The Diagnosis of Underventilation Following Polio

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or with a headache not dissimilar to that associated with hangover due to alcohol.

- Frequent chest infections, often with difficulty in shaking off coughs or colds.
- Waking up with sticky saliva around the mouth.

Of course not everybody has all these symptoms and people can have some of them from other causes. Anyone who has more than two or three has grounds for suspicion and further investigation.

SIGNS

The signs of underventilation include quiet speech with fewer words per breath when speaking, or difficulty in speaking for more than a short time. A reduction in breath holding time and the obvious use of unusual muscles when breathing, for example, the head, shoulders or arms. Difficulty in or a dislike of lying flat is particularly associated with paralysis of the diaphragm, that is the sheet of muscle between the chest and abdomen during breathing, and the special sign of scoliosis. Cyanosis (blueness of the lips and finger nails) is a very late sign of underventilation and its absence should not be regarded as sufficient reassurance that under-ventilation is not occurring.

MEASUREMENTS

Now at last and quite low down the diagnostic list we get to measurements.

- Forced Vital Capacity — Undoubtedly the most important is the forced vital capacity which has to be measured in several positions, for example, lying, sitting and standing where that is possible. Serious underventilation is unusual if the forced vital capacity is over three litres, though it can happen if other problems are present.

- Pulmonary Function Tests — Unfortunately, in people with weak muscles and low vital capacities following polio, formal lung function tests can be seriously misleading. Many of the measurements, for example FEVi, are designed to measure the severity of chronic obstructive airways disease and not underventilation due to a restrictive defect such as muscle weakness.

- Polycythaemia — This term indicates an increase in the red cells of circulating blood and is commonly part of the body's adaptation to chronic underventilation particularly at night. It is not dissimilar to the polycythaemia seen in mountaineers who acclimatize to life at high altitude and it is interesting that we have seen several patients with mild post-polio underventilation who got into very serious trouble after spending even a single night at high altitude while on holiday, or on a long overnight aircraft flight were cabin pressure can be reduced to the equivalent of around eight thousand feet.

- Measurement of the Tension of Oxygen and Carbon Dioxide in the Arterial Blood — While this is the most direct measurement of ventilation, the levels can often be normal during wakefulness by day, only becoming abnormal during sleep. Indeed, as is widely known, underventilation after polio occurs primarily during sleep and to prove that this is happening requires an overnight study of breathing during sleep. This must include a measurement of carbon dioxide tensions which is more difficult to measure reliably from the skin surface than is oxygen tension or saturation and many purported sleep studies can be misleading if both oxygen and carbon dioxide tensions are not measured repeatedly and regularly during the night.

Treatment of Underventilation by Day and by Night*

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There are at least ten different methods of treatment for under ventilation following poliomyelitis and the method selected must not only be fully effective medically, but also socially acceptable and practical in the home. In practice, all methods can be and are used in the home and I think the best thing I can do is to list each method with a brief summary of the advantages and disadvantages.

TRACHEOSTOMY AND INTERMITTENT POSITIVE PRESSURE RESPIRATION

This is normally used by people who need mechanical respiratory assistance both by day and by night and is probably the best method for patients with very severe muscular paralysis. Its advantages are that it is exceedingly effective, can be provided by relatively simple equipment which is small and convenient and can be

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attached to or incorporated in wheelchairs. Its disadvantages lie mainly in the tracheostomy which is always a route for the introduction of infection, can erode surrounding structures, and prevent glossopharyngeal breathing without an attendant being present to occlude the tracheostomy. Tracheostomy tubes can become blocked; speech is possible with a non-cuffed tube but it is intermittent during the inspiratory stroke of a respirator. Some patients who would undoubtedly benefit by it are reluctant to undergo tracheostomy because they feel that it increases their disability, makes them look even less like a normal person and prevents, for example, the wearing of a collar and tie which, even in these days, many believe to be part of being properly dressed.

IRON LUNG OR TANK VENTILATOR

This is also a reasonably efficient form of artificial ventilation. Its use is normally only justified for people who need artificial ventilation by night as well as for all or some of the day. Modern iron lungs such as the Cape Alligator or Rotator, are quick and easy to get into and out of, and we have recently designed and made one in which self insertion and release are possible for people with reasonable strength in their arms. The disadvantages of the iron lung are fairly obvious: it is very large in size and once inside a nonself-release tank, the user is effectively trapped and needs an attendant to be released. Nor is it easily portable for overnight stays from home.

MOUTHPIECE INTERMITTENT POSITIVE PRESSURE BREATHING

This technique has become increasingly popular in recent years and a large variety of mouthpieces which stay in place during sleep have been developed. It is adequate for those with moderate respiratory weakness, but some of the more severely paralysed find that they can only use it for a limited number of nights in succession and need to resort to alternative devices from time to time. The equipment is small and easily portable, though the technique requires some practice and trial and error before it can be regularly used.

NOSEPIECE INTERMITTENT POSITIVE PRESSURE BREATHING

This is similar to the mouthpiece method and may have advantages in that it is less likely to produce obstruction of the upper airway. Development of adequate nasal masks is still continuing and many can easily produce soreness and discomfort over the bridge of the nose.

PNEUMOBELT

This is the only method which works by augmenting expiration. It is not particularly efficient and consists of a belt applied around the abdomen and lower chest which is intermittently inflated thus squeezing air out of the lungs. It is suitable only for people with paralysed abdominal muscles and diaphragm who need to use it during the daytime when sitting up. They usually need something more efficient at night. The equipment is small and the pump can be attached to a wheelchair. When used over long periods there is some evidence that it produces damage to the lower parts of the lung.

PROTRIPTYLINE

This is a relatively new drug which can be taken in pill form on going to bed. It acts by reducing the length and frequency of periods of Rapid Eye Movement sleep. This is a particular type of sleep which occurs in most people during which breathing is most disturbed. It is only effective for people with relatively mild underventilation and is particularly suitable for people with congenital or non-paralytic scoliosis. It has the great advantage that no equipment is required, but, unfortunately, the drug has quite serious side effects producing constipation and dryness of the mouth. It can also cause temporary impotence in sexually active men. In general, it is rarely suitable for people with poliomyelitis, many of whom have a distressing tendency to constipation anyway.

There is no doubt that all these different methods have a place and an adequate medical centre should have them all available and be able to select whichever one, or combination of several, is most suitable and effective for each individual. Unfortunately, equipment manufacturers prefer making large numbers of one or two types of machines rather than small numbers of a variety and, at present, adequate designs of all these devices are only available in a few countries.

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