consequence of this first remark, namely, that suggestion is no longer a commonplace and constant phenomenon; it presents itself only in certain cases and under certain conditions which it is necessary to determine. For instance, it is quite plain that with an insane person in dementia the images are no longer systematized, and that consequently the ideas are no longer either understood or developed. But should we immediately assert that suggestion is continually met in the sanest persons? Despite the affirmations of certain authors, we must confess that we have not succeeded in giving suggestions to people of normal good health. This fact appears to me incontestable, and to speak of suggestion with sane persons, one is obliged to consider quite different facts, effects of education, habits, recollections, beliefs, good will, voluntary docility, etc. They are quite different psychological phenomena. On the other hand, every time that we have established in a person unmistakable suggestibility, we have had no difficulty in demonstrating numerous and evident traces of mental disease. It is the sign of a particular mental disease; it requires that the automatic association of the psychological elements be preserved and that the actual synthesis of the phenomena be altered or reduced, exactly what we find in the hysterical state.

Let us now consider all the patients we clinically regarded as hysterical. I say that you will almost always find in them all the phenomena of suggestion, experimentally and accidentally. Inversely the relation between suggestibility and the hysterical neurosis can be verified by studying the disappearance of suggestion. What is most interesting is that it disappears completely when the disease is cured, or when the disease momentarily disappears.

Original Articles.

THE CAUSE OF SO-CALLED HABITUAL LATERAL CURVATURE OF THE SPINE.*

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A PARTIAL statement of a theory concerning the origin of juvenile lateral deformities of the spine has been published by me in this journal¹ which differs considerably from the present conception of the cause of these affections.

During the past half year the theory has been placed upon a firmer basis by the accumulation of a greater number of additional observations upon patients and by further anatomical studies.

The following paper gives briefly *the most important points* of the theory, leaving its thorough description to a more extensive publication in monograph form which will appear soon.

*Read before The Johns Hopkins Medical Society in Baltimore, Nov. 5, 1906.

¹A Contribution to the Etiology of Lateral Curvature of the Spine. BOSTON MED. AND SURG. JOUR., vol. cliv, no. 4, 1906.

Recent Researches on the Pathology and Etiology of Juvenile Spinal Deformities. Clinical Meeting of the Massachusetts General Hospital, BOSTON MED. AND SURG. JOUR., vol. cliv, no. 22, 1906.

ANATOMICAL PART.

(From the Anatomical Department of the Harvard University Medical School.)

The human spine consists normally of 33 to 34 vertebræ. It is divided into regions in a typical way: 7 cervical, 12 dorsal, 5 lumbar, 5 sacral, and 4 to 5 coccygeal vertebræ. (See diagram 1.)

DEVIATIONS from these normal numerical divisions of the vertebræ may occur in two ways; diagrams 2 and 3 show the character of this so-called "NUMERICAL VARIATION."

Diagram 2 represents a VARIATION IN A CRANIAL DIRECTION; that is to say, all the regional boundaries of the spine are placed higher than normally; the cervico-dorsal boundary is between the sixth and seventh, the lumbo-dorsal boundary between the eighteenth and nineteenth, the lumbo-sacral boundary between the twenty-third and twenty-fourth, the sacro-coccygeal boundary finally between the twenty-eighth and twenty-ninth vertebræ; the thorax has moved upwards, as has likewise the pelvic girdle and lower extremities.

Diagram 3 shows just the opposite conditions: the boundaries are placed lower than normally, the thorax and sacrum have moved downwards; the whole represents a VARIATION IN A CAUDAL DIRECTION.

The short oblique lines on each side of the axial line in the diagrams represent the intervertebral joints. From the eighth to the nineteenth vertebræ these joints show the familiar DORSAL TYPE having articular surfaces lying frontally, whereas from the nineteenth to twenty-fourth vertebræ the joints possess the LUMBAR CHARACTER, i.e., they have surfaces, facing sagittally. Between the twenty-fourth and twenty-fifth vertebræ there is a joint of LUMBO-SACRAL type, i.e., its articular surfaces run diagonally. Between the nineteenth and twentieth vertebræ there is normally a very sudden "ARTICULAR CHANGE," that is, the change from the dorsal to the lumbar joint type. (Diagram 1.)

In a cranial variation of the spine this change takes place one vertebra higher (diagram 2); in a caudal variation one vertebra lower than normally. (Diagram 3.)

Diagrams 2 and 3 are schematic and represent extreme degrees of variation which practically never occur. They indicate, however, the character and tendencies of lesser degrees of variation.

These LESSER DEGREES OF VARIATION lead to the production of those peculiar forms of vertebræ at the regional boundaries, called by the anatomist "TRANSITIONAL VERTEBRÆ" (Uebergangswirbel) which have in part some of the features of one region and in part some of the features of the neighboring region. Such are:

(1) Occipito-cervical vertebræ. These are for instance represented by fusions of the atlas with the occipital bone.

(2) Cervico-dorsal vertebræ. These are anomalous conditions of the seventh or eighth vertebra, in which the seventh has a rib ("cervical rib") or the eighth is associated with an under-developed or rudimentary rib.

(3) Lumbo-dorsal vertebræ. These are anomalous conditions of the nineteenth or twentieth vertebra, in which the former loses its ribs or the latter is associated with "lumbar" ribs.

(4) Lumbo-sacral vertebræ. These are anomalous conditions of the twenty-fourth or twenty-fifth vertebra, in which the former is associated with sacral wings or the latter loses them.

(5) Sacro-coccygeal vertebræ. These are anomalous conditions of the twenty-ninth or thirtieth vertebra, where the former loses its lateral masses or the latter is associated with them.

The diagrams differ, furthermore, from nature in that as a rule the spinal regions do not vary in such a regular way as the schematic pictures show, but frequently *one* region shows a greater degree of variation than the others.

Finally both sides of the spine (left and right) frequently vary independently and *asymmetrically*. The latter fact, which interests us especially, is illustrated by diagrams 4, 5 and 6. Diagram 4 shows an *asymmetrical variation* in the lumbo-sacral region; the sacrum begins on the left side with the twenty-fourth vertebra, whereas on the right side with the twenty-fifth vertebra.

In diagram 5 we see the corresponding asymmetrical variation in the dorsal part. The left side of the thorax reaches from the seventh to the eighteenth segment, while the right extends from the eighth to the nineteenth vertebra.

Diagram 6 illustrates an instance of an asymmetrical variation of the "articular change." The articular change in this case takes place between the eighteenth and nineteenth vertebræ on the left and between the nineteenth and twentieth vertebræ on the right.

A beautiful illustration of these conditions is seen in Fig. 11.

FIG. 11. Asymmetrical lumbo-dorsal articular change.

FIG. 11 is taken from E. B. Smith. Two Rare Vertebral Anomalies, Jour. of Anat. and Phys., Vol. 36, 1902, p. 372.

Diagrams 4 to 6 are also schematic and represent conditions which hardly occur as pure as this in nature. For in nature the asymmetry is never as marked as in the diagrams; but usually both sides of the spine vary and an asymmetry exists only in the sense that one side varies more markedly than the other.

The numerical variation of the spine offers so

many interesting points that in all countries embryologists, anatomists and anthropologists have devoted a great deal of study to it.

We owe to embryological researches (Rosenberg, Bardeen) the knowledge that variations of the *caudal part* of the spine may be the expression of a deep developmental disorder, namely, of a faulty attachment of the total lower extremity (pelvis and free extremity) to the trunk, *i. e.*, the spine. An attachment of the pelvis higher than normal results in a shortening, lower than normal in a lengthening, of the pre-sacral spine.

As to the origin of the numerical variation of the *cranial part* of the spine, nothing definite is known, just as the genesis of the typical differentiation at this part of the spine is obscure.

Some anatomists explain the numerical variation in a very interesting way, connecting it with the phylogenetic development of the human race. The father of this theory, the anatomist Emil Rosenberg, considers the normal differentiation of the spine as typical for the present phylogenetic state of mankind, whereas a variation in caudal direction means a lower state, an atavism, and a variation in cranial direction signifies a step into the future, an epigonism.

The present paper shows how great a *clinical* importance this variation may have as an etiological factor in spinal deformities.

HOW CAN THE NUMERICAL VARIATIONS OF THE SPINE LEAD TO LATERAL DEFORMITIES?

(1) Suppose a child is born with a spine like that shown in diagram 4. Free extremity (*a*), ileum (*i*) and sacral wings are attached to the spine one vertebra higher on the left than on the right. Thus the pedestal of the free (pre-sacral) spine is, so to speak, asymmetrical. As soon as the child starts in to walk, these asymmetrical conditions will deform the vertebral bodies of the sacrum and chiefly of the first sacral vertebra. Thus the foundation of the free spine becomes oblique and the latter will have to perform its functions in an abnormal position; the tendency of the body to compensate is added and thus we finally find in a certain period of life a deformed spine as the expression of a development which has been since the start on a wrong track. In this case (diagram 4) the *primary curve* would be located in the LUMBO-SACRAL REGION; the convexity of the lumbar curve would be on the left side.

(2) Diagram 5 shows conditions in which on one and the same vertebra ribs of different character are attached. For instance, on the eighth vertebra, which is normally the first thoracic, we find on the left side the second, on the right side the first, rib inserted. A comparison of normal first and second ribs shows a marked difference between the two. The first is short, strong and little curved, the second is long, nearly twice as long as the first, slender and much curved. Thus we have in our diagram 5, corresponding to the eighth vertebra, a thoracic ring which is formed in front by the sternum, behind by the spine, and whose sides, the ribs, are markedly asymmetrical.

This asymmetry, only slightly developed in the embryo, increases in later life (see page 604 ff.) and causes, in connection with the tendency of the body to restore the balance, lateral deviation of the spine, which is the most movable part in the above mentioned thoracic ring. In this case (diagram 5) the *primary curve* would involve the *cervico-dorsal region* and its convexity would be on the right.

(3) From anatomical studies it is not quite certain whether a variation of the "ARTICULAR CHANGE" as shown in Fig. 6 may lead to lateral deformities. I believe that it may cause lateral deformities of slight degree, but it does not produce those with structural change in the vertebral bodies. However, the variation of the "articular change" may lead in another way to lateral deformities, namely, in a way as illustrated in diagram 7. We have here on the right between the eighteenth and nineteenth vertebræ an inter-vertebral joint of typical lumbar character, the "articular change" thus being one vertebra too high. Whereas on the left side the inferior articular process of the eighteenth vertebra is still dorsal; but the corresponding superior articular process of the nineteenth vertebra is lumbar. Thus there is on the left side between eighteenth and nineteenth vertebræ on account of a lacking conformity of the articular processes no good joint formation at all. The superior process of the nineteenth does not support the inferior process of the eighteenth vertebra sufficiently and the spine above the former will fall over to the left side.

This, and similar disturbances in the formation of the joints, which undergo the "articular change," lead to more or less sharp-angled lateral deformities in the LUMBO-DORSAL REGION with the apex in the abnormal joint. In diagram 7 the lateral deformity would be very sharp-angled ("*lumbo-dorsale Abknickung*") and the angle would open to the left side; the convexity would be on the right side.

(4) Combinations of the three mentioned causes of lateral deformities may lead to combined deformities.

The above description of the character of the numerical variation and of its relations to lateral deformities of the spine represents a short, by no means complete, and somewhat schematic summary of a longer series of studies which have been made on the collection of 54 spines showing numerical variation, collected by Prof. Thomas Dwight, director of the anatomical department of Harvard University Medical School.² It is impossible to give here a full account of these studies, but I would like to illustrate by means of three specimens of the Dwight collection, the morphological character of some forms of numerical variation, and the way in which they produced lateral deformities.

² Dwight: Description of the Human Spines showing Numerical Variation, in the Warren Museum of the Harvard Medical School. Memoirs of the Boston Society of Natural History, vol. v, 1901. An abstract appeared in the *Anatom. Anzeiger*, Bd. 15, 1901.
Dwight: Numerical Variation in the Human Spine with a Statement Concerning Priority. *Anatom. Anzeiger*, Bd. xxviii, no. 1 und 2, 1906.

These types³ are shown in Table II, Figs. 9, 10, 12, 13.

The character of the variation in Fig. 9 resembles the one represented in diagram 4 with the sole difference, that in Fig. 9 the sacrum begins on both sides one vertebra lower. It will be noted in Fig. 9 that the spine shows a PRIMARY LUMBO-SACRAL CURVE to the left and that the twenty-fifth and twenty-sixth vertebræ, that is the lumbo-sacral and first sacral vertebræ, show a special deformity of their bodies.

Fig. 10. This spine corresponds very nearly to diagram 5. We find attached to the seventh vertebra on the left side a markedly developed cervical rib, which is nearly a first dorsal in character, while on the right side we see a less developed cervical rib. The eighth vertebra has on the right a rib of transitional character, resembling in part the normal first, in part the normal second rib; the same vertebra has on the left side a rib also of transitional character, but resembling in its features and sternal attachment much more the normal second rib. The spine shows a DORSAL KYPHO-SCOLIOSIS TO THE RIGHT; and the chest with a prominence posterior on the right and anterior on the left is typical of the conditions we find clinically in some cases of "lateral curvature."

Figs. 13 and 14, illustrate spine No. 9379-34 from the Dwight collection. This spine shows a fusion of the last three lumbar and the first sacral vertebræ. However, what especially interests us here is THE VARIATION OF THE "ARTICULAR CHANGE." This is best seen in an x-ray taken from the lumbo-dorsal region of this specimen. (Table VII, Fig. 33.) The nineteenth vertebra has rudimentary ribs.

Between the eighteenth and nineteenth vertebræ there is on both sides a joint of neither lumbar nor dorsal but of transitional character. (The dorsal joint character may be observed in the joints above, the lumbar type in the joints below the abnormal one. Only the lumbar joints show in the x-ray the space between the articular processes.)

The inferior processes of the eighteenth vertebra on both sides possess chiefly dorsal character, while the superior processes of the nineteenth vertebra only in part show a corresponding type. This is especially marked on the left, where the superior articular process of the nineteenth vertebra for the most part shows lumbar character. These conditions correspond somewhat with those in diagram 7. Thus we find the left inferior process of the eighteenth vertebra articulating abnormally with the corresponding superior process of the nineteenth, so that it lies partly in front of it. This lack of conformity between the articular processes in this case has produced a sharp angled LUMBO-DORSAL DEVIATION in a lateral, posterior and rotary direction as is to be seen in Table II, Figs. 12 and 13. Fig. 33 also shows how the curve starts directly from the abnormal joint.

These three specimens of the Dwight collection may suffice to show that certain types of

³ No. 9379-15, 9379-53, 9379-34, in the Dwight Collection.

numerical variation may lead to certain distinct lateral deformities of the spine, and thus gain PATHOLOGICAL SIGNIFICANCE.

It may be emphasized here, that about *one third of the spines* of the Dwight collection show these *pathological types* of numerical variation, above determined, and consistent with them mostly slight lateral deformities *with* structural changes in the vertebral bodies.

Not only for the study of the relation between lateral deformities and numerical variation but also in another way the Dwight collection has proved to be of the greatest value for this research. It was used as the basis for answering the following questions:

(1) Do THE TWO SEXES differ in regard to the type of numerical variation?

(2) Does the variation affect the RIGHT AND LEFT SIDES of the spine in different ways?

After certain spines *f. i.* from negroes, of uncertain sex or identity were ruled out, 41 spines remained, 24 male and 17 female. Twenty-three spines varied in a cranial, 18 in a caudal direction.

In answer to the first question the following table shows the incidence of the two kinds of variation in the two sexes:

	Male.	Female.	Total.
Variation in the cranial direction,	8	15	23
Variation in the caudal direction,	16	2	18
Total,	24	17	41

In answer to the second question the following may be said: Among the 41 spines 7 show a symmetrical and 34 an asymmetrical variation. Among the latter 18 vary in a cranial, 16 in a caudal direction. These 34 spines with asymmetrical variation were examined with reference to whether the left or right side varied more in the direction of the total variation.

The following table gives the result. In the column X are registered those aberrant forms of variation in which the single regions vary irregularly as to the side involved and which cannot be considered here.

	Greater Variation on: Left Side.	Right Side.	X.	Total.
Variation in the cranial direction,	12	3	3	18
Variation in the caudal direction,	3	11	2	16
Total,				34

In the light of these observations the questions propounded above can be answered as follows:

(1) THE FEMALE SPINE HAS A MARKED TENDENCY TO VARY IN A CRANIAL, WHILE THE MALE SPINE HAS A STRONG TENDENCY TO VARY IN A CAUDAL DIRECTION.

(2) THE LEFT SIDE OF THE SPINE HAS A STRONG INCLINATION TO VARY IN A CRANIAL, THE RIGHT SIDE TO VARY IN A CAUDAL DIRECTION.

Thus: Considering the spine of both sexes together, THE LEFT SIDE SHOWS IN ITS VARIATION THE SAME RELATIONSHIP TO THE RIGHT SIDE AS DOES THE FEMALE SPINE TO THE MALE SPINE.

The importance of these findings for our subject will be shown later.

CLINICAL PART.

(From the Orthopedic Department of the Massachusetts General Hospital.)

If it has been demonstrated in the anatomical part that the peculiar developmental error which leads to numerical variation of the spine may in certain distinct cases lead at the same time to lateral deformities, in the clinical part we have to reverse the question in the following way:

Do cases of juvenile lateral deformities of the spine, such as, are called commonly "lateral curvature," show the anomalies above described so frequently that an undoubted causal connection between them becomes apparent? Do cases of "lateral curvature" show numerical variations at the seat of the primary curve, and represent these variations those "pathological" types we would expect to find there in view of the results above detailed in the anatomical part?

From Jan. 1 to Oct. 1, 1906, I have studied 24 cases of "lateral curvature." In all of these cases an origin from poliomyelitis, rickets, empyema or purely static conditions was carefully ruled out. In accordance with exact measurements the cases were classified into the following groups:

- (1) Lumbo-sacral scoliosis.
- (2) Cervico-dorsal scoliosis.
- (3) Lumbo-dorsal scoliosis (including the "total" scoliosis).
- (4) Combined, s-scoliosis; *i. e.*, spine in its parts equally deformed.

The measurements were made in the medico-mechanical department of this hospital by means of the Zander apparatuses for back and chest measurement and of a little instrument designed for measuring the back in forward-bending, which is an imitation of Beely's cyrtometer.

Table IV, Figs. 18-21, show the clinical types of the curvatures, under which the cases were classified. The photographs of the patients, from which the measurements were taken, Table III, Figs. 14-17, will help others to understand this classification.

RÖNTGENOLOGICAL PART.

(From the X-Ray Laboratory of the Massachusetts General Hospital.)

The spine of each patient was thoroughly examined by means of x-rays. The technique will be described here specially for the benefit of other workers. In the first place 3 plates of the spine were taken with the patient lying down: (1) of the dorsal spine and thorax with the neighboring lower cervical and upper lumbar parts; (2) of the lumbar spine with the neighboring lower dorsal and sacral region; (3) of the cervical spine. In order to count the cervical spine it is necessary to show the atlas in the picture. This can be attained by x-raying the neck with the patient's head turned to one side.

If we succeed in getting thus clear plates they may be sufficient to form a composite picture of the whole spine. But in many cases it is necessary to take besides these gross pictures detail pictures of certain interesting places with the

compression cylinder. The piecing together of the detail pictures has to be done in strict comparison with the gross pictures. Finally a lateral picture of the occipito-cervical region must be taken. This picture is of special importance in cases of the cervico-dorsal group.

In the way just described *all the twenty-four cases* were examined,⁴ and an exact knowledge

⁴ In few cases cervical spine and occipito-cervical region has been omitted.

of the numerical and morphological conditions of the spine has thus been gained. Four spines may be shown here as types. Table VI, Figs. 26-29. They are taken from the patients, whose measurements are shown in Table IV, Figs. 18-21; compare also photographs Table III, Figs. 14-17.

The results of the clinical and Röntgenographic examinations are briefly given in the following table:

The table shows the following: Three cases,

No.	Race.	Sex.	Age.	Age at which deform. was first noted.	Clinical diagnosis.	Morphological and numerical conditions of spine.	Anatomical diagnosis.	Illustrations.
I.								
1	white	female	15	12 years	left lumbo-sacral scoliosis.	7 c. 12 d., last ribs overdeveloped, 5 l., 1 ls., 4 s., 1 sco.	Asymmetric a l variation in a caudal direction	Fig. 14 Fig. 18 Figs. 22 and 26 Diag. 8
2	white	female	17	16 years	left lumbo-sacral scoliosis.	7 c. 12 d., last ribs overdeveloped, 1 ld., 5 l., 1 ls., 4 s. Pelvic-halves are of marked primary asymmetry	Asymmetric a l variation in a caudal direction	
3	white	female	38	unknown	left lumbo-sacral scoliosis	12 d. 6 l.	Variation	
4	white	female orphan	18	ever since "she can remember"	right lumbo-sacral scoliosis	12 d., 2.1 Fusion of 3 last lumbar and first sacral vertebrae. Open canalis sacralis. Spina bifida occulta	Congenital fusion of vertebrae	
5	white	male	12	7 years (uncertain)	left lumbo-sacral scoliosis.	12 d. 5 l., First sacral vertebra shows signs of imperfect development, for instance ununited arch	Congenital lack of vertebral development	
6	black	male	10	18 months	left lumbo-sacral scoliosis	7 c., 12 d., 5 l. First sacral vertebra has exactly the same appearance as in Case V.	Same	
II.								
7	white	female	21	14 years	right cervico-dorsal scoliosis.	6 c., 1 cd, 11 d., 5 l., 1 ls. On the eighth vertebra there are ribs attached, from which the left resembles more the normal second, the right more the normal first rib	Asymmetric a l variation in a cranial direction	
8	white	female	20	16 years	right cervico-dorsal scoliosis.	6 c., 1 cd., 12 d. Last ribs rudimentary, 5 l. The character of the ribs attached to the eighth vertebra are much as in the former case	Asymmetric a l variation in a cranial direction	Fig. 15 Fig. 19 Figs. 23 and 27
9	white	female	16	13 years	right cervico-dorsal scoliosis	Atlas fused to occiput, 6 c., 1 cd., 11 d., 5 l., 1 ls., i. e., incompletely sacralized. Ribs attached to eighth vertebra are rudimentary, on the right more than on the left	Asymmetric a l variation in a caudal direction	
10	white	female	15	14 years	right cervico-dorsal scoliosis.	6 c., 1 cd., 12 d. Last ribs rudimentary, 4 l., 1 ls. Ribs attached to eighth vertebra are both in shape more like normal second ribs.	Symmetrical variation in a cranial direction	
11	white	female	16	11 years	right cervico-dorsal scoliosis.	7 c., third and fourth improperly developed, 1 cd., 11 d., 5 l. The right rib of the eighth vertebra is rudimentary.	Asymmetric a l variation in a caudal direction	
12	white	male	13	11 years	right cervico-dorsal scoliosis.	Atlas fused, 6 c., 12 d., 5 l., 5 s., 1 s co. Ribs attached to eighth vertebra are both somewhat rudimentary	Symmetrical variation in a caudal direction	Fig. 30 Table VII
13	white	female	13	12 years	right cervico-dorsal scoliosis.	Atlas (?) 6 c., 1 cd., 11 d., Last ribs overdeveloped, 5 l., 1 ls. The left rib of the eighth vertebra is rudimentary.	Asymmetric a l variation in a caudal direction	Fig. 31 Table VII
14	white	female	20	18 years	left cervico-dorsal scoliosis	Atlas fused, 6 c., 1 cd., 11 d., 5 l. The left rib of the eighth vertebra is rudimentary	Same	

¹ There is a decided heredity in this patient's history: Two brothers of his, one sister and one aunt of his mother have "lateral curvature" of the spine.

No.	Race.	Sex.	Age.	Age at which deform. was first noted.	Clinical diagnosis.	Morphological and numerical conditions of spine.	Anatomical diagnosis.	Illustrations.
III.								
15	white	female	15	14 years	lumbo dorsal scoliosis. Convexity right	7 c., 11 d., 1 ld., 5 l. Articular change between eighteenth and nineteenth vertebræ: right complete, left incomplete	Asymmetric a l variation in a cranial direction	Fig. 16 Fig. 20 Figs. 24 and 28
16	white	female	16	15 years	lumbo dorsal scoliosis. Convexity left	7 c., 11 d., 5 l., 1 ls., (incompletely sacralized). Articular change between eighteenth and nineteenth vertebræ, left complete, right incomplete	Asymmetric a l variation in a cranial direction	
17	white	female	16	14 years	lumbo-dorsal scoliosis, but impure	7 c., 11 d., 1 ld., 5 l. The ninth dorsal vertebra is a semi-vertebra; artic. change (?)	Variation in a cranial direction and congenital lack of vertebral development	
18	white	female	16	14 years	lumbo-dorsal scoliosis. Convexity left	Atlas fused, 6 c., 12 d., last ribs overdeveloped; 1 ls. Articular change between nineteenth and twentieth vertebræ: left complete, right incomplete	Asymmetric a l variation in a caudal direction	
19	white ²	female	13	13 years	lumbo-dorsal scoliosis. Convexity left	(?) c., 11 d., 1 dl., 5 l. Art. change above dl. vert.; left complete, right incomplete	Asymmetric a l variation in a cranial (?) direction	
20	white	female	16	12 years	lumbo-dorsal scoliosis. Convexity right	Atlas fused, 6 c., 1 cd. (?), 11 d., 5 l. Articular change between nineteenth and twentieth vertebræ: right complete, left incomplete	Asymmetric a l variation in a caudal direction	
21	white	female	18	17 years	lumbo-dorsal scoliosis. Convexity right	(?) c., 11 d., 1 dl., 5 l., 6s. Articular change see Fig. 32, Table VII	Asymmetric a l variation, cranial (?)	
IV.								
22	white	female	23	17 years	Combined s-s scoliosis, left lumbar, right dorsal.	6 c., 1 cd., 11 d., 1 ld., 4 l., 1 ls.	Asymmetric a l variation in a cranial direction	Fig. 17 Fig. 21 Figs. 25 and 29
23	white	female	22	14 years	Combined s-s scoliosis, left lumbar, right dorsal.	7 c., 12 d., last ribs rudimentary, 4 l., 1 ls. Ribs attached to eighth vertebra are both more of the character of the normal second rib	Symmetrical variation in a cranial direction	
24	white	female	34	Patient is not conscious of having a scoliosis	Combined s-s scoliosis, left lumbar, right dorsal	7 c., 1 cd., 11 d., 5 l., 1 ls. The right rib of the eighth vertebra is rudimentary	Asymmetric a l variation in a caudal direction.	

REMARKS. The following abbreviations are used in this table: c=cervical, d=dorsal, l=lumbar, s=sacral, co=coccygeal, cd=cervico-dorsal, etc.

² The deformity in this case is hereditary. The mother of the patient, as I could convince myself, has a scoliosis of the same type.

Nos. 4, 5 and 6, belong apparently clinically as well as anatomically to the class of scolioses, which at present are called "congenital." They do not show a numerical variation of the spine.

A fourth case, No. 3, does not allow a proper clinical or anatomical classification.

The other 20 cases form clinically a separate group, inasmuch as the onset of the deformity in these cases takes place in about the first half of the second decade of life. They belong to that large class of idiopathic scolioses, which we mostly see

in schoolgirls and which is, according to the present conception, usually considered as due to faulty attitude, and therefore called habitual scoliosis. In all these 20 cases we find a numerical variation of the spine present. According to Bardeen's⁵ recent statistical researches 15% to 16% of all human beings show one or the other numerical variation of the spine. The extreme frequency of variation in these 20 scoliotic

⁵ C. R. Bardeen: Numerical Vertebral Variation in the Human Adult and Embryo. *Anatom. Anzeiger*, Bd. xxv, Jena, 1904.

spines suggests some relation between "habitual" lateral curvature and numerical variation of the spine.

The x-rays show furthermore in 16 out of these 20 cases the chief variation at the primary seat of the scoliosis, and just those "pathological" types of numerical variation which we would have expected to see in view of the results obtained from our anatomical studies.

Thus we have to answer the question which we put at the beginning of the clinical part, in regard to these 16 cases, in the affirmative.

These facts compel us to consider in these 16 cases of "habitual" lateral curvature (Nos. 1, 2, 7, 8, 9, 11, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24) that the variation found is the cause of the lateral deformity present.

In the face of this logical conclusion all theoretical objections must take a second place.

There may be one chief objection based upon the following considerations which naturally come forward: as the table shows, the deformity in the 20 cases of "habitual" scoliosis first becomes noticeable usually between the tenth and sixteenth years or, on the average, at about fourteen years; but the cause, according to this theory, is a congenital one.

This seems to be inconsistent with the truth of the theory if we accept the clinical dogma that congenital deformities must show directly after birth.

If we insist upon the correctness of our x-ray findings, and upon the truth of our conclusions, this dogma must be wrong. And, indeed, it is wrong as to spinal deformities.

If we compare spine and chest of a new-born child with those of an individual at the time of the puberty, we shall come to the following conclusions:

The spine and chest at the time of birth are as, to their form and structure, to be regarded as unfinished. They undergo, during their development from birth to puberty, not only marked quantitative but also qualitative changes. Besides the disproportional longitudinal growth of the lumbar spine (Aeby, Moser and others) and the fixation of the normal lumbar curve, both of which physiological changes take place chiefly in the second decade of life, there are the following points of special interest for our present question:

(1) While in the embryo and in early childhood the chest grows chiefly in a sagittal direction, it extends chiefly in a frontal diameter at a later period. Out of the thorax of the child, the cross-section of which is heart-shaped, develops the chest of the man, the cross-section of which is bean-shaped.⁶

(2) The intervertebral joints in embryonic life and in early childhood have a uniform character which is of the dorsal type (Rosenberg). It is only in later life that the lumbar joints assume their definite character by turning their articular surfaces inwards. Consequently the "articular

change" does not develop until this late period, which is about the beginning of the second decade.⁷

Clinical symptoms which are based upon abnormalities in this development, especially in the frontal growth of the ribs, and in the articular change, cannot possibly manifest themselves before the proper physiological conditions are present to allow of their development, i. e., the first half of the second decade of life.

Since, indeed, in our 20 cases the deformity begins to manifest itself at this period of life, the apparent inconsistency referred to is not only explained but becomes an argument in favor of the theory of a causal connection between "habitual lateral curvature" and "numerical variation" of the spine.

Still other points may be urged in favor of the theory. Long standing questions in researches upon scoliosis are the following:

(1) What is the reason for the more frequent occurrence of "habitual lateral curvature" in the female sex?

(2) Why does the lumbar curve deviate usually with its convexity to the left, and why the dorsal curve mostly to the right side?

The first question cannot yet be answered by this theory. For according to anatomical statistics, numerical variation of the spine is apparently more frequent among men than women. But it has been shown (page 601) that the female and the male spines have different tendencies in their variations, and it is likely that in the future in some way this difference in the spines of the two sexes may lead to a satisfactory answer to the first question referred to above.

The fact referred to in the second question stands in entire harmony with the theory here advanced. The description above given of the genesis of the primary lumbar and of the primary dorsal curve makes it clear in general that:

(1) The lumbar curve with its convexity will lie on the same side on which the ileum and the lumbo-sacral boundary are placed higher. (Compare diagram 4.)

(2) The dorsal curve with its convexity will lie opposite the side on which the ribs are longer, i. e., opposite the side on which the cervico-dorsal boundary is moved up. (Compare diagram 5.)

These rules are not without exceptions, and no one will be surprised at this who considers that in the end the lateral deformity is the result of a developmental disorder of which the "numerical variation" of the spine may be only one sign.

Let us combine these rules with our findings described above: viz., that the left side has a pronounced tendency to vary in cranial direction, to move upwards. Thus we would easily understand why so frequently we find in "habitual lateral curvature" a deviation of the lumbar curve to the left, and of the dorsal curve to the right side.

To sum up all the arguments: The anatomical studies teach us that certain "pathological"

⁶Hueter: Die Formentwicklung am Skelett des menschlichen Thorax. Leipzig, 1865.

⁷Merkel: Über den Bau der Lendenwirbelsäule. Archiv für Anatomie und Entwicklungsgeschichte, Leipzig, 1877.

FIG. 1. Normal numerical conditions of the human spine.

FIG. 2. Variation in a cranial direction.

FIG. 3. Variation in a caudal direction.

FIG. 4. Asymmetrical (cranial) variation of lumbo-sacral region.

FIG. 5. Asymmetrical (cranial) variation of cervico-dorsal region.

FIG. 6. Intervertebral joints in asymmetrical variation in cranial direction.

FIG. 7. Incomplete lumbo-dorsal articular change in variation in cranial direction.

FIG. 8. Incomplete lumbo-sacral articular change in variation in caudal direction.

TABLE I.

Diagrams showing different kinds of numerical variation of the spine.

Diagrams 1-5 correspond to a front view, diagrams 6-8 to a back view of the spine.

FIG. 9. Lumbo-sacral (caudal) variation and lumbo-sacral scoliosis.

FIG. 10. Cervico-dorsal (cranial) variation and cervico-dorsal scoliosis.

FIGS. 12 and 13. Lumbo-dorsal (cranial) variation and lumbo-dorsal scoliosis; [see also x-ray of this spine, Table VII, Fig. 33.

TABLE II.

Spines showing certain types of numerical variation consistent with the lateral deformity present.

From the Dwight Collection in the Warren Museum of Harvard University Medical School.

FIG. 14. Lumbo-sacral scoliosis. Case 1.

FIG. 15. Cervico-dorsal scoliosis. Case 8.

FIG. 16. Lumbo-dorsal scoliosis. Case 16.

FIG. 17. Combined S-scoliosis. Case 22.

TABLE III.

Photographs from patients, whose measurements are given in Table IV.

Lumbo-Sacral Scol.

FIG. 18. From Case 1.

Cerv.-Dors. Scol.

FIG. 19. From Case 8.

Scol. Spine equally affected.

FIG. 21. From Case 22.

Lumbo-Dors. Scol.

FIG. 20. From Case 16.

TABLE IV.

Measurements illustrating 4 different types of juvenile, so-called "habitual" scoliosis.

In the measurements are seen:

- (1) The back, in frontal view showing the outlines of the body, the line of the spinous processes, the position of the head, the basis of the shoulder blade. This picture is taken by the Zander apparatus for back measurement.
- (2) The chest circumference; the cross line in this picture represents the connection of the spinous process with the middle of the sternum. This picture is taken by the Zander apparatus for chest measurement.
- (3) The upper part of the back, corresponding to the lower third of the dorsal spine, in forward bending.
- (4) The lower part of the back, corresponding to the middle of the lumbar spine, in forward bending.

The latter two measurements are taken by a little instrument which is an imitation of Beely's cyrtometer.

FIG. 22. Compare Fig. 20. 19th vert. has overdeveloped ribs; 25th vert. shows in its lumbar character. *Variation in a caudal direction.* Conditions of intervertebral joints see diagram 8. From Case 1.

FIG. 23. Compare Fig. 27. 7th vert. has "cervical ribs"; 19th vert. bears rudimentary ribs. Lumbar spine normal. *Variation in a caudal direction.* 8th vertebra has on the left a rib, which in its shape and curve resembles a second rib, while the rib on the right in its shape and curve is almost a typical first one. From Case 8.

FIG. 24. Compare Fig. 28. 19th vert. does not bear ribs. 24th vert. is partly sacralized. *Variation in a caudal direction.* Lumbo-dorsal articular change takes place above the 19th vert. completely on the left side, in an incomplete and transitional manner on the right side. From Case 16.

FIG. 25. Compare Fig. 29. 7th vert. bears "cervical ribs"; 19th vert. has a rudimentary rib on its right side, none on the left. 24th vert. is sacralized on the left, while the right side is still of lumbar character. *Variation in a caudal direction.* Intervertebral joint between 23d and 24th vert. is on the left side sacral, i. e., fused, on the right side lumbo-sacral. Ribs attached to the 8th vert. show the assuming of the character of the normal second ribs, on the left more than on the right. (The X-ray which shows these conditions is not published here.) From Case 22.

TABLE V. Diagrams made from the original x-rays shown in Table VI.

Fig. 29. Comb. Scol. From Case 22.

Fig. 28. Lumbodors. From Case 16.

Fig. 27. Cerv. dors. Scol. From Case 8.

Fig. 26. Lumbo-sacral scoliosis. From Case, 1.

TABLE VI. X-rays of the spines of the four patients, whose measurements and photographs are given in tables III and IV.

FIG. 30. From Case 12. Fusion of Atlas and Occiput.

FIG. 31. From Case 13. Rudimentary first rib on the left.

FIG. 32. From Case 21. Incomplete and asymmetrical lumbo-dorsal articular change. The right joint above the vertebra bearing rudimentary ribs has transitional character; in the left joint two articular processes of different character meet: the cranial process is of dorsal, the caudal of lumbar type. Tracing from the plate.

FIG. 33. X-ray from the specimen shown in Figs. 12 and 13. For description, see text.

TABLE VII.

forms of numerical variation of the spine may cause certain kinds of lateral deformities.

The x-rays show that corresponding clinical types of "habitual lateral curvature" in the great majority of cases show the variation expected at the seat of the primary curve.

The "habitual" scoliosis manifests itself at the very time at which physiological growth and changes allow the appearance of curves, based upon a "varying" development.

The different affection of the two sides of the spine in "habitual lateral curvature" corresponds with the peculiar relation of the right and left sides of the spine to the numerical variation.

Based upon these arguments and upon the fact that, in 16 out of 20 cases of so-called "habitual" scoliosis those "pathological" types of variation were found at the primary seat of the deformity present, the following statement seems to be justified:

THAT DEVELOPMENTAL ERROR OF THE HUMAN BODY OCCURRING IN EMBRYONIC LIFE, WHICH HAS ITS MORPHOLOGICAL EXPRESSION IN THE SO-CALLED "NUMERICAL VARIATION" OF THE SPINE, CAUSES UNDER CERTAIN CIRCUMSTANCES THOSE IDIOPATHIC LATERAL DEFORMITIES OF THE SPINE WHICH MANIFEST THEMSELVES IN THE FIRST HALF OF THE SECOND DECADE OF LIFE AND WHICH HITHERTO HAVE BEEN CONSIDERED AS AFFECTIONS ACQUIRED IN POSTNATAL LIFE OWING TO PURELY FUNCTIONAL OR FUNCTIONAL-OSTEOPATHIC CONDITIONS.

IT SEEMS TO BE THE ETIOLOGICAL FACTOR OF "HABITUAL" LATERAL CURVATURE, BETTER NOW TO BE CALLED DELAYED CONGENITAL SCOLIOSIS OR SCOLIOSIS CONGENITALIS TARDA.

In concluding, I desire to thank here all those who have given me advice, help and assistance in carrying out the work.

First of all, I wish to thank Prof. Thomas Dwight, director of the Anatomical Department of Harvard University Medical School, for much instruction, for his great courtesy in placing his valuable collection at my disposal for study and publication. My thanks are furthermore due to Drs. Goldthwait and Osgood, surgeons to the Orthopedic Clinic of the Massachusetts General Hospital for the interest they have taken in the work and for the use of their material; to Dr. Painter, surgeon to the Orthopedic Clinic of the Carney Hospital, who placed his entire curvature material at my disposal; to Dr. Brackett, surgeon to the Orthopedic Clinic of the Children's Hospital, who has also supplied me with some cases.

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EXPLORATORY PUNCTURE OF THE PERICARDIUM, WITH A REPORT OF THREE RECENT CASES.

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CASE I. Philip R., seventy years old, was admitted March 17, 1906. He had never been ill enough to be in bed since his youth. Two weeks before admission pain came on suddenly in his left side and for about a week was extremely troublesome. Dyspnea accompanied the pain and he soon noticed that his abdomen and legs were swollen. On entrance he had general edema. The area of cardiac dullness showed decided enlargement. The heart's action was somewhat irregular, but no murmurs were heard. Two days later a well marked friction rub developed over the precordium. It became less audible after a few days. The precordial dullness gradually extended until it reached on the right nearly to the nipple line, and on the left to the nipple line at the level of the fourth rib, where it merged into an area of dullness situated at the base of the left chest. The upper limit extended to the second rib, the general shape of the dull area being triangular. The heart sounds became very feeble and distant and the impulse imperceptible. No pulsus paradoxus. Over the dull area at the base of the left chest fremitus, voice and respiration were diminished. His temperature ran an irregular course but rarely exceeded 100°. As there was no tendency for the fluid to absorb, and as the patient's general condition was growing less satisfactory, the pericardium was aspirated on April 10 through the fifth left space outside the nipple line and 650 cc. of bloody serum were removed. The needle was then withdrawn as the heart could be felt beating against its point. The fluid at first came freely without suction. The patient expressed himself as considerably relieved, and the edema diminished, but the fluid rapidly recollected. The effusion in the left pleura increased and on April 24 it was tapped and 1,000 cc. of clear, yellow serum were drawn off. Reaccumulation was rapid and but temporary relief was obtained. The patient complained of considerable dyspnea which was somewhat paroxysmal in character. There was marked obstruction to the return flow of blood from the upper extremities. The capillaries of the neck and upper part of the trunk showed a condition of stasis, and the ears, nose and finger tips were slightly cyanotic. An attempt was therefore made, on April 29, by introducing a needle in the fifth space just outside the previous puncture, to empty both the pleural cavity and the pericardium without withdrawing the needle. Immediately after it was inserted there was a sudden gush of a few drams of bloody fluid, similar in appearance to that obtained before from the pericardium, and then its color changed abruptly to a clear yellow. Four hundred cubic centimeters of the latter were withdrawn before it ceased to flow. The needle was then pushed in the direction of the heart until it came in contact with a pulsating body, which was either the pericardium or the heart. The determination of this point was not made as through an oversight on the part of the house physician, to whom I had delegated the operation, the needle selected was so large that I feared to enter it further, although the sense of resistance suggested pericardium rather than heart. This was confirmed at autopsy, which also showed that the sudden gush of bloody fluid could have no other source than the pericardium. He was somewhat relieved by the removal of the pleural fluid and no further effort was made at this time. On the fourth