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THE DISPLACEMENT OF THE BLADDER AND URETHRA DURING LABOUR

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IT is generally held that during labour the bladder is lifted forwards and upwards to become an abdominal organ, and that along with this change the urethra becomes elongated and the bladder neck or vesico-urethral junction displaced forwards and upwards to a position immediately behind or above the symphysis pubis. A study of present-day textbooks reveals a variety of opinions as to the extent of these changes, when they occur, and what is responsible for them, and published statements tend to be vague or conflicting. Most authorities state that an uplift occurs and is the result of the dilatation of the cervix and the formation and elevation of the lower segment. Greenhill in De Lee's *Principles and Practice of Obstetrics* (1947) states: "The disposition of the bladder during labour varies in different women. In all women during the second stage the bladder rises into the abdomen because the cervix is pulled up." This may be compared with the following statement in the *Combined Textbook of Obstetrics and Gynaecology* (1944), by Munro Kerr and others: "The cervix being fixed by paracervical tissue is only very slightly altered in position—there is little, if any, dragging of the cervix over the foetal head. In addition there results a gradual uprising of the bladder into the abdomen during the first stage of labour. The bladder is pulled up and the utero-vesical pouch raised. Eventually a large part of the organ lies above the symphysis." Stander in *Williams' Obstetrics* (1941) says: "As the uterus rises up into the abdominal cavity it carries with it the bladder, which then becomes an abdominal rather than pelvic organ," while

R. W. Johnstone in *A Textbook of Midwifery* (1948) describes the process as follows: "During the first stage the bladder is gradually drawn up by the ascending cervix and the lower segment, and in the second stage the upper part of the organ is in the abdomen while the lower lies behind the symphysis." Strachan (1947) states: "The bladder in labour . . . tends to be drawn upwards with the anterior part of the pelvic floor by traction of the cervix so that it becomes more an abdominal than a pelvic organ."

In a search of the literature for the origin of the present-day concept of the movement of the bladder during labour all clues lead to Braune's celebrated frozen sections, which he first described in 1872. and which were illustrated in his *Atlas of Topographical Anatomy*. An English translation of the 1874 edition of this atlas, together with the woodcuts, was published by Bellamy in 1877. The sections were also studied and reproduced by Berry Hart in 1884, and the illustrations have since appeared in many standard textbooks. Braune studied sagittal sections of the frozen bodies of two women, one of whom died in late pregnancy, the other in late labour. In both instances the bladder was empty. In the late pregnancy case (Fig. 1) the presenting part is shown above the brim, and the bladder is seen to lie wholly in the pelvis with its neck set well back from the symphysis pubis. Braune's comment on what we ourselves would regard rather as the normal appearances was translated by Bellamy to read: "the bladder has slipped down bodily from the inner surface of the symphysis and is so completely displaced that the course of the urethra has become bent at a right angle." In the woman who died in labour (Fig. 2) the cervix is fully dilated, the foetal head is engaged and the bladder neck and urethra are lying immediately behind the symphysis. Of this Braune writes: ". . . . the bladder was empty and retracted. Behind the symphysis its walls had become so thin as to be hardly recognizable. Above and below the symphysis, where the pressure had not been so great, it was thickened and consequently better seen. On filling the bladder it became distended upwards, so that the anterior wall of the abdomen must have been lifted slightly from the uterus." (Bellamy, 1877). It should be noted that contrary to the assumption of many subsequent writers Braune specifically states that the tissue behind the symphysis was the thinned-out bladder rather than a stretched upper urethra. In other words, though the vesico-urethral junction was displaced forwards it had not undergone much upward displacement.

Barbour of Edinburgh published an *Atlas of the anatomy of Labour* in 1889 and a supplement to it in 1896. In these he reproduced engravings from all the frozen sections of the female pelvic organs which had appeared in the literature up to that time, together with six of his own cases, making a total of 28. Late pregnancy, all stages of labour and the puerperium are represented in this collection, but there are only 7 in which the patient was in the second stage of labour. The first of these was Braune's referred to above. Another was Barbour's, and the illustrations of this are well known; they have been used repeatedly in textbooks to show the anatomy of the birth canal. The foetal head was on the perineum at the time of death and the engravings show quite clearly that the bladder, although pushed towards the pubis, is not elevated, and the vesico-urethral junction is only just above the lower margin of the symphysis (Fig. 3). Barbour himself says: "The bladder lies partly in the abdomen, partly in the pelvis; the pelvic portion is flattened against the pubes, the abdominal part is moderately

FIG. 1a.
Sagittal section of a woman dying late in pregnancy, Table XXX in Braune's *Atlas of Topographical Anatomy* (1872). The foetal head is still above the pelvic brim. The bladder is entirely in the pelvis, and the urethra and bladder base are normal in position. Reproduced by courtesy of J. and A. Churchill, from Bellamy's English Edition (1877).

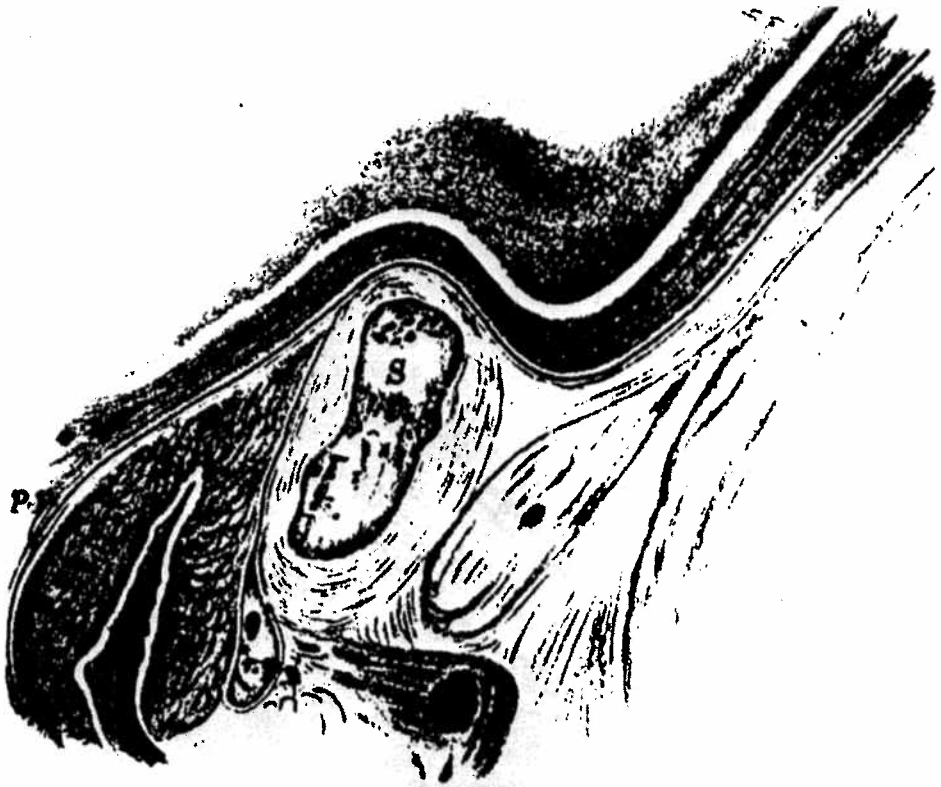

FIG. 1b.
The anatomical details of the anterior uterine wall, bladder and symphysis pubis in the same case as Fig. 1a, showing the opposite half of the sagittal section. Reproduced from Berry Hart's *Female Pelvic Anatomy* (1884), Plate XXXIV, by kind permission of W. and A. K. Johnston, Edinburgh.
S—Symphysis pubis; B—bladder; p.p.—utero-vesical pouch.

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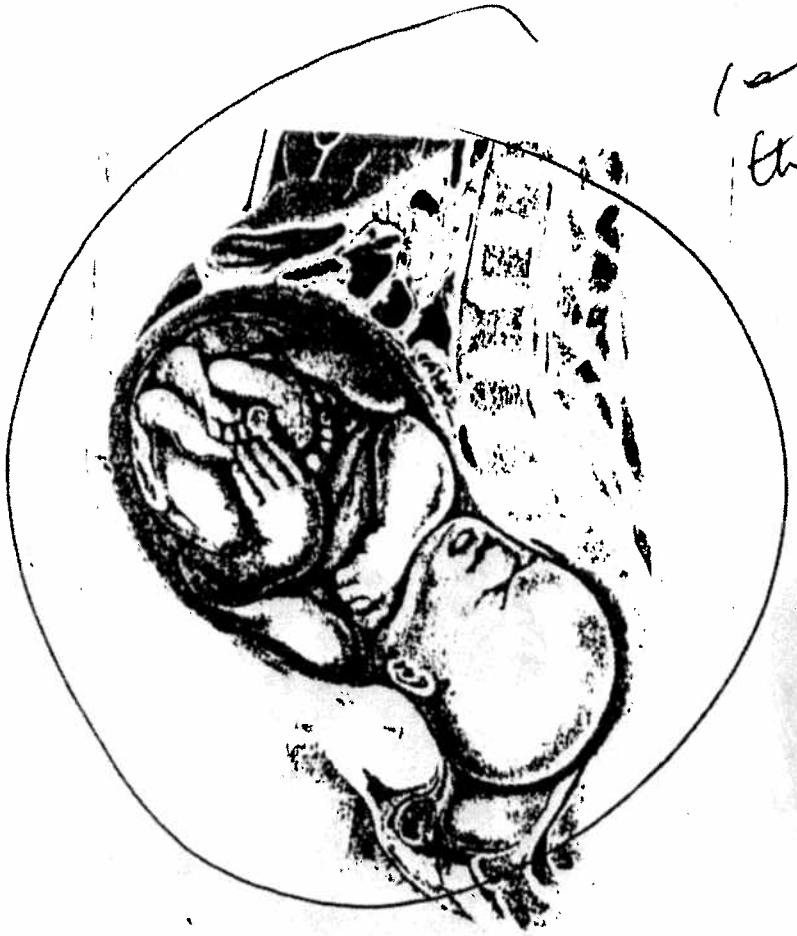


FIG. 2a.

Sagittal section of a woman who died late in labour, from Table XXXI in Braune's *Atlas of Topographical Anatomy*. The foetal head is low in the pelvis with the cervix fully dilated and the membranes intact. The fundus of the bladder reaches above the symphysis pubis, but the bladder base lies behind the symphysis and the urethra is not elongated. Reproduced by courtesy of J. and A. Churchill from Bellamy's English Edition (1877).

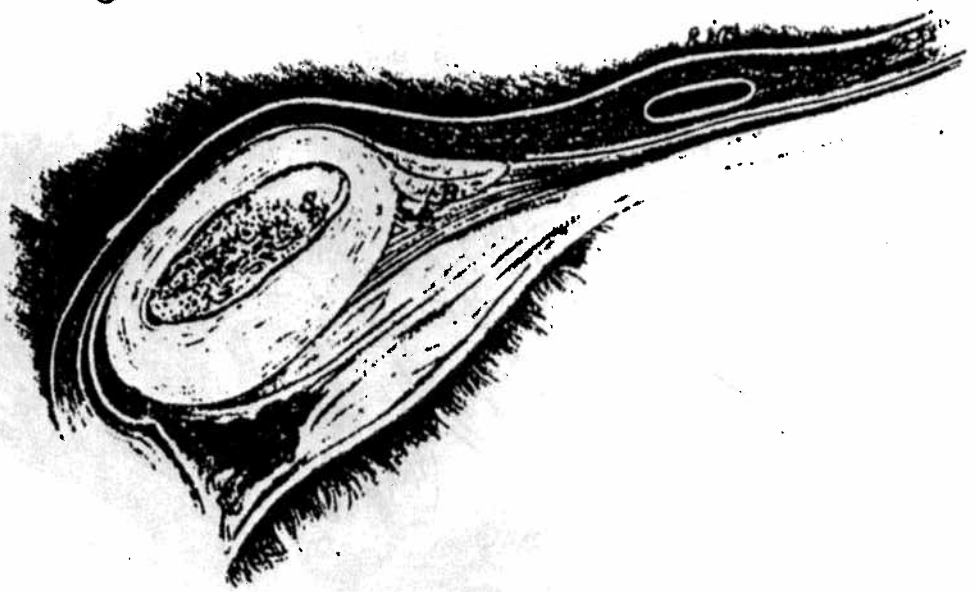


FIG. 2b.

The anatomical details of the anterior uterine wall, bladder and peritoneal relations in the same parturient woman as Fig. 2a, showing the opposite half of the sagittal section. Reproduced from Berry Hart's *Female Pelvic Anatomy* (1884), Plate XXXIV, by kind permission of W. and A. K. Johnston, Edinburgh.

S—Symphysis pubis; B—bladder; p.p.—utero-vesical pouch.

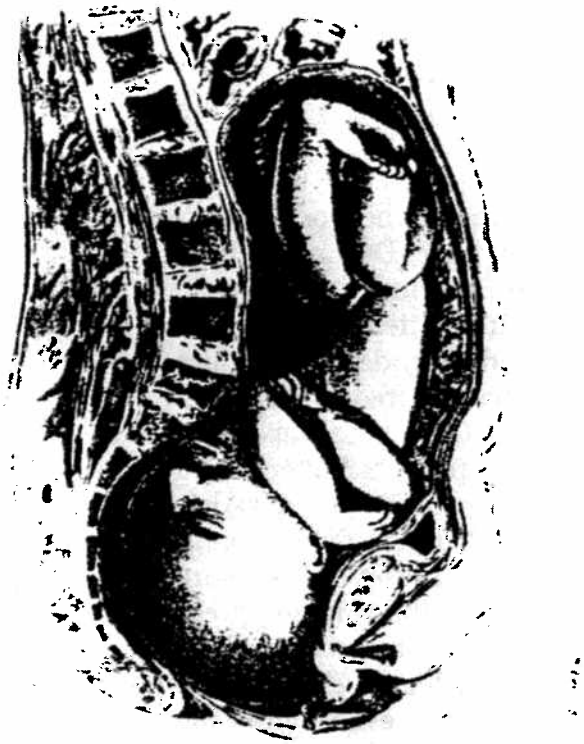


FIG. 3.

The genital tract with the foetus *in situ*, from a frozen section of a woman dying in the second stage of labour. A. H. F. Barbour, *The Anatomy of Labour* (1889), Plate XXII. Reproduced by permission of W. and A. K. Johnston, Edinburgh. The head is on the perineum. The fundus of the bladder extends above the symphysis. The base of the bladder, although pushed towards the symphysis, is not elevated and the vesico-urethral junction is only just above the lower margin of the symphysis. The urethra is not elongated.

distended and rises 1.2 inches above the rim. The urethra is 1.5 inches long." He also noted that the anterior vaginal wall measured 2.5 inches and the posterior 7.2 inches. Another two cases studied in the second stage of labour were described by Chiari. In one the foetal head was on the perineum and again the bladder neck is to been seen only slightly above the lower border of the symphysis pubis. In the other, however, death occurred during an attempt at spontaneous evolution of a transverse lie. The upper part of the foetal trunk is crowded into the pelvis, filling it to capacity, and here the vesico-urethral junction is at the upper border of the symphysis pubis. In Zweifel's first case internal version had been carried out and the foetus was partly born, and the lower limit of the bladder is about half way up the symphysis pubis; in his second case the bladder is not shown. The last case was described by von Mars, a case of ruptured uterus with the foetal head engaged. A considerable portion of the bladder remains behind the symphysis.

Meanwhile, and in 1884, Halliday Croom wrote a monograph on "The Bladder During Parturition." In this he assembled the results of some personal observations and experiments, correlating them with the findings of previous workers, with the object of giving an account of the shape, size and position of the bladder in the non-pregnant woman, during early and late pregnancy, and during labour. In regard to the appearances in labour he, like so many others, relied to a large extent on Braune's two cases. Halliday Croom came to the conclusion that during late pregnancy and just before the onset of labour the bladder remains a pelvic organ, but that it is gradually lifted during the first and second stages of labour until late in labour it is an abdominal organ, no matter whether it be full or empty. He said that this upward movement of the bladder is associated with elongation of the urethra, and this despite the fact that his observations were to some extent based on Braune's second case in which the urethra was not significantly lengthened. He also concluded that the intimate attachment of the bladder to the cervix is the underlying cause of the displacement, elevation of the bladder necessarily following the thinning, the dilatation and the "taking up" of the cervix and the lower segment.

This seems to be the basis of the statements which still appear in the modern textbooks, some 60 years later. During this time they have not been seriously challenged, and there has been little attempt to confirm or clarify them—and that, despite the fact that radiography has offered a new and valuable approach. One of the few who have used this technique is Schubert, who in 1929 published the results of a radiological study of the bladder during pregnancy and labour. He, however, was more concerned with the conditions in late pregnancy and he came to the rather surprising conclusion that the bladder is elevated out of the pelvis at term and even before the presenting part enters the pelvis. This, he said, is true no matter whether the head, breech or shoulder presents. As will be shown later, such a statement is a complete contradiction of our own findings.

These varying accounts of the behaviour of the bladder and urethra in labour raise certain questions which invite investigation and comment. The degree and mode of the displacement of the bladder, at what stage of labour does it occur and is it rapid or gradual? The changes undergone by the urethra and the bladder neck, are they due to the formation of the lower segment, or are they solely attributable to displacement by the presenting part?

The present inquiry was undertaken in the hope of answering these questions or at

least to establish some basal data from which a true picture could be drawn.

Material and Methods.

Thirty-two women in labour were studied by a radiological method. Twenty-eight were primigravidae, this figure including one patient who had had one previous Caesarean section and who for the present purpose may count as a primigravida. Of the 4 multiparae, one was in obstructed labour, the other 3 in normal labour. As a result of the findings in the first few unselected cases several of the later patients who were investigated were chosen because they showed some evidence of disproportion, and had been picked out for a "trial labour. Three more women (all primigravidae) were studied during pregnancy, one at 31 weeks and two at term. The presentation was cephalic in every case but one, a breech presentation which was only investigated before the onset of labour, not during labour itself. Three non-pregnant women (2 multiparae and 1 primipara) were also examined.

In the case of the patients in labour a cystogram was taken wherever possible, (*a*) early in labour when the cervix was not more than 1 to 2 fingers dilated, (*b*) later in the first stage, at 2 to 3 fingers dilatation, (*c*) near the end of the first stage, and (*d*) during the second stage of labour. In 2 patients another X-ray examination was made after labour, in one of them immediately after delivery, in the other 3 hours after.

A series of cystograms during the course of labour and particularly in its final stages involves obvious practical difficulties, especially when the X-ray department is situated at some distance from the labour wards. The variation in the duration of labour itself and the need to avoid causing the patient undue discomfort, or to intervene in the interests of mother or child, are added difficulties and it was therefore impossible, even if it had been necessary or desirable, to take cystograms at all the stages indicated above in all the cases. Excluding postnatal studies cystography was carried out in 9 patients once, twice in 13 patients, three times in 8, and four times in 2, making a total of 67 separate studies of the bladder and urethra in labour.

With the exception of one case in which "lipiodol" was tried, the opaque medium used was sodium iodide in a 4, 8 or 12 per cent solution. The weaker solutions sometimes allowed a more accurate visualization of the bladder; in most cases, however, the 12 per cent solution was used. The amount injected was such as to give the patient a sensation of fullness, usually 250 ml., but sometimes 300 ml.; it was kept constant for each cystogram carried out with the same patient.

Preliminary tests with amounts varying between 100 to 400 ml. indicated that the volume of fluid did not significantly affect the shape and position of the bladder base.

One difficulty was to find a semi-solid radio-opaque medium which would show up the urethra and yet at the same time be so malleable as not to interfere with its configuration. Various methods were tried. Urethral bougies of coconut butter impregnated with metals such as barium and iron, which would soften and mould themselves to the urethra, were sometimes effective, but were eventually given up because they were unreliable and often slipped out of the urethra or up into the bladder. "Lipiodol" proved too fluid to be retained in the urethra. The most satisfactory urethrograms were obtained by using an old and very soft rubber catheter previously filled with lipiodol and fitted with a metal marker to indicate the position of the external urethral meatus. The amount of distortion produced by this method seemed to be minimal. Most of the

ormation was obtained from lateral ews taken with the patient lying down; a few cases antero-posterior exposures re made as checks. Criticism may be sed that the films should have been taken h the patient standing. A few of our ients were X-rayed in the standing ition but it was not adopted as a routine it was too uncomfortable for a woman dvanced labour, and our object was to ain a comparable series of pictures for h patient. In fact, so far as we are to determine, posture during labour not influence the position of the urethra bladder neck, although it did slightly lify the level and shape of the fundus he bladder.

ypical cystograms are shown in Figs. , 6 and 19, but for the sake of clarity remaining illustrations consist of acings " of the significant features of X-ray negatives.

lings.

escription and analysis of the films ed more difficult than was anticipated use at first sight the appearances ed to vary from case to case without ys a discernable reason, and in the end est way of approaching the problem ed to be to draw up a list of questions ee how far the data could provide an er to each one.

the outset it became clear that a dis- on must be made between changes in adder base and changes in the fundus. confusion has arisen in the past from t of this point. Clearly changes in ndus are relatively unimportant, they d on the degree of distension and the cation imposed by the forward pres- of the pregnant uterus. It is the es in the bladder base, the vesico- al junction, and the urethra with we are really concerned, and the par- points which seem important are:

1. The position of the bladder neck and the urethra at the onset of labour, and the change in their position as labour proceeds.
2. The shape of the vesico-urethral junction before and during labour and whether the length of the urethra is altered.
3. The position of the bladder base at the start and during the course of labour.
4. The relation between the dilatation of the cervix and the formation of the lower segment on the one hand, and changes in the situation of the bladder on the other.
5. The relation between engagement of the presenting part and the situation of the bladder.
6. The changes in the position of the bladder in a case of dystocia as contrasted with those of a normal labour.
7. The return of the bladder and urethra to normal position after delivery.

The position of the bladder neck and urethra at the onset of labour and the change in their position as labour proceeds.

In late pregnancy and at the beginning of labour the bladder neck occupies a very constant place in the pelvis. It lies on or near the plane of the outlet and in a lateral view is seen on a line joining the tip of the sacrum with the lower border of the symphysis and at a distance of 2 cm. to 3 cm. from the latter (Figs. 5, 7, 8a, 10a, 11a, 18a). The urethra is directed upwards and backwards. The position of the bladder neck is very much the same as in the non-pregnant state; sometimes it may be a little lower but certainly it has not undergone any antero-posterior displacement.

As labour progresses the bladder neck becomes displaced forwards to a variable extent (Figs. 8, 9, 10, 12). If the fit between the head and the pelvis is tight it may by the end of labour come to lie close behind the symphysis. Upward displacement

takes place only to a limited extent; in cases of mid-cavity disproportion the vesico-urethral junction may lie as high as the upper border of the symphysis but not higher (Fig. 11) and in a normal case it remains in the same pelvic plane throughout the labour (Figs. 8, 9, 12, 13, 14). It moves, as it were, on the arc of a circle, the urethra being the radius. The forward displacement of the urethra, however, affects the upper part mostly so that it becomes curved when viewed from the side (Figs. 11b, 12c.). The extent of the forward movement of the urethra is variable and may be minimal in a roomy pelvis, but considerable in cases of mid-cavity dystocia (compare Figs. 9 and 13 with Figs. 10 and 11).

The shape of the vesico-urethral junction and the length of the urethra.

In late pregnancy and at the onset of labour the urethra joins the bladder base at a right angle (Figs. 5, 7, 8a, 10a, 11a). With the progress of labour the posterior part of the bladder base is lifted forwards and upwards and lateral views show it rotating round the fixed pivot, the internal urethral meatus (Figs. 6, 8, 9, 10, 12, 13). In this way the urethra and bladder base come to lie in the same straight line and in some cases it is difficult to say where the urethra ends and the bladder begins (Figs. 8b, 9c, 10b, 11c, 12c, 13, 15). The resulting "tongue of bladder", which from the side looks funnel-shaped, usually remains behind the symphysis pubis (Figs. 8, 9, 10, 12, 13, 14, 15). It is this which has given rise to the fallacious view that the urethra becomes grossly elongated. Usually the length of the urethra is unchanged, or is not more than 1 cm. longer in the second stage of labour than it was at the onset.

The base of the bladder during labour.

The base of the bladder does not change its position until labour begins. The lateral views show it lying on a line joining the lower border of the symphysis with the tip of the sacrum, clearly the line of the upper surface of the pelvic diaphragm (Figs. 5, 7, 8a, 10a, 11a, 18a). The only exceptions to this rule which we have encountered are those comparatively rare cases in which the presenting part is wholly in the pelvic cavity before the onset of labour.

As labour progresses the base of the bladder becomes raised or rolled up from behind forwards. The end result of this "rolling up" is to bring the base into line with the urethra. Ultimately it brings it to lie parallel with the axis of the pelvis (Figs. 9c, 11c, 13b). As has been noted earlier, this rotation modifies the shape of the urethro-vesical junction.

In the earlier stages of labour, when the base of the bladder is still low in the pelvis, the indentations made by the presenting part above and the symphysis pubis below sometimes give the full bladder an hour glass shape as viewed from the side. It then appears to have two segments, an upper one rising above the pubic bone and a lower posterior one into which the urethra opens (Figs. 5, 7, 8a, 9a, 11a). It is the posterior segment with which we are concerned because, as was stated earlier, the fundus of the distended bladder is subject to wide variations and is modified by posture and by the pressure of any surrounding structures. This is in keeping with the fact that the muscular tone of the bladder wall is necessarily low to ensure the zero resting intravesical pressure.

As labour advances the posterior segment, together with the urethra, moves forwards and upwards towards the lower abdomen. The degree and rate of this displacement is variable. Sometimes, when there is ample room for the foetal head in the pelvis, the bladder base is never completely rotated (Figs. 8b, 12c, 13b). In some cases the rotation becomes apparent at the onset

labour or at least by the time the cervix only one or two fingers dilated, in others ıch of the bladder still lies below the esenting part late in labour (Figs. 16, a, 18). In two cases the bladder base d the urethra were seen to lie in their rmal position within two hours of spon- ıeous delivery (Figs. 16, 17). As will seen later, the governing factor in the tation is the level of the presenting part the pelvis.

elation between dilatation of the cervix and formation of the lower segment and the position of the bladder.

We have been unable to demonstrate any rect connexion between the degree and te of cervical dilatation and the time and tent of displacement of the bladder base. ɔth changes take place quite inde- ndently and there is no evidence that the adder and urethra are lifted up by the lating cervix. This is borne out by cases ustrated in Figs. 9, 13, 14, 15, 16, 17, 18,), and it is not surprising in view of the ct that the urethra and bladder base are nnected to the vagina rather than the rvix. It is more difficult to say for cer- in that the formation of the upper part the lower segment plays no part in the splacement of the bladder neck, but nical observations combined with cysto- aphic studies lead us to believe that this so. One case threw some light on the ɔint. A multipara was admitted in labour ith the head obstructed at the brim, and the time the cervix was 3 to 4 fingers lated the uterus was becoming tonically ntracted and the lower segment danger- ısly thinned. These findings were nfirmed at Caesarean section carried out mediately after a cystogram had been ken to show that the position of the sico-urethral junction and bladder base mained undisturbed, despite the formed wer segment (Fig. 19).

Relation between engagement of the presenting part and the position of the bladder.

As might be expected the main cause of displacement of the bladder is the descent of the presenting part. When the presenting part is very low in the pelvis the bladder base may be high early in labour (Figs. 9a, 12a), or possibly even before the onset of labour. When the presenting part is above the pelvic brim, the bladder base is undisturbed and may remain so late in labour if the foetal head descends late—as it does in some multiparae (Figs. 16, 17). In those cases in which labour is obstructed at the brim the bladder may remain in the pelvis quite irrespective of the degree of dilatation of the cervix and the formation of the lower uterine segment (Figs. 18 and 19). It follows too, that the rate at which the displacement takes place varies with the time taken for the head to descend. Sometimes it is a slow and gradual process, and at other times, as in late engagement of the presenting part in multiparae, it may occur with almost dramatic suddenness (Figs. 16 and 17). In all our cases there were only two exceptions to the above rule, one in which the bladder base and the foetal head were both high early in labour, the other in which the posterior segment of the bladder remained low for a time even when the presenting part was engaged. This latter finding, however, is probably explained by the fact that the patient had a very roomy pelvis.

The extent to which the bladder base is lifted depends of course on the amount of space available in the pelvis, and when labour is easy there may be little or no displacement until the very end and just before the delivery of the head. It is in the cases where cavity arrest occurs that the uplift of the bladder becomes extreme, the vesico-urethral junction may then be as high as the upper border of the symphysis

pubis (Fig. 11). It is not always easy to be certain of this, however, for it is in these cases that the urethra seems to merge into the bladder shadow, with a gross alteration of the shape of the vesico-urethral junction (Figs. 11 and 14). In mid-pelvic arrest complete displacement of the bladder neck (i.e. to the upper border of the symphysis pubis) may be evidence that the limit of available room has been reached and may even be indicative of a need for delivery by Caesarean section.

Changes in the bladder base and urethra after delivery.

Cystography was done after delivery in two cases, in one case immediately after the birth, in the other three hours later. In both cases the bladder and urethra showed the normal anatomical appearances (Fig. 17). The vesico-urethral junction had resumed its normal shape and reverted to its proper position set well back from the symphysis pubis. The bladder base unfolded itself backwards to lie just above the plane of the outlet as in the non-pregnant woman and the fundus re-assumed a mainly pelvic position. These findings are confirmed by study of frozen sections of women dying immediately after labour (Barbour, 1889). The immediate return of the bladder base and the urethra to normal position rather supports the view that its displacement in labour is dependent on the foetus rather than any change in the adjacent maternal tissues.

Discussion.

The main conclusions reached from this radiological study can now be summarized. Early in labour, and unless the presenting part is very deep in the pelvis, the bladder base and internal urethral meatus are situated normally on a level with a line joining the lower border of the symphysis pubis and the tip of the sacrum. The bladder neck is then 2 to 3 cm. posterior to the lower edge of the symphysis. As the presenting part descends the bladder base is lifted forwards and upwards, being as it were rotated about a fixed vesico-urethral junction. Later the bladder neck moves forwards until it comes to lie close behind the symphysis. This movement bears no relation to the dilatation of the cervix and the time and rate of its occurrence depends entirely on the descent of the presenting part. The extent of the displacement is largely governed by the relative sizes of the foetal head and pelvic cavity. When there is ample space the movement is minimal and may occur late.. Upward displacement occurs later and its not constant. If there is mid-cavity arrest the bladder neck may be lifted as high as the top of the symphysis pubis, but some part of the bladder base usually remains behind the symphysis pubis throughout labour, and there is little if any elongation of the urethra. It would look as though the presenting part acts in some ways as a pelvic tumour in the non-pregnant woman. Only when a tumour of sufficient size is situated so low in the pelvis that it displaces the anterior vaginal wall forwards and upwards do the bladder neck and urethra undergo the same displacement.

Further evidence on the relation between the displacement of the bladder base, the dilatation of the cervix, and the descent of the foetal head was sought in the detailed drawings shown in some of the older books on the anatomy of pregnancy. So far none have been found which do not bear out the conclusions set out above, and there are several illustrations, for instance those given by Smellie (1761) which lend it support, as do the engravings of the frozen sections of all the 28 cases reproduced by Barbour (1889, 1896) including, of course, the cases of Braune and Barbour.

So far the discussion has ranged over the

(a) After 24 hours weak labour pains. Cervix 2 fingers dilated. Membranes intact. Foetal head engaged. The bladder base has rotated forwards and the vesico-urethral junction has become funnel-shaped and has moved forwards to lie behind the symphysis pubis.

(b) Antero-posterior view taken at the same time as (a).

(c) After 31 hours in labour. Cervix almost fully dilated. Foetal head only slightly lower than in (a). The position of the bladder base is unchanged.

(d) Antero-posterior view taken at the same time as (c).

FIG. 4. C. C., primigravida. Low forceps delivery after 36 hours in labour. Baby 7 pounds 4 ounces.

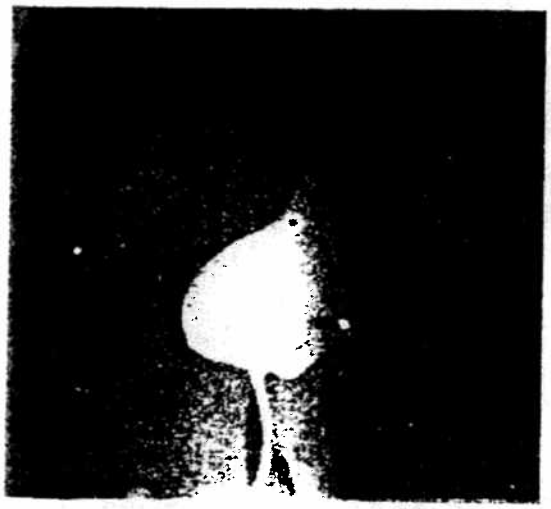


FIG. 5.

D. L., primigravida. Slight disproportion. Spontaneous delivery after trial of labour. Cystogram taken at 1 to 2 fingers dilatation after only 4 hours in labour. The head is still above the pelvic brim and shows posterior asynclytism. The bladder base and urethra are normal in position and shape.

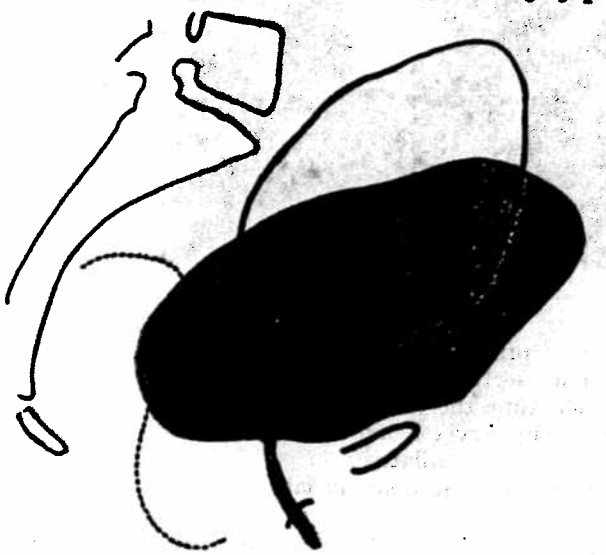
FIG. 6.

B. R., primigravida. Lower segment Caesarean section after 16 hours in labour, at which time there was evidence of foetal distress, the cervix being only 3 to 4 fingers dilated.

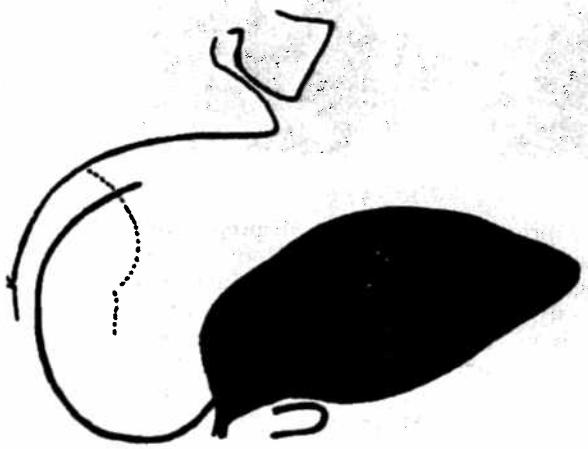
Cystogram after 14 hours in labour. Cervix 3 fingers dilated. The head is half through the pelvic brim and the bladder base is beginning to rotate forwards, producing funnelling of the bladder neck. The vesico-urethral junction has not lifted but has moved a little towards the symphysis pubis.

This shows the typical appearance early in labour, with the bladder base on a level with a line joining the lower border of symphysis with the last piece of the sacrum and a square vesico-urethral junction. The fundus has an hour-glass shape as it accommodates itself to the presenting part above and the symphysis below.
Cystogram taken after 3 hours in labour. Membranes ruptured, cervix 1 finger dilated.

FIG. 7. K. M., Primigravida, spontaneous delivery, labour 24 hours. Baby 9 pounds 6 ounces.

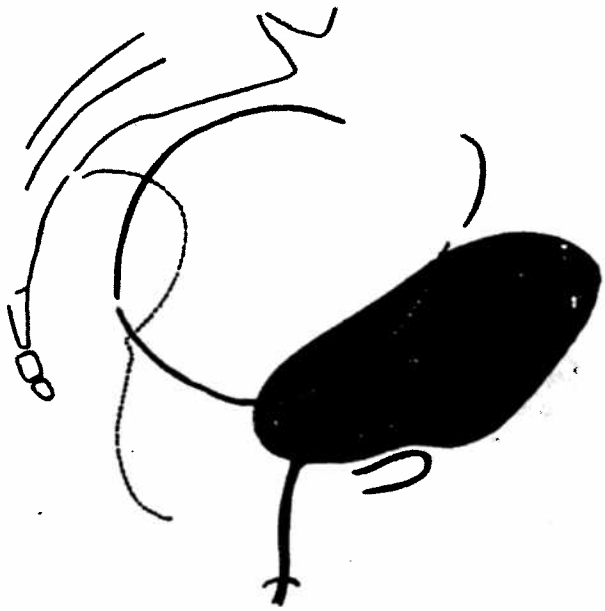


(a) After 2½ hours labour. Head high, membranes intact, os one finger dilated. Bladder and urethra in normal position.



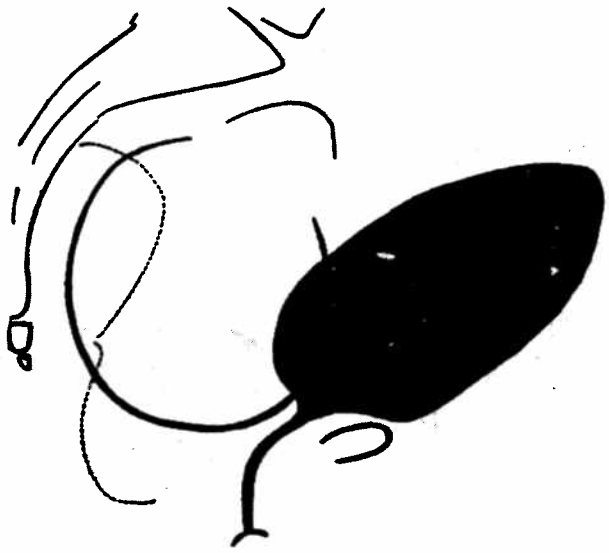
(b) After 7 hours labour. Head on perineum, cervix fully dilated, membranes ruptured. Delivery effected 20 minutes after this cystogram. Bladder base now rotated and vesico-urethral junction is funnel shaped. The latter has moved towards the symphysis but is not displaced upwards.

FIG. 8. M. F., primigravida Slightly contracted pelvis, but small baby (5 pounds 7 ounces). No disproportion, spontaneous delivery after 7½ hours labour.

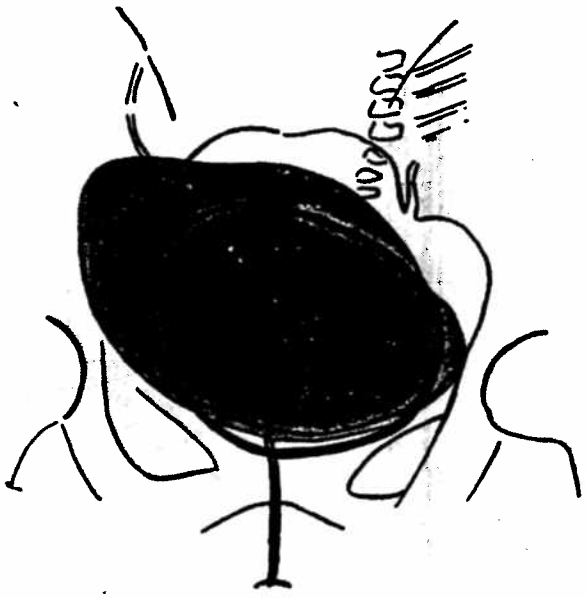


(a) After 2 hours weak labour pains. Cervix 1 finger dilated; membranes ruptured. The bladder base is rotating forwards, bladder neck not displaced.

(b) Antero-posterior view taken at the same time as (a).



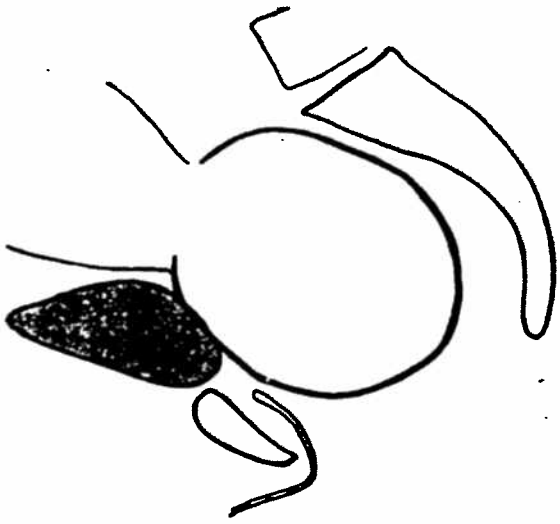
(c) After 19½ hours labour. Cervix almost fully dilated. Head low in pelvis. Vesico-urethral junction is funnel-shaped and has moved behind the symphysis. Very little if any elongation of the urethra.



(d) Antero-posterior view taken at the same time as (c).

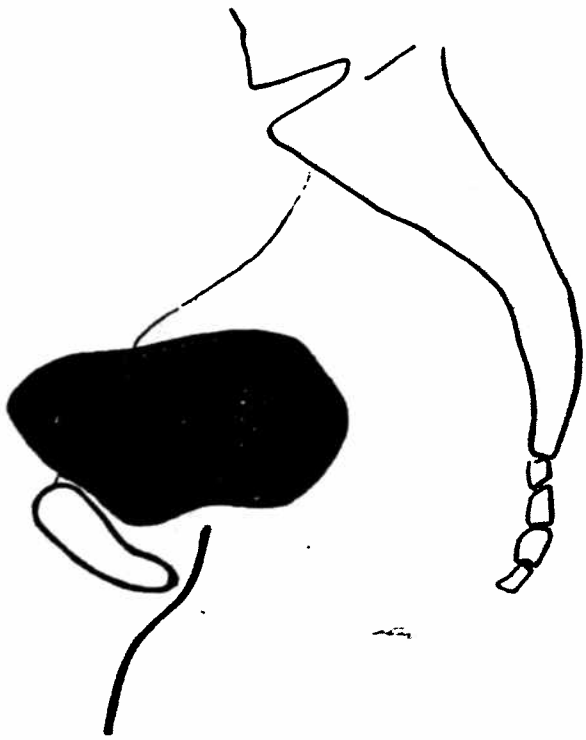
FIG. 12. J. C., primigravida. Spontaneous delivery after 22 hours labour. Baby 7 pounds 8 ounces.

(a) At onset of second stage. Cervix fully dilated, head engaged. Bladder base and urethra still in normal position.



(b) A few minutes later, immediately before delivery. Bladder neck displaced forwards and upwards.

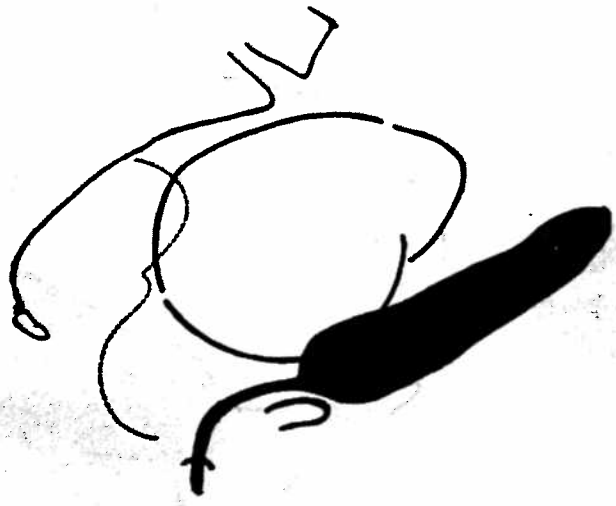
(c) Immediately after delivery. Bladder base and urethra back to approximately normal position.



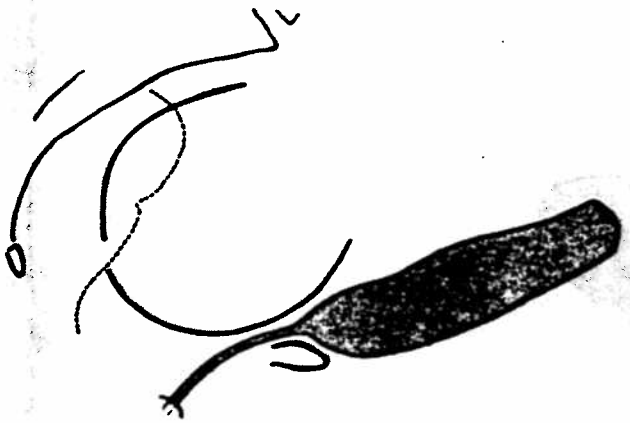
(d) Another case, three hours after delivery. Bladder base and urethra in approximately normal position.

FIG. 17. Mrs. F., multigravida. Easy, spontaneous delivery. Late and rapid displacement of bladder.

(a) After 12 hours weak labour. Membranes intact. Cervix taken up and 1 finger dilated. The head is still high and the bladder base is in normal position, the urethra joining it at right angles. Tendency to hour-glass shape of bladder is also shown.

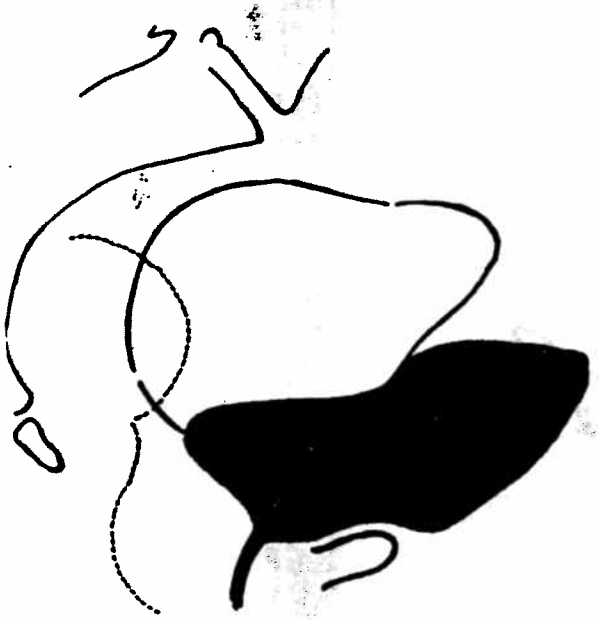


(b) After 36 hours labour. Membranes ruptured. Cervix 3 fingers dilated. Foetal head has entered pelvic cavity. Base of bladder has now rolled forwards and is in line with the axis of the birth canal. The bladder neck has become funnel shaped and is displaced towards the symphysis, and is also lifted up. The latter change is probably related to the straight sacrum and cramped cavity of the pelvis.

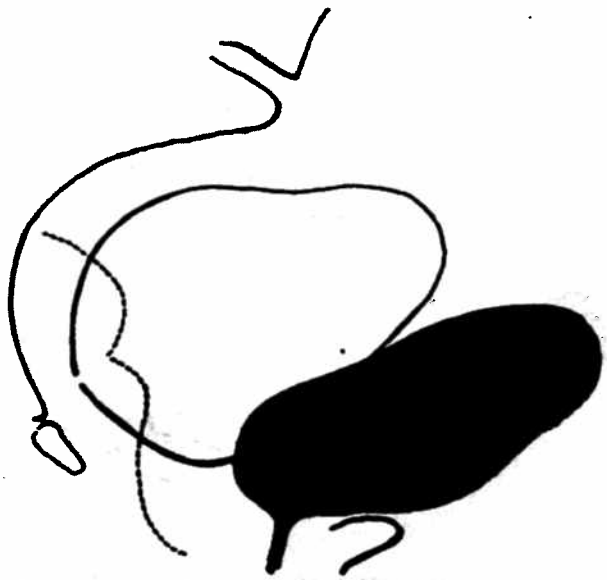


(c) After 41 hours labour. Cervix fully dilated, head lower. It subsequently became arrested and had to be delivered with forceps. The bladder neck has lifted and is practically at the level of the top of the symphysis pubis This illustrates complete displacement of the bladder associated with mid-cavity dystocia.

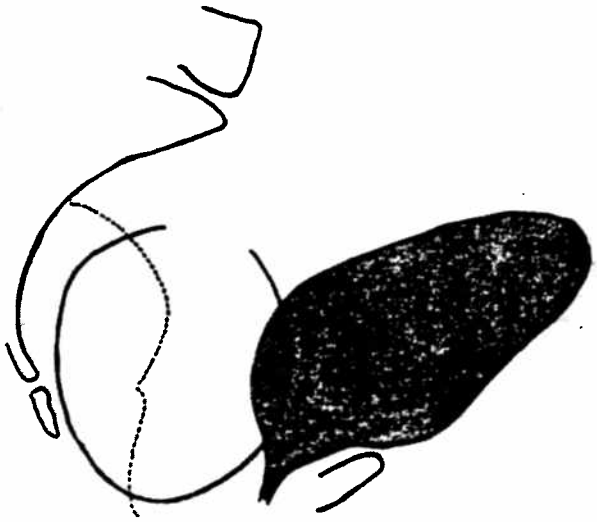
FIG. 11. D. E., primigravida. Slightly contracted pelvis. Head high at term. Trial labour, mid-cavity arrest. Low forceps delivery after 44 hours labour. Baby 6 pounds 4 ounces.



(a) After 1 hour of labour. Foetal head engaged. Membranes ruptured. Cervix 2 fingers dilated. The head is two-thirds through the brim and the bladder base is commencing to lift, producing slight funnelling of the vesico-urethral junction.

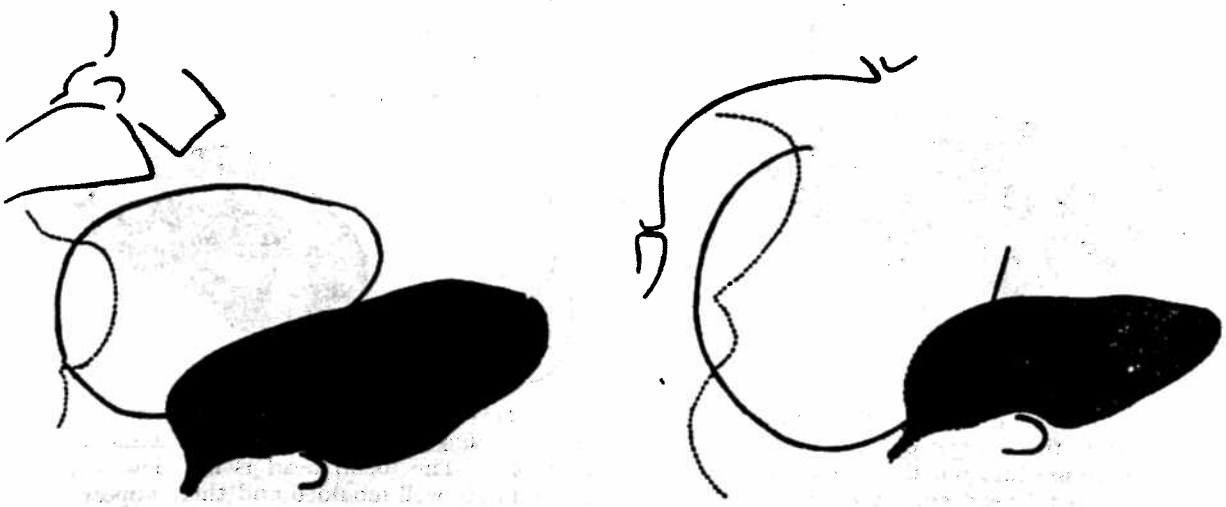


(b) After 15 hours labour. Head lower, cervix 4 fingers dilated. Very slight increase in rotation of bladder base but no change in position of bladder neck.



(c) After 19 hours labour. Head on perineum. cervix fully dilated. Bladder neck now showing typical funnel shape, but it has not lifted and is only slightly displaced towards the symphysis.

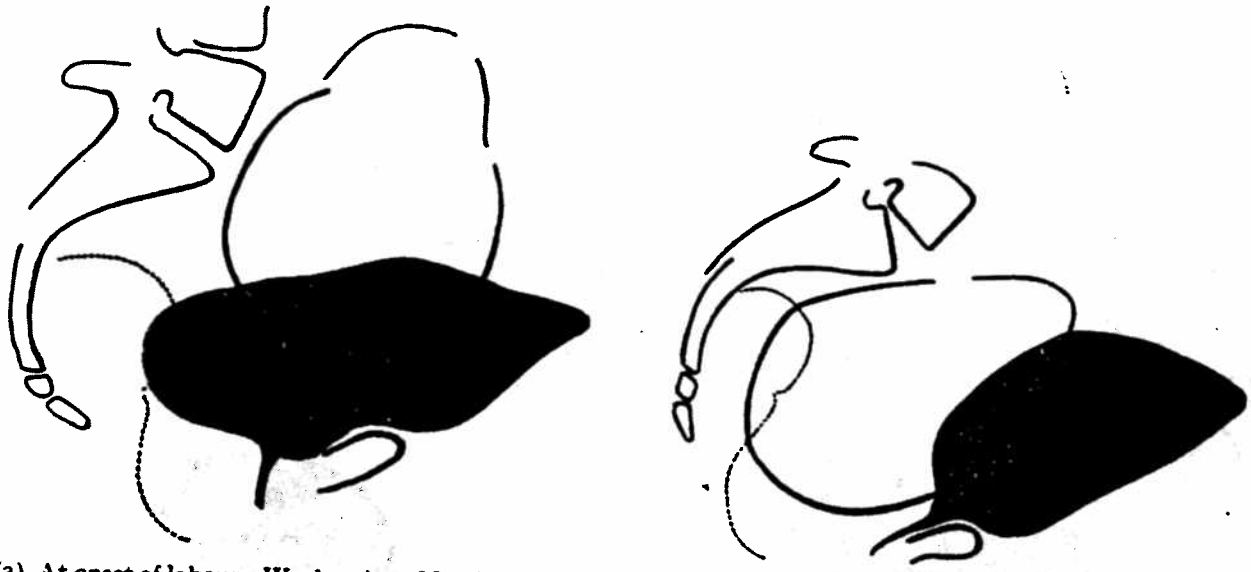
FIG. 9. M. S., Primigravida. Spontaneous delivery after 21 hours labour. Roomy pelvis with only slight displacement of bladder. Baby 7 pounds 4 ounces.



ıfter 8 hours labour. Cervix 2 fingers dilated. lembranes intact. The foetal head is engaged ıd the bladder base is rotating forwards. The ladder neck is funnel shaped but in normal ›sition.

(b) After 12 hours labour. Cervix fully dilated, mebranes ruptured and foetal head at the outlet with coccyx already tilted backwards. Bladder base has rotated further but there is no uplift of the bladder neck. Bladder still lies behind symphysis. Three hours after this cystogram the head became arrested in the transverse position.

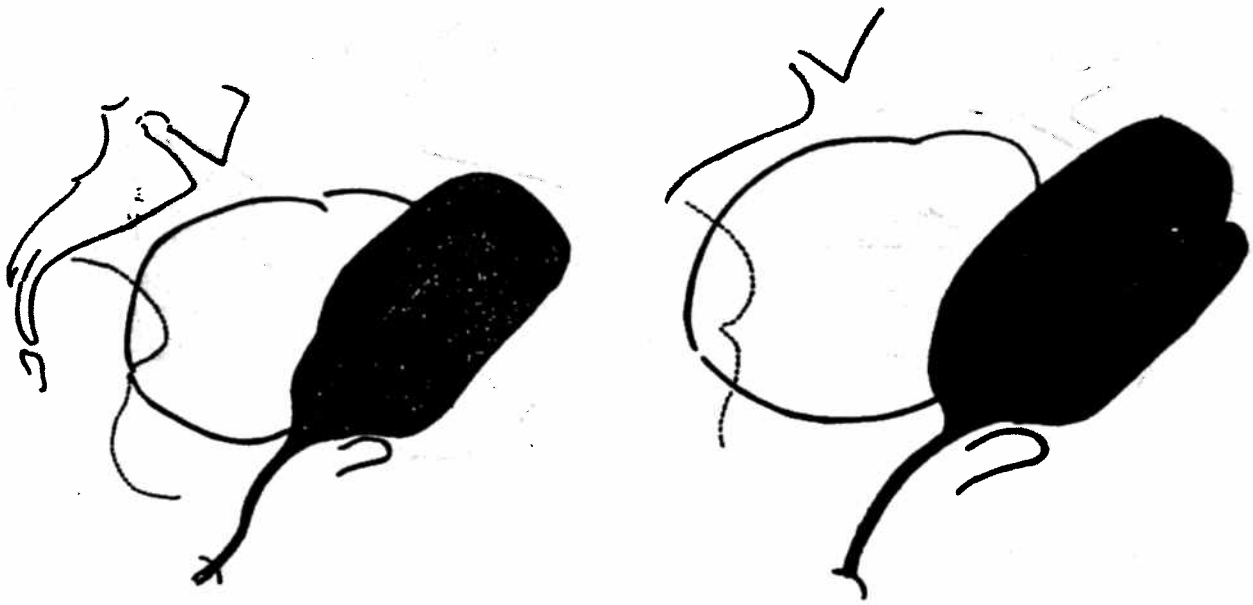
FIG. 13. M. T., primigravida. Deep transverse arrest of head. Roomy cavity with only slight displacement of bladder neck. Forceps delivery after 15 hours labour. Baby 8 pounds 8 ounces.



(a) At onset of labour. Weak pains. Membranes intact. Os admits tip of finger only. The bladder base and vesico-urethral junction are normal in all respects. Foetal head still above the brim.

(b) After 11½ hours labour. Membranes ruptured, cervix 4 fingers dilated, strong uterine contractions. The foetal head is now low in the pelvis but is well moulded and there appears to be a " tight fit." The bladder base and urethra have rotated forwards, the bladder neck is fusiform and has also lifted to some extent. However, a pouch of bladder still remains behind the symphysis.

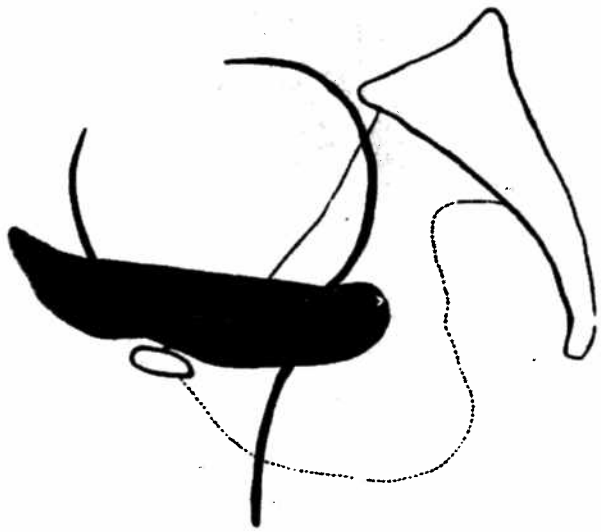
FIG. 10. E. P., primigravida. Slightly contracted pelvis, head high at onset of labour. Trial labour, spontaneous delivery after 14 hours. Baby 8 pounds 2 ounces.



(a) After 14 hours labour. Cervix 2 fingers dilated, membranes intact, widest diameter of foetal head has passed the brim. Bladder base rotated forwards and the bladder neck is funnel shaped. It is displaced behind the symphysis but has not lifted appreciably.

(b) After 20 hours labour. Cervix almost fully dilated. Head lower. Position of bladder neck is unchanged, no elongation of the urethra. Spontaneous delivery after episiotomy 4 hours later.

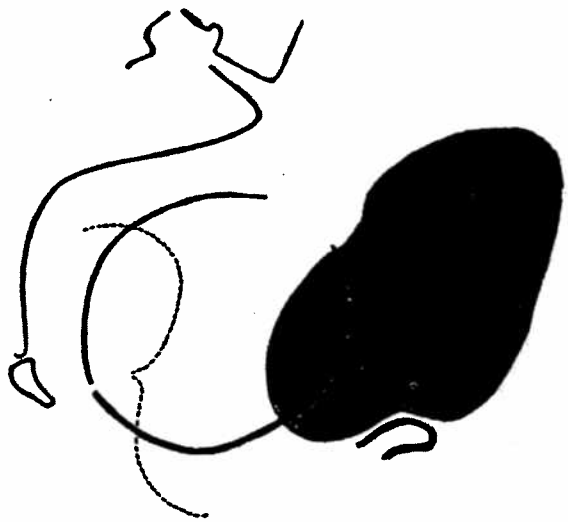
FIG. 15. I. C., primigravida. Spontaneous delivery after 24 hours labour. Baby 6 pounds 4 ounces.



Cystogram taken at the commencement of the second stage of labour. Cervix fully dilated. Membranes ruptured. The foetal head is still high and the bladder base and urethra remain undisturbed. Delivery was completed two hours later.

FIG. 16. Mrs. H., multigravida. Spontaneous delivery.

(a) After 9 hours slow labour. Cervix 1 finger dilated, membranes intact, head half through brim. Commencing rotation of bladder base.

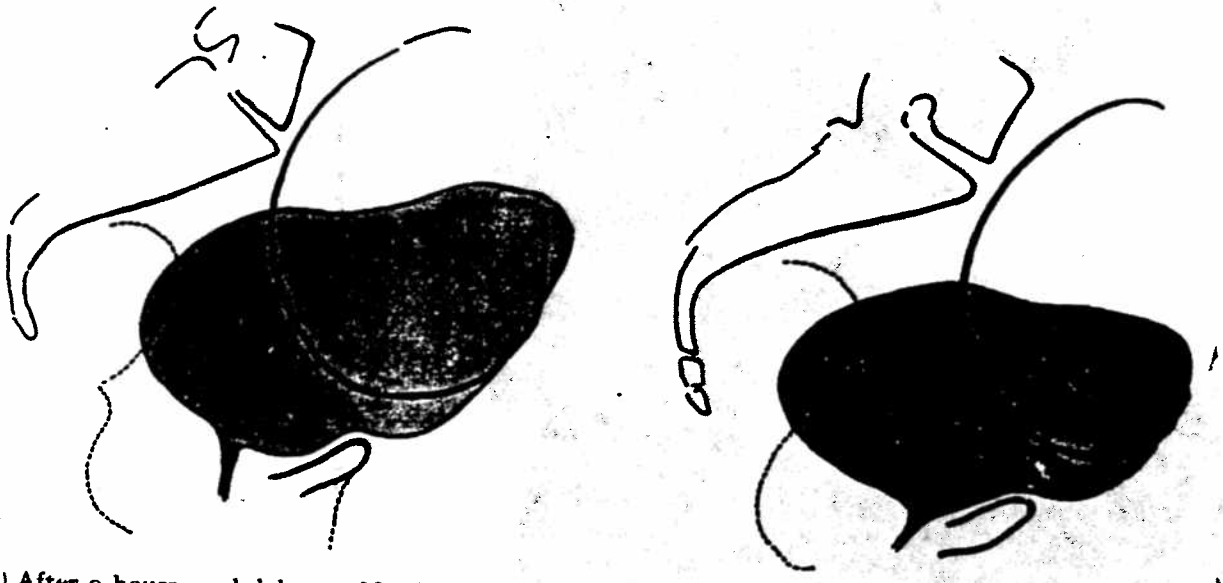


(b) After 15 hours labour. Cervix 4 fingers dilated, membranes intact, head low. Large pouch of bladder behind symphysis. No apparent displacement of bladder neck.

(c) After 17½ hours labour. Head on perineum and visible at vulva. Bladder base fully rotated, bladder neck fusiform but no uplift of urethro-vesical junction. Spontaneous delivery within half an hour of this cystogram.

FIG. 14. N. R., primigravida. Spontaneous delivery after 18 hours labour. Baby 5 pounds 12 ounces.

In this series the catheter was removed, thus allowing more accurate visualization of the shape and position of the bladder neck.

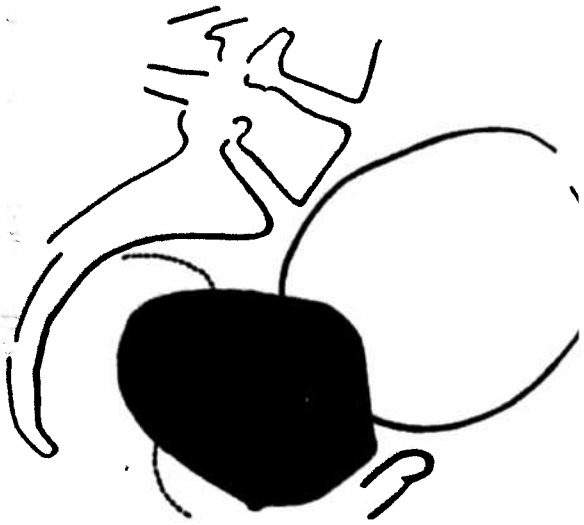


) After 9 hours weak labour. Membranes intact. Cervix taken up and 1 finger dilated. Bladder base and neck in normal position.

(b) After 20 hours labour. Membranes [illegible] Cervix 3 fingers dilated. The head [illegible] completely above the brim. The bladder [illegible] remains in normal position and although the vesico-urethral junction is rather close to the symphysis pubis, it has not lifted.

FIG. 18. M. L., primigravida. Contracted pelvis. Labour obstructed at the brim. Caesarean section after 22 hours in labour. Baby 8 pounds 12 ounces. Posterior position.

(a) The X-ray negative.



(b) Tracing of X-ray negative

FIG. 19. R. S., 3-gravida. Two previous spontaneous deliveries of small children. Contracted pelvis. Labour obstructed at the brim. Delivery by Caesarean section.

Cystogram after 14 hours in labour. Cervix 3 to 4 fingers dilated. Uterus contracting very strongly and frequently, lower segment dangerously thin. The foetal head is above the brim whilst the bladder base and urethra remain in normal position. No evidence of displacement of bladder

description of the anatomical changes, but it may not be out of place here to discuss their bearings on some clinical problems. Some clinicians have long taught that in cases of cephalo-pelvic disproportion observation of the position of the bladder during labour assists in assessing the outcome. Thus it is said by some that a bladder high in the abdomen and inability of the patient to pass urine are good signs, others take the view that they mean a "tight fit." Both these views need qualifying. If the disproportion is extreme and the head does not engage, the bladder base and the bladder neck will remain in their normal position, no matter what degree of cervical dilatation is present. In such a case no disturbance of micturition will occur. On the other hand the extreme displacement of the bladder neck which may accompany cavity arrest is a good sign in that it indicates adequate engagement of the head, a bad sign in that it indicates that the limit of available room has been reached.

The development of urinary fistulae from pressure necrosis following difficult labours may be touched upon. The site of these fistulae has a bearing on the problem we are considering. Their usual site is the bladder base and not the urethra. This is difficult to explain on the basis of the widely held view that the bladder is lifted above the symphysis pubis. In such cases it would be the elongated urethra which would be subject to pressure. If, as we suggest, some part of the bladder nearly always remains in a retropubic position then the site of these fistulae is understandable. One of the few writers who makes this point is Johnstone (1948), whose statement about the displacement of the bladder is quoted earlier. It might also be added that if the bladder did not remain in the pelvis at the end of labour no obstetric manoeuvre would incur the risk of injury to it, and the oft-repeated warnings to catheterize the patient before applying forceps would be unnecessary.

An everyday clinical observation which is often held to support the view that the urethra is elongated in labour is that a catheter has to be passed a greater distance to withdraw urine. The most likely explanation, however, is that the catheter has to traverse a compressed and empty retropubic pouch of bladder before the urine in the upper pouch is reached.

Although the direct observations which may be made during the performance of Caesarean section do not strictly come into the purview of a radiological study they perhaps may be touched upon as furnishing a check on the radiological findings. There can be no doubt that in cases of obstructed labour a diversity of bladder positions is encountered at this operation. In some cases perhaps this is explained by anatomical variations in depth of the utero-vesical pouch. Generally when the lower segment is overdistended and tonic contractions are threatened or established, the bladder is found high on the front of the lower segment, stripping up the peritoneum and covering the operative field. In those cases in which disproportion becomes evident early and in which an inco-ordinate type of uterine action develops without the formation of a distended lower segment, this elevation of the bladder and obliteration of the utero-vesical fossa of the peritoneum is not observed; indeed the fossa may seem deeper than usual. This is because in this type of case the uterus is so inefficient that the presenting part is not forced into the pelvis to a significant extent. In other words the presence of marked upward displacement of the bladder is evidence of failure of labour in those cases only in which a substantial portion of the head is the cavity. This, for instance, occurs in the common cases where uterine activity is adequate to force a considerable

part of the head into the pelvis, simulating the vaginal criteria of apparent engagement, whereas in fact the greatest diameter of the presenting part is still above the brim.

The relationship between the changes in the bladder and urethra and the development of stress incontinence.

In this context the important points seem to be that the upper end of the urethra is not displaced upwards to any extent in labour but that the bladder base is first rotated and then forced upwards so that the vesico-urethral junction becomes fusiform, or to use a homely simile, the shape of the junction comes to resemble a pear and its stalk, in contrast to the normal appearance of an apple and its stalk. Seeing that the displacement of the bladder base is forwards it cannot be that the cause of stress incontinence is a separation of the bladder neck and urethra from their attachment to the back of the symphysis, as some writers have supposed. What would seem likely is that an extreme rotation of the bladder base from its normal horizontal position in the plane of the outlet to a vertical position stretches its fascial investment and particularly the fascial investment of the posterior aspect of the bladder neck. After delivery this fascia does not recover its strength, and the ring of fibrous tissue which maintains the normal perpendicular attachment of the urethra to the bladder is left stretched. The guard which the muscular pelvic diaphragm maintains against the sudden rises of pressure accompanying sudden efforts such as coughing is impaired because the fibrous attachments of the muscle fibres are too lax. The problem of stress incontinence is of course a difficult one, and the view that it is due to a minor degree of relaxation of the investing fascia of the bladder neck needs consideration in light of three other aspects of this symptom. The first is the fact that of very little evidence of injury to the vagina wall can be demonstrated in quite seve cases of stress incontinence. The seco is the question of the existence and role the bladder sphincters. The third is th degree of pressure raised within the bladd by the sort of effort which causes stre incontinence as compared with the intr vesical pressure of normal micturition.

Perhaps the matter of the intravesic pressures may be best considered fir because the strength of the supports an any sphincters that may be present mu be adapted to the pressure they have t withstand. Much of our knowledge o intravesical pressure is based on the work of Denny-Brown and Robertson (1933) and following their work it is not difficult to devise simple manometric measurements of the intravesical pressure in normal women and in women complaining of stress incontinence. The resting pressure of urine in the bladder is zero. This is the reason why it does not follow that a catheter passed before operation with the patient lying prone necessarily empties the bladder. In voluntary micturition the pressure rises quickly to as much as 100 cm. to 200 cm. of water, but the rise with an effort such as a cough is nowhere near this level, usually only a little above zero. Even a sustained paroxysm of coughing does not raise the intravesical pressure much more than 10 cm. of water. This means that the anatomical resistance required to maintain continence against casual stresses need not be very strong.

In regard to the nature and role of the vesical sphincters in women the work of Denny-Brown and Robertson (1928) is again of great importance. Briefly, these workers consider that no true involuntary sphincter exists, and that the role of the voluntary sphincter, the compressor urethrae, is not to maintain continence but to

provide a reflex mechanism whereby the act of micturition can be cut short. Such a view accords with Barrington's (1928) experimental findings in the cat. Normal continence depends on the zero pressure of the resting bladder and the apposition of the tissues round the meatus. There is no voluntary or involuntary muscle mechanism constantly on guard, all that is necessary is a resistance sufficient to counteract the quite small rise of pressure that occurs with effort.

These considerations throw some light on the extent of the lesion necessary to cause stress incontinence, a lesion which, as is well known, is sometimes quite minimal. If the structures which normally support the female bladder neck are built to withstand a pressure only one-tenth that of normal micturition we should not expect to find them of imposing strength. Such an argument is borne out by anatomical dissections of the bladder and urethra. It follows that when these structures are damaged, even to the extent of producing incontinence, no very striking evidences of damage are likely to be seen. It is only when a massive protective structure such as the pelvic floor is injured that we should expect to find gross physical signs of trauma.

It is not the aim of the present paper to discuss the operative cure of stress incontinence, but the foregoing conclusions would seem to show that attempts at its cure must aim at reconstituting a normally-shaped vesico-urethral junction in its right place on the plane of the outlet, that urethroplasty of any sort is unsound, and that the strength of the support given by any plastic operation is not nearly so important as to ensure that it is made in the right place.

Summary.

1. The movement of the bladder and urethra in labour was studied by a series of cystograms. Lateral views suggested that:

(*a*) At the onset of labour the bladder base and the urethro-vesical junction are at the level of a line joining the lower border of the symphysis pubis and the tip of the sacrum.

(*b*) Dilatation of the cervix and thinning of the lower segment does not directly influence the position of the bladder base.

(*c*) As the presenting part descends the bladder base is rolled up from behind forwards until is comes in line with the urethra. Both bladder base and vesico-urethral junction then move towards the symphysis.

(*d*) In the normal case there is not much upward movement of the bladder neck, nor is there significant lengthening of the urethra. Part of the bladder just above the bladder neck, which becomes funnel-shaped as viewed from the side, usually remains behind the symphysis.

(*e*) The extent of the displacement of the bladder and urethra depends largely on the relative sizes of the presenting part and the pelvic cavity. When the cavity is cramped and there is mid pelvic arrest of the head, the bladder neck may lift to the level of the top of the symphysis pubis and the urethra is somewhat lengthened. Such a state of affairs may indicate the need for delivery by Caesarean section.

2. Some of the clinical implications of these findings are discussed.

3. It is suggested that in cases of stress incontinence the essential lesion is a failure of the fascia investing the bladder base behind the urethro-vesical junction to recover tone.

We are indebted to the other members of the visiting staff of the Liverpool Maternity Hospital for allowing us to make use of some of their cases in this study.

ADDENDUM.

The early part of this work was described in a preliminary communication by one of us (P. M.) made to the North of England Obstetrical and Gynaecological Society in 1945. The further investigations were carried out in 1947 and early 1948, and the results were submitted for publication in March 1949. During this period H. I. Kantor, J. E. Miller, and J. C. Dunlap carried out rather similar work, which they described at the Sixteenth Annual Meeting of the Central Association of Obstetricians and Gynaecologists, Denver, in September 1948, and which was published in the August number of the *American Journal of Obstetrics and Gynecology*, 1949, **58**, 354. It is of interest to note that these workers have also, and independently, come to the conclusion that the bladder base remains low in the pelvis early in labour, and that its subsequent movement is governed by the descent of the presenting part and not by the dilatation of the cervix and lower uterine segment.

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