proven Legionella infection due to sero-
groups other than 1 did not show a serolog-
ic response to the serogroup 1 antigen. 
These cases could well have been missed if 
polyvalent pools of Legionella antigens 
other than serogroup 1 had not been used.

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Aluminium-induced dialysis osteomalacia

We were interested to read the paper by 
Buchanan et al in your issue of December 
1981 concerning the use of Aluminon 
(aurine tricarboxylic acid) to stain 
aluminium in the bone of haemodialysis 
patients.1

Over the past few years we have success-
fully applied this technique (together with 
other standard methods for staining 
aluminium such as solochrome azurine 
and naphthochrome green) to demonstrate 
aluminium in formalin or alcohol fixed 
undecalciﬁed bone sections after embed-
ding in our standard resin (Bondaglass, 
Polymaster 1209 AC).

The stains are positive in experi-
mentally induced peritoneal aluminium 
granulomata, in the bones of rats given 
adulmin chloride and in the bones of 
patients with chronic renal failure dialysed 
with water containing aluminium and 
seem to provide a reliable indication of 
the presence and localisation of aluminium 
in bone. Thus these patients and the 
experimental animals have raised serum 
aluminium concentrations, increased 
amounts of aluminium in bone as estimated 
by neutron activation analysis and recently 
it has been conﬁrmed by microprobe 
analysis that the aluminium is located in 
the region of the mineralisation front2 3 
precisely where the positive staining reac-
tion occurs.

In our experience the staining reaction 
appears mainly in the site of the mineralisa-
tion front as a narrow ﬁnely granular line at 
the interface between mineralised bone 
and osteoid and just spreading on to the 
osteoid itself corresponding to the position 
and appearance of a toluidine blue stained 
normal mineralisation front. In addition 
there is frequently a narrow line of positive 
staining at the bone surface not covered by 
osteoid or in cement lines. In some patients 
treated for years with a dialysate contain-
ing aluminium cement lines giving a posi-
tive reaction may be seen deep in bony 
trabeculae and in cortical bone. Less fre-
quently the stain is positive in ﬁnely granu-
lar patches in osteoid where there are 
attenuations in mineralisation. In the past 
we have noted this type of positive 
reaction in the osteoid and surrounding 
osteocyte lacunae particularly in the bones 
of patients with aluminium-induced 
osteomalacia who had been treated with 
1α-hydroxy vitamin D3 and phosphate 
supplements before the cause of the 
osteomalacia was fully appreciated.

The locations described probably rep-
resent the true sites of accumulation of 
aluminium in bone. Incorporation of 
aluminium in the mineralisation front with 
subsequent interference with normal 
mineralisation would provide a convenient 
rationale for the development of 
osteomalacia in the dialysis patients and 
aluminium-treated experimental animals. 
It could be argued however that the 
aluminium is located elsewhere in the bone 
or marrow in life and diffuses during the 
processing of the bone to become sec-
darily “ﬁxed” in the region of the mineral-
isation front. Studies of rapidly frozen fresh 
bone by microprobe analysis will be 
needed to resolve this problem.

In some haemodialysis patients initially 
without osteomalacia we have noted the 
accumulation of aluminium in bone and 
development of osteomalacia in serial iliac 
bone biopsies and any osteitis fibrosa ini-
tially present tends to resolve. However 
there are some patients with increased 
amounts of bone aluminium, as judged by 
the staining reaction and conﬁrmed by 
nucleon activation analysis, who do not 
develop osteomalacia. These patients tend 
to be amongst those with progressively 
severe hyperparathyroidism and osteitis 
fibrosa and interestingly we have observed 
that osteomalacia may develop in some of 
these patients following parathyroidec-
tomy. It seems that severe degrees of 
hyperparathyroidism may provide some 
protection against the adverse effect of 
aluminium on bone mineralisation.

Since the importance of aluminium in 
inducing osteomalacia was appreciated the 
disease has been eliminated in most centres 
by using appropriate water treatment 
(deionisation, reverse osmosis). In Newcas-
tle, which was formerly a centre with acripp-
pling dialysis osteomalacia, no new cases 
have occurred in recent years. We still see 
occasional referred examples from centres 
elsewhere and wish to stress the value of 
using these simple staining techniques 
when examining iliac bone biopsies from 
dialysis patients.

This type of osteomalacia does not stem 
from following the use of the newer vitamin D3 
metabolites such as 1α-hydroxy vitamin 
D3 or 1,25 dihydroxy vitamin D3 and 
troublesome hypercalcaemia with soft tis-

eue calcification often ensues.4 The 
aluminium stain provides a simple means of 
distinguishing this particular group of 
patients.

The main source for the aluminium is the 
water used for the preparation of the dialys-
sate, particularly in those regions where 
aluminium is added to the water supply to 
ufloculate or precipitate it. 

Increased serum aluminium and deposition 
of stainable aluminium in bone can result 
from the use of oral aluminium-containing 
phosphate binders even in predialysis 
patients with chronic renal failure. In addi-
tion we have studied bone biopsies from 
several patients who developed multiple 
fractures after treatment by a closed loop 
haemofiltration system (Redy cartridge) in 
which there has been osteomalacia and 
characteristic deposition of aluminium. In 
such instances the aluminium is released 
from the cartridge.

Dialysis encephalopathy is another com-
plication of aluminium intoxication and 
may accompany dialysis osteomalacia. The 
chelating agent desferrioxamine has been 
used to treat this condition and with some 
success.5 Recently we have observed heal-
ing of aluminium-induced dialysis 
osteomalacia in serial iliac bone biopsies 
from a patient treated with desferri-
amine and the amount of stainable 
aluminium in the bone was apparently 
reduced. With the exception of renal trans-
plantation, it has been our experience that 
other forms of treatment are usually inef-
tective in this type of osteomalacia.

Finally, it is worth mentioning that the 
aurine tricarboxylic acid stain is reliable 
and reproducible provided one ignores 
false-positive reactions which may occasion-
ally occur at the fragmented and fibro-
ated ends of traumatised trabeculae of 
cortical bone at the margins of the bone 
biopsy.

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