NEUTRON ACTIVATION ANALYSIS OF HUMAN TISSUES, ORGANS AND BODY FLUIDS TO DESCRIBE THE INTERACTION OF ORTHOPAEDIC IMPLANTS MADE OF COBALT–CHROMIUM ALLOY WITH THE PATIENTS ORGANISMS

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In order to describe the impact of corrosion of medical implants on the trace element balance of man samples of blood, serum and of a variety of tissues and organs were analysed for their trace element composition using instrumental neutron activation techniques. By the analysis of blood and serum the trace element status after long-term implantation as well as its dependence on time after implantation was investigated. Using autopsy samples of human organs such as heart, spleen, liver, of aorta and of lymphatic tissue from the lower pelvis transport and storage of the corrosion products was studied. These investigations were supplemented by a comprehensive study of „normal“ human blood, serum, tissues and organs from patients without implants. The results demonstrate that there are high enrichments of corrosion products in several tissues and organs and that also blood and serum reveal the presence of the metal implants in the trace element levels, increasing shortly after implantation and pertaining during the entire implantation time. Thus the corrosion of metallic implants is a process not only affecting tissues from the vicinity of the implants but also influencing the trace element balance of the entire organism.

Introduction

Metal implants as used in orthopaedic surgery and odontology represent pools of (essential) trace elements in the patients body. By the interaction of the implant surfaces with the highly corrosive body fluids these pools are mobilized and disturb the trace element balance of the surrounding tissues as well as of the entire organism /1/.

Trace element analysis of human tissues and body fluids is a necessary prerequisite for the investigation of the interactions of the human organism with metal implants. The chemical analysis has to provide the data base of the changes in the trace element composition which then may be used for an assessment of risk by connecting the concentration or dose data with the possible health effects.

Instrumental neutron activation analysis is particularly well suited for the required analyses. As a multielement technique it allows for the simultaneous determination of nearly all alloy constituents and of a num-
R. MICHEL et al.: NEUTRON ACTIVATION ANALYSIS OF HUMAN TISSUES

ber of further essential elements thus giving a comprehensive survey on the trace element status of the patient. Its inherent low blank values, its excellent accuracy are further advantages. However, there are some limitations with regard to sensitivity which only can be overcome by applying time consuming radiochemical techniques.

During the last years in our laboratory comprehensive studies of the changes of normal trace element levels in man and animal due to the corrosion of Cr-Ni(AISI 316L)-alloys /e.g. 2,3/ and Co-Cr-alloys /e.g.4,5/ used for osteosynthesis, alloarthroplasties and total joint replacement have been performed, see /1/ for a survey. Up to now, most of the existing data are related to tissues from the surroundings of the implants. For such tissues the analyses reveal extreme burdening by corrosion products. The actual tissue concentrations, however, are influenced by both the type of corrosion and the mobility of the particular elements in the body.

Investigations of tissues far from the implants, organs, blood and blood constituents are still rare and to a large degree suffering from severe methodological drawbacks. A detailed discussion of the work done in the past and on the methodological problems will be given elsewhere /6/. Therefore, a systematic investigation was initiated in order to study the release of metals from totalendoprostheses (TEP's) of the hip joint made of Co-Cr-alloys to the patients body. This project covers the analysis of whole blood and serum after long term implantation as well as the investigation of the dependence of trace element concentrations of these materials as a function of time after implantation. Moreover, autopsy material from deceased implant bearers is analyzed to study transport and storage of corrosion products in the patients body. These investigations are supported by a comprehensive study of normal trace element levels in human tissues and body fluids.

Experimental

In order to study the trace element status after long-term implantation whole blood and serum was analyzed from 19 patients (5 male, 14 female), aged 49 to 91 years. All patients had TEP's of the hip joint made of Co-Cr-alloys in form of metal-polyethylene combinations. 9 of them had TEP's at both hip joints. One patient additionally had an angle plate made of AISI 316L stainless steel. The duration of implantation ranged from 7 to 216 month. In spite of the fact that the prostheses originated from several manufactu-