Determination of metal ion levels in circulation in patients with joint replacement

Lucie Válková[1,*], Jan Emmer[2], Jan Kuta[3] and Monika Pávková Goldbergová[1]

[1]*Department of Pathophysiology, Faculty of Medicine, Masaryk University, Kamenice 5, Brno, Czech Republic*
[2]*1st Department of Orthopaedics, St. Anne's University Hospital, Pekařská 53, Brno, Czech Republic*
[3]*Research Centre for Toxic Compounds in the Environment (RECETOX), Masaryk University, Kamenice 5, Brno, Czech Republic*

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INTRODUCTION: In the past century, total joint arthroplasty has been recognized as one of the most successful and effective orthopaedic procedures. This approach, which treats mostly hip and knee joint disorders, may reduce pain, correct deformity, and improve the patient's quality of life. Materials of choice for orthopaedic implants include stainless steel, cobalt-chromium alloys, and titanium alloys. [1] When using a metal implant, some degree of material degradation is unavoidable, which can cause issues for the patient. Various factors leading to implant deterioration are expected to result in the release of nanoparticles or ions, which can cause loosening and osteolysis. The release of oxides and metal ions can be detectable within the first few days after the alloy implantation. The tissue surrounding the implants can collect dissolved metal ions, or the ions can be discharged into bloodstream and accumulate in distant organs. The present study is focused on monitoring metal ions released from implanted material into circulation.

EXPERIMENTAL: Patients indicated for total joint replacement who have signed an informed consent and agreed to enter the study were included in the project. Blood samples of 100 patients were drawn before implantation, 24 hours after implantation, and in 6 to 12 months' follow-up. Concentrations of Ti, V, Co, and Ni in samples of whole blood were determined by inductively coupled plasma mass spectrometry (Agilent 8900 ICP-MS/MS, Agilent technologies) after 10× dilution of samples by solution containing deionized water, a nonionic surfactant Triton X-100 (0,04 %), ammonia (1 %), butanol (2 %), EDTA (0,04 %), and the appropriate internal standards for ICP-MS/MS (20 ng/ml of Sc, Ge, In, Lu and Bi). The method was validated by analysis of samples spiked with known amount of analytes and by analysis of following certified reference materials (SERO AS, Norway): Seronorm™ Trace Elements Whole Blood Level 1 and Seronorm™ Trace Elements Whole Blood Level 2.

RESULTS AND DISCUSSION: Concentrations of vanadium ions were elevated immediately after implantation, irrespective of patient characteristics. In some cases, higher concentrations of cobalt and nickel were measured, especially in the case of implants with a CoCr/polyethylene articulating surface. An increase in Ti ion concentration was observed in blood drawn 6–12 months after surgery. All cases of significant increases involved uncemented implants of several specific types.

CONCLUSIONS: The results showed that the use of cement in implants affects the release of metal ions, especially titanium. The presence of metal ions in human body, as well as their influence on tissues and cells, raises questions regarding their safety and toxicity over time.

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*Corresponding author E-mail: lucie.valkova@med.muni.cz