ive action on the co-ordinating structures, as is well shown, not only in acute intoxication, but also in those cases which bear the name of pseudo-tabes or alcoholic tabes.

The method by which exposure to cold and wet might act as a producing cause for tabes is no more clear than the method by which it acts to produce other diseased conditions. The only case of this kind which has come under my observation was one in which the exposure first produced a neuritis which seemed to secondarily involve the cord.

CASE 9.—Male, aged 67, a pastry cook, seen in Kings County Hospital. He gave history of two previous attacks, each of which occurred after exposure when overheated. The first occurred nineteen years before, and involved both legs, and the second one occurred one year later and also involved the arms. The present attack was of nine months' duration. Examination showed a well-marked quadriplegia, with foot and wrist drop, diminished knee-jerks, anesthesia dolorosa of the extremities, tenderness over the nerve trunks, and edema of the feet. The condition slowly improved, but at the same time he developed lightning pains, attacks of diplopia, and occasional retention of urine. By the end of three years he presented the ordinary picture of tabes, of which he died, and which diagnosis was confirmed by an autopsy.

The remaining alleged etiologic factors may be divided into three groups: 1, Toxins formed in the body as the result of some contagious disease; 2, toxins formed as a result of perverted metabolism; and 3, those factors which act by lowering the general vitality.

The first two groups may be considered together, for in both we are dealing with the relationship of a toxin to the nervous system. If we admit syphilis and alcohol as causes for tabes, it appears that we are now dealing with similar poisons, and that there is no substantial grounds for denial that other similar poisons might not act in the same manner. All these substances are known to be able to produce degeneration of the peripheral neurons, which may secondarily involve the cord, and also degeneration of the arteries. This contention is further supported by a recently reported case of Herzog, in which a tabetic condition followed a myelitis secondary to gonorrhea; and if the observations of Fulton as to the preceding digestive disturbances are correct, it would account for some of the cases in which we are unable to assign an etiologic factor. The etiologic relationship of the factor of the third group, such as sexual excess, prolonged labors and excessive hemorrhages, can only be explained on the theory that any cause in which the vitality is sufficiently reduced to produce degeneration of the neurons would, from the anatomic facts already cited, first show themselves in the posterior columns of the cord. This explanation, however, does not account for the fact that while these causes are very common, tabes ascribed to these causes is exceedingly rare.

To sum up, then, it appears from our present knowledge of the etiology of tabes dorsalis, that the disease can be as clearly attributed to other causes as to syphilis.

The "Goryous" Fourth.—Is it not about time to ask what, if anything, has been done, or will be done, to prevent the destruction of another four and a half hundred children following the next glorious and gory Fourth? When the extent of last year's statistics became impressed on the public mind, one heard some talk of legislation to suppress the toy pistol, and it began to look as if some definite steps would be promptly taken in this urgently needed reform. What has been done?—*Cleveland Medical Journal.*

A STUDY OF THE ANATOMY, PATHOLOGY AND ETIOLOGY OF SCOLIOSIS,

ALSO PRESENTING THE SCOLIOTONE, AN APPARATUS FOR ELONGATING AND LESSENING THE ROTATION OF THE SPINE IN LATERAL CURVATURE.*

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In search for more definite etiologic factors and further pathologic conditions in scoliosis, I have found it necessary to make a thorough analysis of the spine, the various motions which it allows, and the physiologic relation which it bears to the pelvis, ribs and various muscles acting directly or indirectly on it. I also wish to say something in regard to treatment.

A STUDY OF THE ANATOMY OF THE SPINE.

The spine is a flexible column which tapers in size from below upward. In the cervical region the bodies are broader from side to side and have a tendency to limit the lateral as compared with the anteroposterior motion. Their superior and inferior surfaces are concavo-convex, and, of course, favor the motions in flexion and extension, and to a less extent from side to side, but have a tendency to limit rotation.

The articular processes in this region are oblique, and tend to permit flexion and extension and to restrict rotation; indeed, rotation can not take place without lateral bending, the greater part of all motions of the head occurring at the occipito-atlantal and atlanto-axial articulations. All of the processes in this region, both transverse and spinous, are short, which, of course, lessens the amount of leverage for rotation.

In the dorsal region the lateral and anteroposterior diameters of the bodies are about equal, their superior and inferior surfaces are flat, and have a tendency to limit flexion and extension, but favor rotation. The bodies being heart-shaped, favor oblique bending, especially as the apices of the heart-shaped bodies are forward. The articular processes are vertical, with the superior articular facets directed backward and outward, while the inferior look forward and inward; and this has a tendency also to limit flexion and extension, but to favor rotation. The spinous processes, being long and oblique and overlapping each other, limit extension, and, as they are close to the center of motion, favor rotation. The transverse processes are longer and directed outward and backward in this region, which circumstances tend greatly to favor rotation and to limit flexion and extension.

In the lumbar region the bodies are very large, and their transverse are greater than their anteroposterior diameters; this limits lateral motion more than flexion and extension, and also limits rotation. Their upper and lower surfaces are broad and flat, restricting flexion, extension and rotation. Their articular processes are vertical, and so arranged that the superior articular processes of one vertebra clasp laterally the inferior processes of the vertebra above it, making flexion and extension easy and rotation difficult. The spinous and transverse processes here are shorter than those in the dorsal region and their leverage for rotation less.

To sum up the result of this analysis, we see that the osteology in the cervical region is most conducive to flexion and extension; in the dorsal region, to rotation and lateral oblique bending, and in the lumbar region, to flexion and extension.

* Read before the American Orthopedic Association.

Now, in the dorsal region, in addition to the favorable conditions already named for rotation and lateral oblique bending, we have a most powerful set of levers, the ribs, which, through ligamentous attachments to the bodies and transverse processes of the vertebræ to the extent of one to two inches, according to the individual's size, when pulled on asymmetrically, may cause rotation and lateral oblique bending of the spinal column.

Now, while there are movable articulations between the ribs and dorsal vertebræ, their motion is limited, and when that limit is reached, they begin to act on the spine as rotators and lateral oblique benders in one-sided muscular action.

The costal cartilages being elastic and articulating with the sternum, do not limit asymmetrical positions and distortions.

The time of complete ossification of the vertebræ is not reached until the twenty-fifth or thirtieth year. The cartilaginous plates on their upper and lower surfaces do not begin to ossify until the twenty-first year, so that a constant rotation and a lateral oblique bending could readily change their shape.

In the pelvis the Y-shaped cartilages between the components of the ossa innominata begin to ossify as late as the thirteenth or fourteenth year, but the ossification of the ossa innominata is not complete until the twenty-fifth year. The sacral vertebræ unite between the eighteenth and twenty-fifth years. The sacro-iliac joints and symphysis pubis allow more play in childhood than in adult life.

Thus it will be seen how easily the pelvis can be distorted in growing persons, if faulty attitudes and irregular ossification from ill health, trauma, etc., are brought to bear.

On examination of the spine with the ligaments intact, one can easily see that the vertebral bodies are held together on all sides by a layer of inelastic ligaments, consequently no stretching of the intervertebral discs is possible, although unequal compression at any point may readily take place when force is exerted other than through the weight-bearing center. This inelastic ligamentous layer is reinforced to form the anterior and posterior common ligaments.

The elastic intervertebral discs of concentric vertical layers (and of heart shape in the dorsal region) favor compression, lateral oblique bending and rotation. The ribs being long, thin and naturally twisted, can be readily distorted by a continued disturbance of the muscular equilibrium of the trunk.

Each of the muscles of the abdomen, including the external and internal oblique, transversalis and recti, has partial attachment at one end to three or more of the eight lower ribs or their cartilages and at the other end to the pelvis. The first three are partially attached to the crest of the ilium, and with the recti are also partially attached to the os pubis; especially are their muscular portions attached to the iliac crest.

The external oblique, being the largest muscle of this group, having the most extensive bony attachment, which is the farthest from the center of the body and considering the direction in which it pulls, seems to be the most powerful for rotating and bending the spine. I think it never acts entirely independently of the muscles of the same or of the opposite side. This muscle is the only one of this group that is attached to the ribs proper, all of the others being attached to the costal cartilages. (The seven lowest costal cartilages are

much longer than those higher up, and thus are capable of being more greatly distorted.)

As to the muscles of the back, I think, from my study of scoliosis, that they have been unjustly accused in the etiology of lateral curvature. The first and second layers are to support and control the movements of the shoulders. The other layers, except the iliocostalis and quadratus lumborum, are too close to the spine to have any appreciable power as rotators or even lateral benders, and they seem to be principally for erection of the spine.

PATHOLOGY.

Beely says: "We may consider the bones of the bodies as atrophied on the concave side and hypertrophied

Fig. 1.—Patient showing scoliosis, rotation, lordosis and round shoulders.

on the convex, but at the same time we must not forget that the atrophy in the vertical diameter is accompanied by a hypertrophy in the horizontal, and vice versa." From his description this malformation looks as if it must have taken place before complete ossification of the bodies. To this Bradford adds adaptive shortening of the ligaments and fascia of the spine.

In addition to the wedge-shaped vertebral bodies and the contracted ligaments and fasciæ usually described by writers, I find that there is a distortion of the pelvis, the ribs and an inequality of the muscles of the abdomen. On the side of the concavity, the ribs are straighter at the posterior angles, more acutely curved anteriorly and are directed more obliquely downward than normal, while on the side of convexity there is the

opposite condition, e. g., a more acute posterior angle, a straighter anterior extremity and a more horizontal direction of the ribs.

The ilium on the side of the concavity is tilted more forward, downward and outward than normal, while on the opposite side the ilium is more vertical and its crests more horizontal.

The abdominal muscles on the side of the concavity are longer and more tense, while on the convex side these muscles are shorter and flabby. The iliocostalis and the quadratus lumborum also seem shorter and more tense on the concave side of severe scoliosis, and the normal curves of the spine are increased.

Fig. 2.—Left rotary lateral curvature in a normal individual produced chiefly by contraction of the right abdominal muscles.

Scudder has demonstrated that scoliotics are not up to the average in strength. This is easily explained when we analyze the existing conditions and see that the burden of supporting the spine is thrown mostly on one set of muscles, be they partly on one side or partly on the other. This weakened condition gives rise to the marked lordosis and stoop-shoulder (Fig. 1) accompanying these cases, the deformities being the result of the effort to maintain the equilibrium.

In the review of the literature on lateral curvature, I find a failure on the part of most writers to mention the distortion of the pelvis and ribs and the unequal length of the abdominal muscles on the two sides. McKenzie,¹ however, reports the case of a scoliotic girl, in

which the right iliac crest was one inch higher than the left, and in which the left ilium was normally developed, while the right approached more nearly the vertical as in the male. These facts he attributed to the asymmetry in the development of the pelvis.

In examining the pelvis of all the cases of scoliosis that have recently come under my observation, there seemed to be always an enlargement of one side. To prove this asymmetry of the bony pelvis, I made certain measurements. With the trunk bared, the shoes removed and the patient standing as nearly correctly as possible and without any undue exertion, measurements are taken as follows: 1. Between the anterior and posterior spinous processes of the ilium. 2. From the anterior superior spinous processes to the floor.

Fig. 3.—Same individual, back view, showing increased obliquity of ribs on concave side of curve, also the narrowness of that side of the back.

3. From the tip of the great trochanter to the floor. 4. From the anterior superior spinous processes to the internal malleoli. 5. Along Nélaton's line. 6. The shortest distance between crests of the ilia and the ribs on each side.

From these measurements I have found that the distance between the anterior and the posterior superior spines is about equal on the two sides; that the anterior superior spine was from one-half to three-quarters of an inch higher on the convex side when the legs are equal in length or when the leg is longer on the side of the convexity (as measured from the floor); that the distances from the anterior superior spines to the floor are nearer equal when the leg on the side of the concavity

1. Trans. of the American Orthopedic Assn., vol. vii, p. 343.

is longer; that it is impossible to get the correct length of the leg by measuring from the anterior superior spine to the internal malleoli, for they often measure the same between these points, when there is a considerable actual difference as measured from the great trochanter to the floor; that the trochanters are usually on Nélaton's line, and that the ribs are closer to the crest of the ilium on the side of the convexity.

ETIOLOGY.

Guerin claimed that scoliosis was produced by the active muscular contractions on the concave sides. Malgaigne taught that lax ligaments and weakened muscles on the convex side formed the predisposing causes. Bernard Roth thinks that the chief factors are weakness of the spinal muscles and long-continued standing or sitting in the relaxed or stooping positions. He has observed an inherited weakness of the muscles and liga-

the stronger set of muscles is situated. Drs. Sayre and Adams differ in placing the strong muscles on opposite sides of the body. Schreiber believes that, in early stages of scoliosis, there are changes in the muscles, the

Fig. 4.—Same individual producing curvature and rotation in the forward-bending position by contraction of same muscles as in Figures 2 and 3.

ments, associated probably with excessive softening of the bone. He writes: "Anything which weakens the muscular system tends to produce lateral curvature."

Adams believed that, in the early stages of lateral curvature, spinal muscles on both sides are, as a general rule, decidedly passive, but that as the curvature advances the muscles on the convexity are called into increased action, and serve the purpose of limiting the extent and preventing the increase of the spinal curvature.

L. A. Sayre believed that rotary lateral curvature depends entirely on spinal muscular contraction. The spinal column, he says, is held in its normal upright position by the action of the muscles situated on either side of it, and which should exactly balance each other. If for any reason one set of muscles overcomes those on the opposite sides, the spine yields and a curve is produced with its concavity toward the side on which

Fig. 5.—Resting on trestles; lordosis and round shoulder obliterated, back flattened, rotation and curve shown.

Fig. 6.—Scoliotone attached to rib stool.

muscular changes being due to long-continued stretching and disuse.

Eulenberg holds that slight continuous muscular action is necessary for the maintenance of the upright

position of the body; that this action must be equal on either side of the spine; that the most frequent cause of deviations of the spine is a disturbance of the power of the spinal muscle; that by frequently repeated passive torsion, necessary in assuming faulty positions, gradually the trunk muscles are weakened.

Lorenz sums up his opinion by the statement that anatomically, pathologically and clinically there is no foundation for a theory of a disturbed muscular antagonism, but that there is an element of general muscular weakness present in cases of lateral curvature, pure and simple, as has hitherto been assumed.

Fig. 7.—Scoliotone attached to gaspipe frame.

From my studies I am forced to hold the view that the distorted pelvis is the starting point of all cases (except those following paralysis, empyema and those accompanying Potts' disease); whether due to sitting or standing in faulty attitudes during the growing period before the bones have matured or while in a rachitic condition; unequal or irregular ossification; difference in the length of the legs caused by coxalgia, coxavara, congenital dislocation of the hip, acute inflammations, flat feet, etc.; that this is immediately followed by unequal action of the muscles of the abdomen (Fig. 2), so that those on the side, in which we find the anterior superior spine the lower, are put on the stretch, and

hence act more forcibly in pulling the ribs downward, forward and straightening their angles (Fig. 3). The ribs in turn, through their long leverage on the spine, produce a dorsal concavity in it, and a rotation forward toward the same side.

On the opposite side, in which the anterior superior spine and the ribs are closer together, the abdominal muscles can not act efficiently and the ribs become more horizontal and curved at their angles (Fig. 4) and allow the bodies of vertebræ to rotate toward the convex side.

It is impossible at this time to present the full treatment antagonistic to these conditions, but I will mention a few of the most important points. Should there be an inequality in the length of the legs (as shown by the above measurements) they should be equalized, either by operation or mechanically, according to the cause. The patient should be imbued with the importance of assuming correct attitudes. Then we should establish a treatment by gymnastic exercises, jackets made over corrected casts and forcible machine correction that will tend to overcome the distorted pelvis, stretch and strengthen the weakened and shortened abdominal

Fig. 8.—Rotation and curve corrected by application of weighted strap.

muscles, which further enables us to correct the distorted ribs, lordosis, stoop-shoulders, rotation and curves.

In conclusion, I wish to present the forcible correction machine, which I have called the scoliotone. This consists of two padded adjustable trestles, on which the upper thorax and pelvis are supported, with the legs at right angles to the body (Fig. 5). By these means we in a degree overcome the lordosis and round shoulders. On the end of each trestle is a padded upright, which causes counter-pressure against the axilla and the pelvis when the weights are applied. A strap armed with hooks to hold weights passes over the convexity, being made fast to the machine on the side of the concavity of the curve. This attachment of the strap to the machine is so accomplished by hooks that it may be adjusted by sliding along on a rod, so as to pull against the greatest angle of the deformity; and in addition, the rod to which it is attached may be lowered or raised, depending on whether we desire to act more on the rotation or curve.

This machine differs from Beely's in that it has fixed supports for the thorax and pelvis, while in his machine the patient rests on the feet and elbows.

This machine may be attached to the ordinary rib-stool (Fig. 6), or may have a quadrangular frame of gas-pipe to support it (Fig. 7). The weights are lifted by a lever, and the amount of weight varies according to the tolerance or resistance met in the individual cases. Patients can remain in this machine for a more prolonged period than in the majority of corrective appliances, and for the past eight months I have found it a most helpful aid in the treatment of this class of cases. It overcomes lordosis, straightens the spine antero-posteriorly from end to end, strengthens the abdominal muscles, and by means of the weighted strap tends to overcome the rotation and lateral deviation (Fig. 8).

A STUDY OF GONOCOCCUS METASTASIS; WITH REPORT OF A CASE.

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Gonorrhea, as the term is ordinarily understood, is usually thought of as an affection of the urethra, or at most as a urethritis complicated by affection of the eye or joints, but the possibility of its being complicated by metastatic abscesses in various other parts of the body is not so generally kept in mind. It has only been within the last half century that practitioners as a whole have recognized the connection which exists between gonorrheal infection of the urethra and certain joint affections, and a thorough understanding of the nature of this connection has been possible for a much less time. It is generally admitted that Selle and Swediaur¹ were the first to recognize in the coincident urethritis the cause of what is now known as gonorrheal arthritis. Swediaur describes this complication of gonorrhea in his work entitled "Practical Observations on the More Obstinate Venereal Complaints," which appeared in London in 1784, reporting six or eight cases; and also in a treatise on syphilis, published in 1801.

According to John Elliottson,² Sir Astley Cooper, as early as 1806, gave notice of the fact that gonorrhea may be followed by painful disease of the joints. In his article on "Urethral Rheumatism and Ophthalmia," above referred to, Elliottson says: "I can remember the time when the most of the medical profession denied the occurrence of gonorrheal rheumatism, saying that a person with gonorrhea might, like any other, have rheumatism accidentally, or that a rheumatic patient might catch gonorrhea. My first knowledge of the occurrence of the disease was obtained from Sir Astley Cooper's lectures, which were delivered at St. Thomas Hospital in 1806-7 and 1807-8. How many years previously he had mentioned or seen it, I can not say."

In 1879, however, the discovery of the gonococcus by Neisser, and the observations made on it by Baumm, cleared up the question of the etiology of gonorrhea, and opened up new fields for investigation. Practitioners became divided into several schools as regards the question of gonorrheal rheumatism and gonorrheal metastasis in general. Some believed that the cause of the gonorrheal arthritis lies in the presence of the gonococcus itself in the affected joint, while others held that the arthritis, though due to the gonorrheal infection, was

the result of the absorption of its toxins from the urethra. Still others asserted that the urethral lesion simply offered a port of entrance through which other pyogenic organisms could invade the body and so reach the joints or tendon sheaths. It was not long, however, before the gonococcus itself was discovered in the synovial fluid and membrane of affected joints by Petrone, Neisser, Long, Bordoni, Kamerer and Afreduzzi.

Attempts have been made at various times, notably by the earlier workers, to produce abscesses and other lesions by injections of pure cultures of the gonococcus, but with little or no success.

The writers have been able to find reported in the literature the following cases of suppurative lesions occurring during the course of gonorrhea, other than those in the urethra, in which attempts have been made to demonstrate the presence of the gonococcus as the exciting cause.

Smirnoff³ found large numbers of gonococci in fluid obtained by puncturing an affected joint during an attack of gonorrhea. Sonnenburg⁴ reported a case of caries of the hip occurring in the course of gonorrhea, in which gonococci were found on resection of the joint. Bockhart,⁵ in a suppurating bubo and a periurethral abscess occurring during the course of a gonorrhea, found no gonococci, but the *Staphylococcus pyogenes aureus*. In another case he found gonococci in the pus of a kidney abscess which complicated a severe gonorrhea. Sahli⁶ was able to demonstrate typical gonococci in pus corpuscles from a large abscess in the neighborhood of the knee joint.

Weichselbaum⁷ found the *Streptococcus pyogenes* on the valvular vegetations in the heart of a 25-year-old man who had died from ulcerative endocarditis three weeks after the contraction of a severe gonorrhea. He also found some organisms on the valve flaps resembling in some particulars the gonococcus, although not grouped in the same way, and staining well with Gram's.

Haab⁸ reports a case of a patient suffering from a severe general infection, with effusions in the knee and elbow joint and abscesses in the left axilla, and who had lost an eye from gonorrhea. In the abscess in the armpit there were found staphylococci but no gonococci.

Guyon and Janet⁹ punctured the knee joint in three cases of gonorrheal arthritis, and in the seropurulent fluid were unable to find any micro-organisms either by the microscope or by various culture tests. They believed, therefore, that these cases were instances of the action of ptomaines produced as a result of the growth of the gonococcus in the urethra.

In 1893, Lang and Palttauf¹⁰ reported a case in which an abscess, associated with a teno-synovitis, occurred on the back of the hand, and in which the presence of the gonococcus was demonstrated both microscopically and by cultural methods.

Horwitz,¹¹ in 1893, reported a case similar to the preceding and to the one which is reported below, associated with a tendovaginitis. The gonococcus was ob-

3. Russk. Med., 1886, iv, 487.

4. Berl. klin. Woch., 1886, 231.

5. Monatshefte f. prak. Derm., 1887, vi, 13.

6. Correspondenzbl. f. schweitzer Aerzte, 1887, xvii, 496.

7. Ziegler: Beiträge z. path. Anat. u. allg. Path., 1888, iv, 174.

8. Schweitzer Correspondenzblatt, 1889; Gesellsch. d. Aerzte in Zürich.

9. Ann. de mal. gen. urin., 1889, vii, 462.

10. Arch. f. Derm. und Syph., Wien, 1893, xxv, 330.

11. Wien. klin. Woch., vi, 59.

1. London Medical Gazette, 1784.

2. London Medical Times and Gazette, June 30, 1860, vol. 1, p. 642.