Though nocturnal polysomnography is the accepted gold standard for diagnosing childhood obstructive sleep apnoea, it is expensive and not widely available. The small number of sleep centres with trained paediatric staff coupled with increasing public demand for childhood sleep evaluations have strained resources. Alternative methods of diagnosing childhood obstructive sleep apnoea therefore need consideration.

Goldstein et al have shown that a comprehensive clinical assessment can diagnose childhood obstructive sleep apnoea with 48% accuracy.⁶ The assessment consists of a validated quality of life survey, review of an audiotape for snoring and "snort arousals" (sensitivity 88%, specificity 52%, positive predictive value 62%), evaluating the lateral neck radiograph for adenoidal hypertrophy, voice recording assessment for hypernasality, and an electrocardiogram. Though 48% accuracy is far from optimum, this assessment is nevertheless a useful tool for the general practitioner.

Another substitute for nocturnal polysomnography is physical examination combined with the inexpensive and easily available technique of nocturnal pulse oximetry. Brouillette et al from the Montreal Children's Hospital have shown that when the clinical history suggests obstructive sleep apnoea, an abnormal overnight oximetry trend graph has a 97% positive predictive value.⁷ A normal overnight oximetry study does not, however, exclude mild or moderate obstructive sleep apnoea as only 93/210 (44%) of their patients with sleep apnoea proved by polysomnography showed abnormal results on oximetry.

Though adenotonsillectomy is widely used for treating childhood sleep apnoea, its benefit has not been definitively established through more evidence based research. About a fifth of patients below the age of 36 months develop dangerous postoperative airway oedema after adenotonsillectomy, so all children in this

age group should be closely monitored for cardiorespiratory compromise for at least 24 hours. Positive pressure airway breathing is helpful in those with obstructive sleep apnoea that persists despite adenotonsillectomy. Weight reduction measures intuitively make sense, but again their value has not been established through randomised controlled trials. Corticosteroids such as intranasal fluticasone seem to reduce the size of adenoids and the severity of symptoms slightly⁸ and serve as an adjunctive treatment.

Increased interest in childhood obstructive sleep apnoea should prompt the randomised trials that are now necessary to assess the best ways of managing the condition.

Suresh Kotagal *consultant*

Sleep Disorders Center, Division of Child Neurology, Mayo Clinic, Rochester, MN 55905, USA
(kotagal.suresh@mayo.edu)

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Radiotherapy for the future

Protons and ions hold much promise

Charged particle beams (CPB), consisting of protons or carbon ions produced in a cyclotron or synchrotron, are an important development in radiotherapy.^{1 w1} Compared with conventional x rays, charged particle beams produce excellent dose distributions to tumours and reduced doses to normal tissues. They thus hold out the promise of enhanced treatments for cancer and improved quality of life for patients being treated.

All the major technical advances in radiotherapy, such as increasing x ray energies and better target localisation have improved accuracy and outcomes,^{w2 w3} without direct evidence from randomised clinical trials. The one modern exception, conformal radiotherapy (using better shaped x ray beams to conform with tumour geometry), was tested in a randomised trial only in the United Kingdom: the reduction in serious morbidity found has led to extensive use.^{w4}

Treatment with charged particle beams marks a more radical change from incremental improvements in x ray based therapy. Its safe implementation has been made possible by improved tumour and normal tissue imaging using spiral computed tomography and magnetic resonance imaging, rapid three dimensional dose plan computing, and the industrial manufacture of entire CPB treatment centres.

Carbon ions cause denser ionisation than protons and x rays. They theoretically offer better prospects for radio resistant tumours. Like conventional x rays, CPB cause DNA damage, but they deposit energy more selectively. As particle velocity decreases through tissue, ionisation becomes maximal at the "Bragg peak,"^{w5} with none a few millimetres further beyond

Additional references w1-w13 are on bmj.com

that peak. So, compared with a single x ray beam, charged particle beams deliver a reduced proximal dose, an equivalent or higher tumour dose, and either none or a greatly reduced dose distally. For multiple charged particle beams, the advantageous dose distributions are further increased than with the most sophisticated x ray techniques, resulting in a reduced average dose to normal tissues by around 50% or more. Safer dose distributions are obtainable from a smaller number of beams and fewer treatments can be given.^{2-5 w6} These features should result in fewer normal tissues side effects and, if dose escalation is used, increased tumour control: thus, the finely balanced therapeutic ratio in radiotherapy is expected to improve.

The evidence so far is limited to phase I and II dose escalation studies using charged particle beams in a limited range of cancers where conventional radiotherapy results in disappointing tumour control or because of dose limitations imposed by closely situated critical tissues, as in the case of chordomas, paraspinal tumours, air sinus and orbital cancers, bone and many soft tissue sarcomas. Intracranial vascular malformations, acoustic neuromas, and meningiomas have also been treated.^{1 6-8} There is early clinical experience, with high local tumour control rates, in locally advanced head and neck, oesophageal, lung, rectal, cervix, and prostate cancers.^{1 w7}

In cancers for which direct comparisons with existing treatments can be made, cure rates for small T₁N₀M₀ peripheral lung cancers are comparable with those after surgery, but with relatively minor changes in pulmonary physiology. Typical results are 60% survival at five years without deterioration in standard lung function tests such as vital capacity and gas transfer factor after proton therapy in 10 patients, a deterioration of less than 8% in lung function in the first cohort of 81 patients treated with carbon ions, and 15-20% reductions where x rays were combined with protons for larger stage 1-111 cancers.⁹⁻¹² For primary liver cancer, the control rates after 15^{w8} or four¹ carbon ion exposures are equivalent to radical surgery (92% local control rates and a 25% five year overall survival in 24 patients with accompanying liver cirrhosis), but without the serious morbidity associated with hepatic resection. Children represent a special case: the risk of radiation induced malignancy, based on standard radiation protection data, is predicted to reduce by 10-15 fold.^{w9} A theoretical reduced cancer induction risk is also possible in irradiated adults. In addition, older patients with metallic prostheses, such as hip replacements, can have treatment of bladder, prostate and uterine cancers to more reliable central pelvic doses using charged particle beams.^{w1}

The only proton facility in the UK is at Clatterbridge (Wirral), where a cyclotron capable of producing proton energies of 60 mega-electron volts (MeV) is used to successfully treat choroidal melanomas.^{w10} The penetration depth of charged particle beams is proportional to their energy: 60 MeV produce Bragg peaks at around 3 cm depth, sufficient

for eye cancers. For depths of up to 20 cm, which are necessary for thoracic, abdominal, and pelvic cancers, over 200 MeV is required.

Radiotherapy using charged particle beams shows great promise, and many high energy facilities are already being developed across Europe, the United States, and the Far East.^{1 w1} Yet that promise needs to be researched thoroughly, to establish efficacy and cost effectiveness, with full UK participation. Although the UK tends to implement new radiotherapy technologies slowly^{w11 w12}, it has a good reputation in conducting clinical trials of efficacy^{w1}. At least one high energy UK facility should be established to conduct phase III trials, with equitable patient referral via the cancer networks. In that way the UK can contribute to establishing the evidence base for charged particle beam therapy and British patients will not lag behind in receiving the potential benefits. According to estimates, 10-20% of patients receiving radiotherapy might benefit from charged particle beams,^{9 w3 w7 w13} so the decision to build a major proton facility is an important one for the British government to make.

Bleddyn Jones *professor in clinical oncology*

(bjones.1@bham.ac.uk)

Department of Clinical Oncology, Queen Elizabeth University Hospital, Birmingham B45 8TB

Neil Burnet *lecturer in clinical oncology*

University of Cambridge Department of Oncology, Oncology Centre, Addenbrookes Hospital, Cambridge CB2 2QQ

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