The Value of Angiography in the Diagnosis of Tumors of the Pelvic Cavity and the Peripheral Bones.

Shuichi Mikuriya M.D., Masao Nakano, M.D. Koyo Iida M.D. and Masatoshi Fujii M.D.
Radiology Division
Keiichi Matsumoto M.D.
Urology Division
Tatsuhiro Kasamatsu M.D. and Takashi Nakanishi M.D.
Gynaecology Division

骨髄内臓器及び四肢の腫瘍に対する動脈撮影の意義

国立ガンセンター放射線部
御厨　修一　　中野　政雄　　飯田　孔陽　　藤井　正敏
泌尿器科
松　本　恵　一
婦人科
笠　松　達　弘　　中　西　　敬

（昭和45年7月14日受付）

骨盤内および四肢の腫瘍の診断に，動脈撮影が役立ち得るかどうかを検討した．

1．動脈撮影による膀胱癌の進度分類を行なつた．進度分類はＵＩＣＣの分類に従つた．

2．この動脈撮影による膀胱癌の進度分類は，治療適応の決定に不可欠と思われる．

3．前立腺腫瘍における動脈撮影は，前立腺肥大症と前立腺癌との鑑別あるいは癌の浸潤範囲を知るのに役立つ．

4．陰茎癌，女性外陰部癌は，動脈撮影上は似かよつたパターンを示す．浸潤度判定に役立つことができる．

5．婦人科領域では，子宮頸癌，子宮体癌，卵巣癌の浸潤範囲の診断にはある程度役立ち得るが，子宮体癌，子宮筋腫および卵巣癌の鑑別診断は，子宮動脈，卵巣動脈の特異性から非常に困難な場合も多い．しかし年令や妊娠回数を考慮に入れ，さらに他の検査法と併用すれば，充分に診断に役立つものでありその意義も大きい．悪性絨毛上皮腫の動脈像は特異なパターンを示し，一見それと診断つく場合が多い．

6．直腸癌手術後再発症例の場合，直腸診断もできず，その浸潤範囲を知ることが困難であつたが，動脈撮影により浸潤範囲を知ることが可能になつた．

7．四肢の骨，軟部組織腫瘍においては，悪性腫瘍に特有な末梢血管の新生と腫瘍を栄養する太い異常な血管が出現し，良性腫瘍との鑑別が可能である．しかも巨細胞腫においては，病理組織学的には良性でも，悪性に近い血管像を示すことがある．

以上まとめてみると，骨盤および四肢の動脈撮影の意義としては，その血管像から，腫瘍の浸潤範囲をかなり正確に知り得るので，放射線治療の照射野設定および手術の適応決定の参考となり，また良性腫瘍と悪性腫瘍との鑑別診断にも役立ち得ることが判つた．

I. Introduction

The diagnostic value of angiography consists in (1) demonstrating the vascular lesion itself and (2) making use of it for diagnosis of the primary lesion by the evaluation of the secondary changes of vessels.

Included in the former category are arteriosclerosis, aneurysma, phlebeurysma, arterio-venous fistula, thrombosis and injury of vessels. Included in the latter are angiography performed to diagnose tumors or inflammatory lesions.

Pelvic and peripheral angiography mentioned in this paper are performed mainly in the case of tumors in the pelvic cavity and the limbs.

The purpose of angiography is to make differential diagnosis of tumors and to determine the area of tumorous infiltration. Several years ago, the authors reported on[1] the stage classification of carcinomas of the urinary bladder by pelvic angiography. This time we were able to make enough examinations of angiograms of prostatic tumors, something which we could not do last time because there were too few cases.

In the field of gynecology, angiography is employed in the case of cervix tumors, carcinomas of the uterine body, myomas of the uterus, cholioepithelioma and ovarian tumors.

In addition, in the case of recurrent carcinomas of the rectum and tumors of the limbs, angiography is employed.

II. Materials and Techniques

Materials investigated from the end of December 1962 to the end of November 1968 are 348cases. As for methods, translumbar abdominal aortography and Seldinger's technique are employed. A catheter is inserted through the left or right femoral artery.

In the case of pelvic angiography, a rapid injection apparatus is used. Sometimes selective internal iliac angiography is employed.

76% Urografin or 80% Conraxin are used as a contrast medium. When a rapid injection method is employed, the contrast medium is injected at a pressure of 4 to 6 kg/cm^2 under lumbar anesthesia. The volume is 40 to 60 ml.

In selective peripheral angiography, 20 to 40 ml is injected manually.

III. Angiography of Cancers of the Urinary Bladder[1)2)3)4)5)6)7)]

The stage classification of carcinomas of the urinary bladder is mentioned in UICC's clinical stage classification and presentation of results in malignant tumors of the urinary bladder. Fig. 1 is a schema representing the stage classification.

Examinations such as Cystoskopies, bimanual examinations under anesthesia and biopsies are not enough to determine the stage classification. But if the angiographic techinique is added it can be completed.

The authors now believe that angiography is indispensable in determining the therapeutic indication of carcinomas of the urinary bladder.

The stage classifications of carcinomas of the urinary bladder by angiography:

T1: The vesical artery varies from almost normal to a slightly hypervascular configuration. It shows increased newly-formed vessels or a small pooling appearance in which peripheral branches are

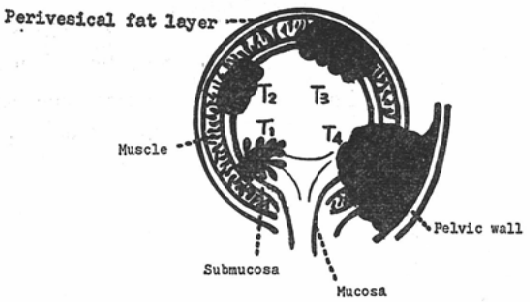


Fig. 1. A schema representing the degrees of increasing extent of the Bladder tumors

clearly demonstrated.

T2: The vesical artery is dilated, and has become hypervascular in its peripheral portion with so-called pooling or small tumor stain and obscure branches. In some cases the peripheral vessels may show marginal irregularity, that is, moth-eaten, chain or spiral-shaped in appearance. However these abnormalities are limited to the periphery of the vesical artery.

T3: Hypervascularity and marginal irregularity of the vesical artery are more prominent than those in the stage T2. Pooling and tumor stain of vessels become more remarkable. But the marginal irregularity of the vesical artery can be seen in its mid portion.

T4: 1) The vesical artery is invaded higher than its mid portion. Marginal irregularity of vessels, that is, moth-eaten, chain or spiral-shaped appearances is demonstrable. In some cases the vesical artery is unvisualized completely.

2) The extravesical invasion of a tumor is demonstrated by the angiographic findings.

Commentary 1: Tumor stain means a pooling of contrast medium; therefore it suggests the outline of a tumor.

Commentary 2: If bilateral vesical arteries are invaded in the stages T1, T2, and T3, each case is classified one stage higher, that is, in the stages T2, T3, and T4 respectively.

Schematic representations of these cases are given in Fig. 2 to 5. A pelvic angiogram of the case of the stage T1 is represented in Fig. 6. The vesical artery is dilated and its periphery shows hypervascularity. In this case selective angiography of the internal iliac artery was performed. The pathological findings of this case are shown in Fig. 7. Tumorous infiltration does not extend across the submucous layer.

A pelvic angiogram of the stage T2 is represented in Fig. 8. The pathologic findings of this case revealing tumorous infiltration with slight extension into the muscular layer are shown in Fig. 9. A case of the stage T2, in which pooling appearance and tumor stain are not demonstrated but the periphery of the vesical artery is invaded, is shown in Fig. 10.

A case of the stage T3 is represented in Fig. 11. It reveals that the vesical artery is considerably infiltrated and has become irregular. Fig. 12 shows the pathologic findings of this case. Tumorous infiltration extends deeply into the muscular layer. If changes of the stage T2 are noted in bilateral vesical arteries, it indicates that tumorous infiltration extends deeply into the muscular layer as in the case of the stage T3. Figs. 13 and 14 represent such cases.

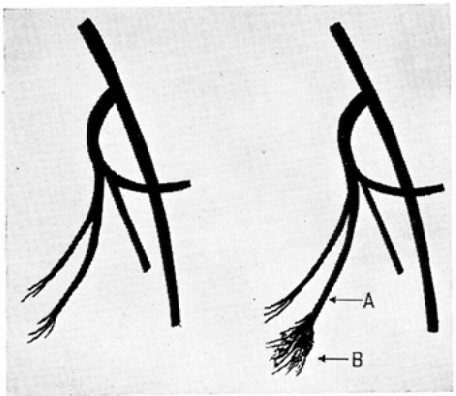


Fig. 2. A schema of angiogram on T1 in urinary bladder carcinoma.
Arrow A: Vessel nourishing the tumor are enlarged
Arrow B: Shows pooling apeparance and in it peripheral branches are appearently noted.

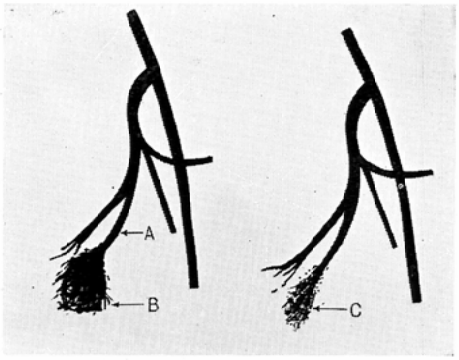


Fig. 3. A schema of angiogram on T2 in urinary bladder carcinoma.
Arrow A: Vesical artery is sometimes enlarged and hypertrophic.
Arrow B: Peripheral vessels show marked hypervascularity and pooling.
Arrow C: Peripheral vessels are invaded, and marginal irregularity of peripheral vessels is demonstrated.

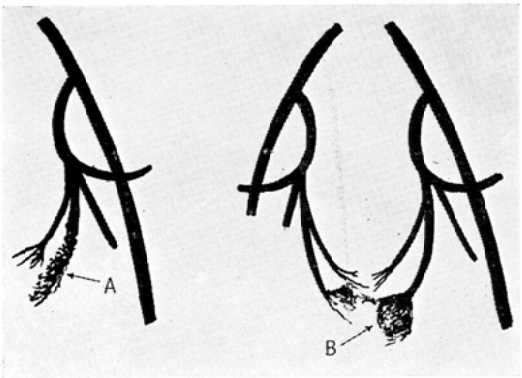


Fig. 4. A schema of angiogram on T3 in urinary bladder carcinoma.
Arrow A: Vesical artery is invaded from the periphery to its midportion, showing motheaten, spiral or chain-shaped appearance. Occasionally the periphery is unvisualized by the invasion.
Arrow B: A phase showing changes of stage T2 in both vesical artery.

Fig. 5. A shema of angiogram on T4 in urinary bladder carcinoma.
Vesical artery is invaded from its origin showing motheaten appearance or spiral or chain-shaped appearance. Occasionally they are unvisualized completely. Absence of orderly tapering in peripheral vessels is also demonstrated.

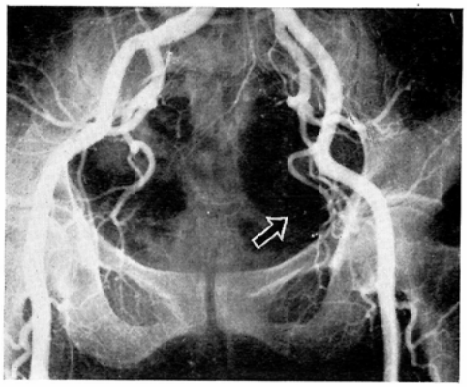


Fig. 6. An angiogram of T1
The vesical artery is hypertrophic and hypervascularity is demonstrated by arrow, but it can be well seen that peripheral branches run into it.

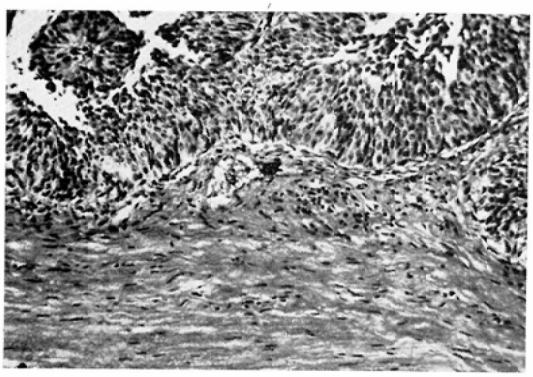


Fig. 7. Microscopic findings of T1.
A case of carcinoma of urinary bladder of stage T1. Tumorous infiltration extends to submucous layer.

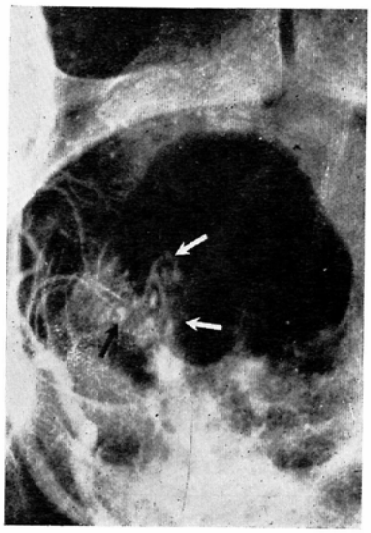


Fig. 8. An angiogram of T2.
An abdominal aortogram. A tumor stain (arrow). Peripheral branches are not clearly visualized.

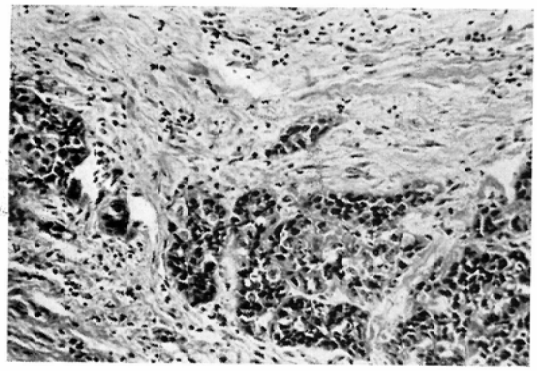


Fig. 9. Microscopic findings of T2.
Carcinoma of the urinary bladder of stage T2. Carcinomatous infiltration extends slightly to the muscular layer.

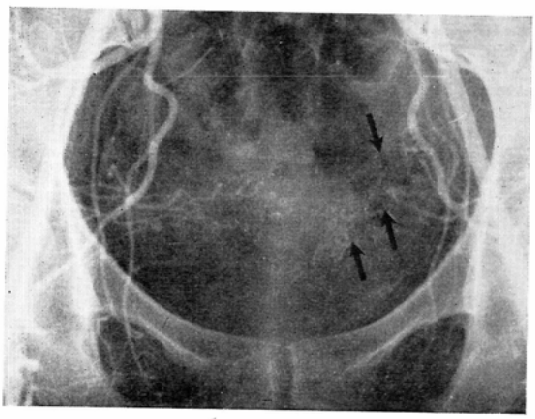


Fig. 10. An angiogram of T2.
Arrows show that the peripheray of vesical artery is included.

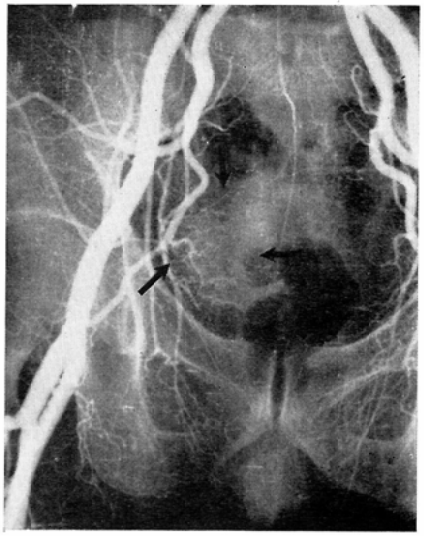


Fig. 11. An angiogram of T3.
Arrows show the invaded urinary artery. Angiogram reveals irregularity of vessels.

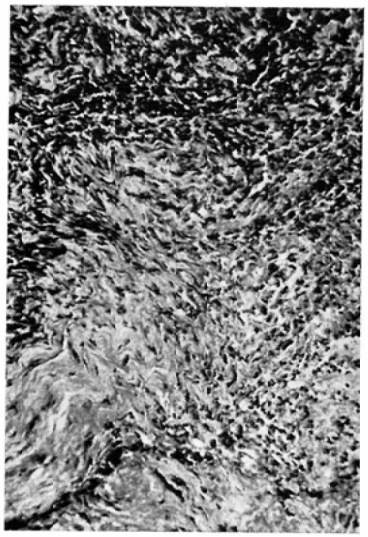


Fig. 12. Microscopic findings of T3.
A case of carcinoma of the urinary bladder of stage T3. Carcinomatous infiltration extends deeply to the muscular layer.

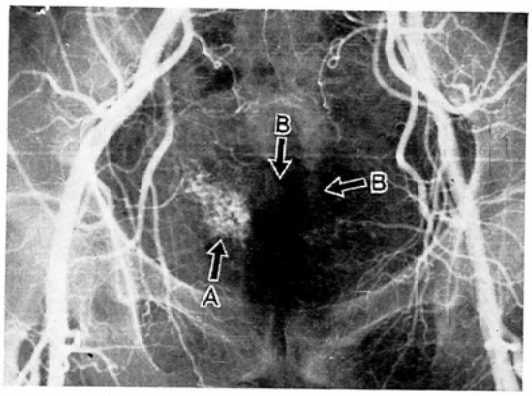


Fig. 13. An angiogram of T3.
Arrow A shows marked pooling of the right vesical artery. Arrow B also show pooling of left vesical artery.

A　　B

Fig. 14. Angiograms of T3

A: Bilateral vesical arteries are invaded. The left vesical artery is hypertrophic. The right vesical artery shows compression by a tumor.

B: A tumor stain is clear.

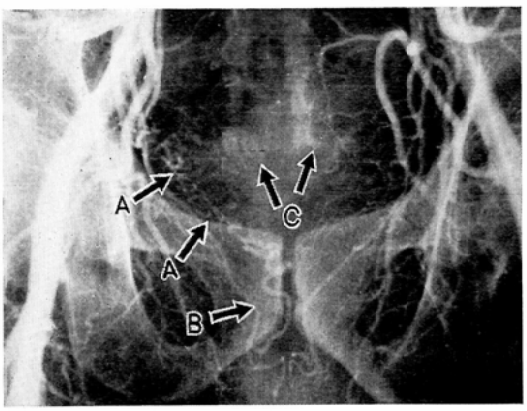


Fig. 15. An angiogram of T4.

The right artery is invaded its origin (arrow A). Collatrale branches (arrow B) from internal pudendal artery are present. Arrow C shows a pooling though it is small.

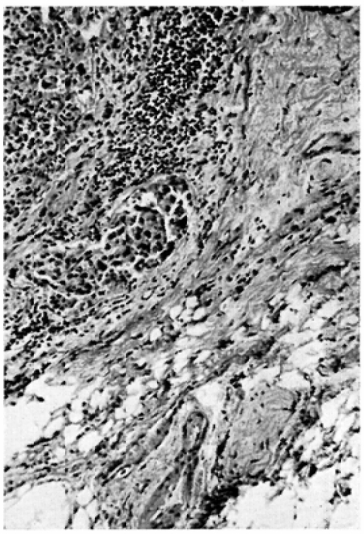


Fig. 16. Microscopic findings of T4.

A case of carcinoma of the urinary bladder of stage T4. Carcinomatous infiltration extends across the mucous membrane.

Fig. 17. An angiogram of T4.
The tumor develop toward the pelvic cavity rather than into the urinary cavity.

The case of the stage T4 is shown in Fig. 15. The vesical artery is invaded to its origin and vessels show moth-eaten, chain or spiral-shaped appearences. The pathologic findings show the infiltration of carcinoma with extension into the perivesical fat layer. In the operation carcinomatous adhesion of a part of the urinary bladder to the pelvic wall was revealed. And as represented in Fig. 17, the tumor developed toward the pelvic cavity rather than into the urinary cavity.

In these cases angiography is more useful than cystoscopic examination.

IV. Angiography of Prostatic Tumors[8)]

As examination methods for prostatic tumors, vesicourethrography, biochemical examination, digital examination and biopsy are employed. But none of these methods always gives us reliable results and

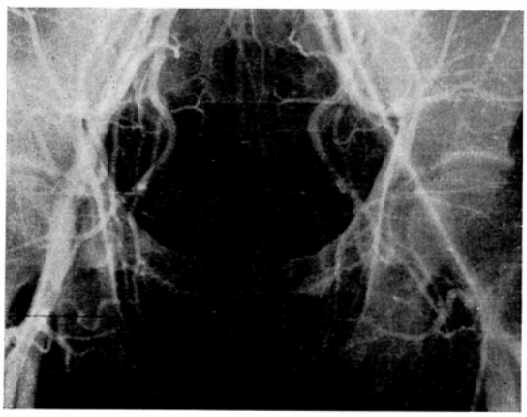


Fig. 18. An angiogram of prostatic hypertrophy.
An almost normal angiogram.

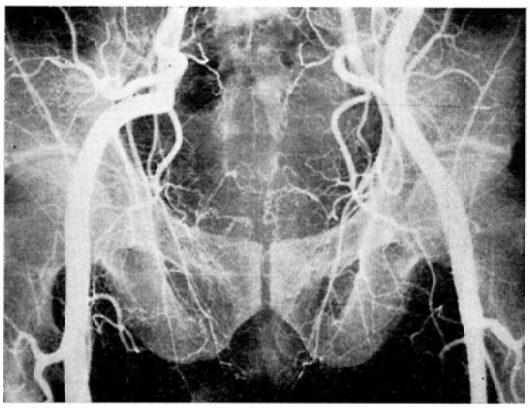


Fig. 19. An angiogram of prostatic hypertrophy.
Peripheral vessels of internal pudendal artery- and vesical artery are hypertrophic and newly formed. But no truncation of vessels is noted It is diagnosed as a benign tumor—(prostatic hypertrophy).

occasionally diagnosis is made impossible.

In such cases pelvic angiography is useful to a certain degree.

Vessels nourishing the prostate are peripheral arteries of internal pudendal arteries and vesical arteries. This region is difficult to visualize. The scarcity of literature on angiography of prostatic tumors may be due to this fact.

As shown in Fig. 18, an angiogram of prostatic hypertrophy reveals normal conditions and sometimes it is difficult to diagnose whether a tumor is present or not. Because a benign tumor grows relatively slowly and does not become very large, there may be almost-normal vessels which nourish the tumor.

Fig. 19 also shows a case of prostatic hypertrophy. Peripheral vessels of the internal pudendal artery and vesical artery are enlarged and newly increased vessels are seen. But these peripheral vessels show no irregularity of the margin of vessels such as truncation and moth-eaten appearance. Judging from these findings, the tumor may be benign. The operation revealed it to be prostatic hypertrophy. As mentioned above, angiograms of prostatic hypertrophy have great variety. Some of them show normal angiographic pattern and others show hypervascularity.

But angiograms showing no irregularity such as moth-eaten or chain-shaped appearance and no truncation are characteristic of prostatic hypertrophy.

The angiogram of prostatic carcinoma shows abnormally enlarged peripheral vessels of the internal pudendal artery and the vesical artery and truncations of vessels are often demonstrated.

Fig. 20 is a case of a relatively early stage of prostatic carcinoma showing abnormally enlarged peripheral vessels.

Fig. 21 and 22 show the infiltration of prostatic carcinoma into the urinary bladder or the spermatic sac. The vesical artery is hypertrophic to the periphery, and irregularity such as moth-eaten or chain-shaped appearance of the margin of the vessels is demonstrated.

Peripheral vessels of the internal iliac artery are hypertrophic and similar irregularity of the vascular margin is noted. Besides, the vesical artery separates into numerous branches and hypervascularity cor-

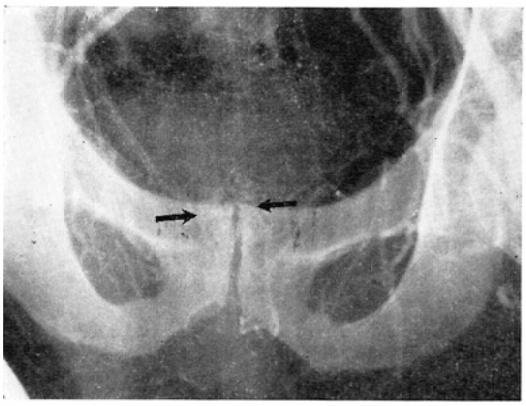


Fig. 20. An angiogram of prostatic carcinoma. Arrows show abnormal peripheray of internal pudendal artery. Vessels are hypertrophic and truncation is noted.

Fig. 21. An angiogram shows the infiltration of prostatic carcinoma to the urinary bladder. Extension of prostatic carcinoma to the urinary bladder.

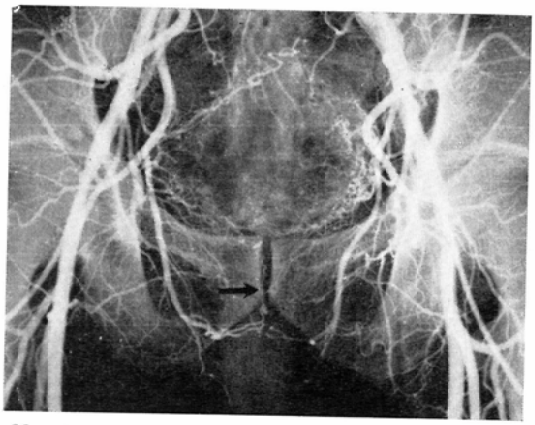


Fig. 22. An angiogram shows the infiltration of carcinoma to the urinary bladder.
A tumor stain is demonstrated. Internal pudendal artery is hypertrophic and flows into the prostate as pointed out by an arrow.

responds remarkably to the area of the urinary bladder and the spermatic sac. And tumor stain is demonstrated though it is weak. By the help of such an angiogram, one can diagnose the extension of tumorous infiltration exactly.

12 out of 16 cases of prostatic carcinomas were diagnosed by angiography. In the three cases out of four which could not be diagnosed, a translumbar abdominal aortogram was performed in the first case, in the second case visualization by method using a catheter was not enough and in the third case the primary lesion was not palpable due to hormone therapy which had been done before angiography.

V. Angiography of Carcinoma of the Penis and Vulva

The diagnostic value of pelvic angiography of these organs is limited. But it is of some value in know-

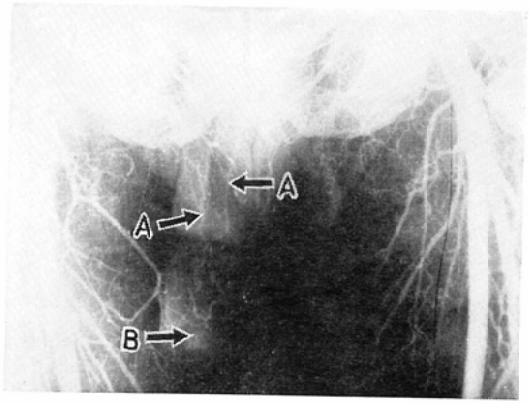


Fig. 23. An angiogram of penis carcinoma. Arrow A points to a hypertrophied penis artery. In a normal case, such an enlarged vessel is not demonstrable.

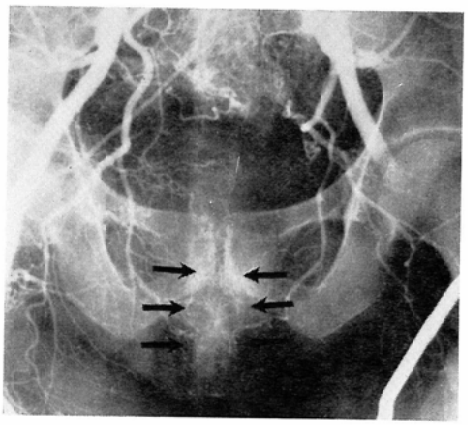


Fig. 24. An angiogram of vulvar carcinoma. Arrows show hypervascularization and pooling with truncation of vessels.

ing the extent of tumorous infiltration.

Fig. 23 is an angiogram of penis carcinoma. Two enlarged vessels originating from the internal pudendal artery flow into the penis and make small blood poolings in its periphery. These poolings correspond to the penis carcinoma. Normally such enlarged vessels are not seen in the penis. It is interpreted that these become enlarged to nourish the tumor.

Fig. 24 is a case of vulvar carcinoma showing abnormally enlarged peripheral vessels of the internal pudendal artery. Their course resembles that of penis carcinoma.

VI. Angiography in the Field of Gynecology[9)-18)]

Diagnosis by angiography in this field is difficult because uterine and ovarian arteries show some conditions that make the diagnosis difficult; Uterine arteries hypertrophy markedly and return to normal size repeatedly and atrophy gradually with age responding to the phenomena that the uterus varies in its volume with the progress of pregnancy and that the uterus atrophies and degenerates at menopause. Vascular degeneration such as sclerosis of uterine arteries resulting from repeated pregnancy varies with the number of pregnancies. And these vascular changes show much individual difference. (In our experience the time when uterine arteries develop most fully might be around 30 to 37 or 38 of age).

These are like ovarian arteries; the ovarian arteries atrophy with the approach of menopause. Therefore pelvic angiographic diagnosis in the field of gynecology must be carried out with careful consideration; besides the abnormality of vessels due to the tumors, there are vascular changes with age and individual difference which are characteristic in the field of gynecology.

Fig. 25 is the schema representing normal uterine arteries reprinted from Fernström's paper which is reported in Acta Radiologica, suppl, 122[12)].

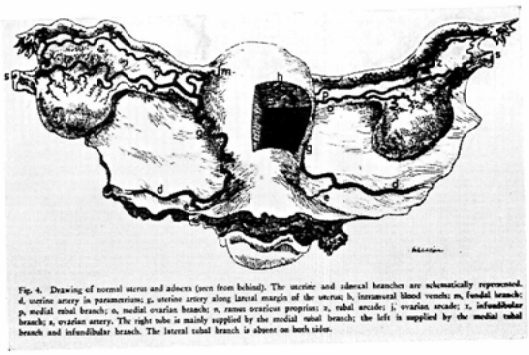


Fig. 4. Drawing of normal uterus and adnexa (seen from behind). The uterine and adnexal branches are schematically represented. d, uterine artery in parametrium; g, uterine artery along lateral margin of the uterus; h, intramural blood vessels; m, fundal branch; p, medial tubal branch; o, medial ovarian branch; n, ramus ovaricus proprius; r, tubal arcade; j, ovarian arcade; t, infundibular branch; s, ovarian artery. The right tube is mainly supplied by the medial tubal branch; the left is supplied by the medial tubal branch and infundibular branch. The lateral tubal branch is absent on both sides.

Fig. 25. A schema of normal ovarian arteries.
This is reprinted from Acta Radiological Supplementum 122, 1955.

Fig. 26 represents uterine arteries during menstruation of a normal woman aged 24.

Fig. 27 represents a 48-year-old woman with abnormal endometrial proliferation. The angiographic changes of this degree may be within normal limits.

1. Angiograms of cervix carcinoma of the uterus.

Figs. 28 and 29 represent angiograms of cervix carcinoma of women aged 30 and 38 respectively, showing hypervascularity of the cervical branches of the uterine artery.

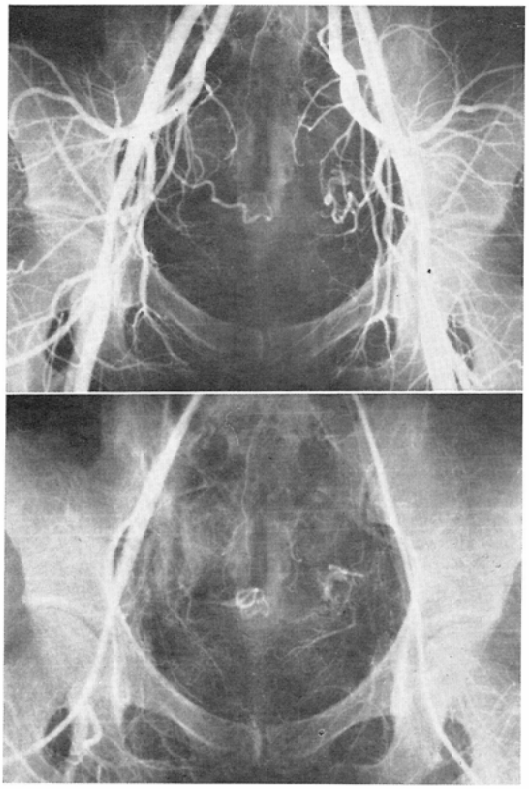


Fig. 26. An angiogram of normal married woman aged 24.

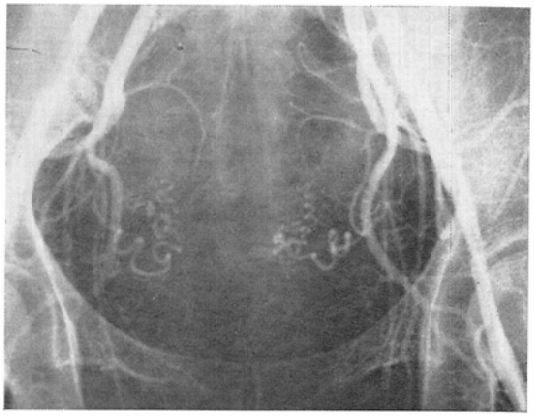


Fig. 27. An angiogram represents an abnormal endometrial prolification of the uterus.
An almost normal angiogram.

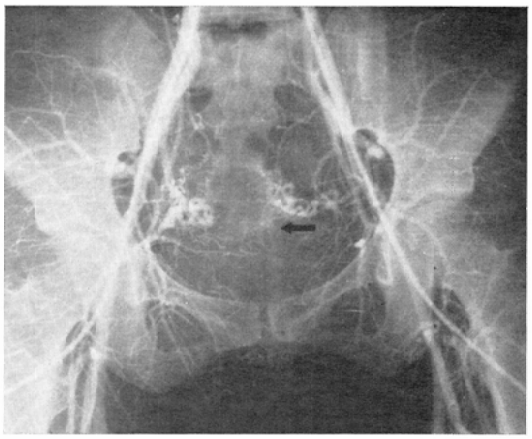


Fig. 28. An angiogram of cervix carcinoma aged 30.
An arrow shows hypervascularity of the cervical branch.

Branches of the uterine wall nourishing the body of the uterus represented in Fig. 26 to 29 would show nearly normal thickness.

Fig. 30 represents a 44-year-old woman with cervix carcinoma and myoma of the uterus. Hypervascularization of cervical branches is observed. Branches of the uterine body are within normal limits or show slight hypervascularity which is difficult to differentiate from the normal pattern.

Fig. 32 represents a case of cervix carcinoma and myoma of the uterus. The right uterine artery is shown to be almost occulted due to arteriosclerosis. Cervical branches of the left uterine artery show marked hypervascularity and tumor stains are also noted. Branches of the uterine body are considerably hypertrophic and hypervascular. They may be due to myoma of the uterus.

2. Angiograms of myoma of the uterus.

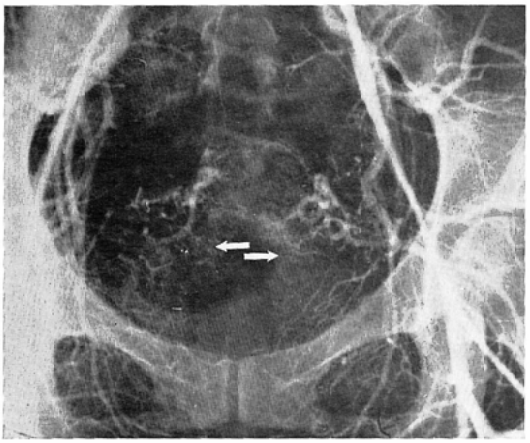


Fig. 29. An angiogram of cervix carcinoma aged 38.
Arrows show hypervascularity of the cervical branch.

Fig. 30. An angiogram represents cervix carcinoma and myoma of the uterus aged 44.
An arrow shows hypervascularity of cervical branches. Branches of uterine body looks normal but for her age the presence of hypervascularity is expected because at the age of 44 uterine arteries normally atrophy considerably.

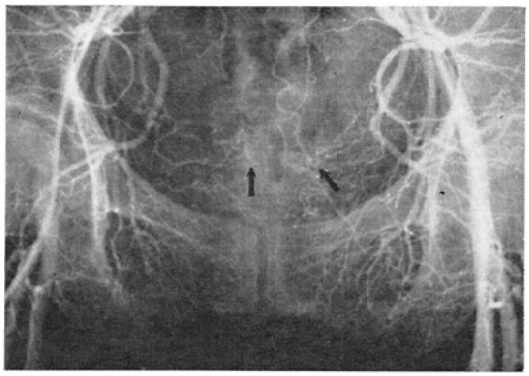


Fig. 31. An angiogram of cervix carcinoma aged 59.
Uterine artery atrophies markedly. But hypervascularity with truncation is noted (arrow).

Farinas, Borell and Fernström pointed out that uterine arteries become enlarged in a case of myoma of the uterus and that the larger the myoma, the more remarkable the enlargement of vessels. But on occasion a few cases show normal angiographic patterns in spite of the presence of myoma of the uterus.

Fig. 33 represents a case of myoma of the uterus. The abdominal aorta and the inferior mesenteric artery are compressed by a myoma of the uterus and the uterine artery hypertrophies in thickness to the size of the internal illiac artery. Gradually branches of the uterine artery are visualized and a large tumor stain is demonstrated. The tumor is diagnosed to be benign because no abnormality is found in the course of the branches of the uterine artery nor is moth-eaten appearance or truncation of chain-shaped vessels noted.

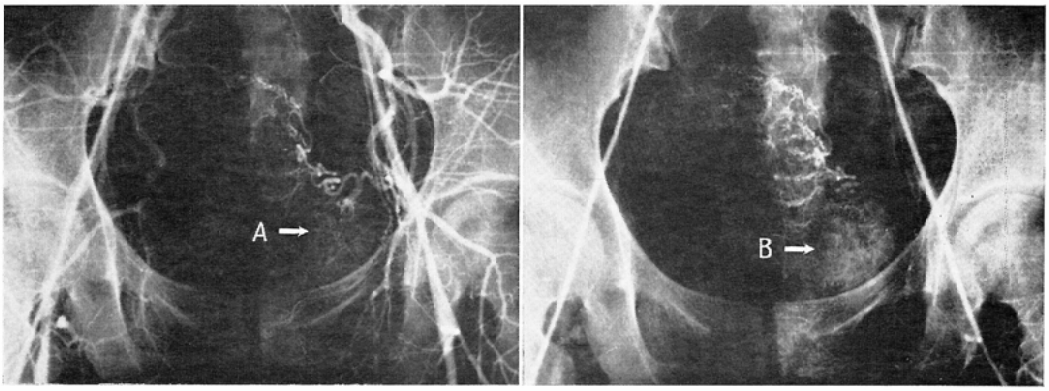


Fig. 32. Angiograms of cervix carcinoma and myoma of the uterus.
Right uterine artery is occluded. Hypervascularity of cervical branches (arrow A) and a marked tumor stain (arrow B).

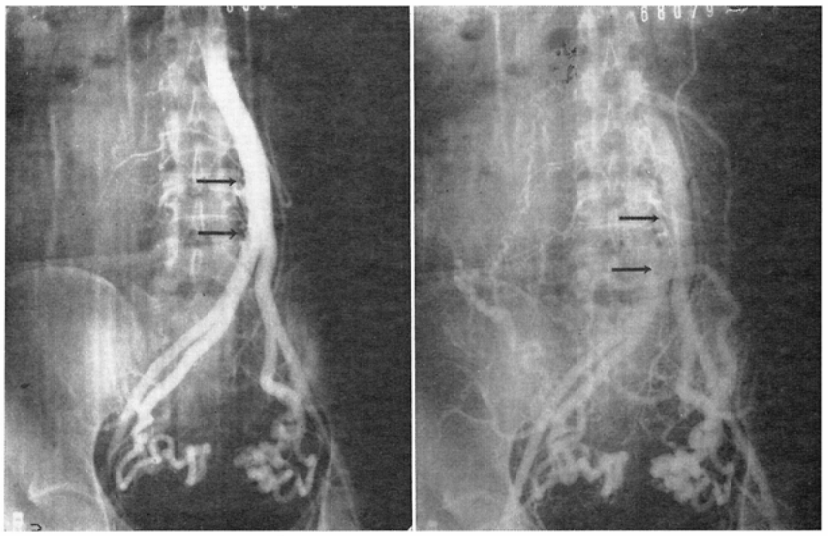


Fig. 33. Angiograms of myoma of the uterus.
Arrows show the compression of abdominal aorta by a myoma of the uterus.

Fig. 34 is also a case of myoma of the uterus. The right uterine artery is abnormally hypertropic and is compressed by a tumor. The left uterine artery is also relatively hypertrophic.

In Figs. 35 and 36 branches of the uterine body are highly vascular but in the central part vascularization is minor suggesting compression. Compression and hypervascularity are remarkable around the uterus. They are different from that of carcinoma of the uterus in which branches of the uterine body show hypervascularity with strong crooking like a corkscrew which is characteristic of carcinoma of the uterus. And a tumor stain that looks the full moon stained uniformly is demonstrated on the later phase films.

3. Arteriograms of carcinomas of the uterine body.

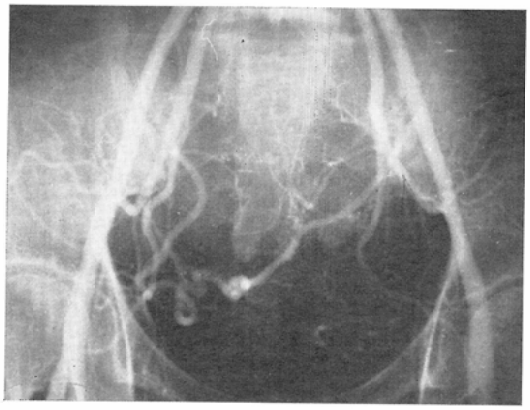


Fig. 34. An angiogram of myoma of the uterus.
Right uterine artery is abnormally hypertrophic and gives off numerous branches. All branches course gently. These findings suggest a benign tumor. Left uterine artery is normal.

Fig. 37 is a case of carcinomas of the uterine body. Uterine arteries are hypertrophic and branches of the uterine body are hypervascular toward the inner side of the uterus. With careful observation each shows strong crooking like a corkscrew. This case is not infiltrated across the body of the uterus, and a tumor stain outlining the swollen uterus is noted as the case represented in Fig. 37 B, C. Generally, young women have thicker uterine arteries than the old. Fig. 38 is a case of carcinoma of the uterine body, too. Uterine arteries are relatively atrophic but hypervascularity with purposeless arrangement and marginal irregularity of vessels is demonstrated. This case is in an earlier stage than the case of Fig. 37.

Fig. 39 represents a 57-year-old woman with relatively early stage carcinoma of the uterine body. The right uterine artery has atrophied considerably. The left uterine artery has hypertrophied and branches of the uterine body show hypervascularity which is characteristic of carcinoma of the uterine body. Compared with Figs. 37 and 38, it is obvious that this case is in the earlier stage.

4. Angiograms of chorionepithelioma.

The characteristic pattern of uterine arteries of this disease was mentioned by Borell and Fernström.

Figs. 40 A, B and 41 represent cases of chorionepithlioma showing hypertrophic arteries and hypervascularity of the branches of the uterine body. They are rich in vessels as if they had grown rapidly in a short time. And uterine arteries are more hypertrophic within the marginal portion or in the branches of the uterine body than those which run in the connective tissue around the uterus. Besides, formation of arteriovenous fistula is seen as mentioned by Borell and Fernström[18]. Serial angiograms revealed a formation of a globular shadow in the early arterial phase and a tumor stain in its later phase.

These angiograms are different from that of carcinoma of the uterine body or myoma of the uterus. And as they show characteristic patterns, they can be diagnosed at a glance.

Fig. 40 is an arteriogram showing two mentastases in the fornix vaginae.

5. Angiograms of ovarian carcinoma

Vessels nourishing the ovary are ovarian arteries and ovarian branches which are peripheral branches

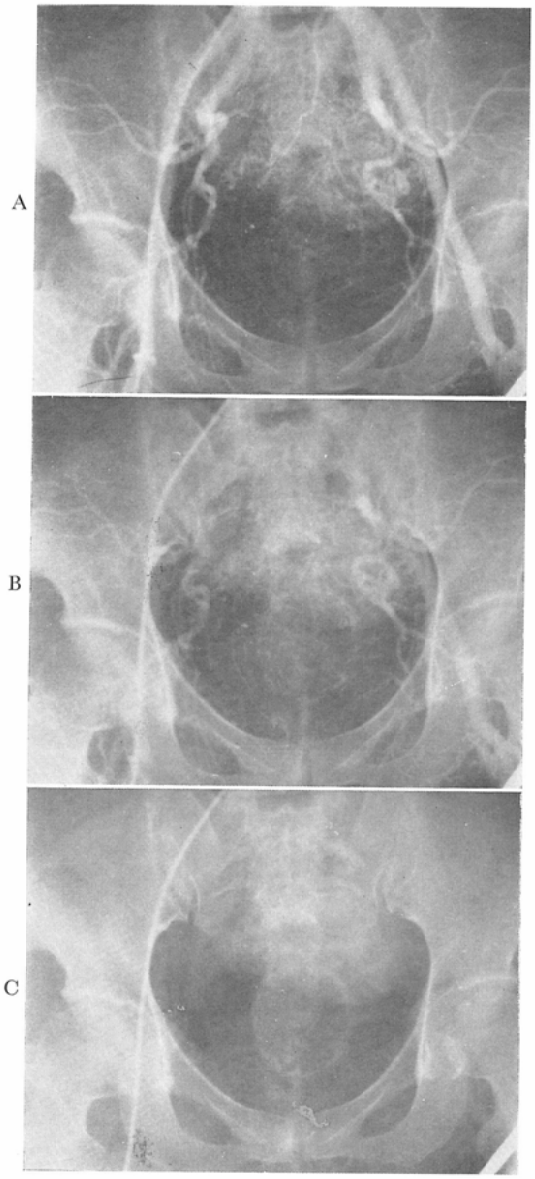


Fig. 35. Angiograms of myoma of the uterus aged 51.

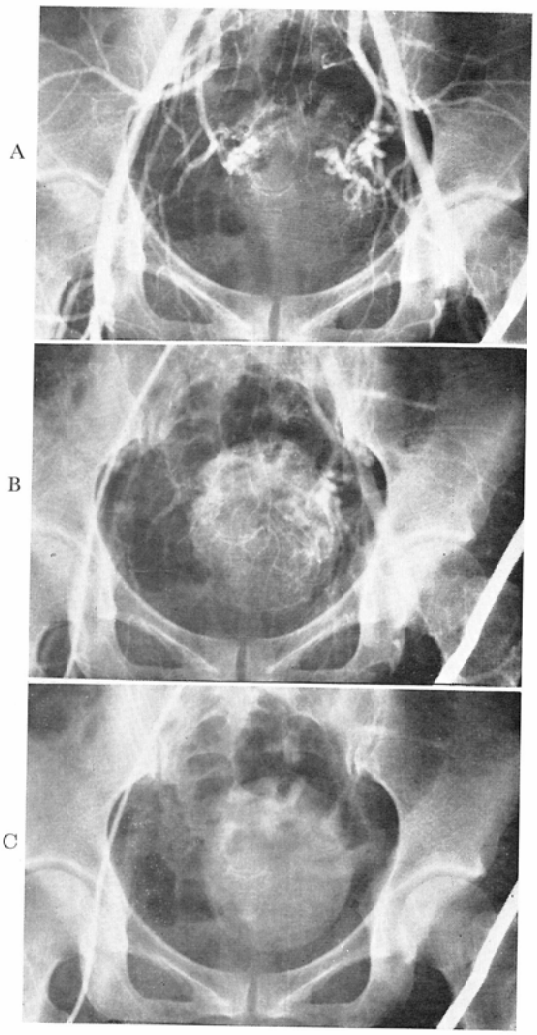


Fig. 36. Angiograms of myoma of the uterus aged 44.

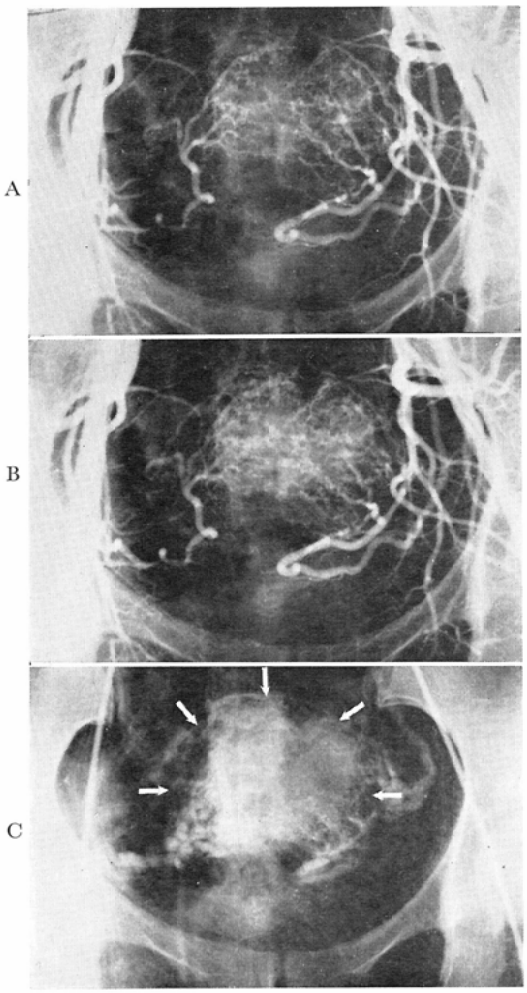


Fig. 37. Angiograms of carcinoma of the uterine bodyaged 30. Arrows (C) show a tumorstain.

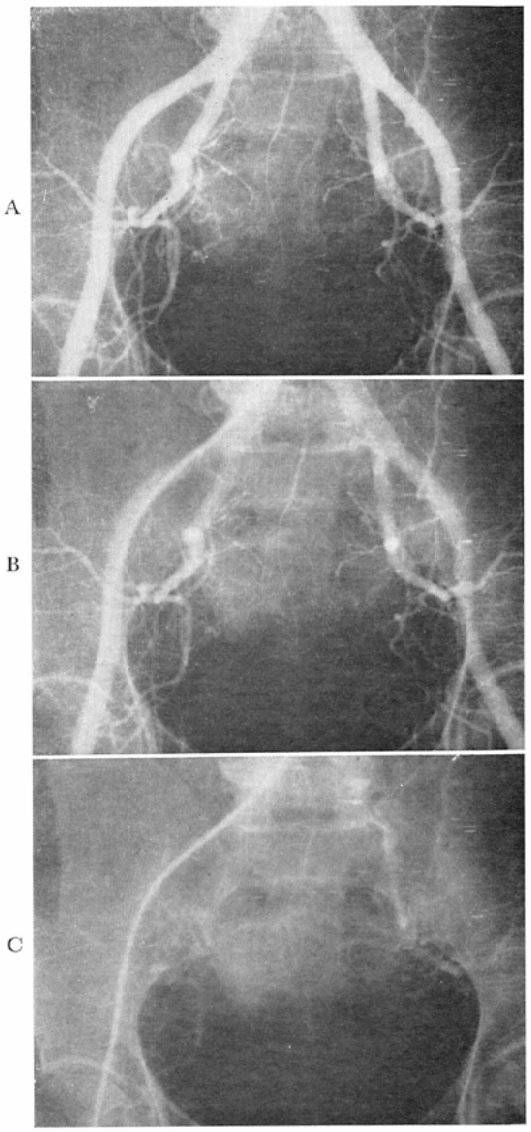


Fig. 38. Angiograms of carcinoma of the uterus. Uterine artery is highly atrophic but hypervascularity with strong crooking is demonstrated.

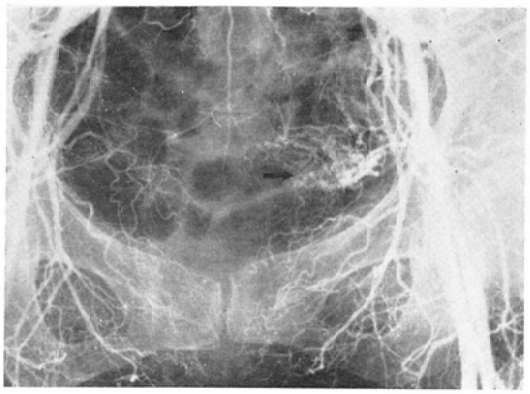
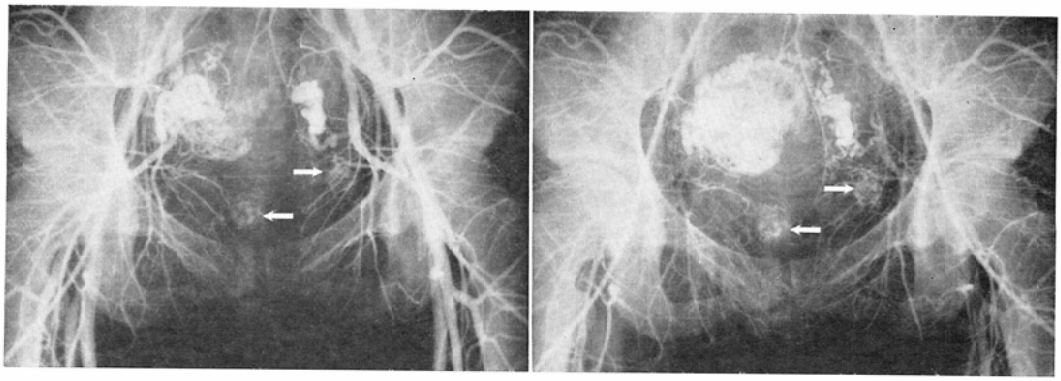


Fig. 39. An angiogram of relatively early stage carcinoma of the uterine body aged 53.
Hypervascularity of left uterine artery is present (Arrow). Right uterine artery is within normal limits though it shows tendency to slight atrophy in proportion to her age.



A B

Fig. 40. Angiograms of chorionepithelioma.
A: Branches of bilateral uterine arteries are dilated and crook strongly. Arrows show metastasis to the fornix vaginae.
B: A tumor stain is clear

of the uterine artery. It is said that in 63% of normal cases, these vessels can be visualized by aortography[13].

Fig. 42 is an angiogram of ovarian carcinoma. Hypervascularity with truncation of vessels is more noted in the peripheral part of ovarian branches than in the branches of the uterine body. In our experience differential diagnosis of ovarian carcinoma from carcinoma of the uterine body or myoma of the uterus is possible to some degree.

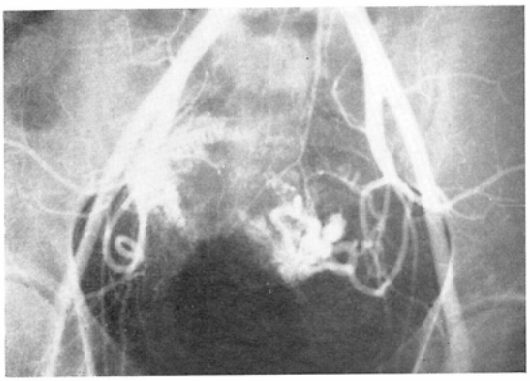


Fig. 41. An angiogram of chorinoepithelioma. Shows a pattern similar to Fig. 39. Enlarged vassels out line the tumor.

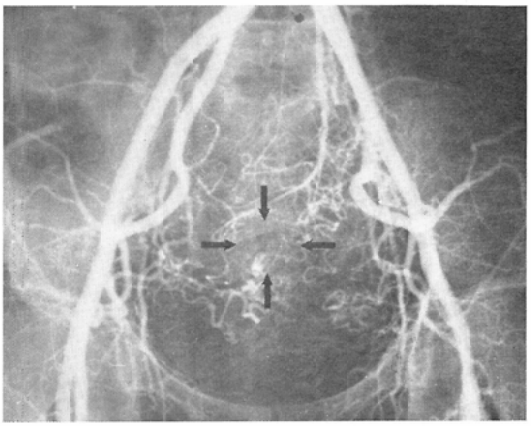


Fig. 42. An angiogram of ovarian carcinoma. Ovarian artery is not visualized. Hypervascularity with truncation is noted in the ovarian branches of uterine artery.

VII. Angiography of a Case of Recurrent Carcinoma of the Rectum

In a case of recurrent carcinoma of the rectum after an operation, digital examination of the rectum is impossible and it is difficult to know the extent of tumorous infiltration. In such cases it is difficult for radiotherapists to determine the irradiation area when they are asked to undertake radiotherapy. Pelvic angiography is occasionally useful in these cases. We have already performed it in five cases and it was useful in determining the irradiation area and for prognosis.

Fig. 43 is a pelvic angiography of carcinoma of the rectum demonstrating the extension of tumorous infiltration within the minor pelvic cavity. It is diagnosed that tumorous infiltration does not extend to

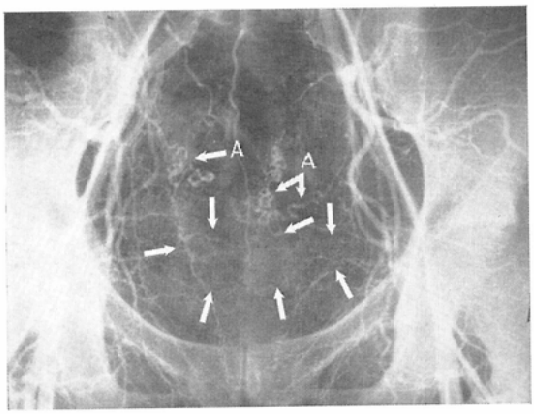


Fig. 43. An angiogram of a case of recurrent carcinoma of the rectum.

Arrow A point to the uterine artery. The area surrounded with other arrows is hypervascular and shows the invaded extent of carcinoma. Once infiltrated area is demonstrated, it is easy and exact to determine irradiation area.

the uterine artery and the vesical artery because they show no abdominal angiographic appearances.

VIII. Angiography of Tumors of the Limes[19)-22)]

The nourishing vessels of tumors of the limbs are far simpler than those of pelvic organs, therefore peripheral angiography has been employed for many years.

Sarcomas and non-epithelial benign tumors are main lesions in this field, different from those of the pelvic organs. Diagnostic values applied clinically are those mentioned below.

1. Differentiation of malignant and benign tumor is almost possible.

Fig. 44 represents a case of ossifying exostosis of the right tibia. In a case of benign tumor like this,

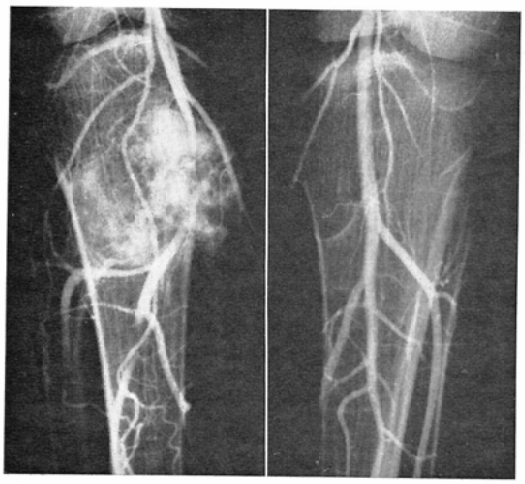


Fig. 44. Ossifying exostosis of tibia.
Compression of popliteal artery by a tumor and formation of collateral circulation ar cdemonstrated. Vessels nourishing the tumor are not demonstrated. It is possible to diagnose as benign by angiogram. To compare with normal angiographic pattern, angiograms of bilateral limbs are taken symmetrically. A cloud- shadow which looks like a tumor stain shows ossifying changes.

angiograms show compression of major arteries by a tumor with the formation of collateral circulation. But increased newly formed vessels nourishing the tumor are not noted in most cases.

But the closest attention must be paid to a benign lesion like a giant cell tumor which is rich in increased newly formed vessels.

On the other hand, in the case of a malignant tumor, compression of the major artery by the tumor is also demonstrated in most cases. Moreover., newly formed enlarged branched which nourish the tumor originating from the major artery are characteristic. At the same time, new formations and enlargement and meandering of peripheral vessels are noted. So-alled blood poolings are sometimes demonstrated.

2. Determining the degree of malignancy.

The malignancy of a tumor can usually by diagnosed by the degree of hypervascularity of the vessels nourishing the tumor and it corresponds well to the clinical course. For example, out of malignant tumors of bones, a chondrosarcoma (Fig. 45) or the like with a low frequency or metastasis to remote places in the

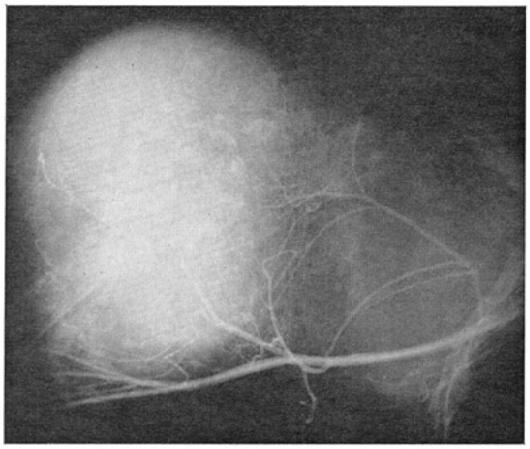
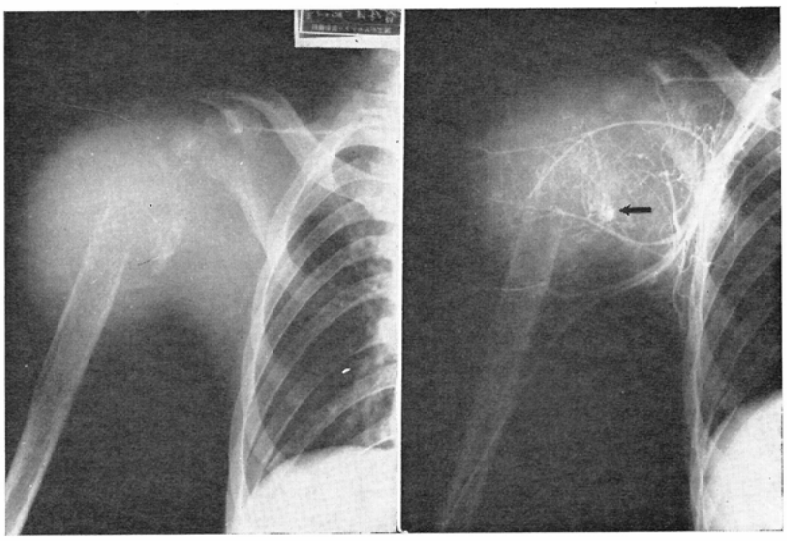


Fig. 45. Chondrosarcoma of a brachial bone head.
The tumor is big and dislocation of the shoulder joint is noted. Compression of brachial artery by the tumor is distinguished. Newly formed vessels nourishing the tumor are noted but are fewer compared with those of osteosarcoma. Low malignancy is diagnosed. The patient is alive and well two years later without recurrence after amputation.



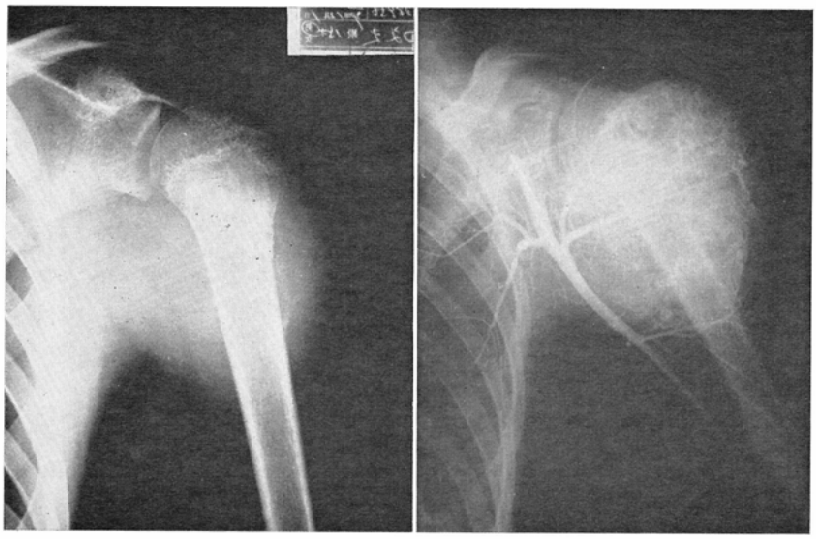
A　　B

Fig. 46. Osteosarcoma of a brachial bone.
A: Plain radiography: Osteosarcoma showing ossification.
B: Angiography: Compression of brachial artery by the tumor is distingished. Small poolings (arrow) and hypervascularization is demonstrated But they are not excessive for the largeness of the tumor. It is diagnosde to be of low malignancy among sarcomas. The patient is alive two years and later without recurrence after amputation.

early stage, which are considered tumors of low malignancy, show a not very marked new formation of vessels around the tumors, although compression of major vessels is remarkable. This malignancy depends on the kind of tumor, but also shows difference in various degree even in the same kind of tumors.

Osteosarcoma (Fig. 46) which has few with newly formed vessels, although the tumor itself is large, is considered to be of low malignancy. The patient has some possibility of living for a long time if amputation is performed.

Osterosarcoma with prominent hypervascularity extending from the peripheral part of the tumor into it is highly malignant and its prognosis is poor especially in case of bone destruction as represented in Fig. 47. Such a case has a poor outcome in a relatively early stage and the degree of malignancy diagnosed by angiogram corresponds well to the clinical course.

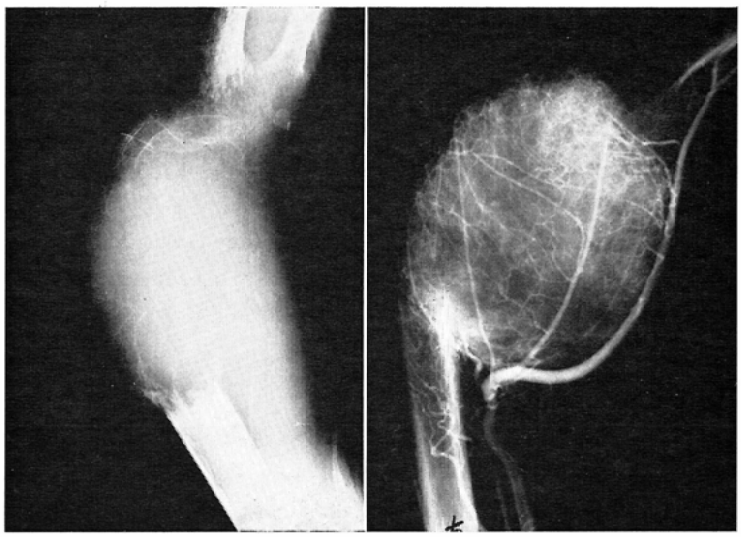


A B

Fig. 47. Osteosarcoma of a brachial proximate bone.
A: Plain radiography: The bone destruction is poor.
B: Angiography: Hypervascularity from the periphery into the tumor is noted. Diagnosed to be highly malignant. Six months after amputation metastasis to the lung was found. He died eight months after amputation. Hypervascularity in Fig. 47 is more remarkable compared with that of Fig. 46.

3. Angiographic characteristics of the kind of tumors

Giant cell tumors, claimed to have vascular origin, show a characteristic angiographic pattern rich in numerous newly formed capillaries. Especially marked hypervascularity is noted within the tumor. These giant cell tumors are also called "osteoclastoma". Bone defects are the main X-ray findings and show different characteristics compared with other benign bone tumors; as represented in Fig. 48, although hypervascularity is noted, erosion of vessels by a tumor which would be clearly noted in the case of a malignant tumor is not present. And newly formed vessels do not extend across the bone defect. These findings suggest that this tumor may be benign.



A　　B

Fig. 48. A benign giant cell tumor of the distal thigh bone.
A. Plain radiography: The bone destruction is clear.
B. Angiography: Marked hypervascularity is demonstrated. But the tumor does not jut out much from the part of bone defect. Course of newly formed vessels is gentle. Small tumorous extension for the degree of bone defect is characteristic of a giant cell tumor.

4. Angiograms of bone metastasis of carcinoma.

Carcinoma found in the limbs are metastatic carcinoma from other parts of the body in most cases. It is difficult to differentiate a solitary bone defect of a long bone caused by metastatic carcinoma from that of a giant cell tumor by bone X-ray films. But as shown in Fig. 49, in the case of bone metastasis of carcinoma, angiography reveals marked erosion of vessels by the tumor. Newly increased vessels of the marginal portion of the tumor of marked hypervascularity within the tumor which accompany a non-epithelial tumor, are not demonstrated. From this point differentiation between metastatic carcinoma and non-epithelial tumor is possible.

5. Diagnosing the extent of tumorous infiltration.

As represented in Figs. 46 A and B, angiograms demonstrate the extent of tumors far more clearly than the bone destruction demonstrated by plain radiograms. By pursuing the deformity of major vessels and abnormality of peripheral vessels, angiography is useful in determining the extent of tumorous infiltration. The above is helpful in determining the surgical area or irradiation area in case radiotherapy is proposed.

6. About the difference in angiographic patterns between carcinoma and non-epithelial tumor, especially sarcoma.

Concerning a cancer, erosion of vessels is marked in a highly progressed cancer, as mentioned before, around the carcinoma of the urinary bladder.

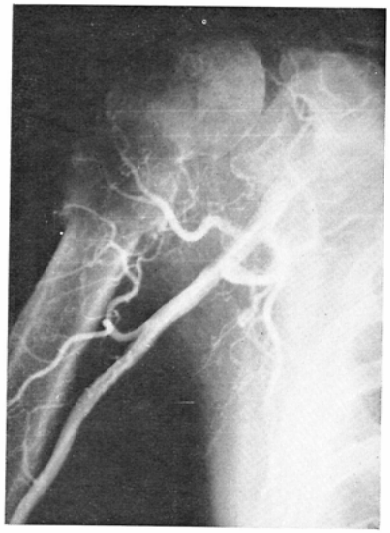


Fig. 49. Bone metastasis of carcinoma of the lung (Brachial proximate bone).
Bone defect is present. But the periphery of the vessels nourishing the tumor is not eroded. This is the characteristic of carcinoma. Plain radiogram of carcinoma is almost indistinguishable from that of a non-epithelial tumor especially that of a giant cell tumor. But with angiography it is possible to distinguish.

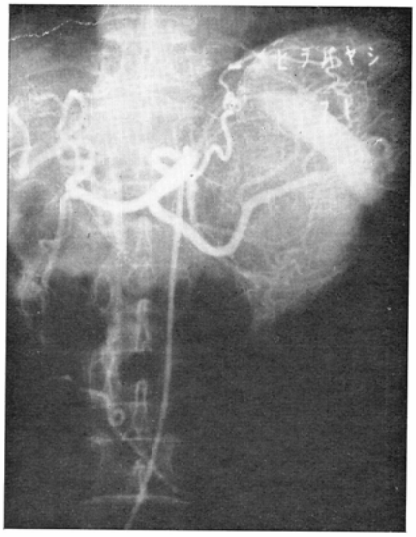


Fig. 50. Leimyosarcoma of the stomach (Selective celiac angiography).
Clinical diagnosis: Pancreatic tumor. Radiological diagnosis of the stomach: An extra-gastric-tumor. Angiographic diagnosis: A giant tumor on the side of the lesser curvature of the body of stomach, nourished by left gastric artery shows hypervascularity within the tumor. The course of vessels is just like a curled drooping willow or "Unryu" willow. The angiographic appearance shows close resemblance to that of osteosarcoma. A diagnosis of sarcoma of the stomach was made. Surgical diagnosis: Leiomyosarcoma of the stomach.

In the case of sarcoma, so-called moth-eaten appearance and truncation of vessels are not demonstrated if the tumor becomes large, though marked hypervascularity shows curling and kinking within the whole tumor.

No erosion but hypervascularity in spite of the development of the tumor is characteristic of sarcoma. These findings are useful for differential diagnosis from cancer.

Not only sarcoma of the limbs but also of other parts of the body show similar angiographic patterns. Such a case will be presented below.

Fig. 50 represents a case in which a large upper abdominal mass was palpable. Fluoroscopic examination of the stomach and gastrocamera suggested the possibility of an extra-gastric tumor such as a pancreatic tumor. Selective celiac angiography revealed that the tumor was nourished by the left gastric artery and that from the periphery of the tumor into it, marked hypervascularity was noted, which is characteristic of sarcoma as mentioned above.

A diagnosis of sarcoma was made. The operation revealed that the diagnosis by angiography was

correct. It was leiomyoma of the stomach.

IX. Summary and Conclusion

Whether angiography is useful for diagnosis of tumors in the pelvic cavity and the limbs is discussed.

(1) Pelvic angiography is widely used in the diagnosis of tumors of the male and female genito-urinary organs. Its usefulness in the diagnosis of malignant tumors was also proved in our experience. Angiographic findings which are generally shown in malignant tumors are as follows; 1. dilatation, displacement and streching of the arteries of involved organs, 2. increased vascularity of the tumor regions, 3. tumor stain or pooling of contrast material, 4. existence of tumor vessels which are characterized by a purposeless arrangement, marginal irregularity, sacular dilatation and the absence of orderly tapering as they extend peripherally.

These changes of vessels are useful in diagnosis of malignant tumors in angiography; especially, the existance of tumor vessels is the most important sign.

(2) The authors have reported on the stage classification of carcinomas of the urinary bladder by angiographic methods.

In this paper we have been able to examine and to report on many more cases than before. The stage classification depends on and UICC's classification.

(3) Angiography of prostatic tumors is helpful in differentiating prostatic hypertrophy from prostatic carcinoma or in knowing the extent of tumorous infiltration.

(4) The stage classification of carcinomas of the urinary bladder by angiography is applied clinically by the authors. It is essential to determine whether therapeutic indication is present or not.

(5) In the case of carcinoma of the penis and vulva, angiographic examination shows similar patterns. It is useful in determining the extent of tumorous infiltration.

(6) In the field of gynecology, angiographic examination is useful to some degree to discover the extent of carcinoma of the ovaries, cervix and uterine body.

But differential diagnosis between carcinoma of the uterus and myoma of the uterus or ovarian carcinoma is sometimes very difficult due to characteristics of uterine and ovarian arteries.

But if age and number of pregnancies are considered and other examinations are employed together, angiography has useful diagnostic value. Since an angiogram of chorionepithelioma has a characteristic pattern it may sometimes be diagnosed at a glance.

(7) In the case of recurrent carcinoma of the rectum after an operation, it is difficult to know the extent of tumorous infiltration because digital examination is impossible. Angiography provides us with the opportunity to demonstrate it.

(8) Concerning neoplasms of the bone and soft tissue of the limbs, malignant tumors show characteristic new formation of peripheral vessels and the appearance of abnormally enlarged vessels nourishing the tumor. These findings make the differentiation from benign tumors possible.

But angiographic examination of giant cell tumors occasionally resembles that of malignant tumors though it is diagnosed to be benign pathologically. To summarize the value of pelvic and peripheral angiography is that it is useful in determining the irradiation area in the case where radiation therapy is proposed or to determine the precise location of the operation, because it is possible to know the exact extent of

tumorous infiltration. It has also proved to be useful for differential diagnosis between malignant and benign tumors.

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