materials is not prohibitive, but the time needed for cell labelling may restrict the technique's use. The second reason that the technique is not more widely used is that, while gammacameras are now installed in most health districts, some departments do not possess radiopharmacy facilities and have to obtain radiopharmaceuticals daily from larger centres. This means that patients needing ^{111}In labelled leucocyte scanning have to travel to the centre for cell labelling, and many are too ill to be moved.

Several developments could ease these difficulties. A preliminary report suggests that blood may be transferred to and from radiopharmacies without damaging cell function,[22] and methods of in vivo cell labelling are being investigated,[23] as are non-cellular carriers such as prophyrins[24] and sucralfate.[25] More extensive use of donor cells may be possible, and a method of labelling leucocytes with technetium-99m has been described,[26] although others have reported a high false negative rate with the technique.[27]

These new procedures need to be developed and fully evaluated. Until then the ability of ^{111}In labelled leucocyte scanning to localise sepsis and its increasing use in gastroenterological practice should encourage all departments with radiopharmacies to include this investigation among their routine procedures.

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1 Anstall HB, Coleman RE. Donor-leukocyte imaging in granulocytopenic patients with suspected abscesses: concise communication. *J Nucl Med* 1982;23:319-21.
2 Dutcher JP, Schiffer CA, Johnston GS. Rapid migration of 111 indium-labelled granulocytes to sites of infection. *N Engl J Med* 1981;**304**:586-9.
3 Datz FL, Jacobs J, Baker W, Landrum W, Alazraki N, Taylor A. Decreased sensitivity of early imaging with In-111 oxine-labeled leukocytes in detection of occult infection: concise communication. *J Nucl Med* 1984;25:303-6.
4 Datz FL, Luers P, Baker WJ, Christian PE. Improved detection of upper abdominal abscesses by combination of 99mTc sulfur colloid and 111In leukocyte scanning. *AJR* 1985;**144**:319-23.
5 Mountford PJ, Coakley AJ, Hall FM, Wells CP. Dual radionuclide subtraction imaging of vertebral disk infection using an In-111 labelled leucocyte scan and a 99mTc-tin colloid scan. *Eur J Nucl Med* 1983;8:557-8.
6 Seabold JE, Wilson DG, Lieberman LM, Boyd CM. Unsuspected extra-abdominal sites of infection: scintigraphic detection with indium-111-labeled leukocytes. *Radiology* 1984;151: 213-17.
7 Carroll B, Silverman PM, Goodwin DA, McDougall IR. Ultrasonography and Indium 111 white blood cell scanning for the detection of intraabdominal abscesses. *Radiology* 1981;**140**:155-60.
8 McAfee JG, Samin Ami. In-111 labeled leukocytes: a review of problems in image interpretation. *Radiology* 1985;**155**:221-9.
9 Saverymuttu SH, Peters AM, Lavender JP. Clinical importance of enteric communication with abdominal abscesses. *Br Med J* 1985;**290**:23-6.
10 Knochel JQ, Koehler PR, Lee TG, *et al.* Diagnosis of abdominal abscesses with computed tomography, ultrasound, and In-111 leukocyte scans. *Radiology* 1980;**137**:425-32.
11 Schauwecker DS, Park HM, Mock BH, *et al.* Evaluation of complicating osteomyelitis with Tc-99m MDP, In-111 granulocytes, and Ga-67 citrate. *J Nucl Med* 1984;25:849-53.
12 Kaps HP, Georgi P, Sinn H. Pitfalls with white bloodcell scanning in orthopaedics. In: Schmidt HAE, Ell PJ, Britton KE, eds. *Nuclear medicine in research and practice.* Stuttgart, FK Schattauer, 1986:150-2.
13 Mountford PJ, Hall FM, Wells CP, Coakley AJ. 99Tcm-MDP, 67Ga-citrate and 111-In-leucocytes for detecting prosthetic hip infection. *Nucl Med Commun* 1986;7:113-20.
14 Froelich JW, Swanson D. Imaging of inflammatory processes with labeled cells. *Semin Nucl Med* 1984;**14**:128-40.
15 Segal AW, Ensell J, Munro JM, Sarner M. Indium-111 tagged leucocytes in the diagnosis of inflammatory bowel disease. *Lancet* 1981;ii:230-2.
16 Saverymuttu SH, Lavender JP, Hodgson HJF, Chadwick VS. Assessment of disease activity in inflammatory bowel disease: a new approach using 111-In granulocyte scanning. *Br Med J* 1983;**84**:1751-3.
17 Buxton-Thomas MS, Dickinson RJ, Maltby P, Hunter JO, Wraight EP. Evaluation of indium scintigraphy in patients with active inflammatory bowel disease. *Gut* 1984;25:1372-5.
18 Anderson JR, Spence RAJ, Laird JD, Ferguson WR, Kennedy TL. Indium-111 autologous leukocyte imaging in pancreatitis. *J Nucl Med* 1986;27:345-52.
19 Mountford PJ, Allsopp MJ, Baird AC, *et al.* A study of leucocyte labelling efficiencies obtained with 111 Inoxine. *Nucl Med Commun* 1985;**6**:109-14.
20 Mountford PJ, Wells CP, Coakley AJ, Hall FM, Baird AC. A simple facility for the aseptic preparation of In-111 labelled leucocytes. *Nucl Med Commun* 1983;4:24-30.
21 Thakur ML, McKenney SL, Park CH. Evaluation of indium-111-2-mercaptopyridine-N-oxide for labeling leukocytes in plasma: a kit preparation. *J Nucl Med* 1985;**26**:518-23.
22 Marshall DSC, Buxton-Thomas MS. Study to examine the feasibility of transporting patients blood to another hospital for indium leucocyte labelling. *Nucl Med Commun* 1986;7:277.
23 Locher JTH, Seybold K, Andres RY, Schubiger PA, Mach JP, Buchegger F. Imaging of inflammatory and infectious lesions after injection of radioiodinated monoclonal antigranulocyte antibodies. *Nucl Med Commun* 1986;7:659-70.
24 Zanelli GD, Bjarnason I, Smith T, Crawley JCW, Levi AJ. Technetium-99m-labelled synthetic porphyrin for the localization of deep-seated infection and inflammation. In: Schmidt HAE, Ell PJ, Britton KE, eds. *Nuclear medicine in research and practice.* Stuttgart: FK Schattauer, 1986:161-3.
25 Dawson DJ, Khan AN, Miller V, Ratcliffe JF, Shreeve DR. Detection of inflammatory bowel disease in adults and children: evaluation of a new isotopic technique. *Br Med J* 1985;**291**: 1227-30.
26 Pullman W, Hanna R, Sullivan P, Booth JA, Lomas F, Doe WF. Technetium-99m autologous phagocyte scanning: a new imaging technique for inflammatory bowel disease. *Br Med J* 1986;**293**:171-4.
27 Peters AM, Lavender JP, Danpure HJ, Osman S, Saverymuttu SH. Technetium-99m autologous phagocyte scanning: a new imaging technique for inflammatory bowel disease. *Br Med J* 1986;**293**:450-1.

Where should low birthweight babies be born?

Neonatal referral services have contributed greatly to improving survival in low birthweight infants. A logical extension of these services seemed to be in utero or antenatal referral of mothers and fetuses thought to be at risk of neonatal problems to a hospital with intensive care facilities. Unfortunately, however, obstetricians are poor at predicting such a need. As a result some referral centres have become overloaded with patients, many of whom would have been better managed at the referring hospital.

Referral centres have sought to justify in utero transfer, or to stem the increasing tide of patients, by comparing outcome in infants transferred antenatally, in those transferred postnatally, and in those booked into and born at the centre (p 981).[1-3] Such comparisons are bound to be of limited value as these three groups are selected quite differently and comprise infants and fetuses of differing gestations and with differing problems. Attempts to correct for these differences lead to such small subgroups that conclusions cannot be confident. A randomised controlled trial of in utero against postnatal referral would provide an answer, but such a trial would probably be impossible in the current climate of public and professional opinion.

Are we, however, asking the right question? Low birthweight babies arise from geographically defined populations, and any estimate of the effect of referral must include data on those cared for at the original hospital. When such data were examined for a British health region in 1980 for very low birthweight infants the combined survival of those transferred in utero and postnatally and those born in hospitals other than the regional centre did not differ significantly from that of those booked into and born in the regional centre.[4] A cynic could interpret this as evidence that the referral system achieves nothing, but it probably means that because of referral very low birthweight infants booked into district hospitals have a similar chance of survival to those booking into a regional centre.

The important question is not whether in utero or postnatal transfer is better, but rather which is the best balance of the two? Furthermore, how many babies will need transfer? Improvements may come from more precise prediction of neonatal difficulties or preterm labour, but are more likely to arise from more senior doctors deciding when to transfer.

Obstetricians in regional centres often do not like in utero transfer because regional funding might meet the extra costs of looking after the neonate but does not meet those of looking after the mother, who may also be critically ill.

Physiological stability in the first hours of life is critical if neurological injury is to be avoided in the low birthweight infant. In utero transfer reduces such risks because of the availability of trained specialist staff at all hours. Nevertheless, most low birthweight infants are born in district hospitals, and improved training and staffing in those hospitals in conjunction with—not instead of—in utero transfer will offer the best opportunity for further improvements.

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1 Blake AM, Pollitzer MJ, Reynolds EOR. Referral of mothers and infants for intensive care. *Br Med J* 1979;ii:414-6.
2 Crowley P, Lamont R, Elder MG. The obstetric care of the fetus transferred in utero. *Journal of Obstetrics and Gynaecology* 1982;2:129-33.
3 Modanlou HD, Dorchester N, Freeman RK, Rommal E. Perinatal transport to a regional perinatal center in a metropolitan area: maternal versus neonatal transport. *Am J Obstet Gynecol* 1980;138:1157-64.
4 Lobb MO, Morgan MEI, Bond AP, Cooke RWI. Transfer before delivery on Merseyside: an analysis of the first 140 patients. *Br J Obstet Gynecol* 1983;90:338-41.

Trace element analysis of hair

Much of what is "known" about the biological trace elements is a mixture of improbable fact and plausible nonsense. Over 99·9% of all animal matter, including the human body, is constructed from just 11 elements—hydrogen, oxygen, nitrogen, sodium, potassium, chlorine, sulphur, phosphorus, magnesium, calcium, and carbon—but about half the periodic table is represented in the remaining 0·01%. With greater or lesser certainty about 10 elements have been recognised as essential—copper, iron, zinc, cobalt, iodine, molybdenum, manganese, selenium, chromium, and fluorine—but even this subgroup is heterogenous. Zinc, iron, and copper are built into many enzymes, whereas cobalt is found in only one molecule and iodine too has only one function. The inessential elements include: environmental hazards (lead, mercury, and cadmium); some that are given as drugs (bromine, aluminium, and gold); and popular poisons (arsenic and antimony). The rest seem to be contaminants.

What the trace elements have in common is a capacity to enthrall both laymen and scientists. Over 2000 years ago the Greeks burnt sea sponges as a prophylactic against goitre, rightly divining a magic element in the vapour; and as recently as the 1960s a locally common cardiomyopathy was traced to selenium deficiency in central China. Against this background of legend and newsworthiness the analytical advances of the past decades have created new problems as well as new knowledge. The analysis of hair for trace elements is heavily encrusted with both.

For at least 50 years hair has been recognised as a potential repository of all the elements that enter the body, providing, it has been claimed, not just a glimpse of a passing state but also a chemical calendar. A few locks from ransacked graves and lockets have raised unanswerable historical questions. Was the fighting spirit of long forgotten armies sapped by lead? Did Napoleon die from arsenical poisoning?

Of more pressing importance has been the emergence of commercial hair analysis. Numerous private laboratories in the United States and some in Britain offer customers a comprehensive "trace element profile" based on hair. This will give, they say, a painless guide to ills to which orthodox analytical methods and clinical examination furnish no clue. The diagnoses range from humdrum lead poisoning to hairy exotica such as rubidium deficiency. Many lead to anxious requests to one of the specialist supraregional laboratories. In Britain these laboratories are financed by the National Health Service; and while dispelling anxieties is part of their job, allaying fears that should never have been raised and countering misinformation that should never have been imparted is justly resented. Sometimes the false alarm can be traced to slipshod technique; more often it is the result of ignorance. In a wide ranging review Andrew Taylor of the supraregional trace element laboratory of Surrey University has recently surveyed some of the difficulties.[1]

The diagnostic value of any analytical technique depends on the validity of its reference range. Even in conventional clinical chemistry the variables that affect these ranges in different control groups may be treacherous, but in hair analysis they are a swamp. For example, most trace elements —but not zinc—are present in appreciably higher concentrations in the hair of women than in that of men.[2] Wide fluctuations around birth, puberty, pregnancy, and the menopause are superimposed on long term trends. In both baby girls and boys the hair copper concentration increases sharply during the first three months of life and declines between three and six months.[3] [4] In normal boys who are not breast fed zinc concentration declines after birth—but this is not true of girls and of breast fed male infants.[5] [6]

Variations with age are also seen in hair chromium and cadmium.[7] [8] The concentration of zinc is higher in black hair than in blond hair; black hair contains more cadmium but less lead than brown hair; and red hair contains more zinc, cadmium, and nickel but less than brown or black hair.[9] (The lustrous copper of romantic fiction is a literary fancy.) One large study detected no significant difference between grey and pigmented hair from the same head (except for a higher lead concentration in the latter), though hairs from different regions of the scalp vary,[10] [11] and the trace element composition of scalp hair differs from that of pubic and axillary hair.[12] Such variations may be partly racial, but these are difficult to separate from environmental influences. The mean concentrations of lead, manganese, strontium, iron, copper, and nickel are significantly higher in Europeans than in Orientals; and lead, arsenic, nickel, chromium, and manganese are still higher in African blacks. Most strikingly, the mean concentration of lead is 5-18 times higher in blacks than in whites.[13]

An additional difficulty in interpreting analytical results is the tendency to bind ambient rubbish: it clings to metals with a special tenacity. Numerous painstaking investigations have tried to devise a satisfactory preliminary washing procedure using shampoos, rinses, organic solvents, chelating agents, ionic and non-ionic detergents, and deionised water in varying sequences,[14-16] but not even the sequence of acetone washes recommended by the International Atomic Commission can be recommended for all purposes.[17]

Even such a brief sampling of the subject comprehensively surveyed by Taylor raises the question whether hair analysis is ever justified. It cannot be dismissed completely. For almost a century mercury poisoning, the cause of madness in hatters, was regarded as a historical curiosity killed partly by industrial legislation and partly perhaps by the decline of felt hats. It then re-emerged in devastating epidemics in Iraq and Japan, showing that the element in an organic combination —for example, as methyl mercury—is many times more toxic than the inorganic vapour. In investigating these