PELVIMETRY IN OBSTETRICS

By H. Cecil Bull, M.R.C.P.

Pregnancy is by the laws of nature the universal experience of women, parturition no disease, a natural act, tending to become less natural as woman ascends the higher reaches of civilization. The native girl of Ceylon undertakes marriage early while the bones are soft and the muscles hard, pregnancy follows and parturition is an interlude in the working hours. With the economic stresses of western life marriage is later, malformations of the skeleton more frequent, parturition less easy and regard for life keen. Even so parturition for the majority of western women is a natural event taking place under the kindly eye of an elder or semi-skilled female friend.

To this in the past Medicine has stood in benevolent and advisory capacity, willing to help when required. Now, the policy is to round up pregnant women and bring them all under medical care in the early stages. In this antenatal period she is examined to determine her general health and to forecast the probable course of labour. It is an important decision to which the doctor is guided by clinical judgment and the customary obstetrical measurements, crude but accessory aids to build up the clinical picture.

The pelvis has a certain geometrical shape, so has the foetal head; the soft parts are malleable to a degree, expulsion being effected by muscular contraction provided the passage is adequate. The important factors therefore in prognosis are—knowledge of the pelvic canal and clinical judgment.

Now we have with X-rays accurate methods of measuring the diameters of the pelvic canal and of the foetal head as well as of checking the more obvious difficulties—multiple pregnancy, abnormal presentation and lie, anencephalic monster, etc. Full advantage is not made of these methods. Radiologists the world over have worked and written about it and it is difficult at first sight to understand why X-ray pelvimetry is not used in every doubtful case. Radiology calculates mathematically, determining the diameters of the pelvic inlet, midplane and outlet, and with approximate accuracy the posterior sagittal diameters of midplane and outlet, the surface areas of brim and midplane and the biparietal diameter of the foetal head. Besides this we have the positive evidence of presentation and position, extended legs in breech presentations, deformities, etc.

In radiology, diameter measurements are between bony points and therefore greater than fact because they do not take account of soft tissues. Clinically or radiologically we can forecast a normal labour in a pelvis of ample dimensions, or the impossible delivery when the pelvis is contracted. The important group is the intermediate where there may be doubt of a living child or danger to the mother. Here, neither clinician nor radiologist is certain; every art and craft of medicine should therefore be impressed to save a life or forestall a danger. Of old, 'trial labour' was recommended on the argument that the second labour would be easier, provided the mother survived. Now the pendulum swings, perhaps overshings, in the opposite direction and where there is doubt there is Caesarean section. The gap between normal and impossible is too wide, and one way to narrow the gap is to encourage and develop a closer harmony between clinical and radiological investigations.

In the first place there should be a certain standardization of radiological technique, an agreement to accept some methods and reject others. Secondly, it should be recognized that radiology introduces rigid mathematics whose value can only be appreciated in conjunction with clinical judgment.

If radiology be accepted as a real help in forecasting the course of labour, we must integrate the figures produced in terms of obstetrical difficulties. This has been done by Allen (1947) whose table is an excellent beginning, though wide in its limits.

The following paragraphs are concerned firstly with the radiological measurements of the pelvis and calculations therefrom; secondly, with the various types of pelvis and, finally, with the deductions that can be made from these observations and their relation to obstetrical difficulties.

Radiology undertakes:—
1. Measurements

(a) Pelvic Inlet

Anteroposterior (conjugate).
Transverse.
Right oblique.
Left oblique.
Area.

The anteroposterior is the shortest distance between the symphysis pubis and the sacrum. In most patients the point on the sacrum is the anatomical promontory, but where there is sacralization of the last lumbar vertebra and in some other subjects, the first two pieces of the sacrum may be straight instead of curving backwards from the promontory; the shortest distance is then to the second piece of the sacrum.

Transverse—the widest diameter of the brim.

Right and left oblique—from each sacroiliac joint to the opposite pubic ramus. These measurements show if there is asymmetry of the brim but are not otherwise useful in diagnosis.

Anterior and posterior sagittal—intersection of the transverse with the anteroposterior diameter, divides the latter into anterior and posterior sagittal diameters. These are of interest only in the 'android' pelvis of Caldwell and Moloy (1935).

The brim area is calculated from the formula of Nicholson (1938):—

\[
\text{Area} = \frac{\pi ab}{4}
\]

where \( a = \) conjugate.
\( b = \) transverse diameter of inlet.

The error is least in the round pelvis but area measurements are necessarily inaccurate in an imperfect geometric figure. This being born in mind, they are useful in showing the combined value of the two diameters.

(b) Midplane

The midplane is the area bounded in front by the symphysis pubis, behind by the sacrum from promontory to the last piece excluding the coccyx, and laterally by the ischium, pubis and sacrosciatic ligaments. For linear measurements of this space we take:—

Anteroposterior—from lower edge of symphysis to the lower end of the last sacral segment.

Lateral—the distance between the ischial spines.

Posterior sagittal—from the midpoint of the above lateral (bispinous diameter) to the lower end of the last sacral segment.

Midplane area. Calculation is made from the anteroposterior and lateral diameters according to the formula

\[
\frac{\pi ab}{4}
\]

where \( a = \) anteroposterior diameter of midplane.
\( b = \) transverse (bispinous).

(c) Outlet

The transverse diameter is the distance between the ischial tuberosities.

No full anteroposterior diameter can be measured because the protrusion of the head through the subpubic arch cannot be measured. The only linear measurement possible is the ischio-sacral, i.e. from the midpoint of the transverse diameter to the last piece of the sacrum.

(d) Subpubic Angle

Nicholson (1938) gives 75° as the 'critical' angle, meaning that anything less than 75° is likely to lead to obstetrical difficulty. This is inaccurate as will be shown later.

Because of the variable shape of the pelvis no absolute standards of normal can be given, but the following is a list of diameter measurements and area calculations, being an average of routine cases.

Inlet

<table>
<thead>
<tr>
<th>Description</th>
<th>Average normal about</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjugate</td>
<td>120 mm</td>
</tr>
<tr>
<td>Transverse</td>
<td>128 mm</td>
</tr>
<tr>
<td>Right oblique</td>
<td>117 mm</td>
</tr>
<tr>
<td>Left oblique</td>
<td>117 mm</td>
</tr>
<tr>
<td>Brim area</td>
<td>120 sq. cm</td>
</tr>
</tbody>
</table>

Midplane

<table>
<thead>
<tr>
<th>Description</th>
<th>Average normal about</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteroposterior</td>
<td>120 mm</td>
</tr>
<tr>
<td>Transverse (interspinous)</td>
<td>100 mm</td>
</tr>
<tr>
<td>Posterior sagittal</td>
<td>43 mm</td>
</tr>
<tr>
<td>Midplane area</td>
<td>98 sq. cm</td>
</tr>
</tbody>
</table>

Outlet

<table>
<thead>
<tr>
<th>Description</th>
<th>Average normal about</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse (intertuberos)</td>
<td>120 mm</td>
</tr>
<tr>
<td>Anteroposterior (ischiosacral)</td>
<td>80 mm</td>
</tr>
</tbody>
</table>

Subpubic angle—80°.

Perpendicular—62 mm.

2. Shape

Pelves are classified by the shape of the inlet, by the proportion of the conjugate to the transverse diameter.

(a) Round (mesatipellic), the transverse diameter is equal or nearly equal to the conjugate.

(b) Long oval (dolichopellic or anthropoid), the transverse is smaller than the conjugate.

(c) Flat (platypellic), the transverse is greater than the conjugate.

This relationship is expressed by the brim index:—
Conjugate Transverse × 100

Brim Index

Round pelvis 85 to 100
Long oval pelvis over 100
Flat pelvis under 85

A fourth, the triangular shaped pelvic inlet where the rami tend to narrow anteriorly, has been named the 'android' pelvis by Caldwell and Moloy (1935). It may be regarded as a modified anthropoid shape but is important because it leads to obstetrical difficulties. In such cases nothing is learnt from the brim index. The anterior narrowing of the pelvis means there must be more space posteriorly if the head is to pass through. For recognition of the android pelvis we use the relation of the posterior sagittal diameter of the inlet to the conjugate expressed as a percentage:

\[
\frac{\text{Posterior sagittal}}{\text{Conjugate}} \times 100
\]

It is not established how low this ratio may be to come into the classification of android. Opinion ranges between 24 and 40. The formula applies only to the android pelvis and is not an index for other pelvic types.

3. Placenta

The placenta can often be identified in shaded films as a soft tissue shadow on the anterior or posterior wall of the uterus (Fig. 2).

Commentary

To the pelvic brim most attention has been given in obstetrics and it is from the pelvic brim that the classification of types is derived. Most important of the measurements of the brim has been and is the conjugate diameter. The minimum diameter of the foetal head at term is 98 mm.; if either conjugate or transverse diameter is less, the head will not easily pass through.

The relationship of the transverse to the conjugate is the other important brim characteristic expressed as a percentage in the brim index. The oblique diameters measured from the sacroiliac joints to pubic rami are equal, in the symmetrical pelvis.

Shortening of the posterior sagittal diameter of the inlet is a feature of the 'android' pelvis. There is as yet no agreement as to how low the

\[
\frac{\text{Posterior sagittal}}{\text{Conjugate}} \times 100
\]

classified as android, figures from 24 to 36 are given by various workers. It is suggested by Allen (1947) that 40 per cent. should be regarded as the dividing line, ratios below this being android.

In other words the normal posterior sagittal measurement is 40 to 50 per cent. of the length of the conjugate and when we find it to be less than 40 per cent. we are dealing with an android pelvis. The small inaccuracy due to the slightly different plane levels of conjugate and transverse diameters is not significant.

The brim area calculated from the conjugate and transverse diameters is but another, not very accurate figure expressing plane area. It would be accurate if the pelvic inlet were a circle; inexactitude grows in proportion as it departs therefrom.

Midplane

Once through the brim in a normal pelvis the head has more room to move and can rotate since the backward curve of the sacrum gives a greater anteroposterior diameter. There are, however, some sacra which do not curve backwards and some, indeed, which come a little forward so that the anteroposterior diameter between symphysis and sacrum is less than between symphysis and promontory. The narrower diameter is then regarded as the true conjugate. The straight sacrum is usually associated with a congenital anomaly of the first piece; either the last lumbar vertebra is sacralized or the first piece of the sacrum resembles a lumbar vertebra (Fig. 3).

Diameters of the Midplane

The anteroposterior diameter of the midplane from the inner surface of the symphysis to the last piece of the sacrum might be called the outlet of the midplane. It is the smallest anteroposterior length of the midplane and varies with the forward curve of the sacrum. It is one of the essential diameters, rarely measuring as little as 100 mm. in the female, but if it does there will be difficulty, especially if the interspinous is also 100 mm. This anteroposterior measurement disregards the coccyx on the assumption that it will dislocate backwards if necessary.

The interspinous, the diameter between the ischial spines, is an essential diameter through which the full width of the head must pass. There is no slipping in front or behind it, the fact of narrowing here also meaning that the body of the ischial spines fit together and the whole length of descent will be a close fit of approximately the same transverse width as that between the ischial spines. A measurement below 90 mm. therefore is on the danger level. The transverse diameter of the outlet (intertuberosous) is proportional to the interspinous. It is uncommon to find it less than 100 mm. but, if so, it is an index of trouble, not so much on its own account but as a warning that the whole passage through the midplane is narrow.
Fig. 1.—Normal proportions.

Fig. 2.—Placenta on posterior wall of fundus.

Fig. 3.—Sacralization. Breech presentation. The various measured diameters are shown. The patient had two normal births previously but this was complicated by an ovarian cyst. Caesarean section.
FIG. 4.—Subpubic angle.

FIG. 5.—Antero-posterior.

FIG. 6.—Lateral.
Posterior Sagittal of Midplane

The measurement from the midpoint of the interspinous diameter to the last piece of the sacrum is an accessory help in determining the available space for the head in its final passage to the outlet.

The writer has not been able to appreciate the value of the posterior sagittal measurement of the midplane. If the full anteroposterior diameter is adequate the posterior sagittal is of no consequence. If the anteroposterior is not adequate the head will not pass. Similarly if the ischia come together and the transverse interspinous diameter is inadequate no power and no extra room behind the spines will bring the head through.

The bi-parietal diameter of the head at term being 98 mm., any pelvic diameter of 98 mm. may cause difficulty, and when it is as small as 85 mm. passage of the head borders on the impossible. The most certain bar to progress is when the two diameters, anteroposterior and lateral, of one plane are narrowed. Thus an anteroposterior and lateral of 95 mm. is a more likely stop than an anteroposterior of 110 and a transverse of 90 mm.

Outlet

This is the most difficult part of the pelvis to reduce to terms of mathematics because of its peculiar anatomical shape. The maximum transverse diameter of the outlet is the distance between the ischial tuberosities and apart from gross deformity is never a narrow diameter. This transverse diameter marks the division of the outlet into anterior and posterior triangles which lie in different planes. The anterior, subpubic triangle faces forward, having sides formed by the ischium-pubic rami and base by the imaginary transverse intertuberous diameter (Fig. 4). The posterior triangle makes a wide angle with the anterior and faces somewhat backwards. Its anterior boundary is the intertuberous diameter, the lateral walls the sacro-sciatic ligaments and the posterior limit the last piece of the sacrum. The distance from the midpoint of the intertuberous diameter to the last piece of the sacrum is the anteroposterior or sagittal diameter of this posterior area of the outlet, it is not a measurement which has been employed in radiological pelvimetry and may be called the ischiosacral diameter of the outlet.

Too little attention has been paid in the past to outlet measurements. Much has been written on the size and shape of the inlet and we can forecast with fair accuracy whether or not the head will pass through the brim. If our judgment is at fault there is still time to delivery by Caesarean section. Once through the inlet there is space enough for movement through the midplane, but difficulty may begin in the last act, the passing of the head through the outlet. It is no longer possible to go back; it is late for Caesarean section, the head is moulding perhaps excessively and the child must be delivered soon; forceps are necessary but increase the risk of damage to the head and if force is used may result in a tentorial tear.

Such disasters and near-tragedies still happen. They should be largely avoided if all the help modern science can give is correctly brought to bear. Because the head is capable of moulding and the sacroiliac joints allow some backward movement of the sacrum, much is left to chance. Let us consider the matter mathematically from the limits of the fixed bony points to see whether it is not possible to anticipate trouble. In so doing the writer sees no reason for making allowance for moulding of the head. Moulding is an undesirable, however common, insult to the foetal head and slight moulding is accepted only as a compensation for small errors of calculation. In the interests of the breed, extreme moulding and the use of forceps to overcome mechanical disproportion should be discouraged.

We have already noted that the transverse diameter of the outlet is adequate. The difficulties resolve themselves, therefore, into the measurement of the anteroposterior diameter and of the angle of the pubic arch. In default of obtaining a large number of pelves correctly articulated and not too dry for experimental test, the writer has used a geometric figure, a ball of 100 mm. diameter and a variable subpubic angle and ischiosacral length. The rami of the subpubic arch were kept constant at 100 mm. (a little greater than the average normal) and two characteristic intertuberos diameter of 115 and 125 mm. were used as base lines (Figs. 5 and 6). It may be that the results can be expressed as a formula but they can be understood and appreciated more easily as graphs; no reason appears for believing that the facts which emerge differ materially from those of the pelvis in life.

For experimental purposes the foetal head may be looked upon as a circle of 100 mm. diameter which is approximately the biparietal or minimum essential diameter of the uncompressed head. In order that the head may pass through the outlet the anteroposterior and lateral diameters must each measure not less than 100 mm. The anteroposterior diameter consists of the ischiosacral diameter plus the distance the head can push through the pubic arch above the tuberosities. If we imagine for a moment that the pubic arch is filled in by a rigid membrane then the anteroposterior diameter is easy to measure; it is the ischiosacral diameter and must be 100 mm. long if the head is to pass. But the ischiosacral diameter
is usually less than 100 mm.; in fact, it averages 80 mm. The additional length is obtained by the head passing halfway through the pubic arch as soon as the divergence of the rami allows, and by backward rocking of the sacrum. A mistaken conception of the geometrics of the pubic arch has crept into the literature. It is written that a wide angle of the pubic arch makes for ease in delivery and that difficulties may be expected when the arch is narrow. The converse is the geometric truth; the narrower the angle the easier for the head to come forward.

The anteroposterior measurement of the outlet cannot be assessed as a simple figure since, as noted above, it consists of two parts—the ischiosacral from the midpoint of the intertuberosus diameter to the last piece of the sacrum, and the indefinite space the head may occupy by pushing forward through the subpubic arch. This anteroposterior 'space' of the outlet is best resolved in two graphs using the intertuberosus diameter as a base line and taking note of the perpendicular measurement from the subpubic angle to the base line, the 'ischiosacral' from the base line to the sacrum, and the subpubic angle. The graphs (Figs. 7 and 8) demonstrate that the lengths desirable to secure an easy passage are the perpendicular of the subpubic angle and the base line. The angle which the rami make as they come together is of secondary importance and since individual rami do not vary greatly in length the narrower the subpubic angle the greater will be the ease of passage, given an adequate base line width. The necessary length required of the ischiosacral diameter is shown on the graphs and need only be a large one when the subpubic angle is wide, the perpendicular short and the base line narrow. It must be added, however, that this ischiosacral diameter which is measured in the still subject is by no means a fixed diameter during parturition. It is a diameter which is increased in length by the backward movement of the sacrum, an increase which varies with the age of the patient and the mobility at the sacroiliac joints.

Graph A shows that a biparietal diameter of 100 mm. requires an ischiosacral measurement of 80 mm. when the subpubic angle is 90°, whereas 82 mm. is sufficient for an angle of 70°; the base line being 115 mm. in each case. As the base line increases, the need for length in the ischiosacral line decreases, but the decrease is proportional to the subpubic angle (or perpendicular bisector of the base) and the graphs are straight lines (Graph B).
It will be seen that the important linear measurements of the outlet are the transverse (inter-tuberosous) diameter and the perpendicular to it from the subpubic angle. Knowing these measurements we can postulate the length of the ischiopubic diameters necessary for the head to pass through.

We progress so far by reducing labour to a geometric figure and one feels that it expresses a basic truth correcting some of the minor errors. It does not follow in practice, however, that rigid measurements constitute a bar to natural delivery. We find that the ischiopubic diameter can fall short of the desired length by anything up to 15 mm. without obstructing delivery. This is held to be due chiefly to the backward rocking of the sacrum which results from loosening of the ischiopubic joints during pregnancy and which is at present immeasurable and likely to be variable in different subjects.

This is one of the problems in which radiology extends help to the limits of its ability and invites the cooperation of clinical obstetrics to assess its value. The argument cannot be accepted that practice bears no relation to theory merely because nature can make an extra effort to overcome difficulties. There is a point beyond which no effort will be successful and we should be able to make better forecasts of whether or no it is possible to deliver naturally without injury to mother or child.

Table of Pelvimetry Values

A table of values wherein to check results and read off the chances of easy or difficult delivery would be a helpful summary. Such a table is not easily compiled; the diameters are too intimately related. The accompanying table (Fig. 9) is an average of normal cases wherein the diameters have been sufficient for natural birth, and with it are shown measurements theoretically inadequate for the passage of a foetal head at term.

Allen gives a guide to prognosis which is a valuable lead in this direction but suffers from the same disadvantages. His upper limits in which vaginal delivery is certain are above those of the usual normal.

The foetus makes full use of the available space between the bony points and for most women it is a close fit, however adequate. The interspinous is an important diameter and it is interesting to note that the average measurement does not allow much over the minimum. It is not a diameter that varies greatly and, of course, the head can pass even when it is less than 90 mm., but must inevitably be compressed in passage.

The least informative in this table are the outlet measurements since they are more interdependent than any of the others.

Conclusion

Radiology endeavours to give all the help it can by pelvimetry in obstetrics. The best line of approach has not yet been reached and the writer has outlined within his own knowledge the accepted measurements and calculations of the inlet and midplane. There is less unanimity about outlet measurements and in these he has written his own views and how those views have been reached. They are offered for criticism by radiologists and obstetricians in the hope that by their experience they will modify or amplify the findings of the geometrics of the pelvic outlet.

The difficulty often mentioned in this article is to link up the known with the unknown, that is to relate fixed diameters to variables. The conclusions here expressed are based on the law that an object of certain size will not pass through a channel smaller than itself. Radiological pelvimetry must take its stand here and propound the theoretical view of obstetrics according to the calculations of its own science. It only confuses the issue if we begin to make allowance for the variable and immeasurable factors such as moulding of the head and movement of the sacrum at the ischiopubic joints. Such factors lie in the realm of the obstetrician.

It is the purpose of radiology to supply all possible information to the clinician in such manner as may be most useful to him. There are many

<table>
<thead>
<tr>
<th>Average measurements. Natural delivery should be possible</th>
<th>INLET</th>
<th>MID-PLANE</th>
<th>OUTLET</th>
</tr>
</thead>
<tbody>
<tr>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>120 mm.</td>
<td>128 mm.</td>
<td>120 sq. cm.</td>
<td>120 mm.</td>
</tr>
<tr>
<td>Natural delivery theoretically impossible</td>
<td>95 mm.</td>
<td>95 mm.</td>
<td>78 sq. cm.</td>
</tr>
</tbody>
</table>

**FIG. 9**
factors in obstetrics besides mathematics, and judgment will be made on the case as a whole, pelvimetry forming a small but important part of the evidence.

It is to be hoped that if radiological pelvimetry can be standardized and put into general use, a closer correlation may be achieved and a more accurate forecast of difficulties obtained by a study of pelvimetric results.

Acknowledgments
Apart from the books and articles of which a few only are mentioned I am grateful for the facilities given me in the examination of pelves by Dr. Joseph of the Department of Anatomy of the University of London, Dr. Delmas of the Institut de Médecin of Paris and Dr. Horin, Assistant Obstetrician to the Maternity Hospital, Port Royal, Paris.

BIBLIOGRAPHY
Caldwell, Moloy, and D'Esopo (1938), Am. J. Obst. and Gyn., 30, 763.
Pizon, Pierre (1948) 'Radiodiagnostic Obstétrical, l'Expansion Scientifique Française.'

SIR JAMES YOUNG SIMPSON

Sir James Young Simpson (1811-1870) was born and educated in Edinburgh. His great ability and fascinating personality resulted in his appointment to the chair of Obstetrics in 1840. Following his introduction of ether to midwifery he experimented in other less unpleasant agents until in 1847 he published the results of five cases anaesthetized with chloroform. His advocacy of the use of anaesthesia in childbirth involved him in prolonged and bitter controversies, which were only ended in 1853 when Queen Victoria herself received chloroform at the birth of Prince Leopold. His great inventive powers led to the introduction of the long obstetric forcep, uterine sounds, sponge tents and the use of dilation of the cervix uteri as a diagnostic measure.