TECHNOLOGIE 5G

Bulletin de veille scientifique : Juin 2024

Objectifs : réaliser une veille scientifique sur la technologie 5G

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Généralités

Aucun article dans ce bulletin.

Technologie 5G

Performances et sécurité

Enhancing Earth data analysis in 5G satellite networks: A novel lightweight approach integrating improved deep learning.

Efficiently handling huge data amounts and enabling processing-intensive applications to run in faraway areas simultaneously is the ultimate objective of 5G networks. Currently, in order to distribute computing tasks, ongoing studies are exploring the incorporation of fog-cloud servers onto satellites, presenting a promising solution to enhance connectivity in remote areas. Nevertheless, analyzing the copious amounts of data produced by scattered sensors remains a challenging endeavor. The conventional strategy of transmitting this data to a central server for analysis can be costly. In contrast to centralized learning methods, distributed machine learning (ML) provides an alternative approach, albeit with notable drawbacks. This paper addresses the comparative learning expenses of centralized and distributed learning systems to tackle these challenges directly. It proposes the creation of an integrated system that harmoniously merges cloud servers with satellite network structures, leveraging the strengths of each system. This integration could represent a major breakthrough in satellite-based networking technology by streamlining data processing from remote nodes and cutting down on expenses. The core of this approach lies in the adaptive tailoring of learning techniques for individual entities based on their specific contextual nuances. The experimental findings underscore the prowess of the innovative lightweight strategy, LMAED(2)L (Enhanced Deep Learning for Earth Data Analysis), across a spectrum of machine learning assignments, showcasing remarkable and consistent performance under diverse operational conditions. Through a strategic fusion of centralized and distributed learning frameworks, the LMAED2L method emerges as a dynamic and effective remedy for the intricate data analysis challenges encountered within satellite networks interfaced with cloud servers. The empirical findings reveal a significant performance boost of our novel approach over traditional methods, with an average increase in reward (4.1 %), task completion rate (3.9 %), and delivered packets (3.4 %). This report suggests that these advancements will catalyze the integration of cutting-edge machine learning algorithms within future networks, elevating responsiveness, efficiency, and resource utilization to new heights.

Lien vers l'article

Antennes

A flexible dual-band 4 × 4 MIMO antenna for 5G mm-wave 28/38 GHz wearable applications.

This paper presents a novel, dual-band, four-port multi-input-multi-output (MIMO) antenna for 28/38 GHz millimeter wave 5G wearable applications. In the proposed work, we have used a novel design approach to get the dual-band behavior from a MIMO design with a small footprint of $18 \times 8.5 \times 0.25$ mm(3). For this purpose, each MIMO element is designed as a composite form of a circular and elliptical structure connected with a narrow strip and fed by a tapered feedline. The peak realized gains and total efficiencies of the antenna, evaluated in free space, are 4.15 dBi, 7.73 dBi and

80.13%, 85.44% at 28 GHz and 38 GHz frequencies, respectively. To appraise the thorough behavior of the MIMO antenna, we have evaluated all the parameters of the antenna: Envelope Correlation Coefficient (ECC), Diversity Gain (DG), Mean Effective Gain (MEG), Channel Capacity Loss (CCL), and Total Active Reflection Coefficient (TARC), and found them satisfactory. Channel capacity of the antenna at SNR = 20 dB is found to be 21.61 bps/Hz. For wearable applications, the proposed 4-port MIMO antenna is designed on a flexible Rogers 3003 substrate, and the performance is checked by evaluating bending analysis. The safety of the antenna is verified by analyzing the 1 g/10 g SAR at 28/38 GHz and the corresponding average SAR values are 0.11/0.08 W/kg and 0.05/0.04 W/kg, respectively. All the average SAR values for the proposed MIMO antenna are within the acceptable limits according to FCC/ICNIRP standards.

[Lien vers l'article](#)

Wideband high gain metasurface-based 4T4R MIMO antenna with highly isolated ports for sub-6 GHz 5G applications.

Salehi M, Oraizi H. *Sci Rep*. 2024 Jun 24;14(1):14448.

This study presents the design of four 178 × 178 (mm) 2 wideband, high gain, highly efficient metasurface-based 4T4R MIMO (Multiple-Input Multiple-Output) antennas with highly isolated ports, covering the middle and a portion of the upper bands of the sub 6 GHz 5G frequency spectrum for 5G-based systems, such as IoT (Internet of Things) applications, vehicular communications (e.g., rooftop antennas of cars or trains), smart industries (e.g., farms and factories). The radiating elements of these antennas use the aperture-coupled feeding technique with a dumbbell-shaped slot, a truncated square patch with two U-shaped slots, and a metasurface layer. The proposed MIMO structures place four identical radiating elements like a 2 × 2 matrix with 90∘ successive rotations to produce orthogonal electromagnetic waves, improving the isolation between ports. Six-millimeter spaces are added between these elements, and two vertical and horizontal strip slots are carved on the ground as the decoupling structure to decrease the mutual coupling. Simulation results show that Antenna_1, Antenna_2, and Antenna_3 achieve gain values of 6.2 to 9.4 dBi, 8.2 to 11.6 dBi, 6.2 to 9.5 dBi, below - 35, - 25, and - 33 isolation and almost 10 dB diversity gain from 2.8 to 4.7 GHz, 2.8 to 4.5 GHz, and 2.7 to 4.9 GHz, respectively. As a prototype, Antenna_4 is manufactured, and measurements are performed. It achieves 6.28 to 10.45 dBi gain values, below - 23 dB isolation, and 0.001 envelope correlation coefficient over 2.7 to 4.3 GHz. The results confirm that the proposed MIMO antennas are compatible with the 5G essential requisites.

[Lien vers l'article](#)

Architecture réseau

Aucun article dans ce bulletin.

Département EAM

Efficacité énergétique

An intelligent algorithm for energy efficiency optimization in software-defined wireless sensor networks for 5G communications.

Gökhan Nalbant K, Alsuhibany SA, Hassan Alshehri A, Hatira M, Choi BJ. *PLoS One*. 2024;19(6):e0301078.

Wireless communications have lately experienced substantial exploitation because they provide a lot of flexibility for data delivery. It provides connection and mobility by using air as a medium. Wireless sensor networks (WSN) are now the most popular wireless technologies. They need a communication infrastructure that is both energy and computationally efficient, which is made feasible by developing the best communication protocol algorithms. The internet of things (IoT) paradigm is anticipated to be heavily reliant on a networking architecture that is currently in development and dubbed software-defined WSN. Energy-efficient routing design is a key objective for WSNs. Cluster routing is one of the most commonly used routing techniques for extending network life. This research proposes a novel approach for increasing the energy effectiveness and longevity of software-defined WSNs. The major goal is to reduce the energy consumption of the cluster routing protocol using the firefly algorithm and high-efficiency entropy. According to the findings of the simulation, the suggested method outperforms existing algorithms in terms of system performance under various operating conditions. The number of alive nodes determined by the proposed algorithm is about 42.06% higher than Distributed Energy-Efficient Clustering with firefly algorithm (DEEC-FA) and 13.95% higher than Improved Firefly Clustering IFCEER and 12.05% higher than another referenced algorithm.

Lien vers l'article

Autres équipements

Compact metamaterial-based single/double-negative/near-zero index resonator for 5G sub-6 GHz wireless applications.

Ibrahim SK, Al-Bawri SS, Singh MJ, Ibrahim HH, Islam MT, Islam MS, et al. *Sci Rep*. 2024 Jun 4;14(1):12834.

The concept, performance, and analyses of distinctive, miniaturized metamaterial (MTM) unit cell addressing the forthcoming Sub 6 GHz 5G applications are presented in this paper. Two circular split-ring resonators (CSRR) with two parallel rectangular copper elements in front of the design and a slotted square element in the background make up the suggested metamaterial. It has a line segment with tunable features that is positioned in the center of the little ring copper structure. The suggested design offers a significant operating frequency band of 220 MHz together with a resonance of transmission coefficient S21 at 3.5 GHz. Furthermore, in two (z & x) principal axes of wave propagation, wide-range achievement, single/double-negative (S/DNG) refractive index, negative permittivity, and near-zero permeability properties were demonstrated. Through varying central slotted-strip line length, resonance frequencies can be selectively altered. Moreover, the metamaterial has overall dimensions of 9 × 9 mm(2) and is composed on a Rogers 5880 RT substrate. In order to create the suggested MTM's equivalent circuit, which shows similar coefficient of transmission (S21), a proposed design's numerical simulation is carried out in the CST micro-wave studio. This simulation is after that put to comparison with manufacturing of the design.

Lien vers l'article

Applications médicales et industrielles de la 5G

Applications industrielles

5G AI-IoT System for Bird Species Monitoring and Song Classification.

Segura-Garcia J, Sturley S, Arevalillo-Herraez M, Alcaraz-Calero JM, Felici-Castell S, Navarro-Camba EA. *Sensors (Basel)*. 2024 Jun 6;24(11).

Identification of different species of animals has become an important issue in biology and ecology. Ornithology has made alliances with other disciplines in order to establish a set of methods that play an important role in the birds' protection and the evaluation of the environmental quality of different ecosystems. In this case, the use of machine learning and deep learning techniques has produced big progress in birdsong identification. To make an approach from AI-IoT, we have used different approaches based on image feature comparison (through CNNs trained with Imagenet weights, such as EfficientNet or MobileNet) using the feature spectrogram for the birdsong, but also the use of the deep CNN (DCNN) has shown good performance for birdsong classification for reduction of the model size. A 5G IoT-based system for raw audio gathering has been developed, and different CNNs have been tested for bird identification from audio recordings. This comparison shows that Imagenet-weighted CNN shows a relatively high performance for most species, achieving 75% accuracy. However, this network contains a large number of parameters, leading to a less energy efficient inference. We have designed two DCNNs to reduce the amount of parameters, to keep the accuracy at a certain level, and to allow their integration into a small board computer (SBC) or a microcontroller unit (MCU).

Lien vers l'article

Vehicle Occupant Detection Based on MM-Wave Radar.

Li W, Wang W, Wang H. *Sensors (Basel)*. 2024 May 23;24(11).

With the continuous development of automotive intelligence, vehicle occupant detection technology has received increasing attention. Despite various types of research in this field, a simple, reliable, and highly private detection method is lacking. This paper proposes a method for vehicle occupant detection using millimeter-wave radar. Specifically, the paper outlines the system design for vehicle occupant detection using millimeter-wave radar. By collecting the raw signals of FMCW radar and applying Range-FFT and DoA estimation algorithms, a range-azimuth heatmap was generated, visually depicting the current status of people inside the vehicle. Furthermore, utilizing the collected range-azimuth heatmap of passengers, this paper integrates the Faster R-CNN deep learning networks with radar signal processing to identify passenger information. Finally, to test the performance of the detection method proposed in this article, an experimental verification was conducted in a car and the results were compared with those of traditional machine learning algorithms. The findings indicated that the method employed in this experiment achieves higher accuracy, reaching approximately 99%.

Lien vers l'article

Systematic Research and Application of a 5G Medical Unmanned Aerial Vehicle to Deliver COVID-19 Nucleic Acid Samples.

Huang X, Ren F, Liu M, Jin P, Sun Y. *Health Secur*. 2024 May 30.

The purpose of this study was to investigate the feasibility and effectiveness of COVID-19 throat swab samples delivered by medical drones in epidemic prevention and control. This study was carried out in both southern and northern hospital districts of the Affiliated Hospital of Jiangnan University from May to October 2022. The main participants were the Affiliated Hospital of Jiangnan University and Zhejiang Antwork Technology Co., Ltd. We first constructed an urban medical unmanned aerial vehicle (UAV) delivery system and developed a UAV-specific storage box for COVID-19 samples. The UAV system was used to transport COVID-19 throat swab samples from the northern hospital district to the southern hospital district, and the following indexes were obtained: (1) flight time of COVID-19 samples delivered by UAV, (2) real-time temperature of COVID-19 nucleic acid samples during transportation, and (3) the time of distribution of COVID-19 nucleic acid samples by road traffic as measured using the Baidu Maps application, compared with the flight time of UAV. The COVID-19 sample delivery system for urban medical UAV mainly consists of intelligent logistics UAV, low-temperature COVID-19 throat swab sample storage box, unmanned logistics hub, and cloud operation control platform. The flight distance between the northern and southern districts of the Affiliated Hospital of Jiangnan University was 10 km, and the ground distance was 24 km. From May 11 to October 28, 2022, a total of 1,190 UAV flights occurred. The average flight time was 13 minutes, which was 40 to 70 minutes faster than the average road travel time required for manual delivery of COVID-19 throat swab samples. At different time points in the day, UAV delivery efficiency increased by 67.5% to 82%. The use of 5G with the Internet of Things and UAV technology to deliver nucleic acid samples has the characteristics of fast speed, being unaffected by ground traffic conditions, and the ability to ensure the safety of nucleic acid samples in the transportation process, which is worthy of further study.

Lien vers l'article

Département EAM

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

Aucun article dans ce bulletin.

Evaluation population générale

Micro-environmental personal radio-frequency electromagnetic field exposures in Melbourne: A longitudinal trend analysis.

Bhatt CR, Henderson S, Sanagou M, Brzozek C, Thielens A, Benke G, et al. *Environ Res*. 2024 Jun 15;251(Pt 2):118629.

BACKGROUND: A knowledge gap exists regarding longitudinal assessment of personal radio-frequency electromagnetic field (RF-EMF) exposures globally. It is unclear how the change in telecommunication technology over the years translates to change in RF-EMF exposure. This study aims to evaluate longitudinal trends of micro-environmental personal RF-EMF exposures in Australia. METHODS: The study utilised baseline (2015-16) and follow-up (2022) data on personal RF-EMF exposure (88 MHz-6 GHz) measured across 18 micro-environments in Melbourne. Simultaneous quantile regression analysis was conducted to compare exposure data distribution percentiles, particularly median (P(50)), upper extreme value (P(99)) and overall exposure trends. RF-EMF exposures were compared across six exposure source types: mobile downlink, mobile uplink, broadcast, 5G-New Radio, Others and Total (of the aforementioned sources). Frequency-specific exposures measured at baseline and follow-up were compared. Total exposure across different groups of micro-environment types were also compared. RESULTS: For all micro-environmental data, total (median and P(99)) exposure levels did not significantly change at follow-up. Overall exposure trend of total exposure increased at follow-up. Mobile downlink contributed the highest exposure among all sources showing an increase in median exposure and overall exposure trend. Of seven micro-environment types, five of them showed total exposure levels (median and P(99)) and overall exposure trend increased at follow-up.

Lien vers l'article

Risques professionnels

Aucun article dans ce bulletin.

Effets biologiques et sur la santé

In silico

Aucun article dans ce bulletin.

In vitro

Aucun article dans ce bulletin.

Sur l'animal

Effects of 3.5-GHz radiofrequency radiation on energy-regulatory hormone levels in the blood and adipose tissue.

Bektas H, Dasdag S, Altindag F, Akdag MZ, Yegin K, Algul S. *Bioelectromagnetics*. 2024 Jul;45(5):209-17.

In recent years exposure of living beings to radiofrequency radiation (RFR) emitted from wireless equipment has increased. In this study, we investigated the effects of 3.5-GHz RFR on hormones that regulate energy metabolism in the body. Twenty-eight rats were divided into four groups: healthy sham (n = 7), healthy RFR (n = 7), diabetic sham (n = 7), and diabetic RFR (n = 7). Over a month, each group spent 2 h/day in a Plexiglas carousel. The rats in the experimental group were exposed to RFR, but the sham groups were not. At the end of the experiment, blood and adipose tissues were collected from euthanized rats. Total antioxidant, total oxidant, hydrogen peroxide, ghrelin, nesfatin-1, and irisin were determined. Insulin expression in pancreatic tissues was examined by immunohistochemical analysis. Whole body specific absorption rate was 37 mW/kg. For the parameters analyzed in blood and fat, the estimated effect size varied within the ranges of 0.215-0.929 and 0.503-0.839, respectively. The blood and adipose nesfatin-1 (p = 0.002), blood and pancreatic insulin are decreased, (p = 0.001), gherelin (p = 0.020), irisin (p = 0.020), and blood glucose (p = 0.040) are increased in healthy and diabetic rats exposed to RFR. While nesfatin-1 are negatively correlated with oxidative stress, hyperglycemia and insulin, ghrelin and irisin are positively correlated with oxidative stress and hyperglycemia. Thus, RFR may have deleterious effects on energy metabolism, particularly in the presence of diabetes.

Lien vers l'article

Sur l'homme

Summary of seven Swedish case reports on the microwave syndrome associated with 5G radiofrequency radiation.

Hardell L, Nilsson M. *Rev Environ Health*. 2024 Jun 19.

The fifth generation, 5G, for wireless communication is currently deployed in Sweden since 2019/2020, as well as in many other countries. We have previously published seven case reports that include a total of 16 persons aged between 4 and 83 years that developed the microwave syndrome within short time after being exposed to 5G base stations close to their dwellings. In all cases high radiofrequency (RF) radiation from 4G/5G was measured with a broadband meter. RF radiation reached >2,500,000 to >3,180,000 μW/m(2) in peak maximum value in three of the studies. In total 41 different health issues were assessed for each person graded 0 (no complaint) to 10 (worst symptoms). Most prevalent and severe were sleeping difficultly (insomnia, waking night time, early wake-up), headache, fatique, irritability, concentration problems, loss of immediate memory, emotional distress, depression tendency, anxiety/panic, dysesthesia (unusual touched based sensations), burning and lancinating skin, cardiovascular symptoms (transitory high or irregular pulse), dyspnea, and pain in muscles and joints. Balance disorder and tinnitus were less prevalent. All these symptoms are included in the microwave syndrome. In most cases the symptoms declined and disappeared within a short time period after the studied persons had moved to a place with no 5G. These case histories are classical examples of provocation studies. They reinforce the urgency to inhibit the deployment of 5G until more safety studies have been performed.

Lien vers l'article

Evaluation of oxidative stress and genetic instability among residents near mobile phone base stations in Germany.

Gulati S, Mosgoeller W, Moldan D, Kosik P, Durdik M, Jakl L, et al. *Ecotoxicol Environ Saf*. 2024 Jul 1;279:116486.

Human exposure to radiofrequency electromagnetic fields (RF-EMF) is restricted to prevent thermal effects in the tissue. However, at very low intensity exposure "non-thermal" biological effects, like oxidative stress, DNA or chromosomal aberrations, etc. collectively termed genomic-instability can occur after few hours. Little is known about chronic (years long) exposure with non-thermal RF-EMF. We identified two neighboring housing estates in a rural region with residents exposed to either relatively low (control-group) or relatively high (exposed-group) RF-EMF emitted from nearby mobile phone base stations (MPBS). 24 healthy adults that lived in their homes at least for 5 years volunteered. The homes were surveyed for common types of EMF, blood samples were tested for oxidative status, transient DNA alterations, permanent chromosomal damage, and specific cancer related genetic markers, like MLL gene rearrangements. We documented possible confounders, like age, sex, nutrition, life-exposure to ionizing radiation (X-rays), occupational exposures, etc. The groups matched well, age, sex, lifestyle and occupational risk factors were similar. The years long exposure had no measurable effect on MLL gene rearrangements and c-Abl-gene transcription modification. Associated with higher exposure, we found higher levels of lipid oxidation and oxidative DNA-lesions, though not statistically significant. DNA double strand breaks, micronuclei, ring chromosomes, and acentric chromosomes were not significantly different between the groups. Chromosomal aberrations like dicentric chromosomes (p=0.007), chromatid gaps (p=0.019), chromosomal fragments (p<0.001) and the total of chromosomal aberrations (p<0.001) were significantly higher in the exposed group. No

potential confounder interfered with these findings. Increased rates of chromosomal aberrations as linked to excess exposure with ionizing radiation may also occur with non-ionizing radiation exposure. Biological endpoints can be informative for designing exposure limitation strategies. Further research is warranted to investigate the dose-effect-relationship between both, exposure intensity and exposure time, to account for endpoint accumulations after years of exposure. As established for ionizing radiation, chromosomal aberrations could contribute to the definition of protection thresholds, as their rate reflects exposure intensity and exposure time.

Lien vers l'article

The effects of radiofrequency exposure on cognition: A systematic review and meta-analysis of human observational studies.

Benke G, Abramson MJ, Brzozek C, McDonald S, Kelsall H, Sanagou M, et al. *Environ Int*. 2024 Jun;188:108779.

BACKGROUND: We aimed to assess evidence of long-term effects of exposure to radiofrequency (RF) electromagnetic fields (EMF) on indicators of cognition, including domains of learning and memory, executive function, complex attention, language, perceptual motor ability and social cognition, and of an exposure-response relationship between RF-EMF and cognition. METHODS: We searched PubMed, Embase, PsycInfo and the EMF-Portal on September 30, 2022 without limiting by date or language of publication. We included cohort or case-control studies that evaluated the effects of RF exposure on cognitive function in one or more of the cognitive domains. Studies were rated for risk of bias using the OHAT tool and synthesised using fixed effects meta-analysis. We assessed the certainty of the evidence using the GRADE approach and considered modification by OHAT for assessing evidence of exposures. RESULTS: We included 5 studies that reported analyses of data from 4 cohorts with 4639 participants consisting of 2808 adults and 1831 children across three countries (Australia, Singapore and Switzerland) conducted between 2006 and 2017. The main source of RF-EMF exposure was mobile (cell) phone use measured as calls per week or minutes per day. For mobile phone use in children, two studies (615 participants) that compared an increase in mobile phone use to a decrease or no change were included in meta-analyses. Learning and memory. There was little effect on accuracy (mean difference, MD -0.03; 95% CI -0.07 to 0.02) or response time (MD -0.01; 95% CI -0.04 to 0.02) on the one-back memory task; and accuracy (MD -0.02; 95%CI -0.04 to 0.00) or response time (MD -0.01; 95%CI -0.04 to 0.03) on the one card learning task (low certainty evidence for all outcomes). Executive function. There was little to no effect on the Stroop test for the time ratio ((B-A)/A) response (MD 0.02; 95% CI -0.01 to 0.04, very low certainty) or the time ratio ((D-C)/C) response (MD 0.00; 95% CI -0.06 to 0.05, very low certainty), with both tests measuring susceptibility to interference effects. Complex attention. There was little to no effect on detection task accuracy (MD 0.02; 95% CI -0.04 to 0.08), or response time (MD 0.02;95% CI 0.01 to 0.03), and little to no effect on identification task accuracy (MD 0.00; 95% CI -0.04 to 0.05) or response time (MD 0.00;95% CI -0.01 to 0.02) (low certainty evidence for all outcomes). No other cognitive domains were investigated in children. A single study among elderly people provided very low certainty evidence that more frequent mobile phone use may have little to no effect on the odds of a decline in global cognitive function (odds ratio, OR 0.81; 95% CI 0.42 to 1.58, 649 participants) or a decline in executive function (OR 1.07; 95% CI 0.37 to 3.05, 146 participants), and may lead to a small, probably unimportant, reduction in the odds of a decline in complex attention (OR 0.67;95%CI 0.27 to 1.68, 159 participants) and a decline in learning and memory (OR 0.75; 95% CI 0.29 to 1.99, 159 participants). An exposure-response relationship was not identified for any of the cognitive outcomes. DISCUSSION: This systematic review and meta-analysis found only a few studies that provided very low to low certainty evidence of little to no association between RF-EMF exposure and learning and memory, executive function and complex attention. None of the studies among children reported on global cognitive function or other domains of cognition. Only one study reported

a lack of an effect for all domains in elderly persons but this was of very low certainty evidence. Further studies are needed to address all types of populations, exposures and cognitive outcomes, particularly studies investigating environmental and occupational exposure in adults. Future studies also need to address uncertainties in the assessment of exposure and standardise testing of specific domains of cognitive function to enable synthesis across studies and increase the certainty of the evidence. OTHER: This review was partially funded by the WHO radioprotection programme and prospectively registered on PROSPERO CRD42021257548.

Lien vers l'article

Reproduction

Expression levels of tam receptors and ligands in the testes of rats exposed to short and middle-term 2100 MHz radiofrequency radiation.

With advances in technology, the emission of radiofrequency radiation (RFR) into the environment, particularly from mobile devices, has become a growing concern. Tyro 3, Axl, and Mer (TAM) receptors and their ligands are essential for spermatogenesis and testosterone production. RFR has been shown to induce testicular cell apoptosis by causing inflammation and disrupting homeostasis. This study aimed to investigate the role of TAM receptors and ligands in the maintenance of homeostasis and elimination of apoptotic cells in the testes (weeks), short-term sham exposure (sham/1 week), and middle-term sham exposure (sham/10 weeks). Testicular morphology was assessed using hematoxylin-eosin staining, while immunohistochemical staining was performed to assess expression levels of TAM receptors and ligands in the testes of all groups. The results showed that testicular morphology was normal in the control, sham/1 week, and sham/10 weeks groups. However, abnormal processes of spermatogenesis and seminiferous tubule morphology were observed in RFR exposure groups. Cleaved Caspase 3 immunoreactivity showed statistically significant difference in 1 and 10 weeks exposure groups compared to control group. Moreover, there was no significant difference in the immunoreactivity of Tyro 3, Axl, Mer, Gas 6, and Pros 1 between groups. Moreover, Tyro 3 expression in Sertoli cells was statistically significantly increased in RFR exposure groups compared to the control. Taken together, the results suggest that RFR exposure negatively affects TAM signalling, preventing the clearance of apoptotic cells, and this process may lead to infection and inflammation. As a result, rat testicular morphology and function may be impaired.

Lien vers l'article

Dispositifs médicaux implantables

Aucun article dans ce bulletin.