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ORIGINAL ARTICLE

Detoxification of rats subjected to nickel chloride by a biomaterial-based carbonated orthophosphate

Détoxification des rats soumis au chlorure de nickel par un biomatériau à base d'orthophosphate carbonaté

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Summary Recently, the therapeutic approaches of the detoxification against the metals (nickel) in the body are the use of biomaterials such as carbonated hydroxyapatite. The aim of this study is therefore to analyze the physiological and physicochemical parameters of strain white rats ''Wistar'' receiving nickel chloride and to study the protective associative of apatite against adverse effects of this metal, and this in comparison with control rats. Our results showed that the nickel induced in rats an oxidative stress objectified by elevated levels of thiobarbituric acid-reactive substances and conjugated dienes associated with inhibition of the activity of the antioxidant defense system such as glutathione peroxidase, superoxide dismutase and catalase in the liver, kidney, spleen and erythrocyte. Disorders balances of ferric, phosphocalcic, a renal failure and a liver toxicity were observed in rats exposed to nickel. As well as a significant increase in the rate of nickel in the bones and microcytic anemia was revealed. However, the implantation of carbonated hydroxyapatite in capsule form protects rats intoxicated by the nickel against the toxic effects of this metal by lowering the levels of markers

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of lipid peroxidation and improving the activities of defense enzymes. Our implantation technique is effective to correct ferric balance and phosphocalcic equilibrium, to protect liver and kidney function, to reduce the rate of bone nickel and to correct anemia. They clearly explain the beneficial and protective of our biomaterial which aims the detoxification of rats receiving nickel by substituting cationic (Ca^{2+} by Ni^{2+}) and anionic (OH^- by Cl^-) confirmed by physicochemical characterization like the IR spectroscopy and X-ray diffraction. These techniques have shown on the one hand a duplication of OH^- bands (IR) and on the other hand the increase of the volume of the apatite cell after these substitutions (X-ray diffraction).

MOTS CLÉS
Hydroxyapatite carbonatée ;
Détoxification ;
Nickel ;
Substitution

Résumé Récemment, une nouvelle approche de la détoxification des métaux (nickel) stockés dans le corps par des biomatériaux implantés tels que l'hydroxyapatite carbonatée a été proposée. L'objectif de cette étude était d'analyser les paramètres biologiques et physicochimiques d'une souche de rats blancs « Wistar » recevant du chlorure de nickel et d'étudier la protection associative de l'apatite contre les effets néfastes de ce métal, par rapport aux rats témoins. Nos résultats ont montré que le nickel induit chez les rats un stress oxydatif objectivé par des taux élevés des substances réagissant avec l'acide thiobarbiturique et des dienes conjugués associés à l'inhibition de l'activité du système de défense antioxydant comme la glutathion peroxydase, la superoxyde dismutase et la catalase rénale, splanchnique, et érythrocytaires. Des troubles de la balance ferrique, phosphocalcique, une insuffisance rénale et une toxicité hépatique ainsi qu'une augmentation significative du taux de nickel osseux et une anémie microcytaire ont été observés chez les rats exposés au nickel. Cependant, l'implantation d'hydroxyapatite carbonatée protège les rats intoxiqués par le nickel contre ses effets toxiques, ce qui a été montré par la baisse des marqueurs de peroxydation lipidique et l'amélioration des activités des enzymes de détoxification. Notre technique d'implantation est efficace pour corriger l'équilibre ferrique et phosphocalcique, protéger les fonctions hépatique et rénale, réduire le taux de nickel osseux et corriger l'anémie. L'effet protecteur du biomatériau est expliqué par la substitution cationique (Ca^{2+} par Ni^{2+}) et anionique (OH^- par Cl^-), ce qui a été confirmé par l'étude du biomatériau implanté par spectroscopie infrarouge (duplication de la bande OH) et par diffraction des rayons X (augmentation du volume de la maille apatitique).

Introduction

Nickel, an environmental pollutant, acts as an oxidative stress inducing cytotoxicity [1]. This cytotoxicity demonstrated by measuring products of lipid peroxidation. It can also cause genotoxic effects giving tumors with a change in membrane permeability [2]. Thus, the metal causes various adverse effects at the cellular and tissue (disruption of the redox state of tissues, phosphate balance problems, impaired hepato-renal, hematological effects, etc.).

To overcome the problems of this metal, this present study consists of using apatite biomaterials which present biocompatibility, bioactivity and bioresorbable optimized [3–5].

The apatites such as the carbonated hydroxyapatite (HAC) are characterized by the presence of tunnels which have played a very important role in their physicochemical properties. Because of the existence of the tunnels, apatites can behave either as ion exchangers, either as compounds in which the various ions may be substituted such as nickel for detoxification of the body. One of the main characteristics of the apatite structure is to admit a large number of substitutions that leave unchanged the crystallographic structure [6,7].

In previous work, we succeeded in elaborating apatite doped with heavy metals such a lead [8]. There is experimental evidence that the apatite structure is endowed with a very important potential trapping for toxic heavy metals. This trapping phenomenon is already confirmed in solution in the water depollution discharges, by the use of biomaterials membranes [9,10]. Taking account of these results, it seemed interesting to highlight this phenomenon trapping in physiological environment animal (in vivo) without creating any side effects and oxidative stress. To do this, we must exercise implantation in the body of the animal intoxicated beforehand and characterize our biomaterial on the physiological and physicochemical plans after sacrifice.

Material and methods

Synthesis of the biomaterial

The powder of the carbonated hydroxyapatite (HAC) was prepared by the method of double decomposition (wet), which consists in adding a solution of calcium nitrate to a solution of ammonium phosphate in well-defined operating conditions. The product obtained after filtration of the

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