results

Forty participants took part. Twenty (of 40) sets of images could not be analysed for oxygenation due to movement artefacts leading to loss of capillaries between time-points or low contrast due to poorly visualised capillaries making identification difficult. Twenty sets of images were analysed: 7 (35%) from HC and 13 (65%) from SSc. At baseline, the mean oxygenation was 2.8 (SD 8.9) arbitrary units in HC and -0.6 (SD 8.4) in SSc (p=0.416). At occlusion, oxygenation dropped in all except for one HC. The mean change was -12.1 (SD 8.1) for HC and -14.4 (SD 6.3) for SSc (p=0.522). At release, oxygenation increased for all participants and 4/7 (57.1%) HC recovered their baseline level vs. 6/13 (46.2%) SSc (p=1.000). The change upon release had a mean of 14.2 (SD 2.9) for HC and 13.7 (SD 6.8) for SSc patients (p=0.840), Figure 3.

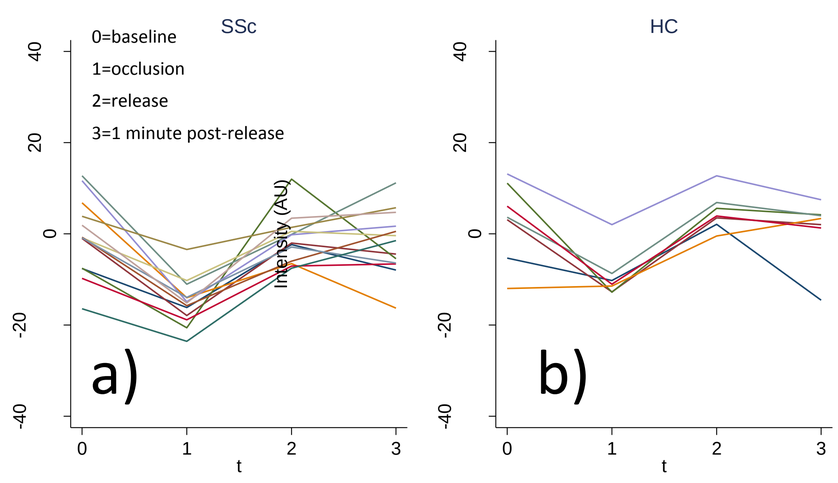

Figure 3: Oxygenation trajectories in individual vessels with time-points in a) patients with SSc and b) HC ; AU on y-axes is arbitrary units.

Conclusion

This feasibility study confirms that the system is sensitive enough to measure, in individual capillaries, changes in oxygenation due to occlusion. However panoramic mosaic images are required to ensure the same field is captured through all time-points. In this small study, no differences could be detected between HC and patients with SSc. Groups started at similar levels of oxygenation. At occlusion, oxygenation dropped for all (but one) and increased for all at release. At release and one-minute post-release, a similar rate had recovered their baseline levels. To minimise movement-artefacts panoramic images can be used to capture the same field at each time-point. More work is required to establish whether oxygenation varies in enlarged or angiogenic vessels in SSc.

Acknowledgements

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