A New Wireless Carotid Doppler Monitoring System with Wearable Neckband Ultrasound Sensors

Jongmin Yoon[1], Ilseob Song[1], Jinbum Kang[1], Yangmo Yoo[1,4], [1]Department of Electronic Engineering, Sogang University, Seoul, Korea, [2]Department of Medical Engineering, Yonsei University, Seoul, Korea, [3]Department of Radiology, The Catholic University of Korea, Seoul, Korea, [4]Department of Biomedical Engineering, Sogang University, Seoul, Korea

Background, Motivation and Objective

Continuous monitoring of blood flows in common carotid arteries (CCAs) is important for assessing not only cerebrovascular but also cardiovascular diseases. Recently-developed portable and hand-held ultrasound imaging systems substantially reduce their sizes and costs for bed-side and intraoperative procedures, but they are still inconvenient to use in continuously monitoring the CCA. In this study, a new wireless neckband carotid monitoring system, in which two 2.5-MHz ultrasound sensors are utilized to obtain Doppler signals, is presented for continuously evaluating blood flow dynamics in both CCAs.

Statement of Contribution/Methods

In the wireless neckband Doppler system, the acquired Doppler signals are quantized by 14-bit analog-to-digital-converters running at 40 MHz and pre-processing operations (i.e., demodulation and clutter filtering) are performed in an embedded field programmable gate array chip (Sparatan-6 LX150, Xilinx Inc., San Jose, CA, USA). Then, the data are transferred to an external smartphone (i.e., Galaxy S7, Samsung Electronics Co., Suwon, Korea) via Bluetooth 2.0. The post-processing (i.e., Fourier transform and image processing) is performed by using an embedded application processor in the smartphone. Moreover, to locate the Doppler sample volume (SV) in the appropriate vessel lumen, the automatic SV disposition technique was embedded in the developed wearable neckband ultrasound Doppler system.

Results/Discussion

Fig. 1(a) shows the developed prototype of the wireless carotid neckband ultrasound Doppler system. As shown in Fig. 1(a), it consists of the two single-element transducers mounted on the neckband, two coaxial cables for the transducer connection, the ultrasound pre-processing module, the Bluetooth module, the power module, the battery pack and the smartphone. Fig. 1(b) represents the spectrograms of the left/right CCAs from a volunteer by utilizing the wireless carotid wearable ultrasound Doppler system prototype. The CCA spectrograms in the smartphone are updated and optimized by the automatic SV disposition algorithm as shown in Fig. 1(c). The developed wireless carotid neckband ultrasound Doppler system can be used as a continuous monitoring tool for measuring risk indicators, and these indicators can be analyzed with Deep Learning for predicting abnormalities in advance.

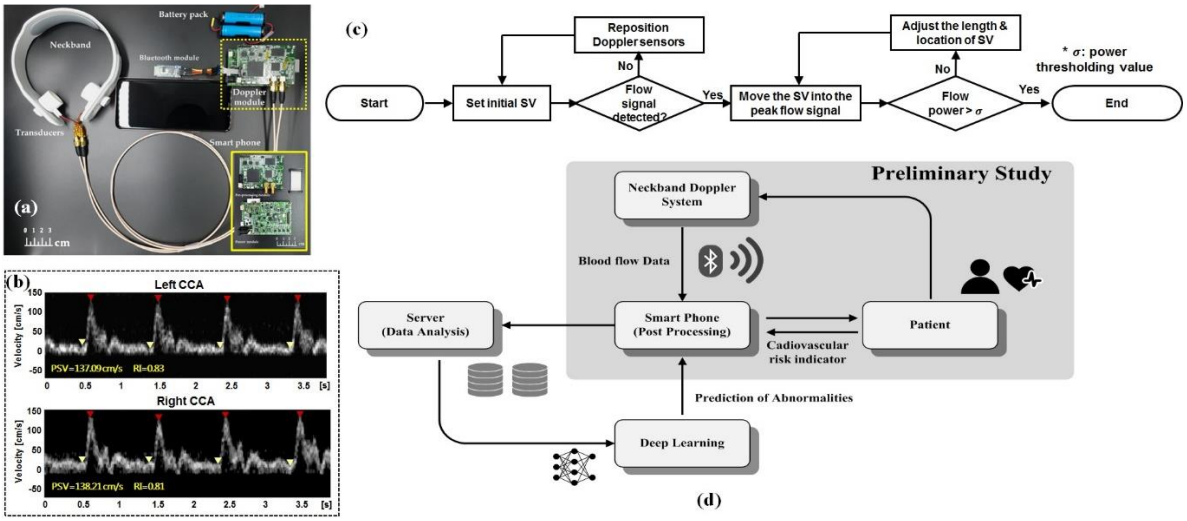

Fig. 1. (a) The developed prototype of the wireless carotid neckband ultrasound Doppler system. (b) The spectrograms of the left/right CCAs from a volunteer by utilizing the wireless carotid wearable ultrasound Doppler system prototype. (c) Flow chart for the single channel based automatic sample volume disposition algorithm in the system. (d) The prediction model of cerebrovascular and/or cardiovascular diseases by using the developed wireless carotid neckband ultrasound Doppler system and deep learning.