# Acute exposure to mobile phone and assessment of internal cerebral circulation in young healthy subjects : a transcranial Doppler study

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# Acute exposure to mobile phone and assessment of internal cerebral circulation in young healthy subjects: A Transcranial Doppler study

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## INTRODUCTION

The rapid worldwide increase in the use of mobile phones raises questions about the possible adverse effects of RF fields emitted by these devices. The temporal lobe of brain is closest to the mobile phone. This may lead to relatively high energy deposition in these parts of human head during the use of mobile phone. The cerebral circulation may be potentially affected due to the exposure to RF emitted by mobile phone. Therefore the studies on cerebral blood flow are essential in order to evaluate the possible interaction exposure to RF with the central nervous system. Data in the literature related to the brain circulation are limited and controversial due to the different methods and protocols applied in these studies (i.e. REG, PET, NIRS,) [1-6].

## OBJECTIVES

To investigate internal cerebral vascularisation in order to define the possible physiological modifications of the using mobile (cellular) phones. The basic approach of our human study is to compare the cerebral blood flow of the exposed and non-exposed hemisphere before, during and after the mobile phone exposure using non-invasive widely accepted diagnostic procedures.

## METHODS

The cerebral blood flow of middle cerebral arteries (MCA) was monitored by transcranial Doppler sonography (TCD). The technique is based upon measurement of the Doppler frequency shift of reflected ultrasonic waves backscattered by moving blood cells [7]. The various cerebral arteries each have their own characteristic TCD waveform, depth, location, and flow direction. This allows their unique identification by sonography [8]. TCD is a noninvasive technique that allows for constant monitoring of mean flow velocity in an intracerebral artery [9]. LOOKI 2TC, ATYS Medical Doppler device has been applied in the study, with a helmet support for bilateral recording by two 2 MHz-probes (ATYS 1133) in temporal position on the head. Mean Cerebral Blood flow velocity (CBF-V, cm/s) and percentage of cerebral blood flow (l/min) have been recorded. Middle cerebral arteries PI and RI were calculated from flow velocity waveforms. PI was calculated as (Vmax-Vmin)/Vmean with Vmax = peak systolic blood flow velocity, Vmin = minimum diastolic velocity, and Vmean = time averaged maximum velocity [10]. In the cerebral vasculature, high PI can indicate higher peripheral vessel resistance concomitant with increased intracranial pressure [11]. RI was calculated as (Vmax-Vmin)/Vmax [12].

Heart rate (HR) was calculated from TCD wave according to the formula: HR=60/R-R (R-R is the interval between an R wave and the next R wave).

A voluntary BH (~ 30 seconds) physiological test was carried out as positive control to check the ability of TCD to demonstrate physiological changes in cerebral artery flow velocity.

The skin temperature was measured continuously during the study. It was measured on the cheek and behind the earlobe on both sides of the head by four channels with a Luxtron optical thermometer (Luxtron Fluoroptic Thermometer, Model 790, California, US).

**PROTOCOL**

Twenty-nine healthy subjects were volunteered in randomized crossover double-blind study aged 18 to 35 years. They were selected after routine, non invasive, clinical and laboratory examinations. Selection criteria includes: regular sleep habits, no medication, no chronic disease or disability, no recent acute illness, no smoking, no neurological or respiratory vascular history. Those selected were instructed to abstain from consuming alcohol and coffee for 24 hours before and during each experimental session.

Pre-exposure period (10 min): a first baseline (BL1) was recorded, then a first breath holding test (BH1) was applied. Exposure period (20 min): the phone (sham or real) was positioned by the holder attached to the helmet on the left side. The exposure period was 20 minutes. Four recordings were performed during the fifth, the tenth, the fifteenth and the twentieth minute of the exposure period. At the end of exposure, the mobile phone was carefully removed. Post-exposure period (20 min): five recordings were performed during the first, the fifth, the tenth, the fifteenth and the twentieth minute of post-exposure period. After post-exposure period a second breath holding test (BH2) was applied (same conditions as BH1). The last recording was the BL2. Each TCD recording was spread over a period of one minute.

**EXPOSURE**

Commercially available mobile phone was used with exposure duration of 20 minutes. The phone was operated in test mode via PC connections to be tuned into constant and controlled RF power emission at the requested power level. The GSM signal was 900 MHz with GSM modulation at peak power 2 W (0.25 W averages). The measurements of absorbed RF power in the head SAR (W/kg), were made in a standard SAM phantom (Specific Anthropomorphic Mannequin phantom, Antennessa, France) filled with standard brain tissue-equivalent liquid (Satimo, France) according to CENELEC standard EN 50361 [13]. The maximum SARs values were measured when the TCD probe was placed on the phantom at the position of cranial window beside the mobile phone according to the protocol of the study. The SARs averaged on 10 g tissue, 1 g tissue, or the peak were 0.53 W/kg, 0.76 W/kg and 1.03 W/kg respectively. The phone was positioned with the touch position to the cheek according to the EN-50361 standard by a helmet holder of TCD probes. The sham or real exposure is realized by a “load” or a “dummy load” connected to the remote antenna connector of the phone [14].

**RESULTS:**

***CBF-V and CBF*:** The mean CBF-V measured in both sessions (exposure and sham-exposure) are shown in Fig. 1. Comparison has performed within session (sham or exposure) between pre-exposure period (BL1), exposure period (EP) and post-exposure period (BL2) and between sessions (sham vs. exposure). Results showed no significant change between different periods of the recording ($p > 0.05$). In addition, similar results were observed when comparing the right (control) and left (exposed) sides during sham and real exposure ($p > 0.05$). Likewise, no differences were observed between the values of CBF at different

periods of recording when the data were expressed as percentage relative to baseline BL1 ($p > 0.05$).

***PI and RI:*** No significant differences were observed in PI and RI when comparing different exposure periods (BL1, EP and BL2) within session ($p > 0.05$) and between sessions ($p > 0.05$). Moreover, when data were compared between left and right side the results were found to be similar suggesting that RF-EMF had no effect on PI or RI.

***Breath holding test:*** Mean values of different measured and calculated parameters during BH in sham and real exposure sessions showed significant increase ($p < 0.001$) in CBF-V and percentage of CBF during BH when compared to BL1. A significant decrease was observed in PI and RI during BH1 and BH2 in both sides and in both sessions ($p < 0.001$). No differences in different parameters were observed during BH when comparing control and exposed side, or sham and real exposure.

***Skin temperature:*** In the right side (with no handset) temperature did not significantly change in the cheek and under the ear. It seems to be stable during sham and real exposure. However, an increase in temperature was observed in the left (exposed with handset) cheek. Indeed, during sham exposure temperature rose up to 1.4°C in the cheek and 0.4°C under the ear respectively, while it increased up to 2°C and 0.5°C during real exposure. Increase in cheek temperature was significantly higher by 0.6°C with the real phone than with the sham phone (*t-test*: $p < 0.05$).

Additional measures of temperature were performed on surface of the phones (real and sham) alone. After 20 min of transmission, the temperature of the sham phone rises from 24.45 to 27.33°C while the temperature of the real phone rises from 24.81 to 28.39°C. Heating produced from the real phone was found to be higher of 0.7°C than the sham phone.

## CONCLUSION

In conclusion, this study assessed the effects induced by a normal daily exposure (duration: 20 min) to a GSM mobile phone on measures of CBF-V noninvasively and safely evaluated by TCD. Data showed no significant changes in CBF-V, CBF, PI, and RI in middle cerebral arteries during exposure. These negative results should not encourage excessive mobile communication, because minor biological and neurophysiological influences may not be detectable by the current method.

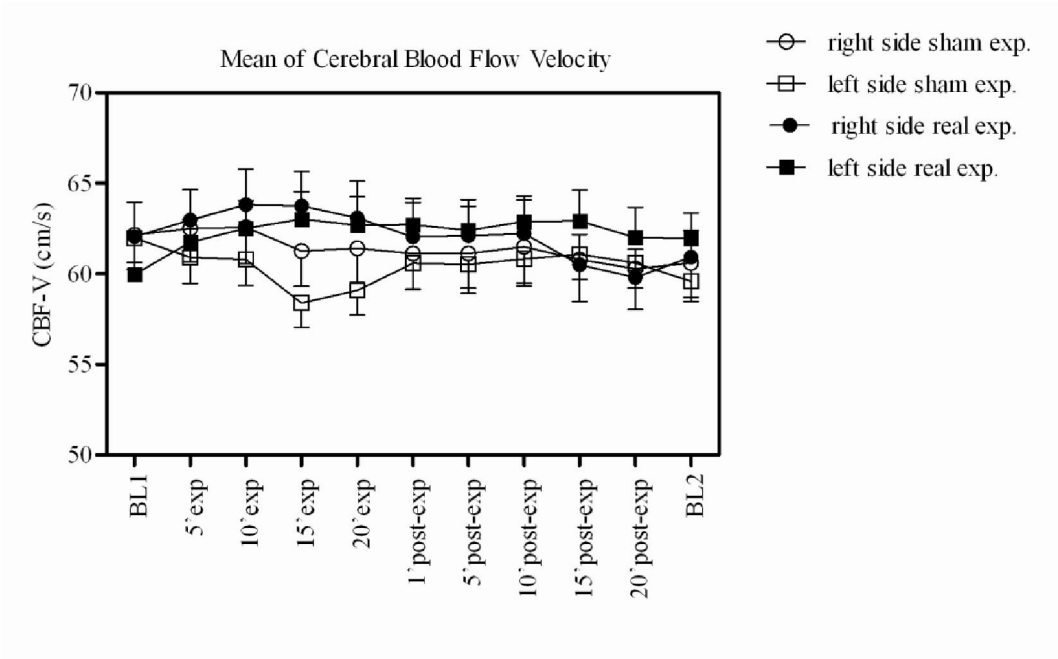


**Fig.1: Mean of cerebral blood flow velocity (CBF-V) in both sides during sham and real exposure.** No significant variations were observed in CBF-V in the right (control side) and the left (exposed side) middle cerebral arteries before, during and after sham and real exposure.

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