

THE DIAGNOSIS OF EARLY PREGNANCY BY
ROENTGENOGRAPHY*

BY REUBEN PETERSON, M.D., ANN ARBOR, MICH.

(From the Department of Obstetrics and Gynecology, University of Michigan)

EARLY pregnancy for the purposes of this communication may be considered pregnancy before the beginning of the sixth month of gestation. At this time usually a definite diagnosis of pregnancy can be established by the positive signs of this condition, the hearing and counting of the fetal heart sounds, the palpation of the outlines of the fetus and the recognition of its active and passive movements.

In 1921 in collaboration with my former colleague, Doctor Van Zwaluwenburg, I showed that pregnancy as early as the second month could be demonstrated by the pneumoperitoneal roentgen ray. Quite constantly it was found that the shadow of the isthmus of the pregnant uterus, or the cross section of the lower uterine segment, differed markedly from that thrown by the nonpregnant organ. Where pregnancy existed, the film shadow showed the isthmus enlarged in its long axis with marked extension into the broad ligaments.

In not a few cases the report of early pregnancy was made in the laboratory from an examination of the pneumoperitoneal film alone without previous knowledge of the history of the case or of the clinical findings. In addition through the changes in the isthmus it was possible to diagnosticate positively the presence of pregnancy in a fibroid uterus at a stage when it would not have been considered probable from the history and clinical findings.

However, in spite of our success in diagnosticating early pregnancy

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by means of the pneumoperitoneal roentgen ray, it was soon realized that the method was of little value except in the hands of those with considerable experience in the interpretation of such films. The roentgenologist as a rule had neither the time nor the inclination to acquire the technic of the method and co-operation with the obstetrician was not always possible. Again it was realized that the discomfort to the patient of the transabdominal injection of the carbon dioxide gas, even though reduced to a minimum, was enough to prevent the general adoption of this method. Moreover, since the diagnosis of pregnancy depended upon the location and extent of shadows not in themselves distinctive, as are the shadows of the fetal bones, even the expert would hesitate to make a positive diagnosis of pregnancy upon this sign alone. Thus the latter would always be a probable and never could be a positive sign of pregnancy, such as the auscultation of the fetal heart and the recognition of fetal movements and the palpation of fetal parts.

For the past year our efforts have been directed toward perfecting a technic whereby some portion of the fetal skeleton could be shown on the film at the earliest possible time after the ossification centers appear in the young fetus, that is, from the end of the seventh week, when the first center of ossification appears in the clavicle according to Hess,¹ up to the end of the third month when practically all such centers have appeared.

It is generally agreed that the positive identification of the fetal skeleton by roentgen ray is *par excellence* the most positive of all the signs of pregnancy. The other signs, even the so-called positive signs, depend upon evidence furnished by the examiner who may or may not misinterpret what he sees, feels or hears. To be sure the same might be said of doubtful fetal bone shadows but positive shadows are never in doubt, not even in the minds of the laymen, accustomed as they are to the appearance of the fetal skeleton.

Our efforts, then, have been directed to the perfection of a technic by means of which fetal bones could be shown on the roentgen film before the other so-called positive signs of pregnancy are commonly elicited. For instance, the fetal heart can usually be heard by the end of the eighteenth or twentieth week of pregnancy. At this latter period it is possible to recognize the fetal parts and movements if the uterine and abdominal walls be sufficiently relaxed. Long before this period it ought to be possible to show the outlines of the fetal skeleton if certain technical difficulties can be overcome.

Probably the reason more progress has not been made in attempts to show the fetal skeleton by the roentgen ray prior to quickening is the fact that the obstetrician and roentgenologist have not cooperated properly. Up to the present time, at least, the obstetrician has either neglected roentgenography altogether or has feared to use it in preg-

nant women on account of its effect upon the fetus. The last question has been answered practically by the results of thousands of diagnostic exposures where no appreciable harm resulted in either fetus or mother. It must be borne in mind that there is a vast difference between diagnostic and therapeutic roentgen ray dosages. Doctor Preston M. Hickey, head of the department of Roentgenology in the University of Michigan, has figured that the current for ordinary diagnostic roentgen ray work is not more than a fiftieth as strong as that used for therapeutic purposes where bad results have been reported, so far as the early embryo is concerned. He assures me, and is supported by the best roentgenologists, that there is absolutely no danger to the fetus at any stage of gestation provided the exposures be short and not too frequently repeated.

Theoretically it ought to be possible to demonstrate the fetal centers of ossification with the fetus *in utero* as early as the seventh or eighth week of gestation since this can be done with the fetus outside the uterus. Practically, there are certain difficulties always present which may postpone such demonstration until later no matter what may be the refinements in technic. The thickness of the abdominal wall of varying degrees in different women offers one difficulty. The maternal tissues are much denser than the structures of the young embryo, so that with the best of screens, with the voltage and exposure necessary to penetrate the tissues of the abdominal wall the ray may pass through the newly formed bones of the young fetus without showing them on the film. So far as fetal skiagrams are concerned this is a distinct disadvantage and unfortunate, for it is just in the cases of obese abdominal walls where the difficulties of roentgenography are enhanced or in some cases insurmountable, that the greatest difficulty is experienced in making a diagnosis of pregnancy by bimanual examination.

Again, the embryo is surrounded by amniotic fluid which may give rise to scattered radiation and offer a decided hindrance to the penetration of the ray with a tendency to fog the film.

While the sign of internal ballottement is not usually obtainable before the beginning of the fourth month of gestation, there is considerable movement of the fetus in the amniotic sac some weeks before this time. This movement of the fetus within the sac may occur at the time of taking the skiagram, which may be an additional cause of failure of fetal roentgenography in the early months of gestation. Furthermore, it may explain why success and failure are noted at apparently the same stages of gestation and with practically the same technic under seemingly identical conditions.

Up to the fourth month of pregnancy, the uterus is practically a pelvic organ. In order for the ray to reach the fetus, it must be directed in the axis of the pelvis, the plate being placed at the pelvic outlet in

order to avoid the bones of the sacrum. Thus it can be seen that the ray must not only pass through the thickness of the abdominal wall but through the soft tissues of the uterus and pelvic floor as well. This means a considerable absorption of the ray, estimated by Bartholomew² and his associates as sixty per cent.

It is one of the cardinal rules of roentgenography that the object to be filmed shall be nearest the plate. One reason for the clearness of the pneumoperitoneal films was that the pelvic organs were tilted forward by the knee-chest position so that they were nearer the plate. Attempts to use this position without the artificial pneumoperitoneum in obtaining skiagrams of the young fetus have not been successful, presumably because the organs do not fall forward without the aid of the gas. In the technic employed at present, that is, the directing of the ray from above in the axis of the pelvis the plate is quite far away from the fetal parts, which may account in an appreciable degree for some of the failures.

Since the density of the fetal structures, the amniotic fluid surrounding the fetus, the movements of the very young embryo, the tissues of the pelvis, uterus and abdominal wall, are facts necessarily unchangeable, it would seem as if better roentgenographic results could only be obtained by some change in technic whereby the plates can be placed nearer the object to be filmed. This is the problem Doctor Hickey and I are working upon now with the expectation of reporting our results later.

In the present communication we wish to report the results of twenty-two roentgenograms of pregnant patients whose gestation periods ranged from between two and three to between five and six months.

They were not selected cases but patients who presented themselves at the hospital clinic with symptoms referable to the pelvis. Some were sent in for diagnosis, others for operations such as the removal of fibroids. While it was not always possible to make a positive diagnosis of pregnancy, the latter condition was thought probable in all the cases and either absolutely proved by the roentgen ray, the fetal heart or fetal movements or the patients were demonstrated to be pregnant by the subsequent histories.

The twenty-two cases have been divided into groups according to gestation periods. Each case has been assigned to a group after a careful consideration of all data available for that particular case, such as the date of the last normal menstrual period and the position of the fundus in relation to the pubes or umbilicus. It has been felt that the gestation period could only be approximated and not definitely settled. The gestation period certainly cannot be determined by the height of the fundus above the pubes or, its relation to the umbilicus, since the size of the uterus may be influenced by too many factors such as multiparity, amount of amniotic fluid and the size of the fetus. It is also

well established that the relative position of the navel varies in different individuals which prevents its use as a fixed point to be used in establishing the gestation period through the height of the fundus. It is well known from common experience that the estimation of the probable date of confinement or the period of gestation from the beginning of the last normal menstrual period may or may not be correct. Experience is invaluable in arriving at conclusions as to the period of gestation, but the impossibility of knowing in each case the time the ovum and spermatozoon met will always prevent more than an approximate estimate of the duration of pregnancy.

Hence, the cases have been grouped not exactly but approximately as follows:

GROUP	GESTATION PERIODS IN MONTHS	NUMBER OF CASES	POSITIVE ROENTGEN-RAY FINDINGS	NEGATIVE ROENTGEN-RAY FINDINGS
1	2-3	1		1
2	3-4	8	3	5
3	4-5	6	3	3
4	5-6	7	7	
		22	13	9

The gestation periods are arranged from the beginning of a month to the beginning of the next. For example, group 1 means from the beginning of the second month, that is, from the second date when the menstrual period should have appeared to the third of such dates.

When there was any doubt about the period of gestation the case was placed in the higher rather than the lower group because we were trying to find fetal bones by the roentgen ray as early in gestation as possible. In only a few cases was it possible to check up on the gestation periods by reckoning back from the date of confinement. Even by this method errors may creep in because of the possibility of the prolongation of pregnancy, the extent of which cannot be estimated.

As would be expected the proportion of positive roentgen-ray findings increases with the advance in the gestation period. In the single case between the second and third month subjected to the ray there were negative results, as would be expected. While the ossification center in the clavicle starts at the seventh week, under the difficulties of fetal roentgenography mentioned above, probably for all time to come it will be a waste of effort to attempt to show fetal bone shadows between the second and third month gestation period. However, each case should be carefully scrutinized and if there be any doubt as to whether it should be placed in the first or second groups, it should be given the benefit of the doubt, placed in group two and subjected to the ray.

In the second group, eight in number, where the patients were from three to four months pregnant, positive bone shadows were found in three out of eight cases. In the next or third group, gestation period between four and five months, six cases in all, the findings were positive

in three or one-half of the cases. In the last or fourth group, seven cases in all, between five and six months pregnant, there were seven positive findings or one hundred per cent.

We wish here to acknowledge indebtedness to Doctors Stein and Arens,³ of the Michael Reese Hospital of Chicago for their uniform kindness and courtesy, and for their aid in our work. It was the demonstration of their success with fetal roentgenography that impelled us to take up this work. Starting with their technic the latter has been modified as our own experience increased. It is with some hesitation, however, that we report our results in this very interesting field in the light of their great experience with over four hundred cases. They state that out of these cases in only three were they sure with roentgenography of the fetus before quickening. Horner⁴ reports two hundred fifty cases in which the roentgen ray was employed in pregnancy at the Chicago Lying-In Hospital and states that his youngest fetus was of five months. He thought that the fetus could not be demonstrated before quickening. Bartholomew² and his associates as a result of roentgenography with twenty-four patients could only obtain a fetal roentgenogram from the beginning of the fifth month of pregnancy. As a result of their investigations they concluded that fetal roentgenography was uniformly negative during the third month of pregnancy or during the period here designated as group two, from the beginning of the third to the beginning of the fourth month of pregnancy. O'Donnell⁵ states that the fetus can be clearly determined from the fourth month but he does not mention cases or give his technic. In a recent article Edling⁶ gives results with early roentgenography in 19 cases which undoubtedly are the most successful of any published. His previous work in this connection has been criticised as inaccurate in that he did not give sufficient data regarding the date of the last menstrual periods or the height of the fundus. It must be remembered that Edling⁶ has had an unusual obstetrical material to draw upon as many abnormal maternity cases are referred to him for roentgenography from Essen Moeller's clinic. In the paper referred to he says he has examined two hundred seventy pregnant women by roentgenography, not as a routine but to answer questions arising from facts connected with these cases.

Even allowing for certain errors in estimating the periods of gestation, and as has been pointed out, all such estimations are likewise liable to be in error, the positive results in Edling's⁶ series of early fetal roentgenograms are very striking.

There were nineteen cases of early pregnancy examined by roentgenography with the following results: Two were under three months and were negative, as would be expected. Evidently Edling⁶ does not include these among the nineteen cases where results are as follows:

third month, 3; between third and fourth month, 7; fourth month 7; between fourth and fifth month, 4. All these save one gave positive fetal roentgenograms, certainly a remarkable showing and makes it quite imperative that Edling⁶ publish his technic in detail so that others may profit by it.

While pregnancy was suspected in all the twenty-two cases reported, the usual positive signs of pregnancy were absent except in five cases where the fetal heart sounds were heard and counted. It was absent in the eight cases in group two between three and four months gestation, present in one case in group three, and in four cases in group four. In other words, while we were quite sure the patients examined were pregnant, in only five cases except for the evidence of the roentgenogram were we positive the patients were pregnant. This is a sufficient answer to those who decry any new method of diagnosis, on the ground that the older tried methods are being pushed into the background and that soon the diagnosis of normal and abnormal obstetrical conditions will be made in the roentgen ray laboratory.

The technic used in the twenty-two cases reported varied according to the weight of the patient, the thickness of the abdominal wall through which the ray had to penetrate and the period of gestation in which it was attempted to demonstrate the fetal roentgenogram. The kilovoltage varied from 45 to 55, the milliamperage between 20 and 30. The spark gap was from 5 to 6 inches and the focal distance varied from 28 to 30 inches. Time of exposure varied from 8 to 12 seconds and double screen superspeed films were used in addition to the Potter-Buckey diagram.

While the great advantage of a positive sign of pregnancy, obtained by the roentgen ray, at a period of gestation too early to elicit the other positive signs of pregnancy should be apparent to anyone, it may not be amiss to report two illustrative cases.

The first case is that of a young unmarried woman, aged twenty-two, who came to the clinic for amenorrhea of between three and four months' duration. She denied exposure but the breasts were enlarged and colostrum could be expressed from the nipples. The cervix was softened and connected with an enlarged uterus rising halfway to the umbilicus. Neither the fetal heart, fetal parts, nor fetal movements could be elicited. The clinical diagnosis was pregnancy, nearly four months. Roentgenography showed fetal bones present. Confronted with the absolute proof of her true condition, the patient confessed exposure and subsequently was delivered at the maternity clinic at which time the approximate date of the gestation period at which the roentgenogram was obtained was confirmed.

Clinically we were quite sure this patient was pregnant but we were not positive until the fetal roentgenogram was obtained. To be sure the experienced examiner is so positive in his own mind that patients like the one in the case cited are pregnant that he makes very positive statements, but he does so without the positive signs of pregnancy being present and surely may be mistaken in his conclusions. Still he much

prefers a positive diagnosis backed by undoubted signs of pregnancy. So much so is this the case that the usual procedure is to state that he thinks pregnancy is present or that he is quite certain but that in another month, since exposure is denied, the diagnosis will be absolutely established by the presence of the positive signs of pregnancy.

The weakness in the roentgen ray sign of early pregnancy is its uncertainty with the present technic. If fetal bone shadows are shown earlier than the other positive signs of pregnancy appear, the patient is pregnant beyond dispute. However, negative findings up to the beginning of the sixth month of gestation are very far from being conclusive, as shown by our work where there were five negative roentgenographic findings out of eight patients pregnant between three and four months, as absolutely proved by their subsequent histories. However, the fact that the present roentgen-ray technic is unsatisfactory in this class of cases does not mean that there exist reasons for such failure impossible to overcome by improvements in technic.

The second case is that of a married woman of forty-four who applied to the clinic for loss of strength, prolapse, and a tumor thought to be a fibroid by her family physician. The patient had had four living children and was positive that she was not pregnant, explaining her five months' amenorrhea as due to the change of life. Examination showed the clinical signs of pregnancy between five and six months but neither fetal parts nor the fetal heart sounds could be elicited. Roentgenography showed a fetus with an estimated development of between five and six months. Although this patient had been very indignant at the suggestion of pregnancy, stating she knew from her experience more than the examiner and that her physician had sent her to the hospital to have a fibroid tumor removed, she was immediately convinced and mollified when shown the fetal skiagram.

Since roentgenography demonstrates pregnancy long before the fetal heart can be heard, it behooves the surgeon to make use of this diagnostic sign at the time of the menopause before attempting the removal of what is apparently a fibroid tumor. Many good surgeons have been deeply humiliated by discovering their mistakes after the abdomen has been opened. Furthermore, in case of such an error, it is questionable how much longer they will be held guiltless if roentgenography has not been employed prior to the operations.

CONCLUSIONS

1. Roentgenography is a valuable aid to the obstetrician in making a positive diagnosis of pregnancy before the other positive signs of pregnancy are present.
2. With the present roentgenographic technic, no fetal skiagram can be obtained before the beginning of the third month of gestation.
3. Negative roentgenography will exceed positive findings between the beginning of the third to the beginning of the fourth month of gestation.

4. At least one-half the roentgenograms should be positive from the fourth to the fifth month of gestation and all should be positive beyond this period.

5. A positive skiagram of the fetus *in utero* is proof positive of pregnancy even before the gestation period when the other positive signs of pregnancy can be elicited.

6. The reverse is not true for with present technic negative findings before the beginning of the fifth month do not mean that the patient is not pregnant.

7. Beginning with the third month of gestation roentgenography should be employed in doubtful cases as an aid to diagnosis, since with the proper technic no harm will result to either mother or fetus.

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