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BREATH

CONTENTS

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September 1988

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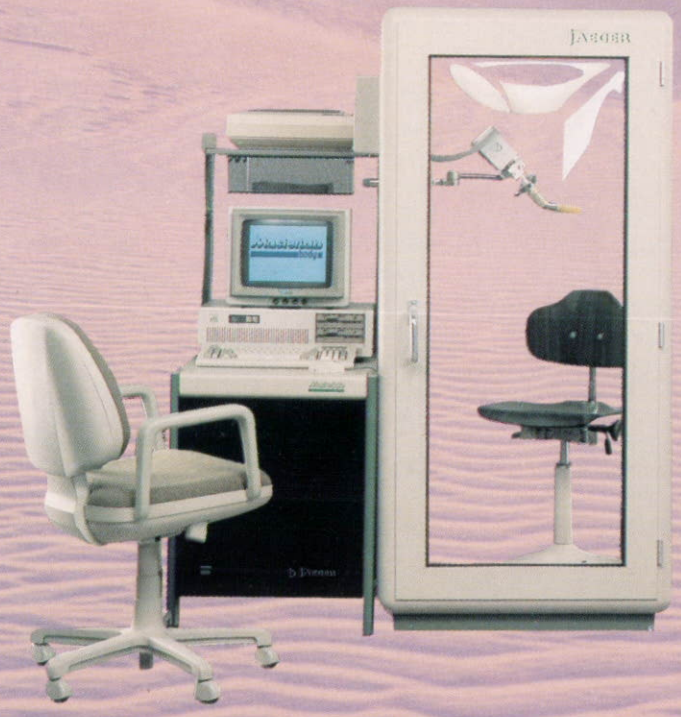

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UNDERDIAGNOSIS AND UNDERTREATMENT OF ASTHMA

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Summary

Asthma is a common disorder and usually responds well to treatment. Unfortunately it often goes undiagnosed and untreated but, even when correctly diagnosed, asthmatics may receive treatment that is inappropriate or inadequate. Long-standing misconceptions about the disease tend to hinder delivery of effective therapy. One must think of asthma in patients of any age with unexplained wheeze, cough or dyspnoea and, having made the diagnosis, one should call it asthma and treat it appropriately.

Introduction

Asthma can be defined as widespread airways obstruction which is reversible over short periods of time either spontaneously or as a result of treatment. Asthma has been well reviewed in an earlier issue of *Breath* (1) and in this article I shall examine problems in the diagnosis and treatment of the disease. Initial treatment is usually with an inhaled bronchodilator, with regular inhaled steroids or cromoglycate if necessary. In most cases asthma is easy to diagnose, and relatively simple treatment can transform the patient's life. One might therefore expect this to be one of the best treated of diseases. Sadly this is not so.

Childhood Asthma

Asthma is one of the commonest disorders of childhood. Speight and colleagues (2) reviewed the management of 179 seven year old Tyneside children with a history of wheezing. They commented, "We found the amount of unnecessary ill health, unhappiness and anxiety we uncovered, most disturbing." Two thirds of the children had never been given a bronchodilator drug, and this was true of one third of children who had more than twelve episodes of wheeze per year. Indeed, only a third of the children experiencing over twelve episodes of wheeze per year had been labelled as having asthma. There is a widespread but erroneous belief that the word 'asthma' should be used only as a last resort when dealing with young children who wheeze. However, not only do parents welcome being given a diagnosis of asthma (2) but children so labelled are more likely to receive correct treatment than those mislabelled as suffering from 'wheezy bronchitis' or 'chestiness'.

Adult Asthma

Adult patients too may be undertreated. I investigated the therapy of adult asthmatics in a South London general practice (3) and identified patients with a written diagnosis of asthma in their case notes. Undoubtedly many other patients had the disease, but the interest lay in the treatment of those actually labelled as asthmatic. One quarter of the 67 patients said they had never been told they had asthma. Poor inhaler technique was common. Of the worst-affected patients (21 asthmatics who were symptomatic and had a baseline FEV_1 <55% predicted), 9 (43%) were receiving no treatment apart from a bronchodilator, and one patient no treatment at all.

In a study of 90 asthma deaths, a British Thoracic Association (BTA) panel reviewed treatment in the year preceding death and concluded that maintenance therapy was unsatisfactory in 61% of patients (4). Stellman *et al* reviewed the response to treatment of asthma patients referred to a hospital clinic (5) and found that pre-referral treatment was often inadequate and that asthma had not been diagnosed in one third of the patients referred; with greater use of inhaled bronchodilators and inhaled steroids most patients improved.

It is not only doctors who are responsible for unsatisfactory treatment. Patients too can ignore their asthma. In my study, seven asthmatics with severe symptoms had repeatedly failed to renew their prescriptions or to visit the doctor as requested (3). Similarly, the 1982 BTA study of asthma deaths found that only 47% of patients had co-operated fully with their treatment.

Case Reports

Clearly, asthma is underdiagnosed and undertreated in both children and adults. Some of the possible reasons for this may become clearer by considering illustrative case reports:

Case 1. A 14 year old girl was referred to the chest clinic with a six-year history of severe wheeze and dry cough. She obtained some relief with a salbutamol inhaler, but had never been able to take part in school sports. Spirometry showed an obstructive picture (FEV_1 0.5 l: FVC 1.3 l: FEV_1/VC 38%). The peak expiratory flow rate (PEFR) was reduced, with negligible reversibility after inhaled salbutamol (Fig. 1). Following a two week course of disodium cromoglycate (Intal spincaps), her PEFR increased markedly (Fig. 1) and spirometry showed marked improvement (FEV_1 2.2 l: FVC 2.5 l: FEV_1/FVC 88%). On maintenance treatment her life is transformed. She remains asymptomatic and is now playing school games.

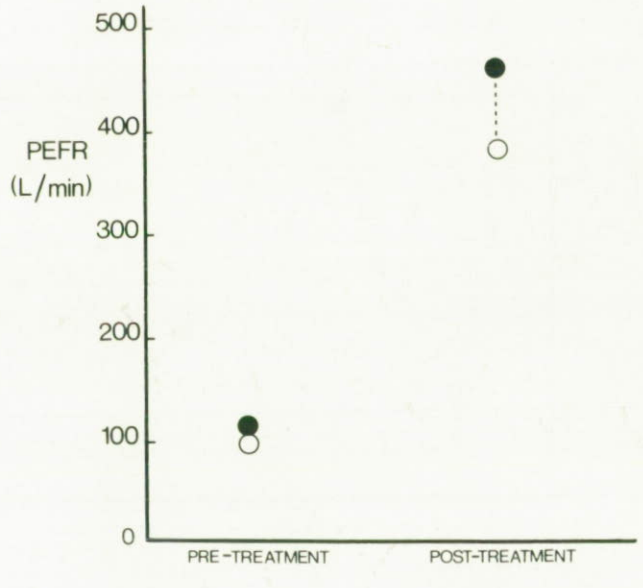

Fig. 1: Case 1. Peak expiratory flow rate measured before and after 2 weeks of treatment with inhaled cromoglycate (open circles, before bronchodilator; closed circles, after bronchodilator).

Comment: 1. This girl had been correctly diagnosed as an asthmatic but for years had received inadequate treatment.
2. Failure to demonstrate significant reversibility at initial assessment does not exclude asthma. If in doubt, a trial of anti-asthma treatment is warranted.

Case 2. A previously fit 27 year old woman presented with a three month history of "chestiness" with severe nocturnal cough. Repeated courses of antibiotics from her general practitioner had been of no help. Her baseline spirometry showed an obstructive pattern (FEV_1 1.2 l: FVC 2.0 l; FEV_1/FVC 60%). Her PEFR was reduced, but there was 70% improvement after inhaled salbutamol (Fig. 2). After two weeks' inhaled beclomethasone she was asymptomatic, with improved spirometry (FEV_1 2.3 l: FVC 2.8 l: FEV_1/FVC 82%) and improved PEFR (Fig. 2).

Comment: 1. Asthma may present primarily as cough rather than wheeze.
2. Asthma should always be considered in recurrent "chest infections".
3. Significant reversibility after inhaled bronchodilator is diagnostic of asthma.

Case 3. A 50 year old man presented with a one year history of nocturnal cough and wheeze. Although a lifelong non-smoker, he had been told he had chronic bronchitis. Clinic spirometry was normal and PEFR was also normal (460 l/min), with only 11% reversibility. Using a Mini peak flow meter he then kept a PEFR chart at home (Fig. 3). This confirmed asthma by showing marked variability, with PEFR values generally lower in the morning than in the evening ('morning dips'). He is now asymptomatic on regular inhaled steroids.

Comment: 1. Asthma may present at any age.
2. Normal spirometry at the time of testing does not exclude asthma.
3. Home PEFR monitoring may be useful in diagnosing asthma.

The above cases are by no means atypical, and show that life can be improved dramatically by simple treatment.

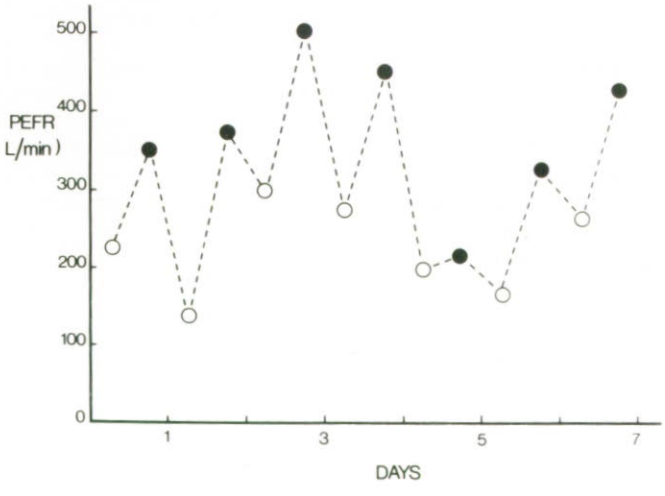

Fig. 3: *Case 3. Peak expiratory flow rate measured on waking (open circles) and in the early evening (closed circles). There is marked diurnal variation.*

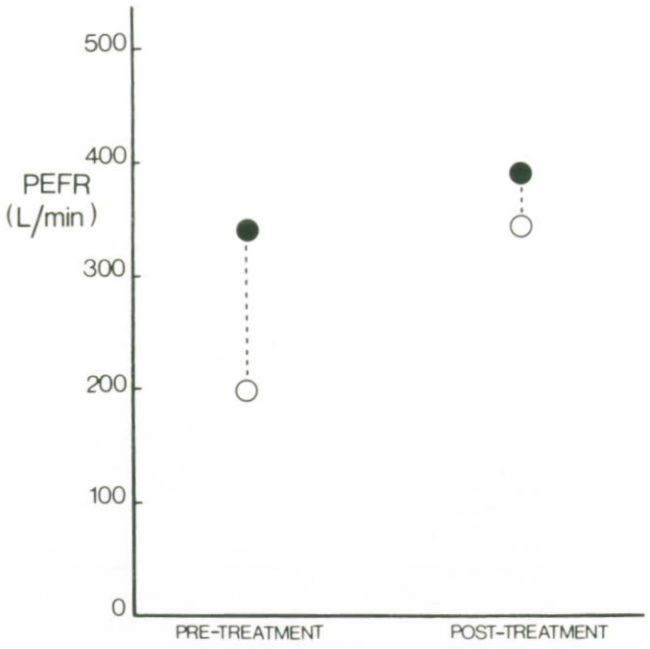

Fig. 2: *Case 2. Peak expiratory flow rate measured before and after 2 weeks of treatment with inhaled steroids (open circles, before bronchodilator; closed circles, after bronchodilator).*

Misconceptions

Some of the widespread misconceptions about asthma have been reviewed in an excellent editorial (6) and include misconceptions about desensitization, exercise, bronchodilator abuse and psychological factors. Patients are often referred to a chest clinic for 'desensitization', yet there is little evidence this is of any value in asthma. One sometimes meets asthmatic children who have been warned not to play games. Surely it would be better for them to use prophylactic inhaled cromoglycate or bronchodilator enabling them to lead a normal life. Patients are frequently told not to overuse their bronchodilators, yet these same patients are not told what to do if their inhalers are no longer providing relief. In practice, the under-use of bronchodilators can be as much of a problem as over-use.

In the past, psychological factors were often invoked to explain asthma. Although emotional problems may exacerbate asthma in some patients (just as do cold air or exercise), stress is not the *cause* of asthma. On the contrary, anxiety in the patient or family often evaporates when frequent or terrifying asthma attacks are brought under control.

Even where asthma has been correctly diagnosed, one sometimes sees patients on totally inappropriate treatment. There is no justification for the routine use of antibiotics, cough mixtures, decongestants, antihistamines or barbiturate containing drugs. I am sceptical of the value of breathing exercises, but not all would agree with me.

Asthma and Respiratory Technicians

One would not treat a hypertensive without measuring blood pressure, nor a diabetic without measuring the blood glucose. However, it is not uncommon to find asthmatics who have never had an objective measurement of lung function. At initial assessment it is useful to perform spirometry and PEFR before and after bronchodilator. The technician may be requested to perform skin prick tests, or to measure lung volumes, flow-volume loops or gas transfer. These tests sometimes help in differentiating emphysema from asthma.

Fig. 4: *It is always important to check inhaler technique. In this example the patient is not inhaling aerosol at all!*

Technicians can have an important role in managing asthmatics, but this varies from centre to centre. In some clinics the respiratory technician will check spirometry and coach patients on correct inhaler technique; in other clinics this is done by the doctor, nurse or physiotherapist. Everyone dealing with asthmatics should be able to demonstrate correct inhaler use, and should be familiar with the different aerosol and powder delivery systems. Faulty inhaler technique is a frequent cause of poorly controlled asthma. In extreme cases aerosol may not even enter the mouth, let alone the lungs (Fig. 4).

Patients can be reluctant to question their doctor, and the lung function technician will sometimes be asked questions on asthma. The technician is in an ideal position to chat informally, provide reassurance and answer questions on topics such as the difference between symptomatic and maintenance inhalers.

Although reversible airways obstruction is the hallmark of asthma, spirometry in asthma may be normal when first assessed (eg Case 3) or, if abnormal, may initially fail to improve following bronchodilator (eg Case 1). It is important when reporting lung function tests to be aware of this. When I report these tests for non-respiratory doctors (particularly if the request card suggests asthma), I use phrases such as "normal lung function on this occasion does not exclude asthma," or "no reversibility on this occasion but asthma not excluded".

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LABORATORY SAFETY I — MANAGEMENT

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Introduction

Each year, about 1500 people die and a further 300,000 suffer injuries which keep them away from work for more than three days, because standards of health and safety at the place of work were inadequate. The approximate economic cost to the community is about £2,000 million a year. However, the real cost in terms of pain, anxiety and hardship suffered by the victims and their families cannot be measured.

Employers and their employees have a responsibility to achieve high standards of health and safety in their place of work, not only to protect themselves, but to protect their colleagues and any visitors who may be unfamiliar with potential hazards. With the removal of Crown Immunity, individual employees, as well as their employers, can now face criminal and civil court actions folowing accidents resulting in death or injury. In addition, employees may face disciplinary action by their employers. It is therefore essential that employees are fully aware of the need for good health and safety practices and take responsibility for ensuring that their actions do not constitute a danger to others.

Like all clinical measurement departments, respiratory physiology departments contain many potential hazards. The purpose of this article is to review safety management and to highlight some of these hazards.

Health and Safety at Work Act (1974)

The Health and Safety at Work Act (HSW) is based on the principal recommendations of the Robens Committee on Safety and Health (1972) at work. The purpose of the HSW is to provide a single comprehensive and integrated system of law dealing with the health, safety and welfare of workers and of the public who may be affected by work activities.

The Act cannot, and indeed does not, seek to cover every possible eventuality, nor does it dictate rules for every work situation. It is simply an enabling instrument based on the concept of a general duty of care with respect to people involved in or associated with work activities. It is flexible, adopting a general approach, and therefore provides legislation that is capable of being adapted and modified to deal with health and safety associated with current technological changes and advances.

Overall, the Act provides for an interaction of responsibility between individuals and organisations associated with work or affected by its immediate consequences. The employer has a clearly defined duty to his employees regarding their health and safety, and the employees have a duty to one another. Suppliers and importers must also ensure that safeguards are incorporated at manufacture and that, when used properly, the equipment will be safe.

Duties imposed by the Act

To be flexible, many of the duties imposed by the Act and related legislation are qualified by the words "so far as is reasonably practical" or by "best practicable means". If prosecuted, the employers or individuals must show the courts that it was not reasonably practical for them to do more than had already been done or that there was no better practicable means than the one that was used to comply with the duty. The two expressions are not defined in the Act, but have clear interpretations within the courts. Courts will take into account the weighting of the degree of risk relative to the physical difficulties, time, trouble and expense involved in taking steps to avoid the risks.

Thus, the employers must, so far as is reasonably practical, provide equipment and other plant that is safe and without risks to health and must maintain them in that condition. They must also ensure that, so far as is reasonably practical, the systems of work are safe and without risks to health. A "system of work" means the way in which the work is organized and includes the layout of the work place and any special precautions necessary to carry out the work. The chain of responsibility for ensuring safety and reducing risks to a minimum involves various individuals or groups. *The manufacturers* must ensure that, so far as is reasonably practical, the materials or equipment are safe and without risks to health when properly used, and *the users* must be given sufficient information and training about proper use and the potential hazards. At the place of work, the duty of the *employer* is to ensure that, so far as is reasonably practical, the *employees'* health and safety are maintained by providing the correct facilities for the use of material or equipment. Information supplied by the manufacturer must be made available to the users at their place of work, and should be written in such a manner that the instructions for use are clear, concise and unambiguous. All users must have a period of supervised instruction in the use of the equipment before being allowed to carry out the work unsupervised.

To ensure safety is maintained, the employer is required to prepare a written safety policy. This will ensure that the employer carefully considers the potential hazards at the workplace, how to reduce the hazards and to make the workplace safe and healthy for the employees. The document should clearly set out the employer's aims and objectives and should therefore increase employee's awareness of the employer's policy and arrangements for safety. Thus, the employer is responsible for bringing the policy statement to the notice of all employees, new and old, and any revisions must be brought to the employee's notice. The employer's policy statement will be of a general nature, and therefore individual heads of departments must devise a more specific policy statement for their own departments.

One of the major innovations of the Act is that the employers have a duty not only to their own employees, but also to workers from outside organisations and to members of the general public who may be affected by work activities. Generally, it is to be expected that the level of health and safety extended by the employers to their employees will also be extended to others not in their employ. All employees must therefore take reasonable care for the health and safety of themselves and of others who may be affected by their work. This duty implies not only avoiding obviously silly or reckless behaviour, but also taking positive steps to understand the hazards of the workplace, to comply with the safety rules and procedures and to ensure that nothing they do or fail to do puts themselves or others at risk.

Laboratory Safety Training

Training is generally defined as the acquisition of new knowledge, skills and attitudes which result in an improved performance. Table 1 shows the principal components of laboratory safety training. This is not exhaustive, but simply defines major content or information areas that can be arranged or combined in various ways to form part of the training programme.

Knowledge areas provide the basic framework of laboratory safety and details need to be provided for each specific work task. The skill areas may be regarded as the application of basic safety principles learnt in the knowledge areas. An overall skill objective to be acquired by everyone is the ability to select, from the various safety procedures, those that will reduce the risks in work practices.

Table 1

Principal components of laboratory safety training

Knowledge:
- Recognition of hazards
- Control of hazards — personal practices
  - — facility design
  - — use of protective clothing
- Waste disposal
- Emergency response procedures
- Safety information resources

Skills:
- Proper use of equipment
- Spill clean-up procedures
- Sterilization and disinfection procedures
- Patient handling techniques
- Use of safety resource information

Attitudes:
- Safety is everyone's responsibility
- Safe practices prevent harm to oneself
- Safe practices prevent harm to others indirectly affected by one's actions

An important part of laboratory safety training is the conveyance of attitudes towards safety. Everyone has a responsibility to convey the correct approach to laboratory safety, and to ensure, so far as is reasonably practicable, that health and safety procedures are carried out. The training programme must convince everyone that, where appropriate, old attitudes and practices must be eradicated and replaced by more up-to-date and safer practices.

The overall objective of a laboratory safety programme is to improve safety performance in the laboratory. The challenge of the training programme is to transmit the necessary information in such a way that it will be accepted, retained and then used by the audience in everyday work practices. Safety training may be carried out by the head of department, by regional groups or by national groups holding symposia and workshops. Where appropriate, outside expertise should be used to cover specific safety areas such as firefighting or resuscitation techniques.

A training programme should be composed of four phases (Table 2) at the end of which the organizers must be able to answer the following questions — i) What will the participants be able to do after completing the training programme? ii) What instructional methods and training aids

will maximize the participants' retention of the material during the training and subsequently during work? and iii) Did the training programme achieve its original objectives?

To answer the first question, the organizers must determine the needs of the training programme, including what the current practices are, what work is involved and what improvements or changes need to be made. Having formulated the needs of the programme, the organizers then need to prepare a set of objectives that the participants (not the organizers!) should accomplish. Rather than using objectives such as "understand" or "appreciate", the objectives should be such that the information provided should specify or define operationally, how the presented information is to be used in daily work practice. Having formulated the primary objectives, the organizers must then address the second question. Information should be presented in such a manner that will allow maximal retention of the material presented both at the training session and back in the laboratory. No one training method will be appropriate for all objectives, and a good training programme will consist of a mixture of lectures, workshops, demonstrations and seminars.

Lectures are most effective as a means of transferring information that is factual, descriptive or explanatory. Carefully devised audio-visual aids, such as slides and videos, can be used to put across the information clearly and concisely.

Workshops allow the participants to become actively involved in the learning process. It has been shown by many workers that individuals learn and remember better when they discover things for themselves. Theory and practical applications can be treated concurrently by incorporating case studies for discussion after general laboratory safety principles have been discussed. Case studies allow the assembled group to see that there is often more than one solution to a problem. Other exercises for group discussion and problem solving might involve asking participants to devise methods for promoting safety as an integral part of the work of their laboratory.

Demonstrations may be included as part of a lecture or as a specific item. This method is ideal for instructing people in a procedure, such as using fire extinguishers, where it is not practicable or cost-effective to allow each member of the group to carry out the procedure.

Table 2

The training process

Planning:
- Assess needs
- Prepare behavioural objectives

Development:
- Select information and resources

Implementation:
- Training period

Evaluation:
- Develop criteria for evaluation
- Conduct evaluation
- Assess feedback from participants
- Modify training programme if necessary

Seminars are particularly useful at the end of a session and allow the participants to discuss their own experiences and practices in the light of what has been presented during the training programme.

Evaluation Probably the most difficult part of the programme is in the evaluation of its success. During this phase one has to determine the level of acceptance of the material presented, the amount of learning that has taken place and whether the information has been effectively translated into safe practices at work. The simplest approach is a carefully devised feedback questionnaire which provides information on the content of the programme and the various elements of the learning environment such as speakers and visual aids. Participants should be asked to express their opinions in a frank and honest way, and to provide any comments of their own not covered by any of the questions. One specific question should relate to what they will do differently as a result of the programme. This should force the participants to review the information presented and to make some initial practical decisions on their actions when back in their laboratory.

Although a training programme may heighten the level of safety awareness of individuals, the programme must be consistently reinforced. Monitoring within the department and subsequent discussion of safety practices will continue to reinforce the need for safety. Feedback from the end user to the head of department will highlight difficulties which can then be openly discussed by members of the department and, where necessary, by safety professionals. Discussion of safety and its promotion is necessary to maintain high standards of safety and should never be neglected.

Safety Planning and Management

Effective and safe operation of a laboratory depends on i) a *well designed laboratory* with equipment suitable for the intended purpose, ii) a well organized *operating system* and iii) a clearly stated progressive and positively implemented *safety policy* that will motiate all those involved. This last point is the most important.

As stated above, the HSW requires employers to provide their employees with clearly written and unambiguous statements on their current health and safety policy, and how it is intended to be implemented in practice by their management and employees. The employers' document will only be concerned with general health and safety objectives and will not cover specialized laboratories in detail. Therefore, it is up to the head of department, in conjunction with the employer and safety professionals, to produce a *safety document* giving details of procedures within the department.

The Safety Document

This document should:

1) State clearly the levels of responsibility and the permissible degree of delegation of authority. One main responsibility of the head of department is to ensure that adequate training and instruction in safe methods of working is given to all members of the department, and that reinforcement of the training occurs at regular intervals;

2) Allow levels of consultation with members of the department on the methods of safety. It is essential that consultation should be effected in such a way that it will encourage staff to accept and exercise their responsibilities in a constructive manner. Open discussion will often highlight faults in the present safety policy and provide alternatives which will improve the working and efficiency of the operating system;

3) Indicate whence detailed information may be obtained. Information should include details of equipment operation, handling and maintenance, and storage of items (chemicals, drugs and general consumables);

4) Where practicable should designate an individual whose responsibility is to collate and disseminate safety information provided by the employer and manufacturers, to members of the department and to organize seminars on safety for the department. An excellent and extensive definition of the qualities and role expected of a laboratory safety officer is given in Code of Practice for Chemical Laboratories (1). Where a number of small laboratories (1-3 members of staff) are located within a defined geographical location, it is perhaps useful for one person to be designated as safety officer and to provide information to all these laboratories.

5) State the procedures in the event of an accident within the department, including how and to whom to report an accident.

6) State all other matters with strong safety connotations which must be considered and organized integrally by laboratory management.

Laboratory Design

Facility design is often something over which the end users have very little control which in terms of safety planning is somewhat ludicrous. Often laboratories are designed by non-experts in respiratory physiology who have no clue about the safe and ergonomic design of a respiratory laboratory. However, when new premises are envisaged or existing premises are to be adapted, considerable planning is necessary. The planning phase must involve as much consultation as possible between the architect, engineers, laboratory staff and the safety officer so that everyone has a full appreciation of the requirements. When designing a laboratory the following points need to be considered:

1) *The space requirements* for comfortable working conditions will vary widely with the range of tests being undertaken. Adequate space for free circulation by people as well as for installed equipment, permanent facilities, storage of portable equipment and of consumables must be allowed to permit safe and effective working. It should also be borne in mind that a number of patients will arrive in wheel chairs or on trolleys and space must be allowed for manoeuvring them around the laboratory to individual pieces of equipment. Recommendations have been made for minimum space requirements per individual (2).

2) *Surface finishes* include bench surfaces and the floor covering. The choice of the latter is very important, as a mistake initially may be expensive to put right later. The material used should be selected on the basis of comfort, durability and ease of decontamination. Wood block, vinyl tiles and cork linoleum of limited use. Impervious PVC sheeting with welded joints and coved edges is probably the most effective floor covering in both laboratories and offices.

Similar care must be taken with bench surfaces. Although traditional teak and hardwood surfaces are visually appealing, they are impractical for areas of potentially high contamination such as the area around a blood gas analyser, where decontamination is very difficult (2). Probably the easiest and safest surface to install is press-bonded melamine-faced laminated boards which are satisfactory for general laboratory use (3).

3) *Ventilation* in laboratories must be effective, since good ventilation is likely to have long-term benefits for the health of laboratory staff and patients, and for the longevity of equipment. To maintain a reasonable level of comfort in a well-ventilated laboratory (10-12 air changes per hour) it is necessary to match the extraction rate with the heat input. Different groups of workers (secretaries and technicians for instance) will require different levels of heating (and therefore ventilation) as their occupational activities will be different. Guidelines have been set for the different types of worker (4). The levels of ventilation and heating will also need to be controlled for the different activities within a laboratory (exercise tests or resting lung function tests) to allow good performance and acceptable patient evaluation. Finally, in designing a laboratory, the siting of certain types of equipment such as mass spectrometers or computers must be considered as large quantities of heat can be produced. Extra ventilation and heat controls may be required in these areas.

4) *Safety equipment:* Its provision and siting is of paramount importance and should be part of the early stages of the overall laboratory design. This will ensure that appropriate extinguishers, fire blankets, alarms, fire doors and escape routes are installed at the outset. The choice of what safety equipment is made available at specific areas within the department is dependant on the use of each room and the type of equipment to be installed.

5) *Furniture:* The choice of furniture for a laboratory from the wide range available will be closely related to the intended work. Laboratory furniture units are usually modules made to fit under continuous runs of impervious benching. Wooden furniture is of proven durability and if constructed well will provide good storage facilities. Wide drawer units (>1m) often jam unless they are well made and have good runners. A jamming drawer may cause damage to its contents. Cupboard door catches should have a positive smooth action and open doors should ideally not obstruct other cupboard doors. Top surfaces of benches or support units for tall laboratory equipment may need to be set below the usual bench height of 0.92m to provide ready access to the equipment for use and maintenance. Other aspects of laboratory furniture are covered by BS 3202 (5). Consideration should also be given to office furniture (6).

6) *Equipment services:* The complexity of modern equipment means that each item may involve several service connections and more than one potential hazard. Most equipment is electrically powered and this requires regular inspection. Where gas supplies are required, secure and possibly permanent gas connection lines and fittings of appropriate materials are essential for safe operation. For gases the choice of fittings (pressure regulators and inlet connections) will be determined by the nature of the gas or gas mixture and should conform to either BS 341 (7) or to BS 1319 (8). Details of correct fittings may be obtained from the gas supplier. Flexible leads for supplying gases must be of adequate durability (9) for the particular application, and again must be inspected regularly for wear and tear.

7) *Bench services:* Benches and working areas may be supplied with a considerable number of piped services, all of which may lead to potential hazards if not properly installed and used. Electric sockets should be plentiful to prevent excessive lengths of cabling to instruments, and as far as possible, extension leads and "multi-block" distribution boards should be avoided. Sockets should have their switches checked regularly and faulty sockets replaced immediately. Gas supplies, either natural or compressed

should have their outlets as near to the equipment as possible. It is preferable that all gas supplies are piped into laboratories, the gas cylinders being stored away from the laboratory. This reduces the potential hazards of accidents and explosion from gas cylinders. Where gas cylinders need to be in the laboratory, they must be securely fixed, and hazard warning notices prominantly displayed at the entrance and inside the laboratory, thus warning visitors (and firemen!) of the potential dangers. Signs should conform to the required British Standards (10-12).

Another important bench service is adequate water and drainage. Both hand wash-basins and kitchen-style sinks must be provided in appropriate areas for hand-washing and cleaning of equipment. For washing and disinfecting of small items (eg mouthpieces and tubing) a dishwasher should be considered and adequate drainage facilities provided.

8) *Lighting* is also an important laboratory service. The level must be adequate for clear vision in all parts of the laboratory, thus reducing the possibility of accidents. Where close work, such as reading or writing, is being performed, general laboratory lighting may be inadequate and users should be provided with additional lighting, either as wall-mounted or as angle-poise lights.

Equipment Management

A safety management programme should include clear instructions on the management of equipment within the laboratory. Recommendations (13) have been made following a number of serious accidents which highlighted major deficiencies in the equipment management process. Management of equipment within a department should include the following details:

1) *Responsibility for equipment management* is at two levels. Firstly, there should be an area or district health authority supervisor whose role is to provide expert advice on servicing and repair, and to operate a system of servicing both in terms of "planned preventive maintenance" and urgent, non-planned maintenance. Secondly, the department should nominate a member of staff to take the responsibility of overseeing the acceptance and commissioning of equipment, ensuring servicing arrangements are adequate and are carried out with minimal disruption to the department and maintaining equipment logs and a complete inventory of all equipment in the department and on loan elsewhere. Faults should be reported immediately to the nominated officer or his appointed deputy so that appropriate action may be taken.

2) *Selection of equipment* should be a careful process, such that all aspects of the piece of equipment are ascertained. Prior to selection, a detailed specification of the user requirements should be drawn up, from which the appropriate equipment that satisfies or very nearly satisfies the requirements can be selected. In considering the choice of equipment, it should be borne in mind that a sensible approach is to purchase equipment that is compatible with existing equipment already in the department.

When manufacturers and their equipment have been selected, a visit should be arranged to the manufacturers or they should come to the department. As far as possible, a thorough evaluation of all possible pieces of equipment should be performed. Evaluation should be carried out by the end-users (not just the head of department!) in conjunction with the safety and equipment management experts. This evaluation should include a) ease of use, b) ease and cost of servicing and availability of spares, c) whether the equipment conforms to the required safety standards, d) what the lifetime costs are expected to be and e) how easy it is to modify the equipment when required. Very careful consideration should be given before purchasing equipment that can only be run by a computer (14). Evaluators should prepare a report on each piece of equipment and make their recommendations to the department.

3) *The acceptance procedure for equipment* (particularly electrical) should be clearly defined. Limited inspection on arrival should ensure that the equipment is undamaged and that all spares and instruction manuals are included. Electrical equipment must be checked by a qualified engineer to ensure it conforms to BS 5724 pt. 1 (15) and the relevant documentation completed (16). On acceptance, the manufacturer should provide a formal commissioning session followed by a training period to cover use of equipment, user servicing and what action needs to be taken if the equipment malfunctions. Although initial user training may be given at commissioning, follow-up sessions should be organized. Commissioning is usually included in the purchase price, but follow up sessions may need to be financed. If "in-house" servicing is to be provided, then at least two qualified engineers should be trained by the manufacturer. Once commissioned, all relevant documents should be filed with the equipment manager and the head of department must sign and accept responsibility for the equipment.

4) *Servicing of equipment* is important to ensure that the equipment is performing correctly and is safe. A maintenance programme for each piece of equipment is therefore essential. User-servicing means the everyday checking of tubing and absorbers and is performed prior to calibration and use. A regular scheduled servicing programme should be organized either "in-house" or by a service contract with the manufacturer. The regularity of the service should be determined by the level of use of the equipment, its complexity and its importance in the functioning of the department. As a rule of thumb, 10-15% of the current purchase price of each piece of equipment should be allocated for servicing per year. Where the equipment malfunctions in between planned services, procedures for emergency repairs should be defined.

5) *Equipment replacement* should be planned well in advance. Equipment will need to be replaced if it is worn out, damaged beyond economical repair, is unreliable, is obsolete or no spares are available. Details of the expected life of the equipment in "average use" should be obtainable from the manufacturer, as should details of how long spares will be available. Allowance should be made where equipment is in heavy use. Damage may occur, but if care is taken in use this should not be a problem. Health authorities should have emergency funds available to replace essential equipment that has been accidentally damaged or worn out.

Assessment, prior to purchase, of the measurement reliability of the equipment should reduce the risk of purchasing unreliable items. Equipment which continually breaks down or is unreliable under normal usage during the period of guarantee should be replaced by the manufacturer, or the purchase price refunded.

As most respiratory function tests do not become obsolete, this does not pose a major problem. However forward planning is required when newer test procedures have become validated and accepted into testing protocols.

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COMPARISON OF HEIGHT AND ARM SPAN MEASUREMENTS

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City Hospital, Edinburgh

Summary

Standing height and arm span were recorded in 73 subjects ranging in age from 10 to 71 years. The two measurements were closely correlated and the regression line differed insignificantly from the line of identity. The 95% confidence limits of the estimate of height based on arm span was ± 8.14 cm. The variance of differences between arm span and height increased with age. The practice of substituting arm span for height in pulmonary function prediction equations could be extremely misleading.

Introduction

Arm span is sometimes used as an estimate of height for patients who have spinal deformities or who are unable to stand. We wished to confirm the accuracy of this estimate and the effect of age, if any, on the correlation with height.

Methods

Subjects were members of hospital staff or patients attending the department for routine pulmonary function tests. None of the subjects was aware of any spinal or other skeletal deformity. Height was recorded in the standard way using a measuring stick attached to the wall. Arm span was recorded with the patients standing against a wall with their arms stretched out at 90° to the trunk and the tip of the middle finger on the left hand touching a solid marker on the wall. A pen was used to mark the equivalent position for the right hand, the distance between the two markers being taken as arm-span.

Results

73 subjects aged 10 to 71 years had height and arm span recorded. Height ranged from 114 to 189 cm and arm span from 111 to 190 cm. There was a close correlation between height and arm span (r = 0.974) (Fig. 1). The 95% confidence limit for the estimate of height based on arm-span for the entire group was ± 8.14 cm.

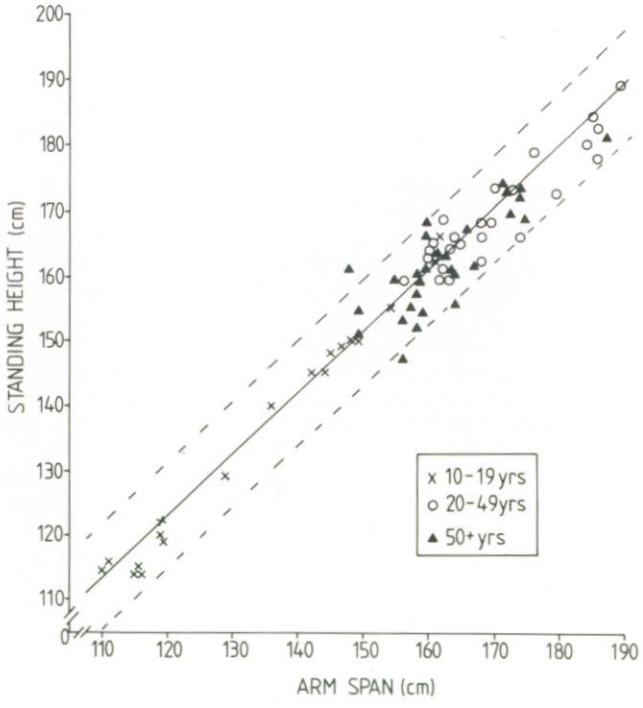

Fig 1. *Relationship between arm span and standing height in 73 individuals. The regression equation is Height (cm) = 0.926 × Arm span (cm) + 11.69. (Correlation coefficient: 0.974. 95% confidence limits: ± 8.14 cm.)*

The subjects were divided into three groups on the basis of age and the mean differences between height and arm span were calculated for each group (Table 1). For the adult groups the means of the differences between height and arm span were close to zero (NS) but in the young group arm span was significantly less than height ($p < 0.005$). The variance of the differences between arm span and height increased with age ($p < 0.05$).

Discussion

There is clearly a strong correlation between the two variables of height and arm span. However in young people straight-forward substitution of arm span for height will tend to underestimate height. In adults the variability of height derived from arm span could lead to quite misleading figures when used in pulmonary function prediction equations. It would seem that for adults with spinal deformities the actual height would yield more useful information in predicting pulmonary function than derived height. For adults who are now unable to stand, the previous height (if known) may be as helpful as height derived from arm span.

Table 1

Difference between arm span and height in three age groups

Age (years)	10 - 19	20 - 49	50 +
No. of subjects	19	25	29
Mean difference - cm. (Arm span – Ht)	– 1.71	+ 0.76	+ 0.43
SD of difference	2.24	3.99	5.05

Acknowledgements

The author would like to thank Mrs J Duncan and Miss S Armstrong for their technical assistance.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Association took place at the Manor Hospital, Walsall on the 30th and 31st October, 1987. We are most grateful to Penny Wright for organising the meeting, to the speakers for their interesting papers and to the following firms who generously sponsored the meeting and exhibited their products:

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Training Seminar

Where is training going? The new manual, the rôle of the supervisor, assessment and implementation of a training programme.

Scientific Papers

Serial Lung Function Tests Following Heart/Lung Transplants. Mr P Lockwood, Harefield Hospital.

Oesophageal Manometry, Routine and pH Studies. Routine Tests or Not? Miss M Marples, Hope Hospital.

A Comparison of Two Clinical Methods of Measuring the Diffusing Capacity of the Lungs for CO. Miss J Lloyd, Manor Hospital, Walsall.

Athletic Performance in Asthmatic Patients. Miss W Freeman, East Birmingham Hospital.

Alveoli, Alps and Acetazolamide — Or Studies in Thin Air. Dr T C Harvey, Manor Hospital, Walsall.

Serial lung function tests following heart-lung transplantation

P. Lockwood, Harefield Hospital

Between December 1983 and August 1987 113 patients underwent heart and lung transplantation at Harefield Hospital, Middlesex. Of these, 62 were studied by serial routine lung function tests, 38 of whom had had the tests done pre-operatively. 5 died during the post-operative investigation period. All suffered from pulmonary hypertension of some form, 24 associated with congenital heart disease and 16 with primary pulmonary hypertension. 7 had cystic fibrosis and an equal number had alpha-1 antitrypsin deficiency emphysema. The remainder had assorted disorders of the lungs.

Routing flow-volume, forced ventilation, lung volume and transfer factor measurements were made before discharge from hospital and then monthly for the first year and three-monthly thereafter.

All showed typical findings associated with a recent thoracotomy for the first few months post-operatively, with limited lung volumes and relatively high values for the FEV_1 although reduced FVC and FEV_1 values in absolute terms. The K_{CO} tended to be normal but the D_{CO} reduced with the volume. In patients with primary lung disease, these "post-thoracotomy"-type findings usually represented a great improvement, even at the testing before discharge from hospital. However, in those patients with primary heart conditions and pulmonary hypertension, this represented a deterioration in lung function.

After this period the results improved towards normal and in many patients with good pre-operative lung function it was surprising how close the post-operative values eventually came to the earlier findings.

Deterioration in lung function, in particular the development of airway obstruction and reduction in lung volumes, presumably due to the obliterative bronchiolitis reported in other centres, was seen to occur in association with increased signs of rejection with chemotherapy. It was often observed that deterioration in airflow was accompanied by improvement in transfer factor, presumably due to the direct effect of the anti-rejection agents upon the lung lining.

Flow-volume indications of upper airway obstruction was shown in 4 cases without clinical signs, and in one case with marked clinical signs, presumably due to tracheal narrowing at the anastomosis.

It was concluded from the study that normal results could be attained post heart-lung transplantation, that indications of bronchiolitis in the tests were a valuable aid in the detection of rejection and that there were likely to be other occurrences, such as the appearance of the effects of upper airway narrowing which must be looked for and assessed as they occur. In all, it was obvious that serial lung function testing could make a valuable contribution to the post-operative control of these patients.

Oesophageal Manometry and pH Studies — Routine Tests or Not?

M Marples, M M Mughal and J Bancewicz
University Department of Surgery, Hope Hospital, Salford.

Oesophageal manometry and pH studies (1) are rapidly becoming accepted methods of assessing oesophageal function, especially in the diagnosis of non-cardiac chest pain (2), unexplained asthma (3), and apnoea in the Special Care Baby Unit (4). The studies are technically complicated, time consuming and uncomfortable for patients. The question, therefore arises, "Should these tests be routinely available?"

We reviewed 401 diagnostic manometry and pH studies performed on the Surgical Investigation Unit, Hope Hospital. 241 patients had pathological gastro-oesophageal reflux. 34 had a primary motility disorder, such as achalasia. 64 had a non-specific motility disorder, with pressure changes similar to those seen in a high proportion of our asymptomatic controls, making diagnosis inconclusive. 62 patients had completely normal results.

pH studies, therefore gave a higher diagnostic yield than manometry. Manometry was mainly of value if gastro-oesophageal reflux was not detected.

In conclusion, as a number of departments are being asked to perform oesophageal studies when they are not specialised in gastro-intestinal techniques, we would suggest the routine use of pH studies, which require less technical expertise. Many pH systems have computer analysis of results, which helps simplify the study. Then, if gastro-oesophageal reflux is not the cause of the symptoms patients should be referred to a specialised centre, where full oesophageal studies, including provocation testing, can be performed. This would avoid purchasing expensive equipment and having manometry performed and interpreted by inexperienced personnel.

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Asthma and Endurance Running Performance

Wendy Freeman, Department of Respiratory Physiology, East Birmingham Hospital

The control of exercise-induced asthma (EIA) is essential if the asthmatic is to participate safely in physical activity and without respiratory disadvantage in sport (Fitch 1986). Although a number of asthmatics do participate in endurance running the physiological effect of this activity on the asthmatic has not been documented. Endurance running involved prolonged hyperventilation often in cold air, conditions which are known to provoke EIA (Strauss et al 1977). Although pre-exercise medication inhibits or minimises EIA in the majority of asthmatics in short-term exercise (Fitch 1986), its effectiveness during prolonged running is not known. The present study examined the physiological responses to running of a group of asthmatic endurance athletes, in order to evaluate both the safety of distance running for the asthmatic and whether the asthmatic participating in endurance running is disadvantaged in any way.

Sixteen endurance running trained asthmatic males (age 35±9 yrs) underwent 3 treadmill tests to document the cardio-respiratory responses to maximal and submaximal exercise and the severity of EIA. The fall in the FEV_1 after exercise when running without medication (24±13%) and the resting airflow obstruction (FEV_1 78±18% pred.) support the diagnosis of asthma in this group. The maximum oxygen uptake (VO_2 max) for the asthmatic athletes was high (61.8±6.3 ml/kg/min), being 153±15% of the predicted normal (Jones and Campbell 1982). The FEV_1 % pred. was correlated with the maximum ventilation achieved on exercise (V_E max) ($r = 0.694$, $p<0.01$), and the V_E max was correlated with the VO_2 max ($r = 0.779$, $p<0.01$). Thus more severe airflow obstruction may impair V_E max which in turn may limit the VO_2 max.

Eleven of the asthmatic athletes had recent performance times for a half-marathon or 13.11 miles (21.1 km). The mean half-marathon time for the group was very respectable (82.4±8.8 min) with a range from 69 to 94 minutes, suggesting performances of élite and recreational runners. The half marathon times were correlated with the VO_2 max ($r = -0.881$, $p<0.01$). Thus a high VO_2 max is required to run the half-marathon in a fast time. Endurance fitness, however, is defined as the ability to sustain a high percentage of VO_2 max for a prolonged period. Thus the time taken to complete the half-marathon was analysed in relation to the laboratory results. The asthmatics were able to utilise 81.9±4.0% VO_2 max for the half-marathon which is similar to that observed for non-asthmatic recreational runners (Williams and Nute 1983). Thus asthma does not prevent the development of a high degree of endurance fitness.

To examine further the effect of endurance running on the asthmatic, the physiological responses to a treadmill half-marathon "race" were compared for 6 asthmatic athletes (with their usual pre-exercise medication) and 6 non-asthmatic athletes. The FEV_1 was recorded at 4-km intervals during the half-marathon without stopping the treadmill and for 20 minutes in recovery. The asthmatic and non-asthmatic athletes showed similar cardio-respiratory and metabolic responses to the treadmill half-marathon. The pre-exercise medication adequately protected four of the asthmatics from EIA. However, two asthmatics experienced marked falls in the FEV_1 from pre-exercise both during and after the half-marathon (34% and 32%). Once EIA developed the running speed was reduced. Despite the reduced running speed and salbutamol from an inhaler the EIA could not be reversed and thus it did not seem to be possible to "run through" the asthma. One asthmatic performed a second half-marathon with the addition of aminophylline to his normal pre-exercise treatment (DSCG and salbutamol) and experienced the onset of EIA at a later stage into the run (12 km vs 20 km). However, the EIA was of a greater severity when aminophylline was taken (58% vs 34% fall in FEV_1).

To conclude, asthma does not prevent the development of a good degree of endurance fitness, although more severe airflow obstruction may reduce the V_E max and thus the VO_2 max. The similar physiological responses to a treadmill half-marathon of the asthmatic and non-asthmatics would suggest that the asthmatic free from EIA should not be disadvantaged in endurance running. However, if EIA is provoked during endurance running this will not only impair performance but may put the asthmatic at risk. Conventional pre-exercise medication may not be adequate for the control of EIA in endurance running.

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Alveoli, Alps and Acetazolamide — Or Studies in Thin Air

T C Harvey, Walsall Manor Hospital, Birmingham Medical Research Expeditionary Society

The life-giving layer of air that surrounds our planet is very thin and most of the Earth's inhabitants live at or close to sea-level where physiological systems are ideally suited for survival. At an altitude of only 5.5 km the atmospheric pressure is already reduced to a half of that at sea-level and prolonged human survival at such heights is impossible. However, Man possesses a considerable capacity to adapt even to extreme conditions and this process of acclimatisation makes it possible to make brief ascents to even the summit of Everest (8.8 km) where gas pressures are less than a third of normal). The mechanisms of adaptation to very severe hypoxia are incompletely understood but are of great interest as they parallel certain disease processes which give rise to hypoxia at sea level.

Hypoxia at altitude induces an increase in ventilation leading to hypocapnia and a respiratory alkalosis which in turn inhibits ventilation. This may lead to periodic breathing ('Cheyne-Stokes') especially during sleep, with episodes of apnoea alternating with hyperventilation. Severe anoxia may occur during the apnoeic phase leading to cerebral and pulmonary oedema and death.

Various natural adaptive changes occur in man to optimise the physiological responses to hypoxia including changes in erythrocytes, cell enzyme systems and also in central chemoreceptor sensitivity. Drugs may also be used to influence these changes and, over the last 10 years, the Birmingham Medical Research Expeditionary Society (BMRES) has carried out a number of expeditions to high altitude to investigate such changes and to study the effects of a carbonic anhydrase inhibitor (acetazolamide) in accelerating acclimatisation.

A brief account will be given of the 1987 BMRES expedition to Gondokoro Peak (5,400m) in the Karakorams in Northern Pakistan together with a summary of the findings from previous trips to the Himalayas, the Alps, Africa and the Andes.

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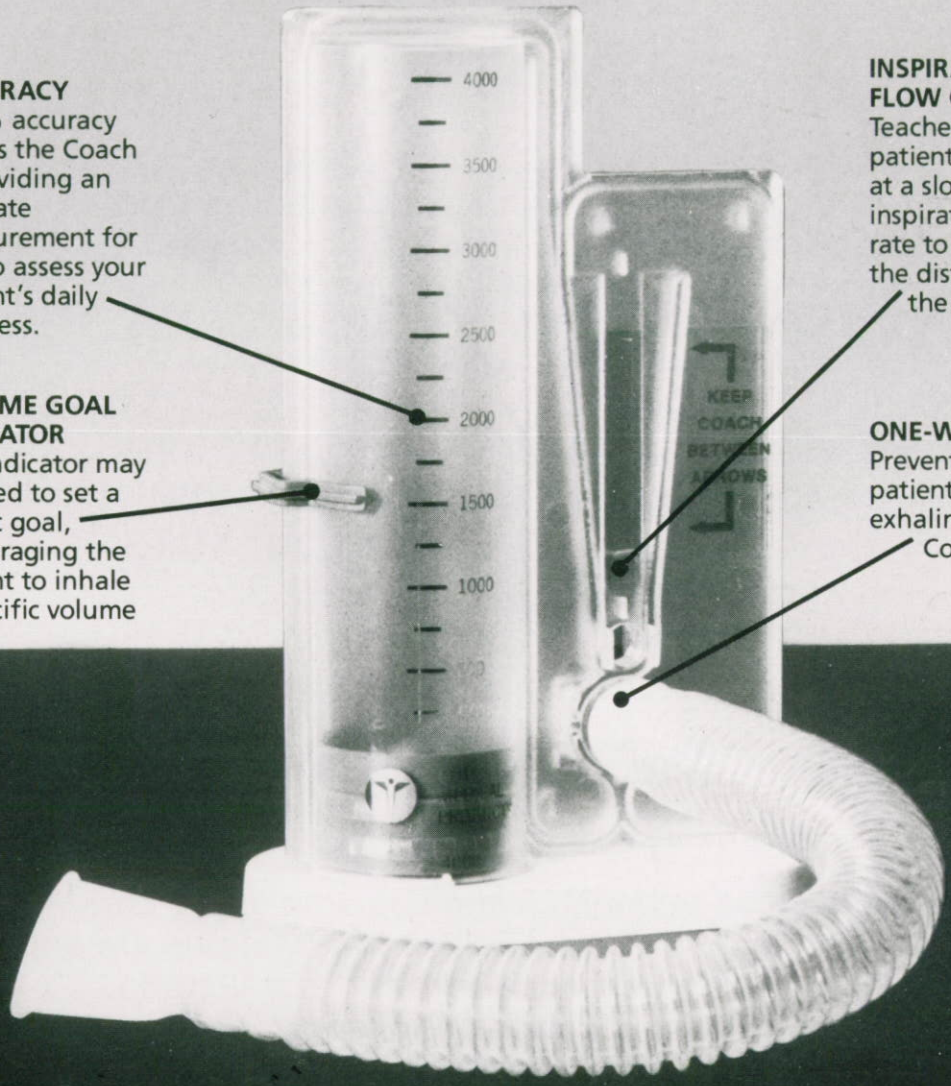

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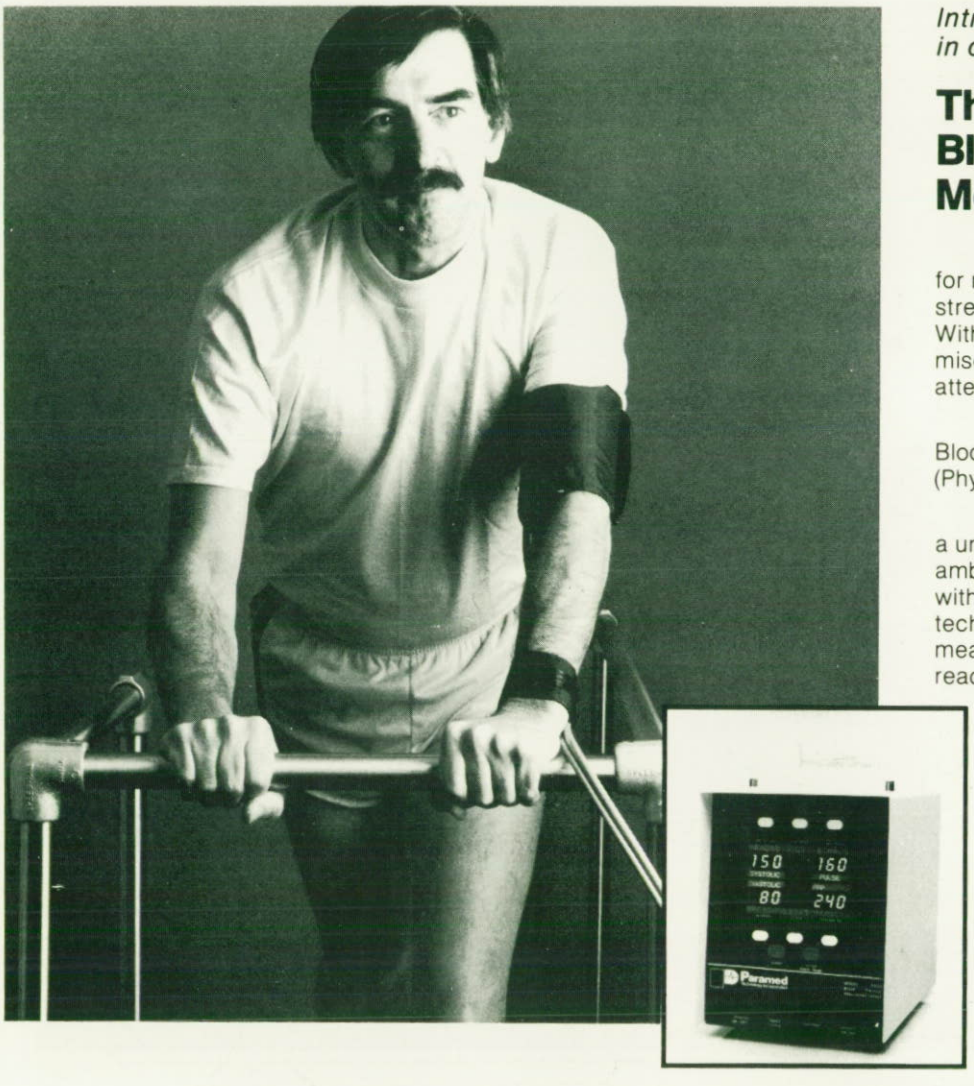

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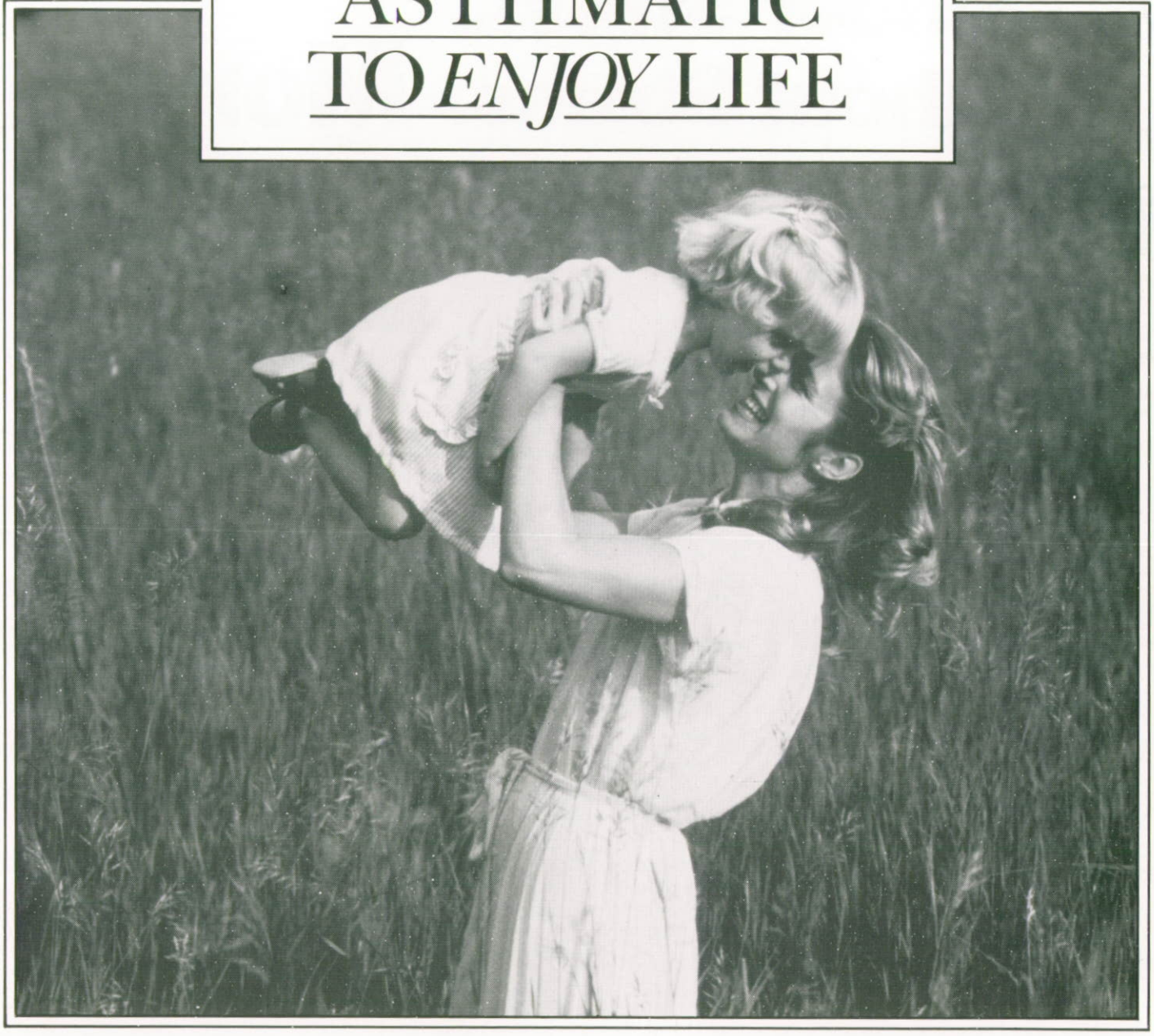

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