

Pure red cell aplasia – still the spectre at the feast

Iain C Macdougall¹, Fernando Carrera²

¹ Department of Renal Medicine, King's College Hospital, London, UK

² Dialysis Unit, Eurodial, Euromedic, Leiria, Portugal

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■ INTRODUCTION

Erythropoiesis Stimulating Agent (ESA) therapy has transformed the management of CKD anaemia over the last couple of decades. Not only is the treatment highly effective, but it is one of the safest therapies that nephrologists use. Adverse effects are uncommon, and apart from occasional exacerbation of hypertension (which is usually easily managed), the treatment is remarkably well tolerated. There have been recent concerns about driving the haemoglobin up to too high a level following the publication of the CHOIR¹ and CREATE² studies, and the subsequent meta-analysis in the Lancet³, but again this is well within the capabilities of the attentive nephrologist.

ESA-associated pure red cell aplasia (PRCA), on the other hand, has in recent years been found to be a sporadic, unpredictable, and serious complication of anaemia therapy, and although this condition is extremely rare, its consequences can be catastrophic⁴. Patients suffering from this condition develop a rapid fall in haemoglobin concentration associated with a profound reticulocytopenia, and sparse or absent erythroblasts in the bone marrow⁵. The condition is mediated by antibodies against erythropoietin. These not only neutralise all currently available ESAs, but also the patient's own endogenous erythropoietin, thus obliterating any possible remaining erythropoietic activity in the bone marrow. There is no analytical technique available for identifying the trigger ESA drug.

Prior to 1998, a few isolated cases were reported in the literature, but following the publication of

Nicole Casadevall's case series in the *New England Journal of Medicine* in February 2002⁶, increasing numbers of cases began to be reported, and there was much effort directed at elucidating the cause of this condition. More specifically, the reasons why some patients broke immune tolerance and developed antibodies against a naturally-occurring recombinant protein were investigated, and several pieces of the "pathogenesis jigsaw" came to light⁷.

■ POSSIBLE CONTRIBUTORY CAUSES TO ANTIBODY-MEDIATED PRCA

Early on in the investigations, it was apparent that the increase in reported cases was not simply attributable to increased patient exposure. The latter had been steadily rising from 1989 onwards, while the PRCA cases clearly developed after 1998 (Fig. 1). There was a clear preponderance of cases with epoetin alfa produced outside the US, and the link between this and the removal of human serum albumin from Eprex (mandated by the European Union in an attempt to control a feared outbreak of Creutzfeldt-Jakob disease) became a likely suspect⁷. Its replacement by polysorbate 80 was also implicated in the "micelles hypothesis", which was based on the fact that this detergent orientated the recombinant protein in such a way as to render it more antigenic⁸. All cases of antibody-mediated PRCA reported since 1998 occurred with the use of the subcutaneous (SC) route of administration, and it is well-known that the SC route of administration is more immunogenic in man, due to the presence of Langerhans cells in the epidermis.

Annual Ab-positive PRCA cases reported and exposure By year of LOE occurrence (Ex-US 1989–2004)



Figure 1

Concerns were also raised about possible breaks in the cold storage chain, leading to greater instability of the protein. Finally, the “rubber leachate hypothesis” was proposed as a major contributory factor⁹. Eprex syringes containing both polysorbate 80 and rubber stoppers showed extra peaks on a chromatogram, and the chemical composition of these leachates from the rubber stoppers was determined. The final piece of the jigsaw was to show that these rubber leachates could act as an immune adjuvant, to intensify the immune response, and some *in vitro* data were generated to support this hypothesis^{9,10}.

Ortho Biotech reacted quickly to their concerns about the “rubber leachate hypothesis”, replacing all the Eprex syringes with teflon-coated stoppers. In addition, their scientists showed that syringes containing teflon-coated stoppers, even when polysorbate 80 was used as the detergent, did not generate any extra peaks on the chromatogram. Thus, the company believed that they had solved this mystery, and the next hurdle was

to convince the EMEA that this was the case. The French health regulatory agency (AFSSAPS) was the first (May 2006) to feel that the data had some credibility, and granted Ortho Biotech a re-instatement of their subcutaneous license which had previously been removed. Portugal (INFARMED) followed suit in July. This renewal was, however, dependent on Ortho Biotech setting up a postmarketing surveillance registry to collect data on 20,000 patient years of exposure to all currently available ESAs. This postmarketing surveillance initiative (the PRIMIS survey) is now underway.

■ Why is the mystery not completely solved?

Although the “rubber leachate hypothesis” may have explained the excess number of Eprex-associated cases in Europe, this cannot be the only explanation for antibody-mediated PRCA. This condition has been seen in patients who have received epoetin alfa prepara-

tions containing neither polysorbate 80 nor rubber stoppers, and also with the other currently available ESAs (epoetin beta and darbepoetin alfa). Thus, there is a low background incidence of antibody-associated PRCA which has not yet been explained, and new cases have appeared in Germany, the UK, and more recently Portugal, all within the last year. There is also concern that, with the impending arrival of biosimilar epoetins, there will be a further upsurge in cases of antibody-mediated PRCA. This concern led three French nephrology societies to produce a June 2006 position statement on the approval and use of biosimilars. We applaud this stance and feel more countries should work towards a national consensus on this issue.

■ INVESTIGATION OF A SUSPECTED PRCA CASE

The diagnosis of antibody-mediated PRCA associated with ESA therapy is not subtle. The patient usually experiences rapid onset of transfusion-dependence, along with a reticulocyte count $<10 \times 10^9/L$. A bone marrow shows absence of erythroid progenitor cells, with the final criterion for the diagnosis of this condition being the detection of circulating antibodies in the serum of the affected patient⁵. The latter is important in excluding other rare causes of PRCA, such as those associated with a thymoma or lymphoma, viral infections, or certain drugs. The vast majority of cases of a loss of response to ESA therapy will not be due to this cause, and other conditions such as bleeding, intercurrent infections, and haemolysis should be excluded first¹¹. The ERA-EDTA Anaemia Working Group devised detailed recommendations in 2004 on how nephrologists should proceed in the face of a suspected PRCA case¹². They also advised that a baseline serum sample be taken and stored prior to switching ESA brands, in order to ascertain more definitively which ESA brand might be responsible if PRCA were to develop.

■ MANAGEMENT

The critical first step in managing a patient who is suspected of having developed antibody-mediated PRCA is to stop the ESA therapy¹². Patients

should not be switched to another ESA since the antibodies cross-react with all currently available agents, and attempts should then be made to suppress the antibody formation with immunosuppressant drugs. Several such agents have been used, including cyclosporin, prednisolone, cyclophosphamide, mycophenolate, and rituximab. The success of these various immunosuppressive regimens is variable but the best chance of remission appears to be with the use of cyclosporin or cyclophosphamide¹³. Plasmapheresis has also been tried, but with disappointing results. Another approach which is currently being tested is to treat such patients with an erythropoietin receptor agonist which does not cross-react with anti-erythropoietin antibodies. This new agent, still in Phase II of its clinical trial programme, is called Hematide, a synthetic erythropoietin-mimetic peptide. Early results from this clinical trial appear promising, and we await the full publication of this study with interest.

■ CONCLUSIONS

Antibody-mediated PRCA is an extremely rare but nevertheless potentially devastating complication of ESA therapy. It is usually fairly obvious clinically, with well-defined characteristics. Its management at the present time consists of stopping all ESAs and instituting immunosuppressive therapy. Although rare, nephrologists should be aware of the features of this condition, in order that an early diagnosis may be made.

The first case of antibody-mediated PRCA in Portugal¹⁴ means that not even this blessed country is spared a visit from this spectre at the feast!

Conflict of interest statement.

Dr Macdougall has received research grants, honoraria, and lecture fees from Amgen, Ortho Biotech, Roche, Shire and Affymax.

Dr Carrera is a scientific consultant, member of steering committees for international clinical trials and/or member of international advisory boards for the following companies: Amgen (Europe), Roche (International) and Shire (International).

References

- 1 Singh AK, Szczech L, Tang KL *et al*. Correction of anemia with epoetin alfa in chronic kidney disease. *N Engl J Med* 2006; 335: 2085-2098.
- 2 Druke TB, Locatelli F, Clyne N *et al*. Normalization of hemoglobin level in patients with chronic kidney disease and anemia. *N Engl J Med* 2006; 335:2071-2084.
- 3 Phrommintikul A, Haas SJ, Elsik M, and H Krum. Mortality and target haemoglobin concentrations in anaemic patients with chronic kidney disease treated with erythropoietin: a meta-analysis. *Lancet* 2007; 369: 381-388.
- 4 Bennett CL, Luminari S, Nissenson AR, *et al*. Pure red-cell aplasia and epoetin therapy. *N Engl J Med* 2004; 351: 1403-1408.
- 5 Rossert J, Casadevall N, Eckardt KU. Anti-erythropoietin antibodies and pure red cell aplasia. *J Am Soc Nephrol* 2004; 15: 398-406.
- 6 Casadevall N, Nataf J, Viron B, *et al*. Pure red-cell aplasia and antierythropoietin antibodies in patients treated with recombinant erythropoietin. *N Engl J Med* 2002; 346: 469-475.
- 7 Boven K, Stryker S, Knight J, *et al*. The increased incidence of pure red cell aplasia with an Eprex formulation in uncoated rubber stopper syringes. *Kidney Int* 2005; 67: 2346-2353.
- 8 Schellekens H. Bioequivalence and the immunogenicity of biopharmaceuticals. *Nat Rev Drug Discov* 2002;1:457-62.
- 9 Sharma B, Bader F, Templeman T, Lisi P, Ryan M, Heavner GA. Technical investigations into the cause of the increased incidence of antibody-mediated pure red cell aplasia associated with EPREX. *Eur J Hosp Pharm* 2004; 5: 86-91.
- 10 Schellekens H, Jiskoot W. Eprex-associated pure red cell aplasia and leachates. *Nat Biotechnol* 2006; 24: 613-614.
- 11 Johnson DW, Pollock CA, Macdougall IC. Erythropoiesis-stimulating agent hyporesponsiveness. *Clin J Am Soc Nephrol* 2007 (in press).
- 12 Locatelli F, Aljama P, Barany P, Canaud B, Carrera F, Eckardt KU, Macdougall IC, Macleod A, Horl WH, Wiecek A, Cameron S. Erythropoiesis-stimulating agents and antibody-mediated pure red-cell aplasia: where are we now and where do we go from here? *Nephrol Dial Transplant* 2004; 19: 288-293.
- 13 Rossert J, Macdougall I, Casadevall N. Antibody-mediated pure red cell aplasia (PRCA) treatment and re-treatment: multiple options. *Nephrol Dial Transplant* 2005; 20 (Suppl. 4): iv: 23-26.
- 14 Vinhas J. 2007 (Personal communication).

Correspondence to:

Dr Iain C Macdougall
Consultant Nephrologist
Renal Unit
King's College Hospital
London SE5 9RS, UK
Tel No: ++44-207 346 6234
Fax No: ++44-207 346 6472
e-mail: iain.macdougall@kch.nhs.uk