Braz J Otorhinolaryngol. 2016;xxx(xx):xxx–xxx

Brazilian Journal of
OTORHINOLARYNGOLOGY
www.bjorl.org

ORIGINAL ARTICLE

Effects of exposure to 2100 MHz GSM-like radiofrequency electromagnetic field on auditory system of rats☆

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Received 13 August 2016; accepted 9 October 2016

KEYWORDS
Cochlear nuclei;
Neuronal degeneration;
Electromagnetic radiation

Abstract
Introduction: The use of mobile phones has become widespread in recent years. Although beneficial from the communication viewpoint, the electromagnetic fields (EMF) generated by mobile phones may cause unwanted biological changes in the human body.
Objective: In this study, we aimed to evaluate the effects of 2100 MHz Global System for Mobile communication (GSM-like) electromagnetic field (EMF), generated by an EMF generator, on the auditory system of rats by using electrophysiological, histopathologic and immunohistochemical methods.
Methods: Fourteen adult Wistar albino rats were included in the study. The rats were divided randomly into two groups of seven rats each. The study group was exposed continuously for 30 days to a 2100 MHz EMF with a signal level (power) of 5.4 dBm (3.47 mW) to simulate the talk mode on a mobile phone. The control group was not exposed to the aforementioned EMF. After 30 days, the Auditory Brainstem Responses (ABRs) of both groups were recorded and the rats were sacrificed. The cochlear nuclei were evaluated by histopathologic and immunohistochemical methods.
Results: The ABR records of the two groups did not differ significantly. The histopathologic analysis showed increased degeneration signs in the study group ($p = 0.007$). In addition, immunohistochemical analysis revealed increased apoptotic index in the study group compared to that in the control group ($p = 0.002$).

☆ Please cite this article as: Çeliker M, Özgür A, Tümkaya L, Terzi S, Yılmaz M, Kalkan Y, et al. Effects of exposure to 2100 MHz GSM-like radiofrequency electromagnetic field on auditory system of rats. Braz J Otorhinolaryngol. 2016. http://dx.doi.org/10.1016/j.bjorl.2016.10.004
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http://dx.doi.org/10.1016/j.bjorl.2016.10.004

Conclusion: The results support that long-term exposure to a GSM-like 2100 MHz EMF causes an increase in neuronal degeneration and apoptosis in the auditory system.

PALAVRAS-CHAVE
Núcleo coclear;
Degeneração neuronal;
Radiação eletromagnética

Efeitos da exposição a um campo eletromagnético na radiofrequência de 2100 MHz, similar ao sistema GSM, no sistema auditivo de ratos

Resumo
Introdução: O uso de telefones celulares tornou-se generalizado nos últimos anos. Embora benéfico do ponto de vista da comunicação, os campos eletromagnéticos (EMF, do inglês *Electromagnetic Field*) gerados por celulares pode causar alterações biológicas indesejáveis no corpo humano.
Objetivo: Nesse estudo, o objetivo foi avaliar os efeitos do Campo Eletromagnético (EMF) na frequência de 2.100 MHz, similar à modulação do Sistema Global para Comunicações Móveis (GSM – *Global System for Mobile Communication*), produzido por um gerador de EMF, sobre o sistema auditivo de ratos usando os métodos eletrofisiológico, histopatológico e imunohistoquímico.
Método: Foram incluídos no estudo catorze adultos ratos albinos Wistar. Os ratos foram divididos aleatoriamente em dois grupos de sete animais cada. O grupo de estudo foi exposto continuamente por 30 dias a um EMF em 2100 MHz com um nível de sinal (potência) de 5,4 dBm (3,47 miliwatts) para simular o modo de conversação em um celular. O grupo controle não foi exposto ao EMF acima mencionado. Após 30 dias, o Potencial Evocado Auditivo de Tronco Encefálico (PEATE) de ambos os grupos foi gravado e os ratos foram sacrificados. Os núcleos cocleares foram avaliados pelos métodos histopatológico e imunohistoquímico.
Resultados: Os registros do PEATE dos dois grupos não diferiram significativamente. A análise histopatológica mostrou aumento dos sinais de degeneração no grupo de estudo ($p = 0{,}007$). Além disso, a análise imuno-histoquímica revelou aumento do índice de apoptose no grupo de estudo em comparação com o grupo controle ($p = 0{,}002$).
Conclusão: Os resultados confirmam que a exposição a longo prazo a um EMF em 2100 MHz similar à modulação do sistema GSM causa um aumento na degeneração neuronal e apoptose no sistema auditivo.

Introduction

The use of mobile phones has become widespread in recent years. Although beneficial from the communication viewpoint, the electromagnetic fields (EMF) generated by mobile phones may cause unwanted biological changes in the human body.[1,2]

The operating frequencies of wireless devices range from 30 kHz to 300 GHz. Devices operating in this frequency range produce an effect area called Radiofrequency Electromagnetic Field (RF-EMF).[3] Mobile phones operate in the 800–3500 MHz frequency range, and third-generation (3G) mobile phones primarily use the 2100 MHz frequency.[4] The EMF generated by these devices and base stations that connect them has emerged as a growing public health issue.[1] In a consensus statement published by the World Health Organization International Agency for Research on Cancer Monograph Working Group in 2011, RF-EMF was accepted as a possible carcinogen for humans after evaluating human and experimental studies on the impact of RF-EMF.[3] Two large multicenter case-control studies investigated the relationship between brain tumors and mobile phone use. One of these studies found a significant association between mobile phone use and the occurrence of malignant brain tumor.[5] In contrast, the other study showed that 10 years of mobile phone use did not increase the risk of acoustic neuroma significantly, but it was emphasized that the follow-up period was insufficient for acoustic neuroma, a slowly growing tumor.[6]

Studies investigating the effects of mobile phone use on the auditory system have usually focused on cochlear hearing loss, and otoacoustic emission studies have been preferred for evaluations. Several of these studies found no significant effect of RF-EMF on the auditory system, whereas other studies had minor findings such as a temporary threshold shift or decreased otoacoustic emission responses.[2,7,8] Retrocochlear pathology is the expected biological damage due to RF-EMF exposure. However, otoacoustic emission testing is used to evaluate the cochlea. Therefore, to evaluate the effects of RF-EMF on the auditory system, the