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REGIONAL ANESTHESIA

edited by Kenneth E. Bray, M.D.

from New Orleans

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PREFACE

Regional anesthesia for many years was in the domain of the surgeon. Necessity compelled him to be adept in nerve blocking, field blocking, and in the induction of spinal anesthesia. As anesthesiology progressed over the past twenty-five years, the need for the surgeon to dabble in methods of pain relief has lessened because good anesthesia is now available nearly everywhere. Except in areas where adequate general anesthesia is not available, surgeons now show little interest in performing their own blocks. Regional anesthesia, therefore, has been relegated almost entirely to the domain of the anesthesiologist. Anesthesiologists, on the other hand, except in the case of a limited few, appear to be less than disinterested in this aspect of pain relief. Many shun these techniques because they feel that less effort is required on their part and that general anesthesia is more pleasant to the patient. In many areas, therefore, regional anesthesia appears to be on the decline. One cannot argue that certain methods of general anesthesia are not superior to conduction techniques. Yet situations so often arise in which a regional method is a better choice that it behooves the anesthesiologist to be well versed in all methods of anesthesia. It is hoped that this volume will serve as a stimulus to anesthesiologists to take up once more what seems to be regressing into a lost art.

Since the time of its introduction by August Bier in 1899, spinal anesthesia has received intermittent bursts of undeserved adverse publicity. Paraplegia following spinal anesthesia is an uncommon complication. Yet it is so generally feared by patients and their friends that many are unwilling to accept it. A single accident following the technique is widely publicized for many years, because the unfortunate victim survives in a helpless and paralyzed state and becomes a living monument to the complication. Physicians aware of the medical–legal implications associated with the method tend to avoid it or have abandoned it and select other and at times not as safe methods.

In spite of all this, spinal anesthesia is here to stay. The enthusiasm for the method waxes and wanes, yet it is still with us and used without fear or difficulties in many areas.

The method has much to offer both from the standpoint of simplicity and safety. During the past sixty years the refinements in techniques and the better understanding of the physiological changes incident to its induction have made this one of the safest methods of anesthesia when used judiciously. Drs. Bray and Parmley have assembled in this volume present day concepts of spinal anesthesia, the details pertaining to refinements of technique, precautions and measures advocated to insure its safety.

JOHN ADRIANI

CONTENTS

REGIONAL ANESTHESIA

Spinal Anesthesia

PHYSIOLOGY OF REGIONAL ANESTHESIA

Rudolph H. de Jong and Irving H. Wagman

IN THIS SYMPOSIUM on regional anesthesia, main emphasis is properly placed on clinical material. However, as is true of other branches of anesthesia, the most effective application of regional block techniques depends on an understanding of the basic sciences. The following discussion presents a brief outline of the physiological characteristics of peripheral nerves, especially those that are basic to the action of local anesthetics.

PERIPHERAL NERVES AND FIBER GROUP CLASSIFICATION

A mixed peripheral nerve is made up of numerous individual nerve fibers, varying in size from about 0.5 to 20μ in diameter. Fibers over 2μ in diameter are covered by myelin; this myelin sheath is of sufficient importance to allow classification of fibers into myelinated and amyelinated. A peripheral sensory nerve fiber is the axon of a nerve cell, the body of which is located in a dorsal root ganglion. The cell body of the motor fiber is in the ventral horn of the spinal cord. Sensory fibers carry messages from the periphery (skin, muscles, joints) centrally, while motor fibers transmit messages to the muscles. These fibers lie side by side within the peripheral nerve, so that both types are simultaneously exposed to the action of a local anesthetic applied to the nerve.

The preparation of this paper, including the experiments illustrated in Figure 2, was supported in part by National Institutes of Health Research Grant GM-8013.

Nerves are a specialized tissue of high irritability. An appropriate stimulus will initiate an impulse in the fiber, manifested as a change in electric potential, which spreads wavelike along the length of the fiber (see below). This *action potential* can be identified after electronic amplification and is characteristic for the type of fiber. The speed of conduction of an impulse varies directly while the threshold varies indirectly with the diameter of the axon. The largest fibers, which are myelinated, conduct at over 100 meters/sec., while small amyelinated fibers may conduct at less than 1 meter/sec. The speed of conduction of myelinated fibers in meters/sec. is approximately six times the diameter of the fiber in microns.

Stimulating a mixed nerve at one point, using a stimulus strength great enough to excite all fibers, while simultaneously recording from a distant point, gives rise to an irregularly shaped wave, since the faster impulses arrive at the recording site before slower ones (Figure 1). Each hump in the curve represents the sum of the action potentials of a group of fibers with similar conduction velocities. The composite action potential of a peripheral nerve is formed by two major groups. One, from myelinated nerves, is the A elevation. The second, less distinct, is from small, slow, amyelinated fibers, forming the C elevation.* The A elevation is further subdivided into four groups, —alpha, beta, gamma, and delta—on the basis of diameter, conduction velocity, and threshold; the A-alpha fibers are the largest, fastest, and most easily excited, and the A-delta fibers are, of the myelinated fibers, the smallest, slowest, and least sensitive to stimulation (see Figure 1).

Although a single sensory fiber may respond to different stimuli to its receptor, the information it carries is dependent to a great extent upon its size. The largest sensory fibers, A-alpha and A-beta, are proprioceptive. Pressure and touch lie in the intermediate A-beta, A-gamma, and possibly A-delta range, while pain and temperature are carried by the smaller and slower A-delta fibers. In addition, pain sensation is also trans-

*Another elevation, the B group, is formed only by preganglionic autonomic fibers which are thinly myelinated. These are blocked during spinal or epidural anesthesia. However, they are of no concern to this discussion, since they are not present in peripheral somatic nerves.

mitted by the even smaller and more slowly conducting amyelinated C fibers; there is some evidence to show that C fibers may also transmit touch and temperature sensations. Motor nerves

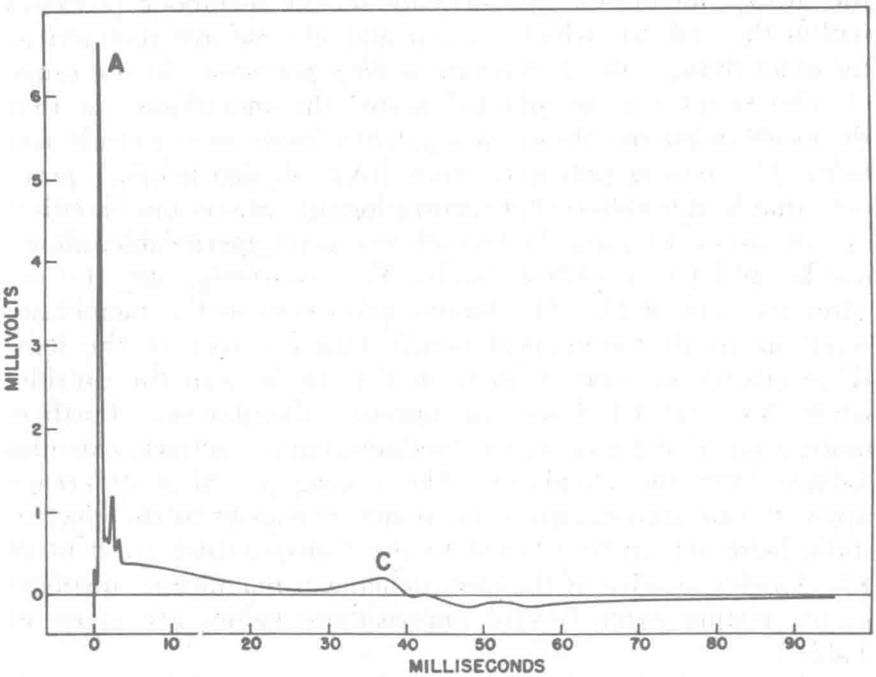

FIGURE 1. The complete action potential, drawn to scale, of a cat's saphenous nerve showing the relative conduction times of the different groups of A fibers and C fibers. This is a composite picture made from different recordings on different time bases. Since the amplitude and conduction times of the various groups are so different, such a complete potential cannot be recorded at once. The individual records of Figure 2 demonstrate this fact quite well. (Modified from Figure 36 of *Neurophysiology* by T. C. Ruch, *et al*. Philadelphia: W. B. Saunders Co., 1961.)

leading to muscle contraction are comprised of large, fast A-alpha and A-beta fibers. Motor nerves supplying the intrafusal fibers are A-gamma.

THE MEMBRANE POTENTIAL

In order to understand the nature of the nerve impulse, one must first consider the characteristics of the nerve membrane. A normal resting nerve may be compared to a loaded pistol. It