Obstetric radiology

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Summary

The uses of radiology in obstetrics are described. The dangers to the foetus are described. It is concluded that with care these can be reduced and the benefits from its use may often outweigh the dangers.

The indications for pelvimetry, the technique and its interpretation are discussed.

Placentography and the use of radiology in determining maturity are also described.

Introduction

Radiology contributes to obstetrics in resolving problems related to pelvimetry and disproportion, to the site of the placenta and to foetal age and foetal abnormality including the diagnosis of foetal death. Over the whole subject looms the problem of radiation hazard.

Radiation hazard

The problem of radiation hazard may involve both mother and foetus and theoretically could encompass somatic and genetic effects to each. For practical purposes it is the potential hazard to the unborn foetus of radiation-induced malignancy that has over the last few years caused such considerable heart searching and disputation. It is necessary to discuss this problem since one's whole approach to obstetric radiology will be determined by the strength of the 'case against radiology'.

Discussion resolves itself into three main problems:

- (1) Does a hazard exist?
- (2) What is the degree of the hazard?
- (3) Is the hazard excessive?

(1) Does a hazard exist?

The first real statement regarding the hazard to the foetus from diagnostic radiology was in the paper by Alice Stewart and her colleagues published in the *Lancet* (Stewart *et al.*, 1956) in which she traced 547 cases of malignant disease (roughly equal numbers of leukaemia and other neoplastic conditions including those of CNS, kidneys and adrenals) occurring in children under the age of 10 years during the years 1953-55. On comparing these with the

controls it was found that there had been radiation to the maternal abdomen in eighty-five cases compared with forty-five in the control group. A further, more detailed report in 1958 (Stewart, Webb & Hewitt, 1958) confirmed an excess of child malignant disease apparently in relation to antenatal radiation, but also pointed out that other factors were also present in excess in the malignant group compared with the controls—notably, maternal virus infection, threatened abortion and excessive maternal age, while post-natally, pulmonary infections and severe injuries were in excess.

Thus, a *prima facie* case has been made out although another report by Court Brown, Doll & Hill (1960) failed to confirm these figures and further it may be argued that the other factors associated with childhood malignancy had not been properly taken into account.

(2) What is the degree of hazard?

The figures for this may best be taken from Stewart & Kneale (1968) and Stewart *et al.* (1958) since they present the case against radiology.

The total incidence of malignancy up to the tenth birthday is one in 1200 live births.

Abdominal radiation roughly doubles the hazard to the foetus.

Less than one in a thousand antenatal X-ray examinations may be said to lead to death from malignant disease before 10 years of age.

Abdominal X-rays may account for about 6% of all malignant deaths occurring before the age of 10 years.

(3) Is the hazard excessive?

The maximum estimated degree of risk has been presented. Against this must be considered the hazards of prematurity, postmaturity, unsuspected malpresentation, placenta praevia, etc., in which antenatal radiography may play a useful part in case management. Whereas it is possible, though as indicated very difficult, to estimate the hazard it is far more difficult to quantitate the beneficial effects of radiology since it is so intricately a part of the whole process of management. When one considers that perinatal mortality is twenty-five per 1000, and

1st-week neonatal deaths alone fifteen per 1000 (Registrar General's Tables 1967), it seems reasonable to deduce that reduction of these figures represents a much bigger problem than radiogenic cancer and the help radiology provides in keeping these figures down or further reducing them, probably represents a genuine gain in return for the small price of the X-ray hazard.

What conclusions can be drawn?

The case that antenatal radiology to the abdomen may predispose to juvenile neoplasia seems proved. For the reasons given the resulting incidence in neoplasia is probably rather smaller than the above figures would suggest and thus they do not totally condemn antenatal radiology. Nevertheless, it should be applied with care both in terms of clinical indications and the manner in which the examination requested is conducted in order to reduce radiation dosage. Clinical consultation with a radiologist and radiological supervision will both help to achieve this.

Finally, it has been suggested that X-ray induced juvenile neoplasia may actually have varied in incidence with varying radiological practice (Stewart & Kneale, 1968) which serves to underline the need for the meticulous practice of antenatal obstetric radiology.

Pelvimetry and disproportion

This is discussed under the following headings:

- (1) Clinical indications.
- (2) Radiographic technique and anatomy.
- (3) Interpretation of films.
- (4) The conduct of pelvimetry (the application of radiographic technique to particular clinical indications).

(1) Clinical indications

The clinical indications for pelvimetry are enumerated below and in consequence the examination may be conducted before, during or after labour.

(a) In a persistent breech-presentation pelvimetry is strongly indicated: the indication may be regarded as absolute for a breech-presentation in a primigravida when vaginal delivery is being considered, i.e. antenatal pelvimetry.

(b) Following a difficult delivery in which routine clinical antenatal examination produced no warning of impending trouble. The delivery may have been accomplished vaginally, with forceps or by Caesarean section. A pelvimetry may be requested even though inco-ordinate uterine contractions or malpresentation was a likely cause for the dystocia since pelvic

inadequacy may have been associated or even causative, i.e. post-natal pelvimetry.

Although this may be regarded as shutting the stable door after the horse has bolted, it does enable the events of a difficult labour to be better understood and to make appropriate allowances in future pregnancies.

(c) Patients in whom antenatal examination suggests the possibility of an inadequate pelvis, e.g. women of very small stature; orthopaedic deformities of hip, spine or pelvis; patients in whom the pelvis is small on clinical examination or who give a history of past dystocia. The results may enable the obstetrician to decide whether and how far to persist in a trial of labour, i.e. antenatal pelvimetry.

(d) Failure of the foetal head to engage, i.e. antenatal pelvimetry.

(e) Failure of progress during a trial of labour, i.e. intranatal pelvimetry.

(2) Radiographic technique and anatomy

The full obstetric assessment of the pelvis is derived from four different projections: (i) the erect lateral, (ii) the AP, (iii) the inlet (brim) view, and (iv) the outlet (subpubic arch) view. It is proposed to consider each of these in some detail describing the manner in which each view is obtained, the anatomical features, both normal and abnormal to be noted, and the measurements obtainable from each view. It should be stressed that the pelvimetry examination should be considered both qualitatively, i.e. the deviation of the pelvis from the ideal shape; and quantitatively, i.e. the measurements obtained from the film.

Before discussing each of the projections in detail, some of the principles involved in the production of the X-ray image must be noted. An X-ray picture is a 'shadow' image of the area radiographed with the X-ray tube being the equivalent of the light source (Fig. 1). Since the region considered, owing to the thickness of the patient's body, is separated by some 15–20 cm from the film, it follows that the radiographic image in the present instance is a geometrical enlargement of the true bony pelvis. Further, as with any cast shadow, distortion of the outline can occur if the pelvis and the X-ray film are out of alignment with each other.

For the present purpose the pelvis can be considered as a number of planes which must be projected without distortion and with measurable magnification on the film. These planes are the inlet, the midline (sagittal) and the outlet and account for three of the four views mentioned above. To demonstrate these an appropriate film is taken with the patient so positioned that the plane in question is parallel to the film (i.e. to prevent distortion), and at a measured distance from the film to facilitate correc-

FIG. 1. This demonstrates how the divergent X-ray beam causes a significant magnification of the patient on the film. A-B is the numerator of the reduction factor and is obtained by subtracting the distance B-C (which is measured by the radiographer) from the distance A-C which is fixed at 1m and forms the denominator of the reduction factor.

tion for magnification. The reduction factor for magnification is:

$$\frac{\text{Distance of pelvic plane from X-ray tube}}{\text{Distance of X-ray tube from film}}.$$

The numerator is obtained by subtracting the pelvic plane-film distance measured in each case by the radiographer, from the tube-film distance. The denominator is usually fixed for all examinations

and for convenience of calculation is set at 1 m. A chart can be prepared to enable the correct measurements to be made directly from the film (Fig. 2).

The erect lateral view (Fig. 3). This shows the features of the pelvis in the sagittal plane and is obtained by standing the patient sideways next to the film holder. The field covered should show the whole of the sacrum and the pubis. The bony features to be

FIG. 2. Reduction chart for direct assessment of corrected measurements on the radiograph.

FIG. 3. Line drawing of erect lateral view. A-B is the inlet conjugate, C-E the pubo-sacral diameter. The lines G-H and D-F are used for additional calculations in combination with other views.

noted are the normality of the curve of the sacrum and the prominence of the lumbo-sacral promontory and of the sacro-coccygeal junction. The inclination of the pelvic cavity relative to the lumbar spine can be seen. The iliac spines are shown projected one over the other and the angle of the sacro-sciatic notch can be assessed: this is usually 90° or over and any

reduction implies funnelling of the pelvis towards the outlet.

The measurements to be obtained are the inlet conjugate and the pubo-sacral and thus indicate inadequacy in the AP plane of the brim or outlet. When this view is used in late pregnancy it may demonstrate whether or not the head is engaged and if so it is very likely that one of the cephalic diameters can be measured (Fig. 4) and corrected using the magnification factor applicable for this view.

Inlet view (Fig. 5). This demonstrates the shape of the pelvic brim and also shows the inter-spinous distance. For this view the patient sits on the X-ray table and in a semi-reclining position, the X-ray beam being directed downwards vertically from

FIG. 4. Erect lateral radiograph. This example shows how the bi-parietal diameter of the foetal head is well shown after engagement has occurred.

FIG. 5. Line tracing of inlet view. A-B represents the transverse diameter of the inlet and C-D the interspinous diameter.

above. This view produces a true, undistorted likeness of the inlet plane on the film. This view should be used in pregnancy only if there is a genuine doubt concerning the transverse capacity of the inlet, since in this view the foetal gonads in a vertex presentation are relatively close to the X-ray source and may receive a disproportionately large X-ray dose (see, however, the section on the AP view, below).

This view shows the shape of the inlet to best advantage. Normally it is almost circular in shape being a little larger in transverse than AP diameter and the transverse diameter intersects the AP diameter near its mid-part.

Major deviations of inlet shape are well shown and include the platypelloid (reduced AP conjugate), the anthropoid (transverse contraction), and android (in which the transverse diameter intersects the AP diameter and its posterior half), and the obliquely contracted pelvis which is often associated with orthopaedic disease (traumatic, developmental, inflammatory, etc.) of the spine, hips or pelvis. It should be noted that the descriptive terms used above (i.e. platypelloid, anthropoid and android) are best used in respect of inlet shape alone since the rest of the pelvis frequently fails to conform truly to type as implied in the earlier descriptions.

On the inlet view the ischial spines are well shown and the measurements obtained from this film are the transverse of the inlet and the ischial interspinous. The measurement of the latter involves an additional correction factor derived from the lateral view.

The AP view of the pelvis (Fig. 6). This is the routine view of the pelvis taken with the patient lying in the supine position on the X-ray table and its main purpose is to give a general impression of the pelvic structure rather than to obtain measurements. The effect of orthopaedic deformities are well shown but from the obstetric point of view the particular feature to observe is the relationship of

FIG. 6. Tracing of a routine AP view of the pelvis. The lines of the pelvic side walls have been drawn in heavy ink.

the dense white cortical lines, one on each side, which represent the bony side walls of the true pelvis. Normally these are parallel or converge only very slightly towards the outlet.

This view may be taken in pregnancy to assess the transverse diameter of the inlet in order to avoid the inlet view with its high foetal gonad dose. Used for this purpose, a measurement of under 14 cm taken directly on the film indicates a dubious inlet capacity and thus the need for an accurate assessment by the proper inlet view. Conversely, if this measurement proves to be over 14 cm no further transverse assessment of the inlet is indicated.

The outlet or subpubic arch view (Fig. 7). This demonstrates the third pelvic plane mentioned above. The subpubic arch is projected onto the film by having the patient sit on the X-ray table, legs drawn apart and leaning well forward so that the inferior ischio-pubic rami are close to and parallel to the table top. The X-ray beam is directed vertically downwards from above, centred through the sacrum. A consideration of the patient's position explains why this view is difficult to obtain satisfactorily in the puerperium and particularly so if an episiotomy had been necessary. For this reason, when possible, full pelvimetry is best delayed for at least 6 weeks after labour.

This film shows the subpubic arch which should normally subtend an angle of 90° or over: the ischial tuberosities are each represented by crescentic dense white cortical lines. Since magnification is very small in this view it is reasonable merely to deduct 0.5 cm from the measurement taken directly on the film to obtain a corrected measurement for intertuberos diameter. This view is also useful for estimating the subpubic waste space, i.e. the region immediately behind the symphysis pubis which the foetal head cannot utilize during descent. This is shown by placing a disc of 9.5 cm diameter, to represent an average foetal head, on the film so that the ischio-pubic rami form tangents to the disc and then measuring the clear space between it and the symphysis.

FIG. 7. Subpubic arch view. The semi-circle within the ischio-pubic rami represents a foetal head. E-F is the subpubic waste space (see also E-F in Fig. 3) A-B is the intertuberos diameter. C-D the line across the base of the ischial tuberosities.

(3) Interpretation of films

The necessity for assessment from both a qualitative and a quantitative standpoint has already been mentioned. The qualitative assessment is derived by examining each film for anatomical features which may prove to be a hindrance to labour in that they differ from the optimal anatomical features briefly described above.

The quantitative assessment is based on the corrected measurements which are:

Inlet conjugate	11 cm
Inlet transverse	13 cm
Pubo-sacral	12 cm
Interspinous	10 cm
Intertuberous	11 cm
Subpubic waste space	2 cm

The double assessment is particularly helpful when the measurements appear normal but the pelvic shape indicates the necessity for above-average dimensions, e.g. in a markedly android inlet the measurements can be normal but the shallow posterior segment and the wedge-shaped anterior part could still make engagement difficult. As a general rule, however, a reduction of 1 cm in any of these measurements may be compensated for by an equivalent increase in the diameter at right angles in the same plane. A reduction greater than 1 cm in any of the above, or the absence of compensation in the same plane indicates the likelihood of obstetric difficulty.

A factor only briefly mentioned is the foetal head, for clearly the functional capacity of the pelvis is its ability to pass the foetal head in question. When engaged, assessment of one of the foetal head diameters is often possible (Fig. 4) and is a valuable guide. This is usually obtained from the lateral view and is best determined when the examination is done in late pregnancy allowing 2.5 mm growth per week prior to term. Otherwise the measurements given above are those found to be adequate to pass a well-flexed average sized head having submento-vertical and bi-parietal diameters of 9.5 cm. Alternatively the foetal head may be measured by ultrasonic cephalometry when available.

Apart from the size of the foetal head, the foetal presentation and descent represent other factors which have to be considered. In antenatal examinations the foetal presentation and attitude may be seen on the film, while in postnatal pelvimetry the salient points of the labour and its difficulties, including the foetal presentation must be known.

It is thus frequently found that a difficult labour is explained in an apparently adequate pelvis by the fact that there is some malpresentation, e.g. occipito-posterior or poor flexion. In a case of an occipito-posterior presentation attention should be particu-

larly directed to the pubo-sacral and interspinous diameters. Although these do not fall on the same plane geometrically, they are sufficiently close to be considered together functionally and the latter diameter may account for poor descent and rotation in an occipito-posterior presentation.

In the case of a breech presentation and particularly in a primigravida measurements should be on the generous side before a vaginal delivery is considered as in this instance obstructed labour or the necessity for excessive head moulding would be disastrous.

Finally it must be remembered that pelvimetry assesses the bony pelvis only; it does not allow for intervening soft parts or for a laxity of pelvic ligaments (a factor of undetermined significance). Most important, it cannot assess uterine functional capacity which may be the true explanation of failure to descend in a normal presentation in a normal pelvis.

(4) The conduct of pelvimetry

Under the heading 'Clinical indications' (p. 33) it was noted that pelvimetry may be conducted as an ante-, intra- or post-natal examination. The timing of the examination will affect the number of films to be taken, while if proper consultation occurs between the obstetrician and the radiologist, a desirable reduction in the number of films may also result.

Antenatal pelvimetry prior to a breech presentation requires a full four-film pelvimetry. Antenatal pelvimetry to assess a deformed pelvis or a pelvis of doubtful capacity may omit the inlet view to avoid the high gonad dose that results when the presentation is by the vertex. The simple assessment of the transverse diameter of the inlet should be made on the AP film and the inlet view taken when this direct measurement is found to be under 14 cm. In these cases pelvimetry should be done some time after the 36th week as a cephalometry may then be obtained and there is also a check on foetal maturity.

Antenatal pelvimetry for failure to engage will inevitably be requested after the 36th week. The erect lateral film should be taken first, and it should also be made certain that the patient has an empty bladder and rectum before the film is taken. The film may now show engagement of the head; if not, the presentation and degree of flexion of the head should be observed as the explanation of failure to engage may lie here. The position of the head relative to the brim should be noted. Marked displacement backwards or forwards would suggest a placenta praevia and the appropriate examination should follow. If the erect lateral film fails to provide an explanation for the non-engagement, a cephalic measurement should be taken and the pelvic brim further examined

in its transverse diameter by means of the AP or possibly the inlet view.

Pelvimetry performed in labour to assess progress is restricted to the erect lateral as it is the only film that can reasonably be obtained and gives most of the necessary information, i.e. degree of descent of the head, its presentation, degree of flexion and the AP dimensions of the pelvis.

Post-natal pelvimetry. A full four-film examination should be obtained.

A note on the erect lateral view. This view is sometimes requested as a single check on the obstetric features of the pelvis. Whereas it must be admitted that this view is probably the most informative of the four films that have been discussed, it must also be realized that it can only assess the pelvis in its sagittal plane, and it is unwise to assume that pelvic deformities or inadequacies are confined only to this plane. It is the purpose of this note, therefore, to stress that pelvic inadequacy can occur in the transverse plane and that false reliance should not be placed on a single film in a mistaken attempt to reduce radiation dosage to the patient or the foetus (Williams, 1958).

Placentography

Using conventional X-rays two techniques are in regular use, namely arterial placentography and plain X-rays. Both can achieve high and similar degrees of accuracy in the demonstration of placental site.

The arterial technique should only be practiced by those skilled in arteriography, when it becomes only a very minor surgical procedure. The placental site can often be determined using one well-timed radiographic exposure but one source of error lies in the possibility of asynchronous sinusoidal filling so that the full extent of a marginal placenta praevia may not be shown on the one film. Another problem is the estimation of what in fact constitutes the lower segment of the uterus, a structure defined in the obstetric textbooks without reference to bony landmarks. For different approaches to the solution of this problem see Basson & De Villiers (1963) and Herlinger (1968). In spite of these possible drawbacks the procedure is, in capable hands, an excellent one.

Alternatively where skilled arteriographic help is not available, plain film techniques, well applied, can provide an invaluable service. Two approaches are possible; firstly, one may attempt to demonstrate the soft tissue shadow of the placenta using AP and lateral films. For the lateral view some form of differential filtration is necessary to reduce the high subject contrast between the posterior and anterior parts of the maternal abdomen (Highman, 1969). Alternatively, a careful appraisal of any anterior or

posterior displacement of the foetal head as it presents at the pelvic brim may be helpful (Highman, 1969). Other techniques at present in more restricted use are ultrasonic and radio-iotope scanning. Their main weakness is in the demonstration of the posterior placenta praevia but this problem is being overcome and in the appropriate centres these techniques may yet come to rival the more conventional ones.

The foetus

Radiology is now only rarely called upon to demonstrate the presence of a foetus but determination of maturity near term, the demonstration of multiple pregnancies, presentations difficult to determine clinically, foetal abnormalities and foetal death may all be valid indications for radiography.

In spite of doubts cast upon it, Russell (1969) has carefully analysed and proved the accuracy of antenatal maturation estimates.

An interesting advance in this field is the finding that oil soluble contrast media (e.g. Ethiodal, B.D.H.) injected into the amniotic fluid becomes less completely fixed to the foetal skin as the foetus approaches term (Fig. 8). This technique has been

FIG. 8. Radiograph taken 24 hr after injection of oil-soluble contrast into the amniotic sac. The limbs, back and head of the foetus are outlined. Maturity 32 weeks.

combined with a cytological method of foetal maturity estimation (Brosens, Gordon & Baert, 1969). Another advance worth recording is the use of ultrasonics either as a scan or by Doppler effect in the diagnosis of twins, confirmation of early pregnancy and in foetal cephalometry.

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