

statement and should not be taken lightly. When you reach this period of crises, you must depend on your physician to help you make decisions.

I think it is important to note that individuals with hypercapnia (excessive carbon dioxide) and apnea (cessation of breathing caused by obstruction, weak chest muscles, or the brain center shutting down) have done quite well following surgical procedures and medical emergencies by being placed in iron lungs or on some other type of ventilation assistance for a short period of time.

All of the above can be evaluated by a knowledgeable pulmonologist and properly equipped sleep study laboratory prior to an emergency situation and should be done if warranted. This is why every polio with respiratory or suspected respiratory weakness should have a complete pulmonary evaluation.

If you did not have bulbar polio and if you do not have chest muscle weakness, you are not at risk for this problem! Should you need oxygen, it is not a problem. You may be treated and supported through a crisis just as any other individual. However, many people are unaware that they did have mild bulbar polio. It is possible you were never tested for it at the time of your original polio, because only the most obvious cases were diagnosed. Therefore, it is suggested that all polios should undergo pulmonary function screening. These tests should include spirometry, lung volume measurements, and a measure of respiratory muscle strength, such as negative inspiratory force.

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The Diagnosis of Under-ventilation Following Polio

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The diagnosis of underventilation after polio is not very different from the diagnosis of any other condition, but maybe it helps to go through it in order, because it can be confused easily with the underventilation and respiratory difficulties which occur in chronic obstructive airways disease. The distinction is important because the treatment is very different and the prognosis, given proper treatment, is very much better.

Firstly, you must be aware that the risk of underventilation after polio exists and that any other unrelated illness, operation or anesthetic may cause trouble. Secondly, you must listen very carefully to the story. If I ever had to make do with only one diagnostic method, this is the one I would choose to keep. It usually gives more information than any other single indicator.

SYMPTOMS

I am going to list the various symptoms of underventilation which I have seen in 150 patients with polio over 20 years. Many of them were thought by the subjects who experienced them and even by their medical advisors to be caused by quite different things.

- There has to be some weakness of the trunk often including thoracic scoliosis.
- Loss of energy and a tendency to fall asleep easily during the day.
- General weakness and fatigue often affecting muscles which the subject has not previously recognised to be polio weakened. This is a trap which can lead easily to the condition being missed if assessment is limited solely to muscle strength.
- A feeling that the air in the room is in some way bad.
- Claustrophobia — fear of confined spaces.
- Loss of mental concentration and reduced work capacity. This is often attributed by the sufferer to oxygen lack to the brain, but treatment by oxygen therapy alone is positively dangerous and in several patients led to an acute crisis and respiratory arrest.
- A sleep disturbance which can take various forms. These include difficulty in getting off to sleep with nightmares, waking during the night feeling desperately short of breath which often can be confused with

(continued on page 8)

The Diagnosis of Underventilation Following Polio

(continued from page 7)

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 FEV₁, 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 where 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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