Orthopædic Surgery

by

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Sixth Edition

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Preface to Sixth Edition

The time has come for this textbook to be rewritten. A new era in orthopædic surgery is emerging, and important developments and significant advances are being made which will surely stand the test of time. Many of these advances have resulted from new knowledge of the neuro-muscular and skeletal systems consequent on developments in the so-called 'basic sciences'. The kinesiology of gait, of hand function, and of the function of the hip and its disturbances, to name but a few, all require for their understanding a fundamental knowledge of anatomy and physiology. In dealing with tumours we should no longer be satisfied with a histological report, but must seek to know their classification, their biological aggressiveness, and their probable life history. Similarly, in infections of bones and joints, it is necessary now to know the background of chemotherapy, its biological character in relation to drug selection and drug sensitivities, and the place of surgery in this new setting. All these new considerations have meaning in so far as the care of patients is concerned; but they are essential also in our efforts to advance orthopædics beyond a system of surgical techniques and auxiliary services.

Today many conditions and syndromes require what may be called a 'multi-disciplinary approach'. This is particularly so of the neuromuscular disorders, of rheumatoid arthritis with its challenge of reconstructive surgery, of amputations and their prosthetic replacements, and of rehabilitation in both adult and childhood disorders. Orthopædic surgery has much to offer as a discipline, but only if its exponents are educated adequately in these related fields.

In the future, greater consideration must be given to the plasticity and the restoration of the musculo-skeletal tissues, and less to the virtues of purely ablative or stabilizing procedures. The orthopædic surgeon must have a working knowledge of the transplantation of tissues and the mutual reactions of transplants and their host. The physiology of growth and development, and the factors controlling them, have also real importance, in so far as such forces may act as aggravating and deforming factors in congenital anomalies.

We have attempted to give a short outline of the 'core material', the significant facets of the anatomy and physiology of bone, joint and muscle. The selection of material for any textbook is bound to some degree to be an arbitrary process, but in this text it is based on our experience of the practice of orthopædic surgery, and of the teaching of both undergraduate and post-graduate students, which have induced an awareness of certain basic needs. In consequence, new chapters and fresh material, together with 400 new illustrations, have been added and much out-of-date material eliminated.

Descriptions of surgical technique and methods have been shortened; their retention would have made the book too cumbersome, and we believe several comprehensive texts are already available. Instead, we have discussed the indications and the purposes of various operations and ventured an opinion on our own preferences. We emphasize that, although surgery is required for many orthopædic conditions, many of the principles of sound orthopædic practice are similar to those of medicine.

With such important developments in the field of orthopædics and such significant changes in practice it is not surprising that it has become difficult for one man to continue to undertake this work. The author of the earlier editions has had the good fortune to have join him an able colleague—and a friend—to collaborate. The younger author possesses an up-to-date knowledge of the newer aspects of orthopædic surgery and has applied himself particularly to those, while the original author continues to devote himself to the more general aspects of orthopædics, its methods and techniques.

Acknowledgements

It is a real pleasure to acknowledge the help and encouragement of many of our friends, such as Drs. William Boger, Charles M. Evarts and Franklin Hoaglund. In addition, this work has been greatly facilitated by many colleagues and friends who have provided much information and material for illustrations. We wish to thank Drs. Philip Winslow, M. Laurens Rowe, Lynn Callin, F. K. Holzworth, H. Todd Stradford, and Frederick N. Zuck for radiographs, and George Mitchell of the Edinburgh School for his work on poliomyelitis and congenital dislocation of hip. We have especially to thank Dr. Tom Ritchie of Roehampton Limb Fitting Centre for great help in the chapter on Amputations and Limb Fitting.

Three specialized fields of activity have been specifically written by men who have dedicated much of their professional life to the development of these subjects: Dr. Frederick N. Zuck on cerebral palsy; Dr. Louis A. Goldstein on scoliosis; and Dr. Robert Berkow on psychological aspects of back pain.

It is also a sincere pleasure to thank Mr. Robert C. Wabnitz of the Medical Illustration Department and Mr. John Gaughn of the Medical Photography Department and their staff, of the University of Rochester, and our secretaries, Mrs. Audrey Young and Mrs. Helena Vatter, and Miss Oliver who, as before, has been indefatigable in typing, correcting, and compiling the index.

It also gives us pleasure to thank the following for having given permission to reproduce their valuable material, and to many others from whom we have gathered knowledge:

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CHAPTER I

Introduction

Sir Arthur Keith has aptly defined the scope of orthopædic surgery: 'To effect the repair of the mechanical framework of the human body by all operations and appliances which may have that aim in view.'

The term 'orthopædy', adapted from the two Greek words, ὀρθός, meaning straight, upright, or free from deformity, and παιδιον, a child, was originally used by Nicholas Andry, whose work, *L'Orthopédie, ou l'Art de prévenir et de corriger dans les enfants les déformités du corps*, first appeared in 1741. The elder Sayre considered that the word Orthopædics was derived from ὀρθος and παιδευω, meaning 'to educate', and as such emphasizes the preventive and advisory nature of the specialty.

Modern orthopædics is concerned with the study of the form and function of the human frame; its attack is directed against those affections that deform the architecture or arrest the balanced mechanism of man's body, and injuries of bones, muscles, nerves and soft structures which result in loss of form or function are thus its legitimate objective.

Andry originally taught orthopædics as a branch of preventive medicine rather than as an offshoot of surgery, and the various methods he described of preventing and correcting bodily deformities in children were, in his own words, within the reach of 'fathers, mothers, nurses, and others entrusted with the bringing up of children'. Andry's words need not be passed over lightly, for they have a moral even for our enlightened days: prevention is always better than cure, and if the principles and practice of preventive orthopædics were more liberally applied today, many of the severer degrees of flat foot, scoliosis, and similar deformities would disappear. But the timely institution of preventive measures demands the early recognition of incipient loss of form or function—an ideal to be attained only by periodical inspection of the young by one trained in orthopædic surgery.

The solution of the problems of an orthopædic case depends on a clear understanding of the pathological nature of each lesion, and success in treatment on a scrupulous attention to minute detail. Orthopædic work is thus exacting; for the surgeon must supervise personally each detail of treatment, and consequently devote more time to each individual patient than in any other branch of clinical work. The stimulus of success, however, will prove an ample reward, and the lightening of the burden of cripples and the deformed—not only the physical and visible burden but the subtler and less evident mental one—may well be considered the pinnacle of surgical achievement. Those who escape contact with the deformed do not appreciate the keen mental anguish which they suffer—a mental anguish that led Gloucester, when bewailing his fate in his sad monologue in *Richard III*, to exclaim:

> Cheated of feature by dissembling nature,
> Deformed, unfinished, sent before my time
> Into this breathing world, scarce half made up,
> And that so lamely and unfashionable,
> That dogs bark at me as I halt by them.

Even if no other word is uttered, it is worth while to hear your patient say, 'You have made me walk.'

The scope of orthopædic surgery

Orthopædics as a specialized branch of surgery, though it has been growing progressively since the days of its great pioneers, has achieved its present prominence largely as a result of two closely related factors; the casualties of the two wars and the accidents incidental to the present mechanical age have, together, shown the need of better treatment for the injured, and aroused surgeons everywhere to greater effort.

Orthopædic affections fall into one or other of six groups:

1. Congenital anomalies.
2. Affections of joints.
3. Affections of bones.
4. Affections of muscles, tendons, and other soft tissues.
5. Affections of the nervous system.
6. Static deformities.

While many of the lesions have a definite pathological basis, it is being realized more and more that a large number of orthopædic disorders are the end results of postural or static anomalies. These are anomalies which are produced by either *postural* forces which result from habit, occupational attitudes or body carriage or *static* forces which are concerned with bodies at rest, or in equilibrium, or acting as weights which are not moving.

Peabody (1938) differentiated between a *postural* deformity which is dynamic in origin occurring in young children with the possibility of continuing growth aggravating it and a *static* deformity in which, because of weakened musculature, structural abnormalities are aggravated by the forces of gravity in all ages.

Posture is dependent upon the tone of the skeletal muscles which is under the control of the sympathetic and somatic nervous systems necessary to maintain position against the forces of gravity. In the standing position, Lovett and Reynolds have described how the lines of forces making up the centre of gravity lie in front of vertebræ, knees, and ankles, and in the coronal plane along the line joining the mastoid process, the greater trochanters, the tibial tubercles to reach the ground at the base of the 5th metatarsal bones. A state of equilibrium is achieved when a vertical line passes through the centre of gravity but falls within the boundary of a supporting base, and this occurs in the standing position. Posture abnormalities arise from abnormal forces, particularly during growth. This is particularly seen in adolescent kyphosis or round shoulders, and is correctable before any bony and disc deformities develop. It is also seen in the genu valgum deformity which is accompanied usually by laxity of ligaments and quadriceps muscle insufficiency. Forces of gravity during growth will produce deformity of bone and this is commonly seen in the over-growth of medial condyles of the tibiae (Fig. 1.1). Many cases of acquired flat foot deformity or pes planus are postural in nature.

In this connexion Goldthwaite has pointed out that only by using the body correctly can the best be got out of it, and that should the elaborate mechanism which controls and maintains the body in its upright position fail, the body processes are upset and the stage is set for many obscure and distressing maladies. The role of the orthopædic surgeon in such a case is to

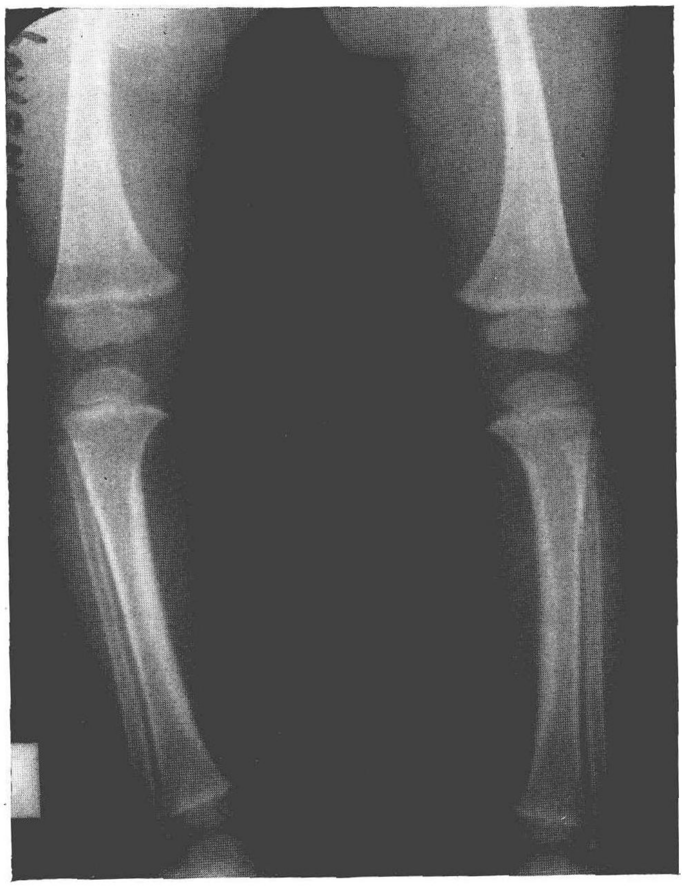

FIG. 1.1.—A standing radiograph of a young girl aged 6 years showing genu varum and over-growth of the medial condyles of both tibiæ

correct body posture. He became convinced, furthermore, that to treat any of the sequelæ of faulty posture was futile without first correcting the posture itself by ensuring the correct use of the body and by modifying faulty mechanics. Many of the following pages are occupied with this aspect of the orthopædic problem; its intrinsic importance is great, and, further, it has an important lesson to teach—that, from the orthopædic standpoint, the body must be viewed as a whole, even though the actual complaint is a local one.

The examination of an orthopædic case

No part of orthopædic training is more important than the acquisition of a systematized method of examination. It cannot be too strongly urged that a true knowledge of disease, which forms the basis of successful diagnosis and treatment, can be founded only on the careful and accurate study of individual cases. Scientific and orderly investigation is as essential in orthopædic conditions as in any obscure internal malady.

I. The history

At the first consultation it is necessary to elicit a complete and accurate history of the patient's complaint, the mode of its onset, and the order in which the symptoms were first observed.

(*a*) *The complaint.* The chief complaint may suggest to some extent the nature of the affection, while it always focuses attention on some definite part of the body.

(*b*) *Manner of onset.* The illness may begin suddenly, or it may be gradual and insidious in its development. Apart from trauma, the most likely cause of sudden derangement is acute infection. When the onset is insidious, it may be due to a low-grade inflammation, granuloma or tumour, a slow degenerative process, or a postural anomaly.

(*c*) *Typical symptoms.* The typical symptoms to be inquired for in any injury, disease or deformity, congenital or acquired, of the musculo-skeletal system and its associated structures are: 1. Pain and its features; 2. Disturbed sensation, e.g. paræsthesia; 3. Deformity: its onset and progress; 4. Weakness or paralysis of muscle power; 5. Limitation of movement of a joint; 6. Instability of a joint; 7. Crepitus.

(*d*) *The question of preceding injury.* There is a distinct tendency to ascribe all orthopædic symptoms and errors to some injury, often sustained at a date considerably remote. An attempt should always be made to ascertain the exact details of any alleged trauma, and to establish its exact relation to the actual lesion as this may have important medico-legal bearings. Such an inquiry should be directed towards discovering whether the symptoms arose at the time of the injury, existed previously, or only appeared subsequently. A good practical rule is to ascertain whether the patient was able to leave the scene of the accident unaided or whether he required immediate assistance.

II. Clinical features: symptoms and signs

The clinical features may be objective or subjective. The objective features, or signs, are those—such as deformity, errors in attitude or gait, and limitations of movement—which are obvious to the examiner. The subjective symptoms are those of which the patient complains but of which the surgeon has no definite positive evidence. Considerable tact and discrimination are often required to disentangle the truth from the complaints of patients who are neurotic, hysterical, or malingering.

III. The examination of the case

The examination of an orthopædic case must include not only the physical condition of the patient but any laboratory tests, and special investigations suggested by the clinical findings. Unless the complaint is a minor one, limited to one extremity, it is wise to make the examination with the patient stripped of all clothing, save, perhaps, bathing drawers, and, in the case of a female patient, some covering for the breasts. The examination may be conveniently considered in two parts:

1. Examination of the body as a whole.
2. Examination of the affected member or part.

(*a*) *Examination of the body as a whole.* The attitude and carriage of the body are observed when the patient stands and walks, and the manner in which the weight is borne on the soles of the feet, and the relation of the feet to the legs, should be noted. The relation of the hips to the pelvis, and of the shoulders to the chest, is observed, and the contour of the spine, chest, and abdomen investigated. The inspection of the body is carried out from behind as well as from the front and laterally. Particular attention is paid to the spinal column, and the situation of the spinous processes and also the lower angles of the scapulæ may be marked with a skin pencil. The position of the pelvis depends upon the iliofemoral ligaments; when these are short, it lies more obliquely, as the pelvis is pulled forwards; when they are long, a greater degree of extension is possible at the hip joints, and the pelvis is tilted backwards and loses a good deal of its obliquity. In men, the pelvic obliquity is less than in women, and the anterior superior spine lies on a plane slightly posterior to that of the symphysis pubis; the curvature of the lumbar spine is thus less than in the female, in whom lumbar lordosis is often marked.

(*b*) *Examination of the affected member or part.* The thorough examination of the affected part demands a considerable knowledge of the anatomy of its joints, nerves, and muscles. It should also follow a routine plan and must never be haphazard or unsystematic. The various details observed and elicited should be carefully recorded.

Method of Examination

(a) **Inspection.** The attitude in which the part is held, its general appearance and colour, and the presence of deformity, are noted. In the case of a limb, a comparison should always be made between the affected and the presumably healthy side, especially for swelling or wastage.

(b) **Palpation.** Handling of the affected part will elicit such objective phenomena as abnormal anatomical relationships, muscle tone, pulsations, tenderness, fluctuation, elevation of local temperature, induration, or gross alteration in shape. Friction within a joint may be discovered by combining palpation with passive movement.

(c) **Passive motion.** Valuable information may be obtained by carrying out the movements of which the part is normally capable, and by comparing this range with that on the normal side. The amount and quality of the movements are assessed in degrees, and the presence or absence of pain determined.

Limited joint movement may be due to some bony block, to adhesions between the joint surfaces, or to reflex spasm of the related muscles, as in early cases of tuberculosis. During movement there may be a grating or crackling sensation, comparable to that produced between the ends of a broken bone. Such crepitation is characteristic of osteoarthritis.

Abnormal joint movement may take the form either of excessive mobility or of false mobility. In the former, the normal range of movement is exaggerated in every direction; in the latter, the joint moves in a new or abnormal direction.

(d) **Active motion.** This represents the degree to which the patient can, without assistance, move the affected part. It is usually considerably less than the amount of passive motion, the limitation being due to a similar cause, aggravated by a greater degree of spasm or weakness or paralysis of the associated muscle groups.

It is advisable to record accurate observations of the range of active mobility; this is usually done by employing an apparatus such as an arthrometer. It is often instructive to compare the readings on subsequent occasions, as in this way an index of improvement is provided. The instrument is a simple one, consisting essentially of two metal strips joined by a hinge. Opposite the joint there is a protractor, graduated in degrees. The joint is controlled by a thumb-screw, so that after the angle or arc of movement has been estimated, the arthrometer can be fixed until the reading is made. Other methods may be employed, but it is important always to adopt the same technique to eliminate possible sources of error.

(e) **Muscle power** of individual muscles or groups of muscles must be carefully observed and recorded, and the following grades are commonly used:

Grade

5—complete range of active motion against gravity and full resistance.
4—complete range of active motion against gravity and some resistance.
3—complete range of active motion against gravity.
2—complete range of active motion with gravity absent.
1—evidence of muscle contraction but no joint movement.
0—no muscle contraction seen or palpable.

(f) **Measurement.** Careful comparison of the measurements of the affected part with those of the opposite healthy side will often demonstrate atrophy or hypertrophy.

The length of the limbs is measured in order to assess any inequality that may be present. In the leg, the measurement is taken from the anterior superior spine to the level of the knee joint, or to the medial malleolus. Certain lines may be drawn in the neighbourhood of the hip joint which are of value in discovering the site of any shortening in that region.

Nelaton's line extends from the anterior superior spine to the tuberosity of the ischium. Normally it passes through the tip of the greater trochanter, but in pathological conditions of the head or neck of the femur the trochanter is displaced upwards and lies above Nelaton's line.

Bryant's triangle is formed by the perpendicular dropped from the anterior superior spine when the patient is lying on his back. The base is the line extending from the tip of the trochanter to this perpendicular, while the hypotenuse is represented by the line joining the trochanter and the anterior superior spine. Here again, in pathological conditions of the femoral neck or head, the base of the triangle is shortened, whereas in fractures of the shaft, or shortening situated in parts other than in the base and neck, the normal relations are maintained.

Schoemaker's line is valuable in that its demonstration requires no movement of the patient. It is drawn from the tip of the great trochanter through the anterior superior spine and prolonged towards the midline. Where the trochanter is displaced upwards, the continuation of the line meets the middle line of the body below the umbilicus, whereas in the normal case the midline is reached above the umbilicus. Measurements should also be made of girths at fixed levels of the limbs.

(g) **Auscultation.** This may be of value, particularly in the neighbourhood of joints, for locating crepitation, snaps, and friction-rubs. As a rule, however, these can be detected without the aid of the stethoscope.

(h) **Neurological examination.** In general, the examination of the central nervous system must be carried out when there are motor symptoms such as loss of power or paralysis involving voluntary movements, or sensory symptoms such as pain, numbness, tingling, altered sensation to touch or temperature, or loss of sense of position.

The motor components

For motor disturbance, one must examine for atrophy or hypertrophy of muscle mass, passive and active ranges of movements of joints, fibrillations or fasciculations as seen in progressive muscular atrophy, amyotrophic lateral sclerosis, and less frequently in syringomyelia. There may be spasm of muscle or irritability of the muscle mass as well as soft-tissue contractures to produce characteristic deformities of joints. Involuntary movements may be present, either as irregular and spontaneous, e.g. in chorea, and in athetosis of a cerebral palsy child; or they can be purposeful and regular such as spasms, tics, and tremors arising from such conditions as multiple sclerosis and other diseases particularly affecting the extrapyramidal system. This consists of the vestibular system and eyes, the spino-cerebellar tracts and connexions with the superior corpus quadrigenium of the midbrain and the cerebellum. It is concerned with the regulation of muscle tone and the co-ordination of muscle movements. Disease of the extrapyramidal tract is also seen as muscle rigidity, but with the presence of normal tendon and cutaneous reflexes, and finally disturbed gait. One should examine for irregularity of gait, e.g. ataxia, the steppage gait and others. The examination of muscle mass, active movements, tone, and reflexes should determine whether the lesion is in the *upper motor neurone*. This involves the pyramidal tract which is concerned with the execution of voluntary movements as well as the control of muscle groups. Disturbance is seen as paralysis, increase in muscle tone or spasticity, exaggeration of tendon reflexes, an extensor plantar reflex, but no atrophy of muscle. With a *lower motor neurone lesion* there is weakness or paralysis of individual muscles with tenderness and pain, decrease or absence of tendon and cutaneous reflexes.

Reflexes result from sudden stretching of tendons or associated structures, and require the presence of a sensory neurone, an internuncial connexion in the spinal cord and finally an executing motor neurone. In the upper extremities, the biceps reflex results from integrity of C5 and 6, the triceps reflex from C6 and 7, and the supinator jerk from C7 and 8 segments. In the lower extremities, the knee reflex results from integrity of segments L2, 3, and 4, and the ankle reflex through S1 and 2 segments. Superficial or cutaneous reflexes are seen in the abdominal reflexes of T8 to 12, the plantar reflex from S1 and 2, cremastic reflex from S1 and 2, bulbar-carvenosus from S1 and 2 and anal reflex from S5. The jaw reflex depends upon the integrity of the 5th cranial nerve.

The sensory components

On examination of the sensory component of the central nervous system one examines for touch, pressure, pain, temperature, vibration, and proprioceptive sensation. With involvement of the posterior nerve root and peripheral nerve, there is loss and impairment of all forms of superficial and deep sensation, with alteration in tendon reflexes and flaccidity of muscle. In disturbances in the posterior columns there is reduced or absence of the deep senses as well as proprioceptive and vibration sense, and tendon reflex changes. Alteration in touch, pain, and temperature sensations are usually on the opposite side except for the areas of skin and present as the typical Brown–Sequard syndrome. With involvement of the sensory cortex one has a contralateral alteration in peripheral sensation and the decreased ability to recognize common objects by prehension, which is termed asterognosis. Examination of the cranial nerves is important and should be carried out.

Lumbar puncture for examination of pressures, Queckenstedt test for complete or partial blocks, particularly of the subarachnoid space, and examination of specimens of the cerebrospinal fluid should be carried out for colour, cell content, protein, sugar and globulin functions, Wassermann test, colloidal gold curve, and for bacteriological investigations.

Electrodiagnostic methods

The electrical examination of a neuromuscular unit has its basis in the character and degree of the response of nervous and muscular tissue to electrical stimuli. An effective electrical stimulus is one which results in muscle contraction. Electrodiagnosis can, therefore, be helpful as follows:

1. To detect denervation and its degree.
2. To observe reinnervation before clinical signs are apparent.
3. To assess the progress of a lesion, whether or not recovery is occurring.
4. To localize the lesion in the spinal-cord structures (myelopathic), in the motor root or peripheral nerve (neuropathic), and the neuromuscular junction or in muscle (myopathic) (Fig. 1.2).

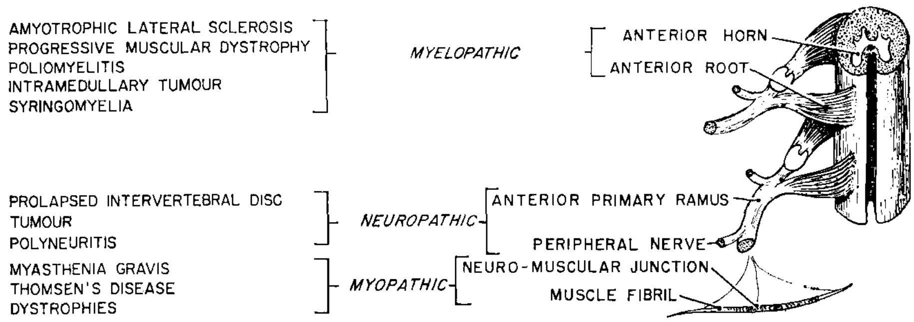

FIG. 1.2.—Lesions most commonly affecting the spinal cord structures, the motor root or peripheral nerve, the neuro-muscular junction and muscle

(1) *Peripheral nerve lesion.* A muscle will contract in response to direct current of long duration (galvanic stimulus) or to a current in which duration is very brief (faradic stimulus) when applied to its motor point. With interruption of peripheral-nerve supply, all response to faradic stimulation is lost within a few days. However, there remains a sluggish response to galvanic stimulation. Erb's reaction of degeneration (R.D.) is the loss of response to faradism with retention of the galvanic response. Alteration of polarity of KCC (cathode closing circuit) becoming greater than ACC (anode closing circuit) is extremely variable, and has little clinical value. The value of this reaction is limited because of its lack of quantitation, as well as its inability to define change in the state of denervation and, hence, prognosis.

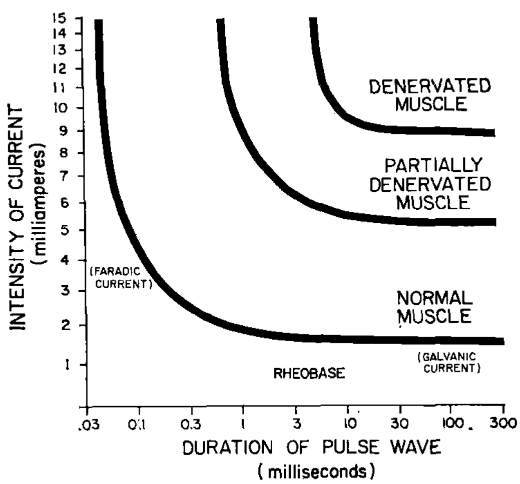

FIG. 1.3.—Contrasting the intensity duration curves of denervated and of normal muscle

When the duration of the pulse rate is shortened, it becomes faradic in type, whereas when prolonged sufficiently it becomes galvanic

(2) *Intensity-duration curves* (Ritchie, 1944) are obtained by stimulating the muscle mass with individual square waves or pulses, the duration and intensity of which can be varied, under control. The rheobase, which is defined as the minimal current required to give a slight muscle contraction or twitch (this requiring certain experience to detect), is determined; the current intensity is gradually reduced and characteristic curves can be obtained (Fig. 1.3). In totally denervated muscle the rheobase is increased and