ON INVERSION OF THE ILIUM AND SACRUM AND ISCHIUM AND PUBES (ILIO-SACRAL AND ISCHIO-PUBLIC BONY SEGMENTS) AS CAUSES OF DEFORMITIES OF THE FEMALE PELVIS.

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In considering this subject it will be advisable to take it up in the first place in the way it presented itself to me.

On 9th February 1903 I delivered a woman at the Edinburgh Royal Maternity and Simpson Memorial Hospital by means of pubiotomy. The patient died on the third day from delayed chloroform poisoning, and not from sepsis. The post-mortem was performed by Professor Stuart McDonald, now of Durham University, and I obtained the pelvis whose measurements will be given along with those of others later.

I was unable to classify this pelvis. It was not rickety nor a pure justo-minor as understood at present, nor funnel-shaped, and I therefore considered it tentatively as non-rickety, generally narrow and flat, although I could not defend this diagnosis fully.

In investigating atypical female sex-ensemble (female pseudhermaphrodisim) my attention was drawn to the fact that one case, No. I., of Fibiger, had a male pelvis, but no measurements were given. It did not strike me then that such inversion had any bearing on this specimen.

Case II., N. N., by the same author, had all the pelvic measurements male, except the obliques at the brim, and was thus practically a male pelvis, although N. N. was a case of atypical female sex-ensemble (female pseudhermaphrodisim). In such cases, then, we may have inversion of the bony pelvis, of the ilium and sacrum, and probably of the ischium and pubes. This suggested to me that inversion of the bony pelvis might be present, not associated with psychosexual pseudhermaphrodisim, and I thus began to look into this aspect. The question was whether we might not get a female pelvis with inversion of part of the bony pelvic factor of the sex-ensemble, with or without any other considerable features of the sex-ensemble also being inverted.

In searching for evidence I came across Dr. Derry's papers entitled "The Influence of Sex on the Position and Composition of the Human Sacrum" and his "Note on the Innominate Bone as
a Factor in Determination of Sex: with Special Reference to the Sulcus Preauricularis”; and also renewed my acquaintance with Arthur Thomson’s contribution, “Sexual Differences of the Foetal Pelvis,” and Fehling’s “Die Form des Beckens beim Fötus und Neugeborenen und ihre Beziehung zu der Erwachsenen.” The first two especially cleared up the difficulties I had, and I now hope to show that this pubiotomy pelvis and several others are really cases where a (male) ilium and sacrum have been inverted into a female bony pelvis, and thus each has a female pelvic ischio-pubic bony segment and a male ilio-sacral; or that the ischium and pubes (male) may be present in a female pelvis so that we have ilio-sacral and ischio-pubic inversions of the bony pelvis giving rise to serious deformity.

The question of what constitutes the differences between the normal male and female pelvis must now be considered.

The obstetrician has usually described the normal female pelvis as differing from the normal male pelvis in its greater size and the lighter build of its components; greater width of brim—transverse and pubic arch, and larger interischial diameter. No convergence of side walls of cavity. The brim is reniform.

The normal male pelvis has heavier, rougher, and more massive bones, a narrower sacrum transversely, with a less marked vertical curve, some convergence of the side pelvic walls, and a narrower pubic arch. On this I may quote what I said in my Guide to Midwifery (p. 27):—

“The differences between the male and female pelvis are pronounced. The male pelvis has heavier bones with well-marked muscular attachments; while the female pelvis is roomier and larger, with the iliac bones flatter. Thus the true pelvis in the female has a much greater capacity than the male owing to its wider transverses. The brim of the female pelvis is reniform in its shape, as compared with the cordate form of the male. In the male the pubic arch is narrow (70° to 75°), while that of the female is markedly wide (90° to 100°). The obturator foramen is ovoid in the male, triangular in the female, and in the former the foramina look more outwards; the male sacrum is longer and narrower” (pp. 27 and 28).

The obstetrician, therefore, considered the larger female pelvic capacity as compared with the male to be due to an increased sacral width as well as an increase in the usual measurements or diameters of the pelvis agreed on by obstetricians.

General anatomists have, however, drawn attention to some
Fig. 1.—Male Pelvis, Lateral Aspect. Note male sacro-sciatic notch and posterior steep aspect of ilium.

Fig. 2.—Female Pelvis, Lateral Aspect. Note large sacro-sciatic notch, and less steep posterior aspect of ilium (Derry).
special differences between the male and female ilium, since it is of importance, as Elliot Smith and Wood Jones have shown in archaeological work, to determine the sex from an isolated ilium.

The following points have come up:—In the normal female ilium the great sacro-sciatic notch (incisura ischiadica major) is much larger than in the male ilium—that is, is almost rectangular, and has a longer periphery, while the male sacro-sciatic notch is smaller, and its boundaries meet above at an acute angle (Plate I., Figs. 1 and 2). The posterior boundary of the female notch is sacral, while in the male the posterior limb of the notch forms the upper part of the posterior border of the notch, only the lower part being sacral. Derry has also shown that the auricular part of the sacrum in the male runs into the third sacral vertebra in whole or in part. The female ilium is thus larger than the male ilium, and its posterior border is less steep and more rounded than in the male. In the antenatal pelvis and in the adult the curve of the iliac crest "reaches a higher level and is more pronounced than in the female" (Arthur Thomson). No text-book in obstetrics notices these facts about the notch, not even von Winckel's Handbuch. These facts about the ilium and great sacro-sciatic notch are of great importance. The greater size of the female pelvis is not only a question of the wider pubic arch and of sacrum breadth, but is also due in great part to the larger ilium, with which is associated the larger sacro-sciatic notch. One could suppose that if the ilium were ductile the female ilium had resulted from a drawing up and back of the male ilium, and also by the increase

Fig. 1.—Brim of Pubiotomy Pelvis with Iliac Inversion.
in size in it and the notch. Another difference is in what is known as the sulcus preauricularis. This is a groove in the ilium “immediately in front of the lower part of the auricular articular surface,” and was so termed by Zaaijer. This is considered to be due to the attachment to the ilium of the anterior sacro-iliac ligaments. It is more frequently present in the female than in the male pelvis. Lohr found it in 41 female pelves out of 59, but only in 9 out of 34 in the male.

A secondary result of the differences of the male and female pelvis is due to the contrast in the sacro-sciatic notches. As the male sacro-sciatic notch curves down on its sacral aspect instead of going out almost at a right angle, the sacral auricular surface in the male is made up usually of two and a half to three sacral vertebrae. In the female normal pelvis, however, the vertebrae making up the sacral auricular surface are usually only two, unless there are six vertebral bodies in the sacrum, or the pelvis is kyphotic, and then the auricular surface spreads on to the third sacral vertebra more or less completely.

While this fact of the female sacral auricular surface being made up of fewer vertebrae than in the male holds good in the normal pelvis, and aids in determining the sex, the question will arise afterwards if the larger involvement of the vertebrae in sacra with six pieces or in kyphotic pelvis makes this criterion less absolute.

One point may be added here: the greater length of the mesial aspect of the male pubes as compared with the female. With these facts in mind I verified them on the normal male and female pelves in my museum, and then went on to examine a series of deformed pelves in my possession. The results were interesting.

In the flat, flat-rickety, scolio-rhachitic flat, and kyphotic and split pelves the sacro-sciatic notch was female, and thus the pressure factor in these deformities had no effect on the nature of the notch. A marked scolio-rhachitic flat had an unaltered female notch. In a Naegle specimen the notch was evidently female on the sound side, but smaller and yet female on the affected side. In a rare Robert’s pelvis the notch on both sides was male and small, but sometimes it is female or male in split pelvis. (See Breus and Kolisko, I., Figs. 14, 21). In the former the ilia are diminutive, the sacro-iliac joints ankylosed, and the pelvic diameters markedly narrowed.

The most interesting find was, however, in the puzzling pubiotomy pelvis. Here both great sacro-sciatic notches were male; the
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ilium and left half of the sacrum were also male. The rest of the pelvis was female, viz. the pubes, pubic arch, and the ischial transverse. (See Figs. 1, 2, 3.)

I also found in my own museum another pelvis which I had classified as flat-rickety, generally narrowed. Both notches, however, were male, the ilia male, and the sacrum the same. The pubic arch was very wide and the ischial tuberosities far apart. I have no history of this pelvis, and no means of tracing it. In fact I do not know how it came into my possession, except that it may have been one of Matthews Duncan’s preparations, obtained through the late Dr. J. B. Buist when the former left Edinburgh.

A pelvis which I had always considered as justo-minor

(generally contracted) proved to have a male notch, and this is probably ilio-sacral inversion.

I next found an inverted pelvis in the museum of the Edinburgh Royal College of Surgeons, and Professor Briggs, who has one of the finest private collections in this country, to whom I wrote on the subject, sent me on a very fine specimen.

Dr. R. W. Johnstone, who kindly examined at my request the Edinburgh University specimens, discovered in the obstetrical museum one deformed female pelvis due to iliac inversion, and an interesting one where the ischium and pubes were male and the ilia female. The pubic arch was pronouncedly male in this rare case. His description of these is given later.

These pelves, seven in all, are instances of bony pelvic inversion, e.g. of ilium and sacrum, or ischium and pubes, into a female pelvis, thus causing serious deformity.

Fig. 2.—Lateral Aspect of Pubiotomy Pelvis with Iliac Inversion, to show Male Notch.
There may also be inverted male pelves, e.g. male pelves with an inverted (female) segment, ilio-sacral, or ischio-pubic, or portions of these. Probably they may be found in the atypical male sex-ensemble cases (male pseudhermaphroditism), or in pelves without a psychosexual sex-ensemble anomaly.

In Tuffier and Lapointes' case of atypical male sex-ensemble (male pseudhermaphroditism), the hips, and presumably the bony pelvis, were clinically female.

Some Preliminary Points as to the Views of the Origin of the Shape and Size of the Normal Female Pelvis.

Matthews Duncan, Veit, and Schroeder studied the question of the upright pressure cause of the shape of the normal female bony pelvis (1868), mainly in relation to the brim, but, curiously enough, left out of account the same question in the male pelvis.

Schroeder believed the foetal female brim to be a long oval or circular, and that the broader transverse of the brim in the adult female was due to the body weight acting down, and the leg resistance in, when the child began to walk. F. H. Champneys pointed out more correctly that the leg resistance did not act in the line of the neck of the femur, but in that of a line joining the foot and acetabulum. Schroeder's explanation was thus a purely mechanical one. If, however, this is the case, the male pelvic brim should be the same as the female one, as both are under the same mechanical conditions; indeed, the male pelvis should be an exaggerated female one, owing to the greater activity of the boy.

Quite a new light, however, was thrown on the question by Fehling of Strassburg (1870) and Arthur Thomson of Oxford. These observers demonstrated that the foetal pelvis after the third month could be diagnosed as male or female, both by the brim transverse and by the sacro-sciatic notch: the latter fact being demonstrated in Thomson's specimens.

Thus the ultimate shape of the bony pelvis is due mainly to a type of growth before birth, and not wholly to post-natal mechanical influences.

It must be noted, however, that the lumbar curve, the greater curve of the sacrum, and the brim inclination to the horizon, are due to post-natal influences, and this must not be forgotten. The shape of the normal female pelvis and of certain deformed ones is congenital, and of the latter the chief are inverted pelves, justo-minor, Naegele, Roberts, achondroplasic, the so-called infan-
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tile, the funnel-shaped pelvis (irregular assimilation pelvis), the split pelvis. The flat, flat-rickety, scolio-rhachitic flat, and some very rare forms are post-natal in their origin. The congenital cases are, of course, subject to post-natal modifications, as in the case of the normal pelvis given above.

The inverted pelvis has thus a prenatal causation. The slight lateral deviation in the pubiotomy specimen has had no influence in its formation, and its diagnosis is based on (1) the smaller ilium, smaller sacrum, and male sacro-sciatic notch; (2) the symmetry of the pelvis; (3) the narrowing of the transverse of the brim. Rickets may be present, and thus we may have an excessively narrowed pelvis, as in one of my specimens.

![Diagram](image)

**Fig. 3.**—Outlet of Pubiotomy Pelvis showing Female Characters—Wide Pubic Arch and Normal Female Transverse.

**Descriptive Anatomy of the Inverted Pelvis in the Female Ilio-sacral Inversion and Ischio-pubic Inversion.**

Seven specimens are available for examination, viz., my own pubiotomy pelvis; another with rickety deformity superadded; a third thought to be justo-minor; a fourth very fine specimen from the museum of Professor Briggs of Liverpool University; a fifth from the Museum of the Royal College of Surgeons, Edinburgh; and two from the Edinburgh University Obstetrical Museum. Of these I describe five.

(1) *The Author’s Pubiotomy Pelvis.*

The following measurements were made by my resident in
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the Royal Edinburgh Infirmary, Dr. Hamilton, and are as follows:

| Diameters taken.          | When sawn surfaces opposed. | When sawn surfaces separated. | Difference. | When parts of bone separated, 1'09 in. | Difference. |
|---------------------------|-----------------------------|-------------------------------|-------------|----------------------------------------|-------------|
| Interspinous              | 9.73                        | 9.87                          | +14         | 10.03                                  | +30         |
| Intercristal              | 10.53                       | 10.62                         | +11         | 10.79                                  | +26         |
| Brim, conjugate           | 3.145                       | 3.21                          | +65         | 3.491                                  | +346        |
| " R. oblique              | 4.64                        | 4.94                          | +30         | 5.24                                   | +6          |
| " L", transverse          | 4.935                       | 5.13                          | +195        | 5.22                                   | +6          |
| Outlet, conjugate         | 5.43                        | 5.755                         | +325        | 5.88                                   | +45         |
| " R. oblique              | 4.0                         | 4.08                          | +08         | 4.225                                  | +225        |
| " L", transverse          | 4.21                        | 4.45                          | +24         | 4.965                                  | +755        |
| Baudelocque's diameter.   | 3.87                        | 4.22                          | +65         | 4.555                                  | -685        |
| Between post.-inf. spines| 6.43                        | 6.5                           | +07         | 6.5                                    | +07         |
| Between post.-sup. spines| 3.325                       | 3.18                          | +145        | 3.1                                    | -225        |
| Diagonal conjugate        | 4.15                        | 4.20                          | +05         | 4.20                                   | +05         |
| Interacetabular           | 4.87                        | 5.13                          | -26         | 5.46                                   | -39         |

The measurements were made (1) with the surfaces of the sawn pubes apart, and (2) when in contact.

The increase at the brim by pubiotomy has been discussed in a previous paper. It amounted to nearly three-quarters of an inch.

It will be seen from these measurements that a full-time labour was impossible but that pubiotomy was indicated and was successful so far as the child was concerned.

In order to display the contours of the brim, outlet, and lateral aspects I had the advantage of Professor Arthur Robinson’s advice to have them traced in outline by means of the dioptograph, and have to thank him for the personal trouble he took in making such satisfactory outlines as are shown in the figures.

Each pelvis had orthogonal tracings of the brim, outlet, and lateral aspects made, but in the pelvis with ischio-pubic inversion a frontal tracing of the pubic region was made instead of an orthogonal of the outlet.

On viewing the brim (Fig. 1) it can be noted to be symmetrical but the linea terminalis is somewhat less curved anteriorly than in a justo-minor (Fig. 1). The sacrum is male as to the left ala sacra, and there is a slight lateral deviation to the left in the lumbar vertebrae. This has no effect on the notch, and
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indeed the pelves I have examined, where there is marked scoliosis in the lumbar region, have female notches. The ilia are small, the sacro-sciatic notch male, and thus the whole ilium is male (Fig. 2).

The ischio-pubic segment is female, as the pubic arch is large, and the transverse at the outlet, 4·62 ins., quite a normal measurement. The outlet conjugate, on the other hand, is 4 ins., an inch less than normal (Fig. 3).

In the second pelvis in my possession the deformity is marked, as will be seen from the measurements given below. The ilia are exceedingly small and the notch markedly male. The sacrum is male.

On the other hand, the pubic arch is excessively wide, a result in part of the rickety condition. Here, then, the sacrum and ilia are male, the ischia and pubes female, and the whole pelvis rickety and somewhat stunted.

The measurements are as follows:

|                      | Conj. | Trans. | Oblique |
|----------------------|-------|--------|---------|
| External conjugate   | 4 ins.|        |         |
| Interspinous         | 8\textsuperscript{\(\frac{1}{2}\)}" | 8\textsuperscript{\(\frac{1}{2}\)}" |        |
| Intercristal         | 8\textsuperscript{\(\frac{1}{2}\)}" | 8\textsuperscript{\(\frac{1}{2}\)}" |        |
| Brim                 | 1\textsuperscript{\(\frac{1}{2}\)} ins. | 4\textsuperscript{\(\frac{1}{2}\)} ins. | 4\textsuperscript{\(\frac{1}{2}\)} ins. |
| Outlet               | 3\textsuperscript{\(\frac{1}{2}\)} ins. | 5\textsuperscript{\(\frac{1}{2}\)} ins. | 4 ins. |

This pelvis is the result of more than one influence. The rickets gave the alteration in the curve of the iliac crests and the
extreme deformity of the conjugate. The pelvis, however, is more stunted than can be accounted for by the inversion and the rickets, and therefore it might be described as inverted (ilio-sacral), rickety, generally narrowed.

The third specimen in Professor Briggs’ possession is a very fine example of inversion, and is in a state of beautiful preservation. The measurements are as follows:

|                | Conj. | Trans. | Oblique. |
|----------------|-------|--------|----------|
| Baudelocque    | 6¼ ins. | 8¼ ins. | 9½ ins. |
| Interspinous   |        |        |          |
| Intercristal   |        |        |          |
| Brim           | 3¾ ins. | 4½ ins. | (4½ ins. R. |
| Outlet         | 3½ ins. | 4 ins. | (4½ ins. L. |

The sacrum is male, especially the left ala sacra, and markedly curved. The ilia are male with a typical male notch. The pelvis is symmetrical, but the left ala sacra is a little smaller than the right, and in detail the transverse process and rib-portion are, in the former, distinctly smaller.

The Brim.—It can be noted that the ala sacra on the left side is smaller than the right. The brim is thus slightly asymmetrical. The side walls are slightly more convergent than in the normal and justo-minor pelves. The ilia (flat upper expansion) are smaller.

The Lateral Aspect.—The striking feature here is the male sacro-sciatic notch (cf. with male and female notches in Figs. 1 and 2). The posterior aspect of the ilium is steep as in the male, but this is a little exaggerated in the figure; where the ilium meets the auricular surface the former is slightly bent (not shown in the tracing). The exaggerated curve of the sacrum is well seen. The obturator foramen is male in shape.

The outlet is female with a large pubic arch. The promontory is not seen as it should be in a normal pelvis, owing to the marked angular curvature of the sacrum (Figs. 4, 5, 6).

In this deformed female pelvis the deformity is due to an inversion of both ilia and probably of the left half of the sacrum. The sulcus auricularis of Zaaier is well marked on the left side but is not present on the right. It is usually more frequently present in the normal female pelvis than in the male. There is also a slight false promontory at the junction of the first and second sacral vertebrae, and the tip of the coccyx is a little twisted to the right side. The sacral vertebrae number five.
The description by Dr. R. W. Johnstone of the following three pelves (Figs. 7, 8, 9) is as follows:

"Pelvis '4.' The ischio-pubic segments are characteristically female, the subpubic arch being wide and roomy.

"The ilia both present male notches—particularly on the right side. On that (R.) side the auricular surface of the sacrum extends to three sacral vertebrae. On the left it extends to two 'and a bit'—being recognisably shorter than on the right side.

"On neither side is there a preauricular sulcus recognisable. The sacrum is female in type.

"The brim is somewhat masculine in shape and the cavity somewhat funnel-shaped.

Fig. 5.—Lateral Aspect of Deformed Female Pelvis with Iliac Inversion, to show Male Notch.

"The dimensions are:

| Description                  | Measurement | 9 3/4 ins. |
|------------------------------|-------------|------------|
| Interspinous                 | 24 cm.      |            |
| Intercristal                 | 27.4 cm.    | 10.9 "     |
| Conj. vera                   | 10.9 cm.    | 4.4 "      |
| Trans. of brim               | 13.1 cm.    | 5.2 "      |
| Oblique of brim (R.)         | 12.8 cm.    | 5.1 "      |
| Oblique of brim (L.)         | 12.4 cm.    | 5.1 "      |
| Ant. post. of cavity         | 12.5 cm.    | 5 "        |
| Ant. post. of outlet         | 11.1 cm.    | 4.8 "      |
| Transv. of outlet            | 9.6 cm.     | 3.8 "      |

"Pelvis '5.' The ischio-pubic segment is characteristically female. The iliac notch on both sides is masculine in type. Each auricular surface extends to three sacral vertebrae. There is no recognisable preauricular sulcus. The sacrum is broad and typically female.
The shape of the inlet and canal is masculine in type (Fig. 7).

Dimensions:

|        | A. P. | Trans. | Oblique. |
|--------|-------|--------|----------|
| Brim   | 11·6  | 13·1   | (R. 12·5|
| Cavity | 13·4  | ...    | (L. 13   |
| Outlet | 8·5   | 9·3    | ...      |

"Pelvis '29.' Well-marked signs of osteo-arthritis.

The ischio-pubic segment is typically male, the subpubic arch being narrow and the angle acute (Fig. 8).

The ilia present typically wide female notches, that on the left side being peculiarly wide and sweeping (Fig. 9).

The sacrum is wide and female in its characters.

The auricular surface just reaches the third body on each side. The left side presents a faint preauricular sulcus.

Dimensions:

|        | A. P. | Trans. | Oblique. |
|--------|-------|--------|----------|
| Brim   | 9·4   | 13·8   | 12·9 on both sides. |
| Cavity | 11·2  | ...    | ...      |
| Outlet | ...   | 9·5    | ...      |

"The shape of the inlet is female, wide, and rather oval. The outlet is roomy, but as the lower part of the sacrum is missing, no statement can be made about it (Figs. 7, 8, 9).

"Pelvis No. 4.

Height of symphysis = 4·5 cm. (including dried subpubic ligament). Acetabula = 5·5 cm. vertically × 5 cm. wide.

"Pelvis No. 5.

Symphysis = 4·5 cm. (practically no ligament). Acetabula = 5·0 × 4·9.

"Pelvis No. 29.

Symphysis = 4·25 cm. (!) (no ligament at all). Acetabula = 5·2 × 5·5."

The 6th pelvis from the Royal College of Surgeons is an ilio-sacral case and need not be detailed.

THE SEXING OF FRAGMENTS OF PELVES BY ELLIOT SMITH AND WOOD JONES.

I now wish to discuss, inter alia, the valuable contribution to the sexing of archaeological pelves from portions and entire
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specimens, in their monograph on the *Archaeological Survey of Nubia*, vol. ii., chapters iii., iv.

The material, human remains, was obtained in the excavations of a tract of land in Lower Nubia necessary for the building of a large reservoir which will ultimately flood the district when the Aswan dam is raised. In the case of the pelvic bones the questions raised were those of age, race, sex, and in certain cases the determination of the sex from a single bone present, usually the ilium.

The following extracts will indicate the general scope of the results:

"Sex contradictions are not uncommon in the individual parts of the pelvis, and the evidence of any one indication may be fallacious at times" (*op. cit.*, ii. 259, foot of page).

"The form of the pubic arch and the depth of the symphysis pubis may be very deceptive" (*op. cit.*, p. 260).

"In 24: 1: L. M., an undoubted woman of the Ptolemaic period, the whole of the anterior part of the pelvis had a very masculine appearance, the depth of the symphysis being 37 mm. and the subpubic angle reduced to 65 degrees" (p. 260).

This specimen is thus like the fifth of those described in the present paper (*vide* p. 20).

"We were particularly fortunate in meeting with no less than five women who died in the later stages of pregnancy, or, probably, to be more correct, died in labour. In every one of these cases the pelvis was of abnormal form and most of them
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exhibited a sex contradiction in some part or other” (op. cit., p. 260).

The following are the measurements (op. cit., p. 249):

| Sex. | Inlet. | | | Outlet. |
|------|-------| ------|------|-------|
|      | Transverse | Apos- | Between | Between |
|      |       | terior. | ischial | ischial |
|      | Mm. | Mm. | Mm. | Mm. |
| Female, with retained foetus. | 112 | 89 | 80 | 95 |
| Female, | 105 | 102 | 97 | 94 |
| Female, | 131 | 129 | 97 | ... |
| Female, | 124 | 107 | 92 | ... |
| Female, | 123 | 116 | 112 | ... |
| Female, | 123 | 123 | 115 | 111 |
| A masculine type of female; j pelvis undoubtedly a woman’s. j | 116 | 94 | 81 | 80 |
| | 117 | 97 | ... | ... |
| | 127 | 111 | 95 | ... |

"Some masculine feature was present in each of these pelves, and but for the presence of the foetal bones within the cavity any single os innominatum might have been classed as male” (op. cit., p. 260).

"The auricular surface is smaller and less uneven in men than in women” (op. cit., p. 260).

"The preauricular groove is a feature to which we have come to attach much importance, and for the determination of sex in fragmentary bodies it is by far the most valuable sexual indication we have” (op. cit., p. 260).

The authors draw attention to increased length of the sacrum in certain cases, the additional vertebra being caudal or cephalic, more usually the latter. “In one of our cases in which the anomaly was found in the skeleton of a woman, an unborn foetus was retained within the pelvis” (op. cit., p. 248). This is of interest, as such six vertebrae sacra, the addition being cephalic, are really funnel-shaped or so-called male pelves, and a fairly common cause of difficult labour (Whitridge Williams).

If we look at such pelves in the light of the present paper it is probable that what the authors call sex-contradiction is really sex-ensemble inversion involving the three primitive segments of the bony pelvis (sacrum and ossa innominata). The most common inversion is iliac, but the same mal-allotment may give a
female pelvis with a male ischio-pubic segment, or smaller inverted portions.

We may now recapitulate what constitutes a typical female and male bony pelvis and what inversions may take place.

The Typical Female Bony Pelvis in the Adult.—This can only be described in general terms. The female pelvis has lighter and smoother bones, and has such diameters that a roomy cavity fit for easy parturition is developed. The iliac bones are more vertical and their posterior ends descend less steeply than in the male. The angle of the pubic arch is $70^\circ + $ to $100^\circ$. The sacro-sciatic notch is large, and usually the sulcus preauricular is present on one or both sides. The anterior mesial vertical surface of the pubes is shorter than in the male.

![Fig. 7. Brim and Cavity of Female Deformed Pelvis with Ischio-pubic Inversion. Note convergence of side walls.](image)

The sacral auricular surface usually involves two vertebrae. In the funnel and kyphotic pelves three may be taken up by it.

In the male adult pelvis, on the other hand, the bones are rougher and heavier. The diameters are less and the inlet heart-shaped instead of kidney-shaped as in the female. The pubic angle is $-70^\circ$ to $70^\circ$; the sulcus preauricularis is less frequently present. The sacral auricular surface usually has two + vertebrae. For identification of sex from an innominate bone the sacro-sciatic notch is specially valuable; next to this comes the sulcus preauricularis. In the entire pelvis the sexing is easy, but what must be considered carefully in the female pelvis is the existence of inversion of the ilio-sacral and ischio-pubic segments, the former being the more frequent. Inversion of parts of these two
segments may also take place independently, but our information on these minor inversions is small as yet. The question of how such inversions take place must now be considered.

**The Mechanism of Segmental Bony Pelvic Inversion in the Special Specimens Considered at Present.**

I have already considered the mechanism of inversion of the sex-ensemble, but may repeat somewhat and expand what has previously been said. The description will gain in clearness from its application to the specific instances taken up.

What one has to explain is the presence in an adult of an opposite sex-ensemble structure, in the present cases, of a male ilium and male sacrum (half or whole) or male ischium and pubes in a female deformed pelvis. It is evident from what I have brought forward in previous papers that the site of the mechanism of this inversion must be sought for in the germ plasma of the germ- and sperm-cells which afterwards become gametes prior to fertilisation, and thus what we have to explain is, how did the determinants for a male ilium and sacrum or ischium and pubes become inverted, and thus abnormally present in one of the fertilising gametes, as we shall see, and absent in another of the opposite sex.

**Inadequacy of the Theory of one Fertilising Gamete on each Side.**

The theory of one gamete, and not a choice of two, on each side at fertilisation is untenable for one reason, whatever others there may be. The zygote formed by the union of one gamete on each side and not by a choice of two, may give rise ultimately to an adult male or female, each with his or her sex-gland possessing oöcytes or sperm-cells, and these are derived from the p.s.c. mass or p.g.c. mass. Thus, according to this view, primitive germ and sperm masses must be present in every zygote, one disappearing, the other persisting, which is absurd, as geometers say.

On the theory of a choice of two gametes on each side we get, however, a more feasible explanation. It is now known that many low organisms have at fertilisation at least two gametes on each side, and Beard and others have given examples of many such. If we suppose that at fertilisation there are two sperm- and two germ-cells, giving rise, by maturation, to two gametes on each side, we get a much more reasonable explanation of some of the results of gametic union.

**Preliminaries on this Point.**—When fertilisation takes place, a zygote is formed (fertilised ovum), and this zygote is early
divided into a primitive germ- or sperm-cell mass for the future sperm- and germ-cells, and a somatic part for the body or soma of the future adult. The cells of the p.g.c. or p.g.s. mass travel through the early germ layers before the Wolffian body or somatic part of the sex gland is laid down, but when that happens, they become ultimately lodged in the sex gland, forming the oöcytes in the ovary or sperm-cells in the testes.

Thus the adult body has a sex gland and a soma, the one containing the early derived sperm- or germ-cells, the other the developed product of the somatic part of the zygote laid aside. The one is germinal and for the future progeny, the other somatic and for its own generation only. It is the former that propagates and has the continuity of the germ-plasma; the latter is the mortal portion, and has in itself no propagative power. Thus it must be noted that the primitive germ- and sperm-cells are not derived from any part of the soma, as is so usually held.

The somatic germ epithelium cells covering the ovary and adjacent peritoneum are not the source of the primitive germ-cells. This has been a most largely accepted view.

When a primitive germ-cell (oöcyte) in the foetal ovary undergoes mitosis there is longitudinal and transverse division and a looped formation of the chromosomes containing the heredity determinants. This does not result in each of the two new germ-cells being an exact replica, but there is necessarily variation, the one being, I hold, a Wolffian germ-cell, the other a non-Wolffian. The male Wolffian gamete contains determinants suitable for the
male Wolffian body on which the testis forms; the female Wolffian gamete, those suitable for the Wolffian body on which the ovary forms, while the non-Wolffian gametes contain usually no sex-ensemble determinants.

What, therefore, the mitosis of the oöcytes or germ-cells in the foetal ovary means is probably as follows: (a) Multiplication of the chromosome determinants and the formation of two germ-cells from one; (b) variation in determinant allotment between (c) the Wolffian and non-Wolffian sperm- and germ-cells on each side.

(a) *Multiplication of the Chromosome Determinants.*—This is the result of mitosis, and we thus get an enormous increase in their number, especially in the case of the testis. In oöcyte and sperm-cell mitoses the division and multiplication is not equal, but a variation, and we therefore now consider—

(b) *Variation in Determinant Allotment between (c) the Two Sperm- and Germ-Cells.*—The result of the mitoses is an increased formation of p.g.c. and s. cells. This power of immense multiplication and variation of living germ-plasma and its passage when the zygote is formed from a determinant to a determinate adult stage, the latter not usually reproducing its somatic condition (only in fact in identical twins), is a striking characteristic of living protoplasm.

It is highly probable that we may consider the multiplied and varied p.g.st. cells as the two kinds of sperm- and germ-cells which ultimately become gametes by the loss of the polar bodies (maturation).

These mitotic changes have been studied by von Winiwarter especially, and his researches have also been repeated by others. In the early foetal ovary the primitive germ-cells are found to undergo mitoses, and it is unfortunate that these are usually interpreted as indicating the development of the germ-cells from the germ epithelium covering the ovary or testis. These double germ- and sperm-cells are microscopically the same in each sex, but differ in their contained chromosomes. We may suppose that one oöcyte has certain determinants, the other complementary ones, and they may be called the Wolffian and non-Wolffian oöcyte or ovum, the former containing the sex-ensemble determinants and some somatic determinants. The typical Wolffian one has thus the sex-ensemble determinants along with certain somatic ones; the non-Wolffian has usually no sex-ensemble determinants but a certain number of somatic determinants. There are Wolffian sperm-cells and non-Wolffian ones on the same plan. The two kinds of germ-cells arising by mitoses will vary greatly in their allotment, but
the most effective probability result will be that of a Wolffian male gamete ultimately combining with a non-Wolffian female gamete and a Wolffian female gamete with a non-Wolffian male gamete. The Wolffian ones should have the Wolffian body and *sex-ensemble* determinants, the non-Wolffian none of these, but certain purely somatic determinants. When really effective double germ-cells are a result they will perpetuate this condition markedly, as the p.g.c. mass will thus contain a large number of like effectives.

In the pubiotomy inversion case I suppose the female Wolffian germ-cell, or gamete after maturation, had no ilio-sacral bony determinants and that it met a male non-Wolffian gamete with the male ilio-sacral determinants, an inversion of such from variation, and that thus the female zygote got ilio-sacral male determinants for part of its pelvis. The pelvis would thus be inverted in its ilio-sacral components. Normally the female Wolffian gamete should have had, *inter alia*, the female ilium determinants and the non-Wolffian sperm-cell no *sex-ensemble* molecule in whole or in part, but the loss on the one side and the abnormal presence on the other gave the inversion when these united.

Thus we may suppose the following:—

For a normal female pelvis, a Wolffian female gamete with the complete *sex-ensemble* molecule meets a non-Wolffian male gamete with no *sex-ensemble* determinants; result, *inter alia*, a normal female pelvis.
For an ilio-sacral inversion in the female, a Wolffian female gamete minus the determinants for the sacrum and ilium meets a non-Wolffian male gamete with these determinants abnormally present; result, an inverted female pelvis relative to the sacrum and ilium.

The gist of the mechanism of inversion of part of the sex-ensemble is as follows. The inversion happens in the determinants when the sperm-cells and germ-cells are undergoing mitosis in the foetal sex-gland and is due to the absence, by variation, from a Wolffian sperm- or germ-cell, of certain sex-ensemble determinants which should be normally present, and their presence in a non-Wolffian one of the opposite sex where they should normally be absent. When such conjugate, inversion necessarily takes place. Such an inversion could be hereditary, i.e. transmitted by distribution. The mother with an inverted bony pelvis would have, for such a deformity, by multiplication, similarly defective sex-ensemble molecules in her ovary, which would pass on this condition in certain of her offspring.

Thus we get a congenital inversion of certain pelvic determinants and their distribution in the future generations. As the male ilium and sacral wings, and also the ischium and pubes, are smaller in the male than in the female, we therefore in such inversions get a seriously deformed female pelvis.

The Question of Narrow Pelvic Outlet.

The question of narrowed pelvic outlet has been much neglected by obstetricians but has been carefully studied by Schauta, Breus and Kolisko, Whitridge Williams, Klien and others. We may leave out of account malacosteon, justo-minor, Naegle and Robert's pelves, as these are readily understood so far as the narrowed outlet is concerned. The pelves specially to be studied under this aspect are funnel-shaped, kyphotic, and inverted pelves, especially the ischio-pubic form.

Funnel-shaped Pelves.—In this form the contraction is at the outlet, the pubic arch being narrowed and the slope of the lateral pelvic walls increased. What lies at the bottom of this change is lumbo-sacral assimilation—high assimilation, as it is called. Instead of the sacral vertebrae numbering five, normal sacral blending or assimilation, the fourth lumbar vertebra is also blended with the sacrum, high blending, and often the first sacral makes a false promontory. Thus the promontory is high, lying nearly at the level of the crests of the ilia at their sacral ends. The result of
On Inversion of the Ilium and Sacrum

this is to tilt in the ischial tuberosities and thus narrow the arch, and approximate the ischial tuberosities so that we get the transverse outlet diameter reduced, 8 cm. being the limit of safety for labour, and sometimes below this. The term male pelvis sometimes applied to it is misleading and quite erroneous.

In the kyphotic pelvis we have a similarly narrowed outlet and also in some cases lumbo-sacral assimilation. The brim of the kyphotic pelvis is enlarged, the conjugate abnormally so, while the transverse is relatively to it enlarged also, but not so, absolutely.

These features of this pelvis have been worked out by Breisky, Freeland Barbour, and Klien among others. The brim increase is caused by the spinal kyphosis acting in a backward direction with fixation of the anterior part of the brim by the Y-shaped ligament (between the anterior inter-trochanteric line of the femur and the inferior anterior spinous process).

The kyphotic pelvic brim is in this subjected to an anterior and posterior pull, elongating the brim, while the high assimilation makes the transverse longer and the inter-ischial less.

The kyphotic pelvis is therefore an acquired one, due to the factors given above.

I defer, however, the consideration of the changes in the kyphotic pelvis for a later communication. The high assimilation is a factor in the kyphotic pelvis hitherto neglected, but a consideration of this at present would unduly lengthen the present paper.

The Inverted Pelvis.—There are two major varieties of inverted pelvis—the ilio-sacral and the ischio-pubic; the former being the common one, the latter much more rare.

The Ischio-sacral Form.—Here the deformity is at the brim as is seen in Figs. 1-7, and such a pelvis requires pubiotomy or Caesarean section. The outlet is also narrowed, but not to the extent of that of the funnel-shaped or kyphotic pelvis, as in the ilio-sacral lumbo-sacral assimilation has not yet been met with. It may, however, exist as a coincidence, and then the outlet of the funnel-shaped pelvis would also be present in a more marked degree.

In the ischio-pubic variety the ischium and pubes are male, and the ilium and sacral, female; thus the pubic arch is male and the intertuberosity diameter markedly diminished (Fig. 8, and measurements, p. 20); as the ilium and sacrum are female, the former having a large sacro-sciatic notch, the real labour hindrance is at the outlet and is formidable.

Methods of Measuring the Pelvic Outlet.—This has been discussed by several observers, and Whitridge Williams considers it carefully.
By Palpation.—The pubic arch and the interischial diameter can be outlined digitally with the patient in the lithotomy posture. The sacral vertebrae can also be enumerated by vaginal examination, and high assimilation in the funnel-shaped pelvis and kyphotic pelvis ascertained. In this way Whitridge Williams determined this point in some of his funnel-shaped cases.

By Instrumental Examination.—This may be ascertained with the ordinary, or special callipers (see Whitridge Williams, op. cit.). Owing to the narrowness of the pubic arch the available space for exit of the head is in the triangular space outlined by the points of the ischial tuberosities and the tips of the coccyx. If the intertuberosity diameter is mapped out and bisected, the anterior and posterior sagittal diameters can be measured as well as the entire outlet conjugate (Klien).

It is to be noted that the forward rotation of the tip of the coccyx is often marked in the kyphotic pelvis, and thus the available exit greatly diminished as an addition to the narrowing of the pubic arch.

Skiagram Examination.—Important information can probably be obtained from skiagraphs of the lateral aspect of the pelvis to determine the maleness or femaleness of the sacro-sciatic notch, but on this point I have as yet no exact information. In this way the funnel-shaped and kyphotic pelves can be separated from the inverted cases where the notch gives the guide to the diagnosis. In the ilio-sacral inversion the sacro-sciatic notch is male, that is, small (Figs. 2, 5).

Labour Prognosis.—In the inverted pelvis the serious deformity is found at the outlet of the rare ischio-pubic inversion (vide measurements, p. 20). This narrowing is less in the ilio-sacral inversion, but here, as already said, the obstruction is at the brim and requires pubiotomy or Cæsarean section.

According to Williams, in narrow outlet “spontaneous labour” in funnel pelves “is unlikely to occur with a transverse diameter of 8 cm. unless the posterior sagittal measures at least 7·5 cm. Spontaneous labour is unlikely to occur with a transverse of 6·5 cm. unless the posterior sagittal measures at least 8·5 cm.”; “spontaneous labour is unlikely to occur with a transverse diameter of 5·5 cm. unless the posterior sagittal measures at least 10 cm.” (op. cit., separate paper, p. 8). Much the same prognosis holds good for the inverted pelvis.

Inverted pelvic bony segments give rise, therefore, to serious pelvic deformities and are congenital, not acquired, unless one regards high assimilation as acquired. It is better considered,
however, as a developmental condition. We thus associate iliosacral inversion with brim and outlet deformity; the ischio-pubic with that of the outlet. This point may be summed up as follows:—Funnel-shaped pelvis; high assimilation and secondary outlet narrowing; sacro-sciatic notch large (?); arrest of head at outlet.

**SUMMARY.**

The following is a summary of the views expressed in the present paper:—

1. The form and size of the sacro-sciatic notch (incisura ischiadica major) is a valuable aid in the diagnosis of the sex of a single innominate bone.

2. It is not quite absolute, as the ilium of the female pelvis may occasionally be inverted.

3. This inversion of the sacrum and ilium gives rise in the female inlet to a marked and serious deformity of the pelvis, necessitating operative measures, usually of a cutting nature, during labour.

4. In all other female deformed pelves the notch is female, but in the Naegle pelvis on one side where the deformity is, and in the Roberts' pelvis on both sides, the notch is smaller and male-like. The ankylosis of the sacro-iliac synchondrosis in the Naegle and Roberts' will prevent any mistake being made as to the sex of the specimen.

5. The ischio-pubic elements of the bony pelvis are more rarely inverted into the female, and as yet I have found only one, and Elliot Smith and Wood Jones record another (vide ante, p. 21).

6. A six-vertebræ sacrum is found in the funnel pelvis as Breus and Kolisko, Whitridge Williams, and others have shewn.

7. In the female kyphotic pelvis the sacral auricular surface may lie in three vertebrae, and there is usually high assimilation.

8. There is therefore a new cause for deformity of the female pelvis, and such may be termed ilio-sacral or ischio-pubic inverted female pelves; the former is the more common, and inverted bony pelvis may be used as a common term.

9. Both in normal and abnormal pelves the bearing of the lateral aspects of the pelvis have been too much neglected by obstetricians. The important structure to be noted here is the great sacro-sciatic notch (incisura ischiadica major).

10. This inversion takes place most probably when double germ- and sperm-cells are formed in the early mitoses of these
structures in the fotal development of the sex-gland. Such mitoses cause variation, and when it happens that some determinants for the sex-ensemble are absent from the Wolffian germ-cells and present in the non-Wolffian sperm-cells, the opposite of their usual allotment, inversion follows.

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THE INCIDENCE OF TUBERCULOSIS.

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I hope it may be considered of value if I amplify and discuss some of the data upon which my Report to the International Tuberculosis Conference of 1913 was based.

Most of us recognise that we are very liable to be led astray if we place too much reliance upon statistics. If we consider, for example, how different is the practical experience, and how varied the training, the scientific knowledge, the precision and skill in diagnosis of the multitude of practitioners upon whose death certificates the Registrar-General's statistical tables are based, we must admit that in dealing with a disease such as tuberculosis, its protean aspects must appeal to different men in different ways. In what is apparently a similar tuberculous process one man may see an end stage, and another an earlier stage; one may focus his attention upon a metastatic terminal manifestation like meningitis,