Power Doppler signal calibration using capillary phantom for pannus vascularity in rheumatoid finger joint – a pilot study

Sirs,

Ultrasound can depict soft tissue hyperaemia in musculoskeletal inflammatory disease (1) and allows a sensitive detection of synovitis (2). Disease activity and treatment response may be estimated by Doppler ultrasound in rheumatoid patients (3). Despite these advantages of ultrasound in the management of rheumatoid patients, it is well known there are significant machine to machine disagreements for signal quantification as well as those between examiners. Thus, there is a need for a tool serving as a standard such as a high quality phantom to make it possible to calibrate ultrasound machines with an ability to reproduce *in vivo* conditions in terms of relatively slow flow vessels proliferated in the pannus.

Therefore we examined the feasibility of the capillary phantom, and investigated the relationship between pulse repetition frequency (PRF) and flow signal count for ultrasound, taking future intra-machine calibration concerning quantification of vascularities in rheumatoid synovitis into consideration.

Before conducting an experimental study, we measured the power Doppler flow velocity in pannus. Fifteen consecutive rheumatoid patients (14 women and 1 men; median age, 47 years; age range, 31–61 years) were enrolled. Disease duration was within one year in 10 patients and more than 1 year in 5 patients. All patients fulfilled the American College of Rheumatology revised 1987 criteria for RA (4). Ultrasonography was performed using a unit (HITACHI EUB-6500, HITACHI, Tokyo, Japan equipped with a 13 MHz linear array transducer) as a diagnostic workup before starting treatment by one of the two ultrasonographers specialised in musculoskeletal ultrasonography with more than 3 years' experience who were blinded to other clinical information. Pulse Doppler settings were standardised for the detection of synovial blood flow by adjusting colour gain, pulse repetition, and flow optimisation parameters according to a previous study (5). Ultrasonography was performed to measure capillary flow velocity in the pannus at all metacarpophalangeal, intrapahangeal, and proximal intrapahangeal joints scanning.

For the experimental study, we measured flow velocity in the perfusion cartridge and signal count in various injection rates and PRFs using power Doppler. The phantom was made by simplifying the previous study (6). Briefly, a perfusion cartridge (Hemodialyzer FLX-18GW, Nikkiso Co., Ltd., Tokyo, Japan) was connected to angiography injector PRESS PRO (Nemoto Kyorindo Co., Ltd., Tokyo, Japan) and ultrasound micro bubble contrast agent (Sonazoid™, Daiichi-Sankyo, Tokyo, Japan) diluted with normal saline was injected. Ultrasound measurements were performed using LOGIQ E9 (GE Healthcare, USA) with a wide band linear probe (6–15 MHz) adjusted at 15 MHz.

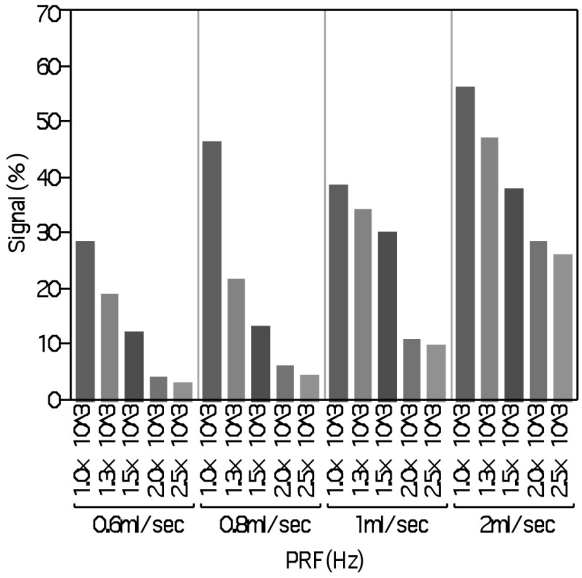

Fig. 1. Signal positive pixel count in the ROI of the perfusion cartridge with variable injection rate and PRF setting.
Signal (%) is measured percentage of positive signal in the ROI. PRF (Hz) is pulse repetition frequency.

In the clinical study, 58 out of 300 joints in 15 patients were positive for power Doppler signal. Median ± SD (range) cm/sec of the maximum peak systolic velocity was 11±10 (7–43) cm/sec. In the experimental study, we have found positive correlations between flow velocity and signal positive pixel count when PRF is constant (correlation coefficient of 0.93644±0.061136 (0.8495 to 0.9982) for mean ± SD (range), and negative correlations between PRF and signal positive pixel count at a constant flow velocity (correlation coefficient of -0.95665±0.027714 (-0.9784 to -0.9168) for mean ± SD (range) (Fig. 1.).

In conclusion, we investigated a capillary phantom for power Doppler quantification. When flow velocity in the phantom was adjusted to that of the capillaries in the punnus of rheumatoid patients, pixel count for power Doppler signal correlates linearly to the flow velocity, which is controllable by altering PRF. Capillary phantom may be useful for calibration purpose in power Doppler analysis of rheumatoid finger joint. Further study is needed to confirm the usefulness of capillary phantom for calibration purpose.

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