SYSTEMIC RELEASE OF COBALT AND CHROMIUM AFTER UNCEMENTED TOTAL HIP REPLACEMENT

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We measured the levels of cobalt and chromium in the serum in three groups of patients after uncremented porous-coated arthroplasty. Group 1 consisted of 14 consecutive patients undergoing revision for aseptic loosening. Group 2 comprised 14 matched patients in whom the arthroplasty was stable and group 3 was 14 similarly matched patients with arthritis awaiting hip replacement. Specimens were analysed using atomic absorption spectrophotometry.

Aseptic loosening of a component resulted in a significant elevation of serum cobalt ($p < 0.05$), but not of serum chromium. The relative risk of a component being loose, if the patient had a serum cobalt greater than 9.0 nmol/l, was 2.8.

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Release of metal from prosthetic materials occurs by wear, corrosion and mechanisms such as fretting, stress and fatigue (Black 1988); it may be associated with tumour formation (Gillespie et al 1988; Visuri and Koskenvuo 1991) or modulation of the immune response (Rostoker et al 1987; Bravo et al 1990; Case et al 1994). The increasing use of porous-coated implants with a high surface area may enhance these effects (Galante et al 1991).

Wear debris from a total joint replacement has been observed in the periarticular tissues (Lee et al 1992), the circulation (Sunderman et al 1989; Michel et al 1991) and in distant solid tissues (Bartolozzi and Black 1985; Jacobs et al 1991; Case et al 1994). Attempts to quantify this have yielded conflicting results because of variation in the types of prostheses studied, the duration of implantation, lack of adequate controls and difficulties with the techniques of assay.

The development of atomic absorption spectrophotometry and neutron activation analysis has allowed the accurate determination of trace elements, although extreme care needs to be taken in both collection and analysis of the specimens (Sunderman et al 1989; Michel et al 1991).

Our aim was to determine the effect of the stability of the components on metal release after implantation of a porous-coated total hip arthroplasty made of cobalt-chromium alloy.

PATIENTS AND METHODS

Subjects were taken from a cohort of 375 patients who had received a Porous-Coated Anatomic (PCA) hip replacement (Howmedica International, New Jersey). The prostheses were all of the earlier design and had a metal stem with a modular head and non-modular metal-backed acetabular component. The metal components were manufactured from vitallium, a cobalt-chromium-molybdenum alloy.

There were three groups. Group 1 was a consecutive series of 14 patients in whom a hip replacement had been revised for aseptic loosening. Group 2 comprised 14 individually matched patients with a stable implant as assessed radiographically. Fixation of the femoral component was maximum according to the radiological method of assessing stem fixation of Engh, Massin and Suthers (1990) and the acetabular component showed no signs of migration, rotation or interface deterioration on successive standardised radiographs.

The patients in group 2 were matched according to age (within 12 years, which was the closest match possible) and diagnosis (primary and secondary osteoarthritis or rheumatoid arthritis) and were within one year of the primary operation. Group 3 consisted of 14 matched control subjects who were patients awaiting joint replacement. Patients were excluded if there was more than one implant in situ or if they had had previous orthopaedic surgery or a history of occupational exposure to cobalt or chromium as dye-industry or sheet-metal workers.

Collection of specimens was undertaken by DNK using a reproducible technique in which blood was drawn through
a 16-gauge polypropylene cannula (Viggo, Sweden). The first 5 ml of blood were discarded and the specimen was then introduced into plastic collecting tubes. Sample collection and analysis for each group proceeded concurrently.

The specimens were analysed in triplicate by atomic absorption spectrophotometry with electrothermal atomisation (ETA-AAS) from a L’Vov platform (1978) using an automatic sampler, pyrolytic graphite tubes and a Zeeman background correction system. Sample preparation was by a 1+2 aqueous dilution, with in situ oxygen ashing during electrothermal decomposition. Calibration was by standard additions and the limits of detection were 1 nmol/l for chromium and 5 nmol/l for cobalt.

Analysis of the data was performed using the Friedman two-way analysis of variance.

RESULTS

The details of the patients in each group and the serum concentrations of cobalt and chromium are shown in Tables I to III. The distribution of the values for serum cobalt and chromium showed ten for cobalt and three for chromium which were below the limits of laboratory detection. Median values are shown with 95% confidence limits. Figures 1 and 2 show the comparisons between the groups of matched patients in graphical form. There was no significant
difference between the patients with stable hips (group 2) and the control group (group 3) in terms of the serum concentration of metals (p = 0.59 for cobalt, p = 1.00 for chromium). In group-1 patients with aseptic loosening there was a significant rise in serum cobalt (p < 0.05) compared with both the stable group and the control group. There was no similar finding for chromium (stable p = 0.59, control group p = 0.42).

DISCUSSION
The consequences of the systemic distribution of metal from a prosthesis remain unknown but concern has centred on the immunological and oncological effects (Apley 1989; Bullough 1994). Wear debris has been shown to initiate an immune response in the periprosthetic membrane (Jiranek et al. 1993), and there is evidence that systemic spread induces a more generalised process (Bravo et al. 1990; Gil-Albarova et al. 1992; Case et al. 1994). Epidemiological studies have suggested that there is an increased incidence of tumours of the lymphoreticular system in patients with prosthetic joint implants (Gillespie et al. 1988; Visuri and Koskenvuo 1991).

The findings of previous authors are conflicting. This is probably because of lack of suitable controls, contamination during the collection or analysis of the specimen and

**Table III.** Details of the patients in group 3 (control)

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Serum Co (nmol/l)</th>
<th>Serum Cr (nmol/l)</th>
</tr>
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<tr>
<td>1</td>
<td>58</td>
<td>M</td>
<td>OA</td>
<td>12</td>
<td>21</td>
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<td>57</td>
<td>M</td>
<td>OA</td>
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<td>31</td>
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<td>37</td>
<td>F</td>
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<tr>
<td>5</td>
<td>58</td>
<td>F</td>
<td>OA</td>
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<td>&lt;1</td>
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<tr>
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<td>58</td>
<td>M</td>
<td>OA</td>
<td>10</td>
<td>25</td>
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<td>RA</td>
<td>&lt;5</td>
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<td>M</td>
<td>OA</td>
<td>&lt;5</td>
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<td>59</td>
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<td>62</td>
<td>M</td>
<td>OA</td>
<td>&lt;5</td>
<td>19</td>
</tr>
<tr>
<td>Mean</td>
<td>50.2</td>
<td></td>
<td></td>
<td>12.5</td>
<td>20</td>
</tr>
<tr>
<td>95% CI</td>
<td>Undetectable to 20</td>
<td>2 to 25</td>
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</tr>
</tbody>
</table>
variables such as variations in implant design, patient demographics, the time from operation before collection of the specimen and the number and stability of the joint replacements in situ (Dobbs and Minski 1980; Bartolozzi and Black 1985; Pazzaglia et al 1986; Stulberg et al 1987; Sunderman et al 1989; Jacobs et al 1991). These errors are reduced to a minimum by the individual matching of patients.

We found that the levels of cobalt and chromium in the serum in a patient with a stable hip replacement did not differ significantly from those in the control group awaiting operation. Similar findings were obtained by Sunderman et al (1989) and Michel et al (1991).

Although loosening of the prosthesis produces deposition of debris, including metal, in the surrounding capsular tissues (Lee et al 1992), the systemic distribution of this material has received little attention. Jacobs et al (1991) found significantly elevated levels of serum titanium when aseptic loosening of a titanium-based alloy prosthesis had occurred. We observed a significant elevation of serum cobalt but not of chromium. The reason for this cannot be determined from this study, although it could be due to fretting, since micromovement occurs between the loose component and host bone. It is probable that the metals are released in equal amounts locally but cobalt seems more likely to be distributed in the body. The patients showed no signs of ill health and the serum cobalt levels were below those considered acceptable for occupational exposure (Lauwerys and Holt 1983; Friberg, Nordberg and Vouk 1986).

The question remains as to whether serum cobalt may be used as a marker for loosening of a total hip replacement. In our series there was overlap between the groups for values of serum cobalt. A concentration of more than 9.0 nmol/l resulted in a poor sensitivity (0.64), a relatively good specificity (0.86) and a relative risk of 2.8 for loosening of one component of a PCA hip replacement.

Conclusions. A stable Porous Coated Anatomic hip replacement is not associated with an alteration in the levels of serum cobalt or chromium, but loosening produced a significant elevation of serum cobalt levels. The long-term effects of this are unknown.

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REFERENCES


