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 diffi-
culty in speaking for more than a short time. A reduc-
tion 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 reas-
sureance 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 under-
  ventilation 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 poly-
  cythaemia seen in mountaineers who acclimatize to
  life at high altitude and it is interesting that we have

seen several patients with mild post-polio underventi-
lation 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 Car-
  bon 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 satura-
tion and many purported sleep studies can be mislead-
ing 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 advan-
tages 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 exceed-
ingly 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 glosopharyngeal 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 non-self-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.

NOSPIECE 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.

PROTRIPTYLNE
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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