Laser Speckle Contrast Imaging of Skin Changes in Arteriovenous Malformation

Anne Humeau-Heurtier, PhD; Ludovic Martin, MD; Paul Bazeries, MD; Pierre Abraham, MD; Samir Henni, MD

A 7-month-old child had an arteriovenous malformation (AVM) manifesting with redness of the skin of her left upper arm and shoulder (Figure). The diagnosis had been confirmed by magnetic resonance imaging performed under general anesthesia with a 3-T whole-body MR scanner (MAGNETOM Skyra; Siemens Medical Solutions, Erlangen, Germany; Figure). Axial fat-suppressed gadolinium-enhanced T1-weighted image in the coronal plane demonstrated a soft-tissue AVM characterized by direct fistulous and plexiform connections between arteries and veins without parenchymal staining. Tubular flow voids indicated high flow velocity within enlarged vascular channels. No surrounding soft-tissue signal abnormality or mass effect was observed.

Ultrasound duplex sonography (US) showed, in B mode, heterogeneous corbeled structures with increased echo density. In the color mode, this vascular structure appeared as multicolor (blue and red) turbulent flows, corresponding to the different directions of the blood flow in the vessels of the AVM level. The pulse wave Doppler in the AVM revealed increased systolic and mean velocities. The feeding arteries to the AVM nidus could not be identified with accuracy because of the child movement and compressibility of the malformation to the slightest pressure on the US probe. The child was referred to the vascular investigation department of the University Hospital of Angers (France) for further investigation with laser speckle contrast imaging (LSCI).

LSCI is a recently commercialized noninvasive and noncontact imaging technology that gives superficial microvascular perfusion maps.[1–3] Although not being able to give an absolute quantitative value of blood flow, LSCI has the advantage of generating images with a high spatial and temporal resolution. Moreover, no anesthesia is necessary for the acquisition. Unfortunately, the perfusion maps are often difficult to analyze because of movement artifacts and pixel heterogeneity. Various image-processing algorithms have, therefore, been proposed for LSCI data. To analyze LSCI data of the child, we processed them with a recently designed algorithm: the multidimensional complete ensemble empirical mode decomposition with adaptive noise (MCEEMDAN) algorithm.[4] MCEEMDAN leads to a decomposition of the data processed into new images (several intrinsic mode functions and a residue) of the same size as the original ones. These new images reflect features of the original data and local textures with characteristic spatial frequencies. These characteristic textural features are not visible on raw LSCI perfusion images and differ with physiological states.[4] Moreover, previous studies have revealed that MCEEMDAN reflects the microvascular vasoconstriction or vasodilation.[4]

The application of MCEEMDAN to LSCI data of the young girl led to images where patterns can be observed (Figure). These patterns—that were not visible on raw LSCI data—highlight the skin pathology. The red spots that were visible on the residue image reflect a vessel corbel. These findings are consistent with the magnetic resonance imaging data, and although LSCI provides no information about deep tissues, it does not require general anesthesia of the child (to overcome movement artifacts, an adhesive opaque surface could be necessary[3]). Similarly, the absence of contact with the skin is of advantage as compared with US when the pressure is low or in case of cutaneous lesions.

MCEEMDAN has already been applied for LSCI data recorded at rest, during biological zero, and during postocclusive reactive hyperemia.[4] The present findings show that MCEEMDAN applied to LSCI data (even on images of limited resolution) can also be of interest to study AVM in young children in whom limitations exist for magnetic resonance imaging and US techniques. By processing LSCI data with MCEEMDAN, we were able to extract physiological information that is consistent with magnetic resonance imaging and US data.

Disclosures

None.

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KEY WORDS: adhesive ■ algorithm ■ arteriovenous malformations ■ empirical mode decomposition ■ laser speckle contrast imaging ■ multiresolution analysis

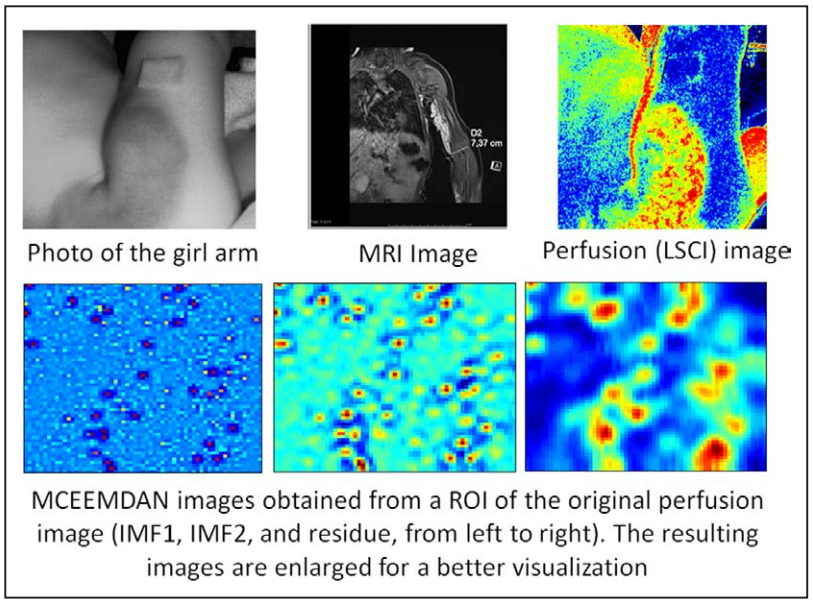

Figure. Data recorded from the subject and resulting images obtained with multidimensional complete ensemble empirical mode decomposition with adaptive noise (MCEEMDAN).

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