PERSISTENT APNOEA ASSOCIATED WITH SUCCINYLCHOLINE CHLORIDE*

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A great deal has been written about apnoea associated with succinylcholine chloride. The frequency of the condition is giving rise to controversy and apprehension. It is generally believed that sensitivity[1] to the drug is responsible; or a substance, mono-succinylcholine[2] which results when the relaxant undergoes a metamorphosis in the body; or that there is a lack of blood cholinesterase.[3,4]

Having administered this extremely potent muscle relaxant in over 5,000 cases, and experienced these so-called apnoeas (I occasionally still do when my technique is at fault), I am firmly convinced that persistent apnoea arising from the drug *per se* and not from errors in technique, is so unlikely that it can be confidently ignored, and that the reported cases are not directly attributable to the drug. In view of the tremendous amount of experimental work that has been done in connection with this subject, I expect my views to receive hostile criticism. However, my deductions are based exclusively on anaesthetized patients (as distinct from experimental animals).

* Scoline is the brand hitherto used by the author.

At the outset, it must be clearly understood that persistent apnoea falls into two distinct categories. One is due to reflex inhibition of the respiratory centre and will be referred to here as *reflex apnoea*. The other is due to delayed return in the tone of the respiratory muscles, and will be termed *atonic apnoea*. Reflex apnoea can readily be distinguished from atonic apnoea in the lightly anaesthetized patient by the fact that in the former condition the reflexes are present and brisk; while in the latter condition the reflexes are absent.

REFLEX APNOEA

Time and again in the anaesthetized patient to whom only a single average (50 mg.) dose of scoline has been administered, one has been able to demonstrate that haphazard pumping of the re-breathing bag is liable to cause undue

delay in the return of automatic respiration. There are many who may recollect similar types of apnoea which occurred before the advent of the muscle relaxants. Those of us who used the closed-circuit technique, especially with that powerful narcotic cyclopropane, were often mystified when this condition occurred even with the carbon dioxide absorber turned off.

The mechanism of reflex apnoea appears to depend on over-distension of the alveoli due to too forceful pumping of the re-breathing bag, a form of hyperventilation. This interferes with the Hering-Breuer reflex,[5] and is facilitated by the relaxed muscles of the thoracic cage, which offer little resistance to insufflation of the lungs. It has been repeatedly confirmed that if over-distension is avoided by careful attention to the tidal volume (and not merely the minute volume), this phenomenon does not occur; nor does it occur with any method of respiration whereby the lungs are inflated by inspiratory recoil. Insufflation with the re-breathing bag is a common and convenient practice but not without the danger of reflex apnoea. Another untoward side-effect occurs when the anaesthetist inadvertently fails to release the re-breathing bag immediately after insufflation; this embarrasses the recoil of the lungs, and after a while alveolar tension becomes raised. This produces reflex slowing of the pulse rate and a rise in the blood pressure. The unsuspecting anaesthetist will be of opinion that all is well.

Treatment of Reflex Apnoea

Since there has been no 'over-scolinization', the treatment is simple. Stop pumping the re-breathing bag, so as to avoid any further possible interference with the Hering-Breuer reflex, but maintain a clear airway. After a varying period of 1–3 minutes or more, depending on the degree of over-stretching of the alveoli, automatic breathing will commence, due to the recovery of the respiratory centre, which must now respond to the stimulus of accumulated $C0_2$; there need be no anxiety during this interval about hypoxia if the patient has been adequately oxygenated (which we can assume), because hyperventilation was the causative factor. When automatic respiration commences after the 'knock-out' blow of scoline, it will be observed that the excursions of the thoracic cage are shallow, and there is a temptation to assist respiration by squeezing the bag. This urge *must be resisted*—the respiratory muscles are still weak, and even a single forceful compression may again disturb the Hering-Breuer reflex. If there is any apprehension however, passive insufflation by recoil may be resorted to, such as by repeated pressure on the lower ribs.

ATONIC APNOEA

The second type of apnoea is more serious. The onset is usually delayed and in many cases is recognized only at the *end* of the operation. It is more likely to occur when scoline is used over long periods in strong concentration, to provide complete muscular relaxation (with the object of reducing shock and alleviating post-operative pain), and to facilitate the controlled method of insufflation of the lungs.

It would appear that the grossly relaxed muscles, particularly those of respiration, need time to regain tone. The anaesthetic may have been stopped long previously, and its effects worn off, yet the patient is unable to breathe or talk, even though full consciousness has returned. Many a patient has testified to this terrifying experience. It seems that this inability results from excessive relaxation of the muscles concerned for long periods. Since the muscles of phonation are weaker, they take longer to recover and the inability to phonate often persists long after respiration has been resumed. A similar situation may arise with the milder and longer-acting relaxants such as ditubocurarine chloride and gallamine (Flaxedil), when used in large amounts and for long periods. Even full doses of antidote (neostigmine) may not result in spontaneous respiration—*the paralysing effect of the relaxant has been neutralized but the antidote can have no effect on the restoration of muscle tone.* The profound effects of scoline must be appreciated, and it is safest to administer it in dilute solution, preferably by intravenous drip. In this way the dosage can be accurately controlled by feeling the resistance of the re-breathing bag. If the drug is administered for long periods one finds that it is necessary to retard the rate of the drip as the operation proceeds, since the resistance of the bag takes longer to return. With the dosage thus controlled, there should be no undue delay in the recovery of muscle tone.

Other important factors in assessing the dosage are:

(*a*) muscularity—a muscular subject requires more; (*b*) age—infants and the aged need less; (*c*) general state of health—the toxic, the bed-ridden and the flabby also need less.

As indicated above, a useful sign of adequate scoline dosage for complete muscular relaxation is the ease with which the re-breathing bag can be correctly compressed *manually*. The correct degree of compression is the pressure required to introduce the physiological tidal volume. The importance of this in general anaesthesia is lucidly explained by Cullen[6] (and stressed by the author[7]). It is in fact the only sure means whereby the subject receives the correct amount of gases, and rids himself of that which is not required. Inadequately paralysed respiratory muscles resist compression of the bag, and produce a resistance which constitutes the indication for further dosage. In the absence of this feeling of the correct degree of resistance, the administrator should temporarily discontinue or slow the drip. It is essential that he train himself in the art of assessing the resistance of the bag with his hand. Furthermore, he must remember to release the bag abruptly after ventilation so that he does not hamper the expiratory recoil.

Treatment of Atonic Apnoea

The treatment of established apnoea arising from atonic respiratory muscles is the maintenance of the tidal volume in the presence of ample oxygenation, pending the recovery of muscle tone. Automatic respiration is shallow at its commencement, and the anaesthetist must be careful not to over-distend the alveoli when assisting respiration, lest he evoke the reflex type of apnoea; insufflation of the lungs produces a stretch of their elastic tissue, of the elements of the thoracic cage, and of the intercostal muscles. It is desirable therefore to refrain from further stretching these structures and to resort to other methods of artificial respiration instead.

While resuscitative measures are in progress the patient should be repeatedly reassured that all is well and that the ability to breathe and talk will return. Apart from this the

less said the better; these patients have vivid recollections of what has transpired and a case has occurred in which the patient reported that bad language had been used during a heated discussion as to what was the cause of the apnoea.

Persistent respiratory atonia after neutralization of a paralysing poison is exemplified in a case of snake-bite poisoning in which the venom has a predilection for the motor nerves and the sympathetic nervous system. The appropriate antidote may counteract the circulating toxins, but persistent paralysis of the muscles, including those of respiration, often results in grave hypoventilation. Artificial respiration must then be an essential part of the treatment, together with urgent measures to combat the concomitant hypotension.

DISCUSSION AND CONCLUSION

There is as yet no specific antidote for succinyl-choline chloride. Perhaps this is just as well. It may be fatal to rely on an antidote instead of directing one's attention and efforts towards accurate control of muscular relaxation. The well-being and even the life of the patient lies in the palm of the anaesthetist rather than in the barrel of a syringe.

The practice of general anaesthesia is not only a science but a highly specialized and complicated art. Success depends mainly on the ability of the anaesthetist to maintain the tidal volume of the subject as near to normal as possible, and the skill with which this is executed.

In all humility, we must realize that, with the advent of the muscle relaxants, our speciality is being revolutionized, and we are being given the opportunity to achieve a better understanding of the physiology of respiration. Provided that we adhere to sound physiological principles, and apply them efficiently, the patient will derive the full benefits of modern anaesthesia—minimal narcosis (analgesia), minimal shock, and minimal post-operative pain and vomiting. If we stray (and we are not infallible) from these principles, we shall be responsible for evoking many of the weird phenomena about which so much is being written. Indeed, our text-books on general anaesthesia are becoming bulkier, and in parts more incomprehensible, instead of smaller and simpler as is the case in other branches of medicine.

The drugs used by the anaesthetist are potentially dangerous. They are dangerous because inevitably, and especially in an unconscious subject, a vital factor—the tidal volume—is affected. Therefore, those anaesthetists who feel that a drug is capable of producing unpredictable effects should adopt the practice of cautious physicians, and abandon the use of such a drug.

However, some of us believe that the effects of the drugs which we use *are* predictable, and are *not* dangerous, provided that the drugs are correctly administered. Scoline is an invaluable muscle relaxant and marks a memorable advance in the development of general anaesthesia.

Surely it is time that we reassess our experimental findings and begin the teaching of modern anaesthesia on sound, logical and comprehensible lines, and cease making a scapegoat of potent drugs—the narcotic[8] and the relaxant!

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