Metal Exposure after Hip Replacement and the Risks of Systemic Toxicity

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Large diameter metal on metal bearings in total hip arthroplasty and hip resurfacing (MOMHR) have been inserted in large numbers both in the United Kingdom and worldwide in recent years (Figure 1). However, because of high prosthesis failure rates the use of these devices has undergone a dramatic decline since its peak at 31% of cases reported to the NJR in 2007 to 1% of cases in 2013. More recently, dual modular necked femoral prostheses have also been implicated in early prosthesis failure. Potential adverse systemic effects of metal release from failing prostheses remain a concern, and our knowledge to date in this area is reviewed here together with the prospects for future understanding in this area.

Background

Cobalt and chromium are the principal metals released by MOM prostheses. Both metals are essential trace elements in man, with physiological circulating concentrations of between 0.1 and 0.2µg/L. Blood levels of cobalt and chromium rise after MOMHR, with late steady state median blood concentrations of between 1.5 and 2.3µg/L in patients with well-functioning prostheses. The majority of MOMHR prostheses have been inserted in younger, more active patients, and the majority of these prostheses are functioning well. The median life-expectancy of prostheses in this age group equates to a duration of exposure to cobalt and chromium that is in excess of 20 years.

Can exposure to high circulating metal concentrations cause systemic illness?

A failing MOMHR prosthesis is associated with circulating cobalt and chromium concentrations that may be several times higher than those seen in patients with well-functioning prostheses. Case reports of patients with failed prostheses also suggest that very high blood metal concentrations are associated with systemic effects including cardiac, neurological, and endocrine dysfunction.

A recent systematic review of the relationship between metal exposure and features of systemic toxicity was conducted by Bradberry, Wilkinson, and Ferner. In this review we searched Medline and Embase between 1980 and 2014 for published cases of possible cobalt or chromium toxicity associated with hip prostheses. Although there were 23 reports describing original case data, a total of only 18 individual patient cases were described within the reports. In 10 of these cases the patient had undergone revision of a fractured ceramic-containing bearing to a cobalt-chrome containing bearing and the source of the elevated systemic cobalt concentrations was ascribed to accelerated wear of the revision metal-containing bearing due to ceramic third body wear (Figure 2). The other eight patients had received a primary MOM prosthesis. Three main categories of systemic toxicity were identified, including neuro-ocular toxicity (14 patients), cardiotoxicity (11 patients), and thyrotoxicity (9 patients). The median blood cobalt concentration in these cases was 398µg/L (range 13.6 to 6521), and was substantially higher in the failed ceramic bearing group than in the primary MOM prosthesis group. Removal of the prosthesis in these cases was usually associated with a fall in systemic cobalt concentrations and an improvement in clinical symptoms.
concentrations associated with well-functioning metal-containing hip prosthesis. The head and liner were subsequently exchanged to a cobalt-chrome on polyethylene bearing that later resulted in accelerated wear of the prosthetic head, metallosis, and grossly elevated whole blood cobalt concentrations.

How might we link systemic illness with metal exposure?

Based on these findings we proposed toxicological criteria for assessing the likelihood that clinical features are related to cobalt toxicity: clinical effects consistent with the known neurological, cardiac, or thyroid effects of cobalt, and for which any other explanation is less likely; increased blood cobalt concentrations (substantially higher than those in patients with well-functioning prostheses) several months after hip replacement; a fall in the blood cobalt concentration after treatment, accompanied by signs of improvement in features. When judged by these criteria, the systemic features in 10 of the reported cases were felt likely to be related to cobalt exposure from a metal-containing hip prosthesis.

Does chronic exposure to low metal concentrations cause systemic illness?

The case for adverse systemic effects due to long term chronic low level elevation of metal concentrations associated with well-functioning MOM prostheses remains unclear. Chronic industrial and accidental over-exposure to cobalt or chromium associates with solid organ damage including the heart, liver, kidneys, pituitary and thyroid glands, and thus there is a theoretical case for association after MOMHR.

Summary

Exposure to very high circulating concentrations of cobalt associates with cardiac, neurological, and thyroid disease. We found in the majority of these cases the associating problem is accelerated wear of a cobalt-containing revision bearing used to replace a fractured ceramic bearing. The case for an adverse effect of chronic exposure to low circulating metal concentrations remains less clear. Our findings of differences in bone and cardiac function between patients groups suggest that chronic exposure to low elevated metal concentrations in patients with well-functioning MOMHR prostheses may have systemic effects. Long-term epidemiological studies that link registry data with other clinical datasets may provide sufficient power to definitively establish whether such associations are clinically relevant.

Clinical toxicological assessment of systemic features in patients with metal-containing hip prostheses

Proposed assessment criteria for cobalt-related disease: 1. History: A MOM or a fractured ceramic-containing prosthesis has been replaced by a metal component; local symptoms of pain are present; the patient’s symptoms are consistent with known cardiac, neurological, or thyroid effects of cobalt, and for which any other explanation is less likely.

2. Clinical and investigation findings: There are objective signs consistent with known cardiac, neurological, or thyroid effects of cobalt, for which any other explanation is less likely. Local abnormalities (damaged prosthesis, metallosis) on radiology or at surgery are present.

3. Timing: Clinical features develop months to years after factors increasing blood cobalt concentrations.

4. Cobalt concentration: Measured cobalt concentrations are substantially higher than those in patients with well-functioning prostheses.

5. Response to removal of the prosthesis: Blood cobalt concentration falls after removal of the prosthesis, and the fail is usually accompanied by clinical improvement.

Mark Wilkinson is an arthroplasty surgeon with a special interest in the interactions between patients and their prostheses. His work includes studying the effects of metal exposure on bone, the heart, and other solid organs, and the risk factors for prosthesis failure.

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References

References can be found online at www.boa.ac.uk/publications/JTO or by scanning the QR Code.
References


