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# RENAL ANGIOGRAPHY IN UROLOGY

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ABSTRACT

Percutaneous transfemoral catheterization is a first choice for renal angiography in urology. A modification of procedure for safe and reliable arterial puncture was described. Damages to arterial wall were avoided using a modified catheterization technique with a catheter fitted to thin guide wire. There were no serious complications by contrast medium in this series.

Various angiograms of renal diseases were demonstrated with some case reports from 104 experiences. Renal angiography is of unquestionable superior value to differentiate renal tumor from other urological diseases. Especially, non-visualizing kidney is only diagnosed by renal angiography. Urological diagnosis became more accurate following the introduction of renal angiography.

## Part I. General Consideration of Renal Angiography

Recently, the clinical application of angiography has been widely used with the development of catheterization technique, and the improvement in radiographic equipment; namely, the image intensifier, television monitoring, high speed film changers, and the development of less toxic contrast media.

Renal angiography has been accepted in urology as a diagnostic method that correctly diagnose renovascular diseases, renal parenchymal lesions, and destructions of upper urinary tracts. The purpose of this paper is to investigate the safest method of the several arteriographic techniques and to emphasize the usefulness of renal arteriographic procedure in urological diagnosis.

### ADVANCES IN RENAL ANGIOGRAPHY

R. Dos Santos and his co-workers introduced translumbar aortography in 1929. They could first demonstrated the renal vessels rentogenologically. Although this method had been used frequently for many years, its use has been declining in recent years because of its relatively high mortality rate. Retrograde aortography was introduced by Ichikawa in 1938, and Farinas in 1941[1]. In case of operative procedures, by Ichikawa, which is now being used in Japen, is safer and gives distinct pictures of aorta and its branches. Peirce in 1951[2] described percutaneous transfemoral aortography using a catheter

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through a needle. With this method, Shimizu reported upright renoaortography in this Journal in 1958[3]. Although this technique could be performed without operative procedure, it was impossible to insert the large catheter for a clear angiogram.

Percutaueous transfemoral aortography was well established by Seldinger in 1953[4]. Seldinger's new method made the catheterization of aorta easier, safer, and wore rapid injection of contrast medium possible. This is the technique of choice for most patients today[5]. By the Seldinger's percutaneous transfemoral method, Ödman, Edholm, and Seldinger introduced the selective catheterization of the renal arteries using an ordinary curved-tip polyethylene catheter[6][7][8]. Selective renal angiography permits superb visualization of renal arterial system and parenchyma, occasionally renal veins, with small amount of contrast media without filling any other vessels[9]. The clinical application of the selective renal angiography has been used with accuracy and safety by the image intensifier, television monitoring, and high speed film changers.

## TECHNIQUE

*1) Translumbar aortorenal arteriography*

a) Materials (Fig. 1)

Needle: 10 cm in length, 18 gaze needle fitted with stylet.

Connecting tube: 10 cm length vinyl tube with lock tips on each ends between needle and syringe.

Syringe: 50 cc glass lock-tipped syringe guarded with metal surrounding.

b) Contrast medium

20 to 30 cc of 76% Urografin.

c) Technique

The patient, sedated with 35 mg Opistan, is placed in the prone position on a X-ray table. Under the intravenous anesthesia, the needle is inserted 4

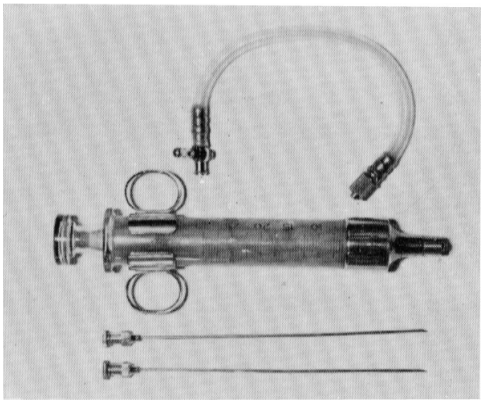


FIG. 1. Materials of translumbar method.

finger breadths lateral to the left of the back midline and just below the 12-rib. The needle is directed medially and superiorly until the aorta is approached. When the aorta is punctured the stylet is removed, then a pulsating flow of arterial blood is seen. The needle is connected to a syringe with a connecting tube. Without preliminary injection, 30 cc of 76% Urografin is injected in the aorta by manual pressure. X-ray is exposed just at the end of injection. After the removal of needle, the patient is kept in bed overnight.

*2) Transfemoral aortorenal angiogrphy*

a) Materials (Fig. 2)

Needle: Hakko's intravenous teflon needle cannula.

Outer diameter: 1.6 mm, inner: 1.0 mm.

This consists of a puncture needle with outerend teflon cannula.

Guide wire: KIFA's thin guide wire.

Flexible round-end coilspring leader with increased softness and flexibility of its distal 3 cm. Its diameter is 0.9 mm and length is 80 to 100 cm.

Catheter: KIFA's lead-polyethylene catheter.

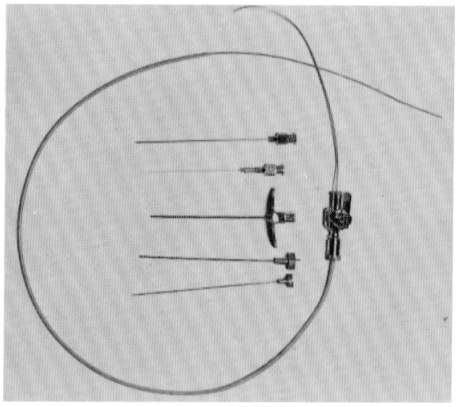
Green: Diameter is 2.4 mm.

Yellow: Diameter is 2.85 mm.

b) Construction of catheter for aortorenal angiography

Common method

KIFA's green catheter is fitted to Seldinger's needle PE 160 and thin guide wire. KIFA's yellow catheter is fitted to Seldinger's needle PE 205 and large guide wire. Catheter with guide wire inside is heated over thin flame and carefully stretched to produce a taper which will fit guide wire snugly but permit easy movement of guide wire. Tapered portion of catheter is cut by



FGI. 2. Materials of transfemoral catheterization.
A: Hakko's teflon needle cannula.
B: Seldinger's PE 160 needle.

rolling catheter on a flat surface under gentle pressure from a razor blade. Tip is then polished with emery paper. Two or three holes are made with punch under the narrow segment of the catheter. Adapter end of catheter is flanged with heated flanging tool.

Modification of common method

Using an automatic pressure injector, KIFA's green catheter gives good visualization of renal artery, but when using manual injection, visualization is poor. If there is no injector, a manual injection by the yellow catheter must be chosen. So that modification was made for the construction of the yellow catheter for manual injection and safe introduction of catheter.

KIFA's yellow catheter is heated and drawn out to produce a taper to fit to the thin guide wire. Then 3 holes, 1.5 mm in diameter, are punched just below the taper tip on either side. The side holes are constructed so that the jet of contrast media flow up toward the upper portion from renal branches of aorta.

c) Contrastmedium

20 to 30 cc of 76% Urografin.

d) Gidland automatic injector

The greatest volume is 100 cc and the greatest pressure is 10 kg/cmm with this injector[10].

e) Technique

The femoral artery is punctured with the Hakko's teflon needle cannula connected with the saline-filled syringe at an angle of approximately 50 degrees just below the level of the inguinal ligament (Fig. 4). As the artery is punctured, a flow of arterial blood is seen in the syringe (Fig. 5). The inner needle is removed with syringe (Fig. 6) and the outer cannula is left in the artery. Then the guide wire is inserted through the cannula (Fig. 7) and

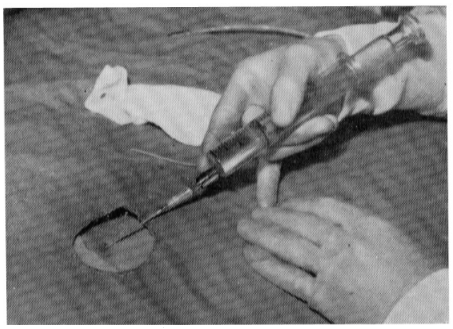


FIG. 4

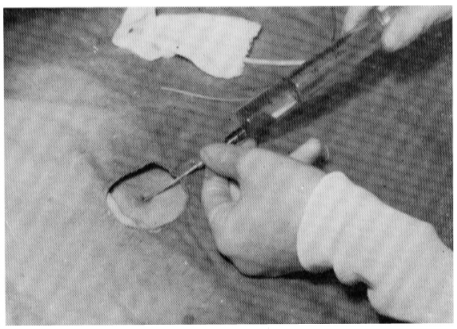


FIG. 5

Fig. 4. Needle is inserted into femoral artery.
FIG. 5. Artery has been punctured. Blood pulsating back into saline-filled syringe.

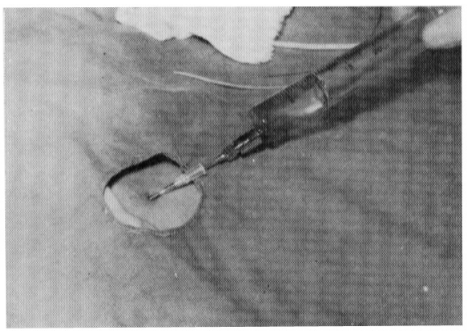


FIG. 6

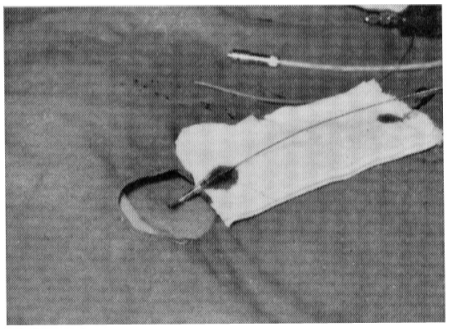


FIG. 7

FIG. 6. Inner needle is being removed with syringe.
FIG. 7. Guide wire is passed into artery through cannula.

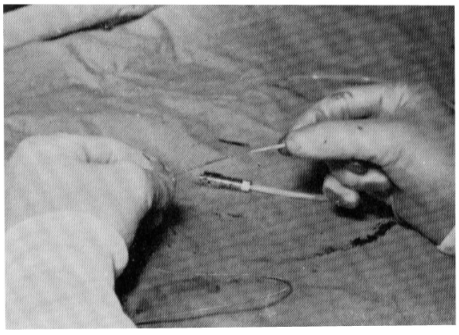


FIG. 8

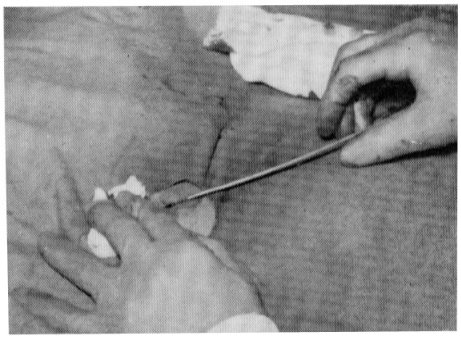


FIG. 9

FIG. 8. Catheter is passed over guide wire.
FIG. 9. Catheter is passed over guide wire and into artery.

pushed up the femoral artery and the aorta until its tip is well above the renal artery. Portion of the guide wire is searched on film or fluoroscopic monitoring. The puncture cannula is removed and a catheter is advanced over the guide wire until the guide wire appeared from the proximal end of the catheter (Fig. 8, 9, 10). The catheter and guide wire are then advanced together, leaving approximately 5 to 7 cm of the guide wire ahead of the catheter to act as a guide. After the catheter is advanced to about the level of the first lumbal vertebra, the wire is removed and the catheter is flushed periodically with physiological saline solution with Heparin so that clotting does not occur in the catheter tip or side holes (Fig. 11).

Fifteen to 25 cc of 76% Urografin is injected through the green catheter at a pressure of 4 to 5 kg/cmm by Gidland automatic injector (Fig. 12). When the injector could not be used 20 to 30 cc of 76% Urografin is injected through the yellow catheter by manual pressure. X-ray picture is taken at the end

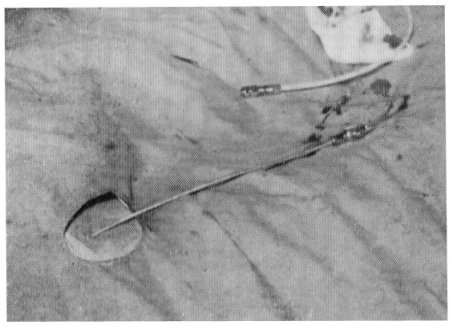


FIG. 10

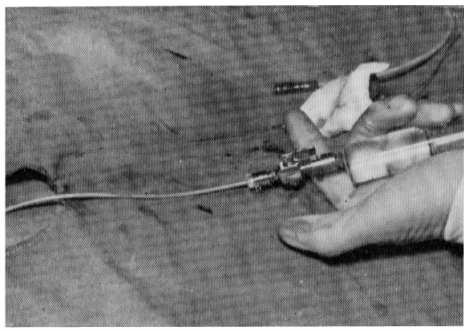


FIG. 11

FIG. 10. Catheter in artery.
FIG. 11. Catheter is flushed with saline.

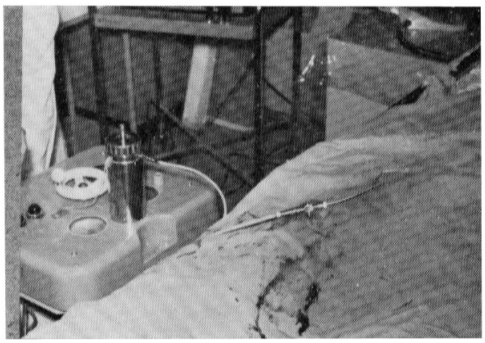


FIG. 12. Catheter is connected with Gidland's automatic injector.

of injection.

If upright aortorenal angiograms are required, X-ray table is rotated 60 degrees. After the preparation, a second film is made. Following withdrawal of the catheter, a manual pressure is applied to the puncture site for 10 to 15 minutes and then a pressure bandage is applied over the femoral artery to prevent blood leakage from the puncture site. The bandage is removed after 12-hours.

3) *Selective renal angiography.*

a) Materials

Needle: Hakko's teflon needle cannula.

Guidewire: KIFA's thin guide wire.

Catheter: KIFA's green catheter. The end of the taper-tip catheter is curved by immersing in hot water and cooling in cold running water. Its curve becames straight when a flexible guide wire is introduced into the lumen (Fig. 3).

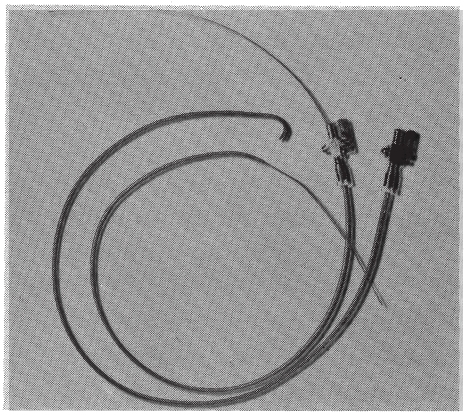


FIG. 3. Catheter for the selective angiography.

Image intensifier: Shimazu or Toshiba's 6 inch television monitor.

Film exchnger: Elema-Schonander's cut film change type angiotable for film size $10 \times 12$ inches.

b) Contrast medium

60% Urografin: 5 to 10 cc.

c) Technique

The guide wire is placed into the artery with the preceding method. When the curved tip catheter is inserted over the guide wire into the artery, its curve become straighter and then the guide wire and catheter are advanced into the aorta to the level of the renal artery. After the guide wire is removed, the bent catheter is placed with its tip toward the lateral wall of the aorta and moved upward and down ward along the aortic wall under fluoroscopical control using the image intensifier. When it reaches the renal artery ostium, the tip of the catheter moves outside of the lateral border of the aorta. Injection of 1 or 2 cc contrast medium under fluoroscopic observation permit the examiner to determine whether the tip is in the renal artery or not. The injection of 5 to 10 cc of 60% Urografin is made manually or by Gidland automatic injector with 1.5 kg/cmm pressure. X-ray picture is taken at a rate of 2 films per second for the first 3 seconds, and then 1 film at each 6, 7, 8 and 9 seconds from the beginning of injection.

## COMPLICATION OF ANGIOGRAPHY AND ITS PREVENTATION

*A. Technical complications and its preventation*

1) Percutaneous transfemoral method

McGraw reported five major complications in 372 percutaneous transfemoral catheterization. There were 5 deaths, 3 cases of arterial occulsion, a case of false aneurysma, and a case of penetration of the aortic wall[11]. A survey in

11402 retrograde percutaneous arteriography by Lang in 1963 encountered 7 deaths, 81 serious complications, and 325 minor complications[12)13)]. The mortality rate was 0.06 per cent. The incidence of serious complication was 0.7% and of minor complications was 3.0% respectively.

Hematoma and hemorrhage

Bleeding from the puncture site is unavoidable on the percutaneous arteriography. Especially, bleeding may be troublesome in hypertensive and suburemic patients. During catheterization, there is a little leakage because the catheter is a "tight fit" at the puncture hole. After the catheter was removed, it is most important to exert firm pressure on the artery until all leakage is stopped and then to keep patients in bed overnight. Three cases of hematoma in suburemic patient was observed in this series but no aneurysma was found.

Damage to arterial wall

Elevation and dislodgement of an atheromatous plaque and subintimal dissection by the guide wire or catheter has been reported as complication of retrograde aortography[14)]. The commonly recommended procedure was to pass the guide wire only a short distance into the femoral artery and to advance only the catheter over the tip of guide wire in the artery[4)5)], but the catheter is too hard for the soft arterial wall. If the soft guide wire is used to guide the catheter until the desired level to the abdominal aorta, subintimal injection and perforation of arterial wall would be prevented. With this procedure the operator could readily detect any resistance to its passage and then, if necessary, stop the procedure at this point before causing any damage. Using this technique, the author stopped the procedure three times and has never encountered vascular damage.

2) Translumbar technique

McAfee's survey in 1957 reported that the mortality rate for translumbar arteriography was 0.28%[15)]. There was no death for this technique in this series. Bleeding after translumbar puncture cannot be prevented as McAfee found 13 cases of serious bleeding from the aortic puncture site in his survey of 12832 translubar aortographies. Intramural injection of contrast medium usuary is not serious. In most cases, the contrast medium is quickly expelled into aortic lumen with no harmful results. But occasionally aortic dissection occurred as a result of the intramural injection and following dissecting aneurysma of aorta, mesenteric or renal artery occulsion (to death). Intramural injection occurs when the tip of the puncture needle lies partly within the aortic lumen but partly overrides the aortic wall[16)17)].

*B. Toxication of the contrast medium*

1) Nephrotoxity

Renal damage due to contrast medium occurs to some degree in all aortography. Animal examination revealed renal damages after the injection of

contrast medium into the renal artery. Most manifestations are albuminuria and microscopic hematuria[18)19)]. Occasionally, elevation of blood urea nitrogen was obserbed but these were reversible changes. There were many reports for renal damage resulting from renal angiography[20)~24)]. Most of them used former types of contrast medium which were considerably more toxic and irritating than the medium available today[25)26)]. Now, up to 2.5 cc per kg body weight is injected in this series of multiple injection without any complication[27)28)]. Elevation of blood urea nitrogen following aortography in suburemic cases had returned to previous levels after 10 days. Double injection of 30 cc of 76% Urografin has not left any trace of renal damage. In order to reduce toxic reaction, it is now thought that adequate hydration of the patient before the procedure and administration of mannitol or 5% glucose for diuresis after aortography is necessary[29)]. If the patient has high blood urea nitrogen, Pereston N is used because it is effective.

2) Others

Allergic reaction for contrast medium is prevented by precautionary test injection.

Other complications of aortography are neurologic damage and gastrointestinal complication due to the contrast medium[30)~33)]. But they are not encountered with the new contrast medium.

## DISCCUSION

Translumbar aortography has many disadvantages. In translumbar method, position of the patient is only prone and changes of his position is not desirable. The position of tip of the puncture needle cannot be recognized without a test injection of contrast medium. Intramural and para-aortic injection may occur. There can be no control of bleeding from the aortic puncture site. Repeated puncture and injection are not desirable[34)].

The main complications of transfemoral method are penetration of arterial wall and dislodgement of atheromatous plaques which may cause formation of emboli. These disadvantages are prevented with the author's procedure. In Seldinger's original method, it is not known if the artery is punctured or not until withdrawal of the stylet, so that it may happen that the needle is inserted through the artery and repeated wastful punctures may be done. Using our procedure, when arterial puncture is done, immediately blood flowing back is seen. If deep insertion of the needle is desired, only the outer teflon cannula is pushed into the artery. The teflon cannula is very flexible, so that arterial damage is not made by the cannula. KIFA's large guidewire is very hard but KIFA's thin guide wire has such a soft tip that atheromatous plaque will not be dis lodged[35)].

Selective renal angiography demonstrates good visualized renal arterial

system with small contrast medium. But origin of the renal arteries and aberrant vessels are not seen clearly. So aortography should be taken prior to selective renal angiography[36].

## Part II. Renal Angiography in Urological Diseases

Diagnosis in urology is more exact than other fields. This is due to application of excretory urography, retrograde pyelography, retroperitoneal pneumography, renogram, and renoscintigram. But there are many diseases that are not clearly defined by conventional methods of urologic diagnosis; for instance, on the roentgenographic non-visualizing kidney it is impossible to cathetheterize through the ureter by retrograde method. Retroperitoneal pneumograms and renoscintigrams gives insufficient information to differentiate hydronephrosis, renal cyst, renal tumor, renal malformation, and renovascular disease. Surgery was the only procedure before the era of renal angiography. Aortorenal angiography, especially selective renal angiography, made possible accurate preoperative diagnosis of such cases[37)~41)].

The following case reports show that renal diseases were not clearly defined by conventional diagnostic radiographic studies and established exact diagnosis by renal angiography. Our experiences of renal angiography began in 1953, and over 100 angiographies have been performed during the past 4 years. Table 1 shows the distribution of 104 angiograms regarding methods and diseases.

TABLE 1

| | Translumbar Aortogram | Transfemoral Aortogram | Selective Renal Angiogram |
|---|---|---|---|
| Renovascular disease | 5 | 14 | — |
| Nephroptosis | 1 | 14 | — |
| Renal agenesis or hypoplasia | 3 | 7 | 1 |
| Horseshoe kidney | 3 | 2 | — |
| Renal tumor | 6 | 5 | 10 |
| Renal cyst | — | 3 | 3 |
| Polycystic kidney | — | 3 | 1 |
| Hydronephrosis | — | 7 | 3 |
| Pyelonephritis | — | 2 | 1 |
| Renal tuberculosis | — | 5 | 1 |

### RENOVASCULAR HYPERTENSION

In 1934 Goldblatt, *et al.* described the hypertension after constriction of the renal artery. There after, many reports have confirmed a concept of renovascular hypertension. In recent years, physicians feel that hypertension

TABLE 2. Urological Examinations for Renal Hypertension

1. Urographic abnormalities[48)49)]
   a. Unilateral delayed appearance of contrast medium on rapid sequence pyelogram.
   b. Unilateral delayed excretion of contrast medium on Mannitol wash-out test.
   c. Unilateral reduction of longitudinal diameter of kidney.
   d. Nonvisualizing or minimally functioning kidney proved urographically normal by retrograde pyelography.
2. Renogram[50)~53)].
   a. Unilateral delay in excretion of the radioisotoped Hippuran.
   b. Unilateral diminished and delayed excretion of the radioisotoped Hippuran.
3. Separated renal function studies[54)~58)].
   a. Decreased urine volume and Na concentration in affected kidney.
   b. Increased concentration of urine creatinine.

due to renal and renal artery diseases is treatable[42)]. Many investigators revealed that hypertension prssure due to renal artery stenosis and renal disease could be reduced by removal of the arterial constriction or removal of the affected kidney[43)44)45)]. Various examinations have been taken for diagnosis of renovascular hypertension (Table 2). Renal arteriography accurately

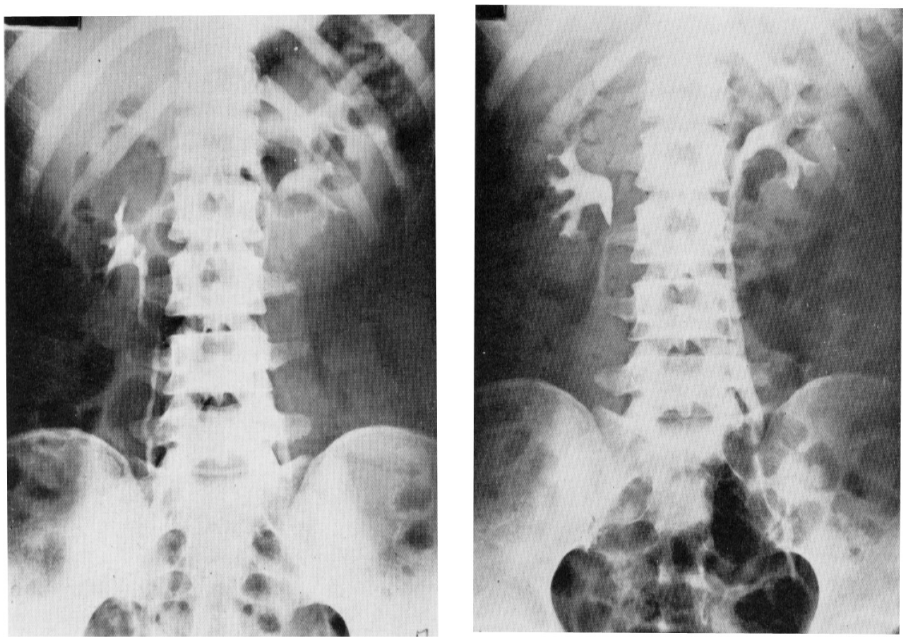


FIG. 13 (Case 1). Renovascular hypertension. Left: Excretory urogram shows hyperconcentration of the right small kidney. Right: Postoperative urogram revealed that hyperconcentration was corrected and mass of the right kidney inceased.

demonstrates the renal artery diseases and is useful for the follow-up study after the surgical correction[46)47)].

*Case 1*

A 23 years old woman admitted to the hospital with a 3 years history of occipital headache and back pain. She was found to have a blood pressure of 160/100 mmHg in summer of 1964. Intravenous urograms showed a smaller and hyperconcentrated right pelvis (Fig. 13). Regitin test was negative. Physical examination revealed only a bruit heard in right flank. Urinalysis and blood chemistry were normal. Transfemoral aortogram showed a stenosis of the right renal artery and dilatation of the upper abdominal aorta (Fig. 14). Renogram and renoscintigram showed decreased blood supply to the right kidney. Separated renal function studies revealed decreased urinary volume and Na concentration and increased creatinine concentration in the right side. Aorta and right renal artery were by-passed with teflon graft. During 15-months after operation the blood pressure continues at nomal level, being 120/60 mmHg. Follow-up renal arteriogram is shown on Fig. 15. Intravenous urogram after operation showed enlarged right kidney and corrected hyperconcentration

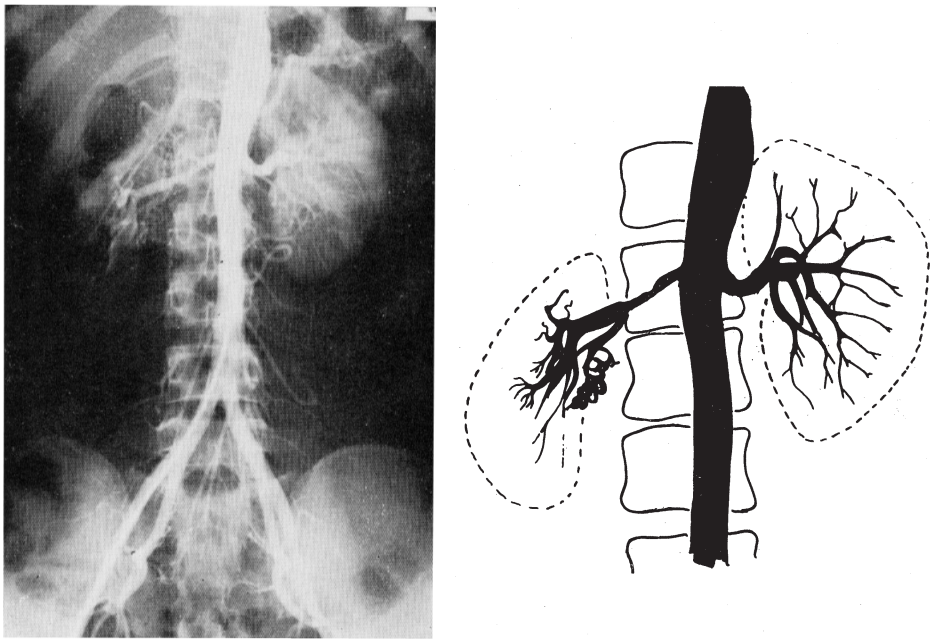


FIG. 14 (Case 1). Aortography shows a stenosis of the right renal artery and dilatation of the upper abdominal aorta.

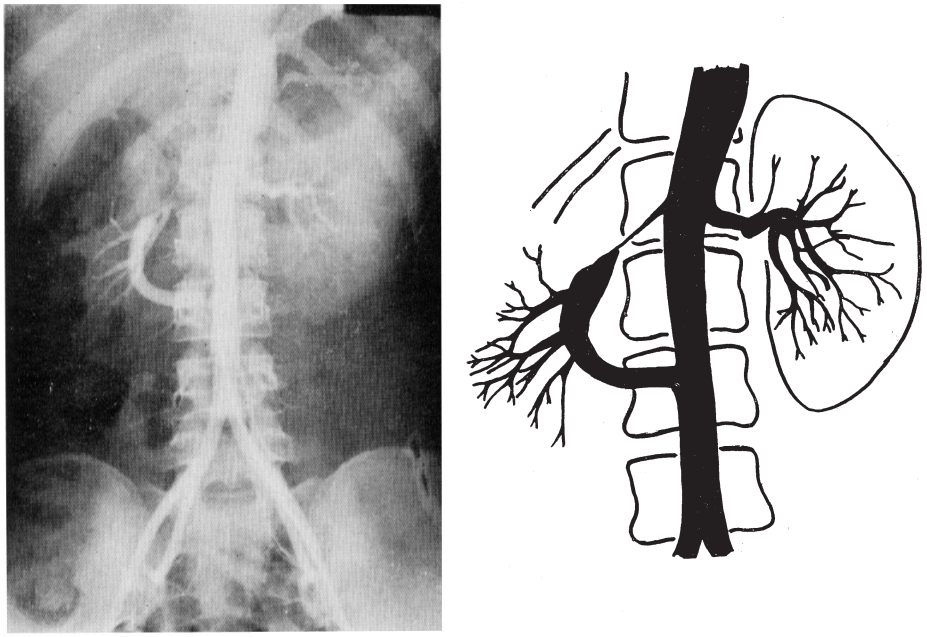


FIG. 15 (Case 1). Aorto-renal by-pass grafting on the right side is showed on the follow-up aortogram.

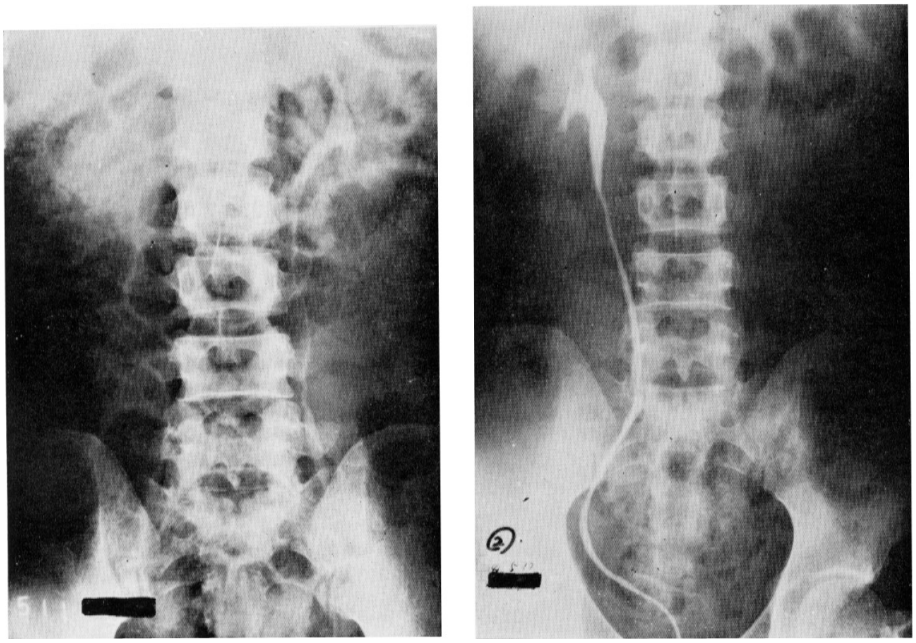


FIG. 16 (Case 2). Renovascular hypertension. Left: The right kidney is not visualized on the urogram. Right: Retrograde pyelogram revealed non-destructed pelvicalyceral system on the right side.

of the right side (Fig. 13).

*Case 2*

A 34 years old man had a 9 years history of frontal headache and high blood pressure of systolic over 200 mmHg. Six months prior to the admission, he had left paraplegia after a cerebral bleeding. During his hospital admission, the blood pressure at rest had been 260/140 to 220/120 mmHg. Blood urea nitrogen was 45 mg/dl. He was emotionally unstable and often combative. Hemogram and urinalysis were normal. A systolic bruit was heard over the mid-epigastrium. Intravenous urogram showed that the right kidney was non-functioning and the left kidney had poor function. Right retrograde pyelogram revealed small right pelvis with normal shape (Fig. 16). Transfemoral aortogram disclosed almost complete occulsion of right artery and stenosis with poststenotic dilatation of proximal left renal artery (Fig. 17). A right nephrectomy and the by-pass grafting between an aorta and the left renal artery were performed. After the surgical correction the blood pressure decreased from 320/150 to 150/100 mmHg. During a subsequent admission and up to the present, the blood pressure has remained 134/80 to 128/74. Blood urea nitrogen decreased to 17 mg/dl. A follow up renal arteriogram is shown

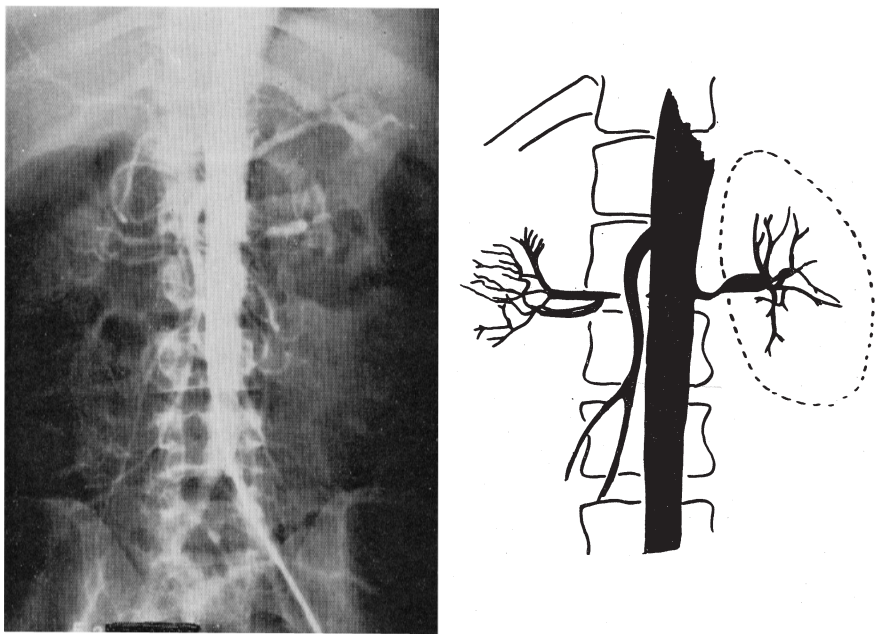


FIG. 17 (Case 2). Aortogram disclosed almost complete occulsion of the right renal artery and stenosis with poststenotic dilatation of proximal left renal artery.

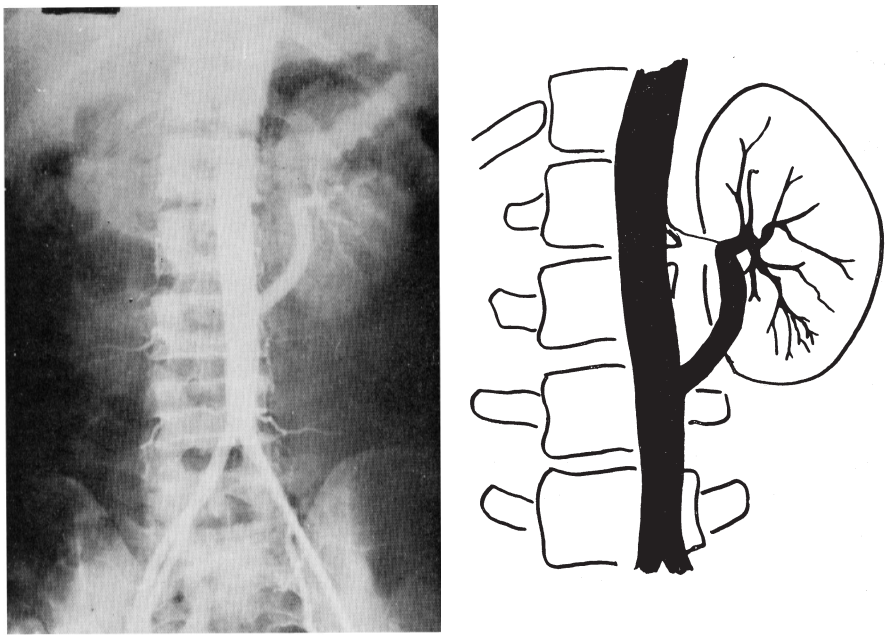


FIG. 18 (Case 2). Aortorenal by-pass grafting on the left side is showed on the follow up aortogram.

on Fig. 18. After extremity massage he is able to walk and has a pleasant character.

NEPHROPTSIS

In erect position, the kidney is pulled downward and the renal artery is stretched. Nephroptosis can be diagnosed by the pyelography in erect position. In the nephroptosis, aortorenal angiogram shows descending kidney, thinned renal artery, and decreased renoaortic angle. Stretching and thinning of renal artery were observed in not only main arteries but also in intrarenal arteries[3].

*Case 3*

A 20 years old man admitted to the hospital with continuous dull back pain and general fatigue for two years. Urinalysis and renal function studies were normal. Excretory urograms showed a mild hydronephrosis on the right side compared with the left. Upright urogram disclosed marked descending of the right kidney (Fig. 19). Upright arteriogram showed stretched renal artery and decreased aortorenal angle on the right side (Fig. 20). After nephropexy the complaints disappeared.

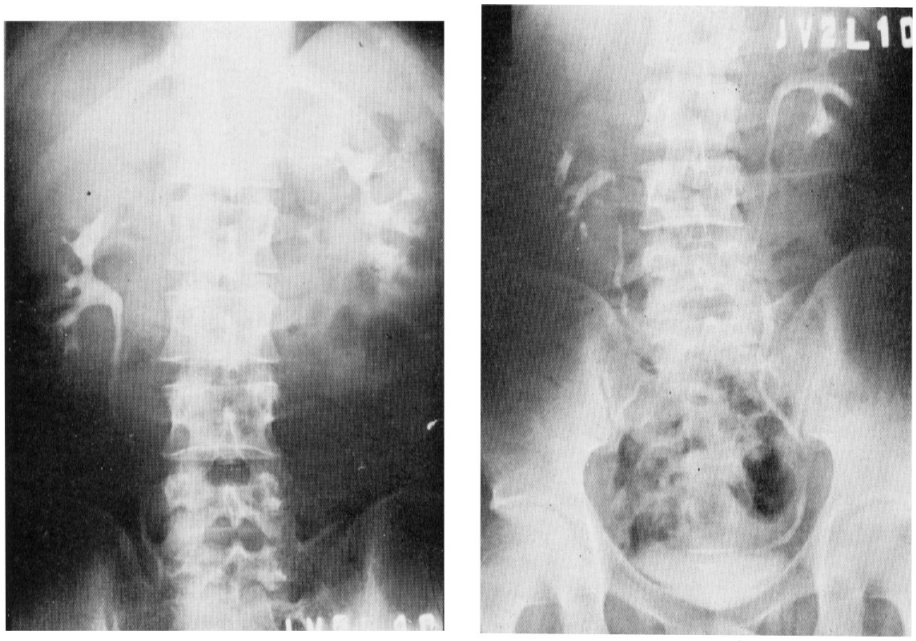


FIG. 19 (Case 3). Nephroptosis. Left: Excretory urogram on the spine position. Right: Excretory urogram on the erect position.

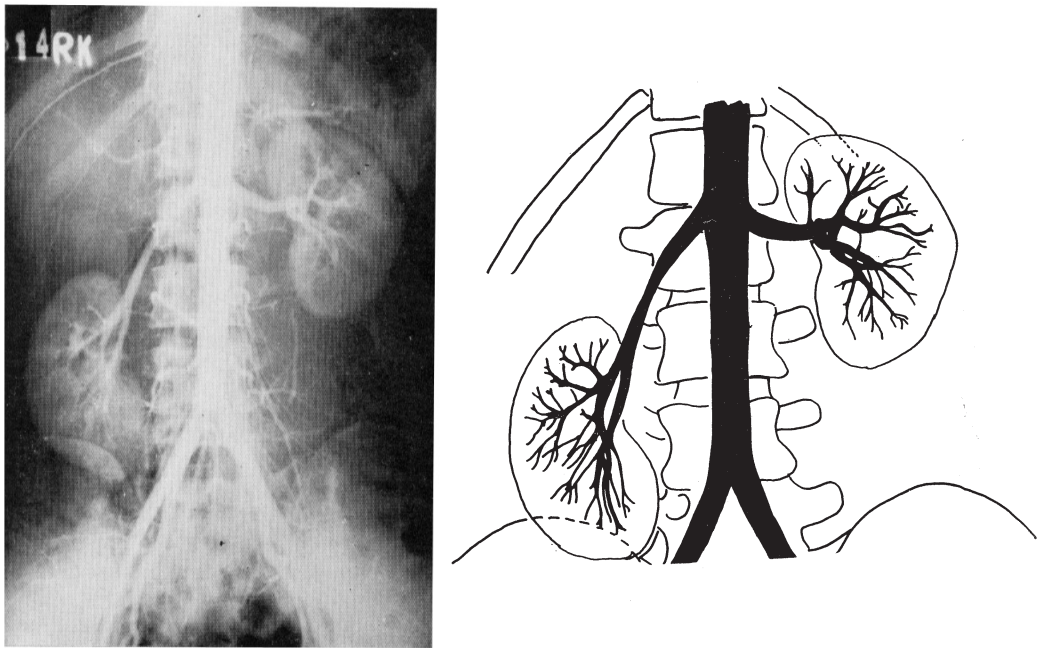


Fig. 20 (Case 3). Upright aortogram showed stretched renal artery and decreased aortorenal angle on the right side.

### RENAL AGENESIS AND RENAL HYPOPLASIA

Clinical diagnosis of renal agenesis made from no ureteral orifice in the urinary bladder, complete absence of renal artery by aortogram, and no shadow of pace occupping mass on a pneumoretroperitoneal film. Hypoplastic kidney have many variations of renal mass, renal artery, renal position, and drainage of the ureter. Aortogram reveals thin and multiple ectopic vessels to hypoplastic mass[59].

*Case 4*

A 11 years old girl had a continuous dribbling of urine. Excretory urogram demonstrated an absence of the right kidney. Cystgram showed a normal oval bladder without leakage. At cystoscopy, no ureteral orifice was demonstrated on the right side. After injection of indigo carmine, blue urine appeared from vagina. But ureteral orifice could not be seen on the vaginal wall. A plane aortogram disclosed no obvious renal vessel on the right side. Series film revealed some abnormal arteries from a branch of right common iliac artery (Fig. 21). A small kidney, $3.5 \times 2.0 \times 0.5$ cm, was removed by surgery. The hypoplastic kidney had double pelves and a ureter. After the surgery there was no incontinence.

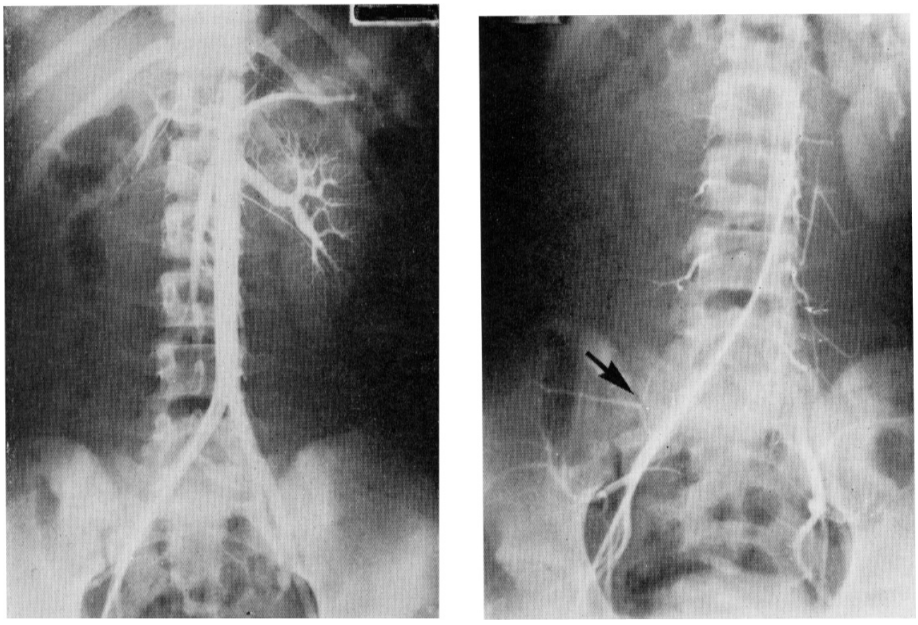


FIG. 21 (Case 4). Hypoplastic kidney. Left: Plane aortogram disclosed no obvious renal vessels on the right side. Right: Series film revealed some abnormal arteries from a branch of the right common iliac artery (arrow).

## HORSESHOE KIDNEY

Horseshoe kidney has some atypical arteries. Multiple renal arteries derive from one side of aorta and supply one kidney. The isthmus is formed by a fibrous band or vascularized parenchyma. Arterial branches to the isthmus are revealed clearly in arteriograpic phase. But on some occasion, this zone will appear as avascular during the nephrographic phase of the angiogram.

*Case 5*

A 32 years old woman was admitted to the hospital with severe back pain and gastrointestinal disorder. The patient had observed progressive weakness and loss of weight in the last 2 years prior to admission. Urinalysis and blood chemistry were normal. Excretory urogram showed the presence of the both lower calyces overlaid with psoas muscles. It was horseshoe kidney. Aortogram was performed in order to demonstrate ectopic vessels and isthmus (Fig. 22).

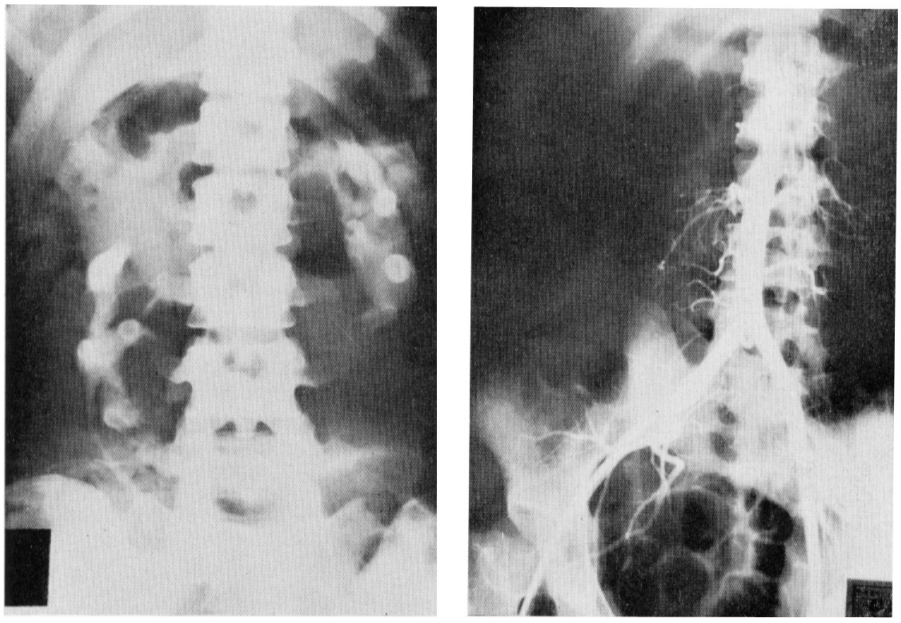


FIG. 22 (Case 5). Horseshoe kidney. Left: Excretory urogram of the horseshoe kidney. Right: Aortogram revealed atypical main renal arteries and some ectopic arteries.

## RENAL TUMOR

*Renal carcinoma (Grawitz's tumor)*

Renal carcinoma is highly vascularized tumor. The vascular changes of the tumor is characterized by large irregular tortous vessels, some of which

are curved and displaced, and others are short and widened, ending abruptly. They form a network. In the nephrographic and venous phase the pathological vessels within the tumor show a tendency of lodging or pooling. In some tumors extrarenal capsular vessels are widened showing an apparent "exorenal arcade"[60)61)].

*Case 6*

A 54 years old man was admitted to the hospital with hematuria of about 10 day's duration. Four years ago he had an episode of hematuria. The patient had observed progressive weakness and reported a weight loss of 5 kg during the past 2 yesrs prior to admission. Physical examination revealed a huge mass in the right flank. The mass movable and elastic-firm. Laboratory data showed anemia and high levels of serum LDH (420 mg/dl) and Al-Phosphatase (16.8 mg/dl). Renal function was within normal limits. The chest film showed some metastatic shadows in the right lower lung field. Pulmonary P was seen in ECG. Excretory urogram showed a normal left kidney, but the right side was non-visualized. Retrograde study revealed an obstruction of the right upper ureter. Selective right renal angiogram revealed the distortion of main vessels and the large vascular sinusoids by malignant tumor (Fig. 23). Another film showed hypervascularized renal capsule on the upper pole (Fig. 24). The patient died of cachxia a few months later. The

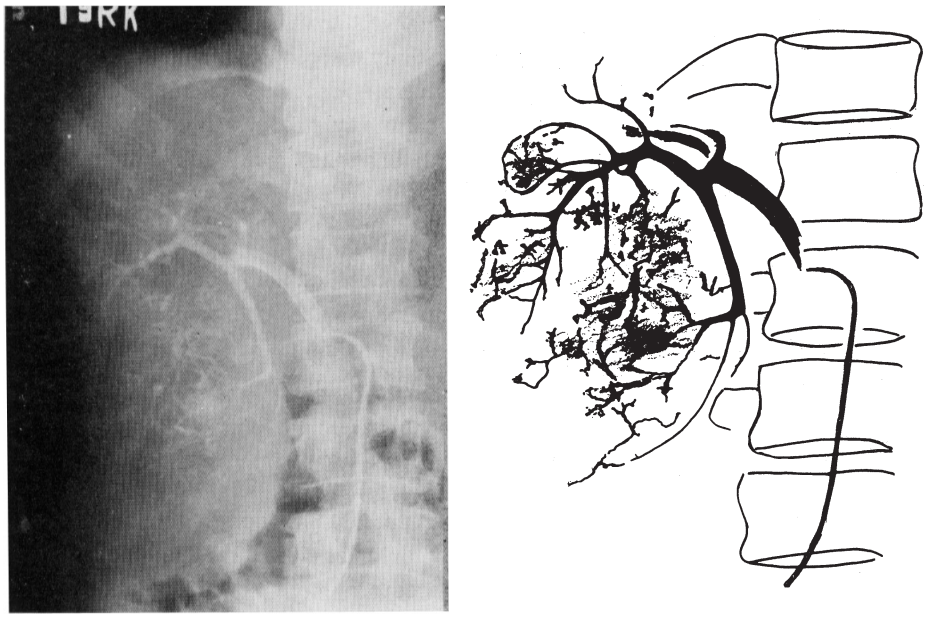


FIG. 23 (Case 6). Renal carcinoma. Right renal arteriogram revealed the distortion of large vessels and the large vascular sinusoids.

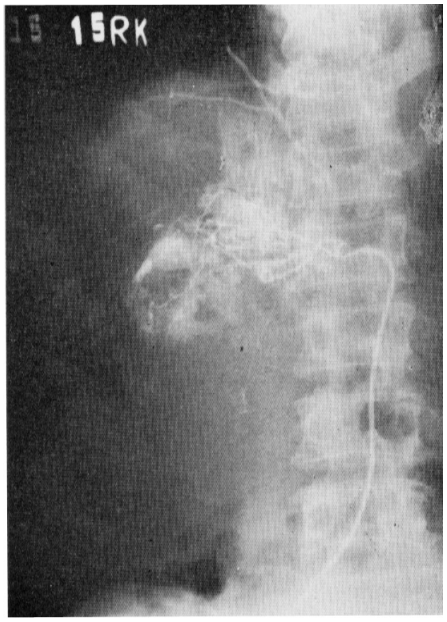



FIG. 24 (Case 6). Hypervascularized renal capsule of the renal carcinoma.

right renal carcinoma with metastasis to the lung was comfirmed at autopsy.

*Transitional cell carcinoma*

Transitional cell carcinoma of the kidney originates from renal pelvis. Infiltrating pelvic carcinoma shows the same appearance as renal carcinoma. This tumor has poor vascular network and many necrotic area. Angiogram of this tumor shows displacement of small branches and wide distribution of tumor vessels but no pooling sign[62].

*Case 7*

A 33 years old woman was admitted to the hospital with hematuria and back pain. Two years prior to the admission, she presented a history of hematuria but previous urologic survey showed negative findings. General condition was good. Physical examination revealed nothing in particular. Laboratory data showed macroscopic hematuria without infection. There was no abnormality of chest film, ECG, hematology, and blood chemistry. The left kidney was not visualized on urogram. Retrograde pyelogram showed an obstruction at the upper portion of the ureter. Selective left renal angiogram demonstrated irregular interlobular arteries with mottled parenchyma but there was no pooling (Fig. 25). Nephrectomy was performed and a tumor of the left kidney was found. The microscopic examination disclosed a transitional cell carcinoma.

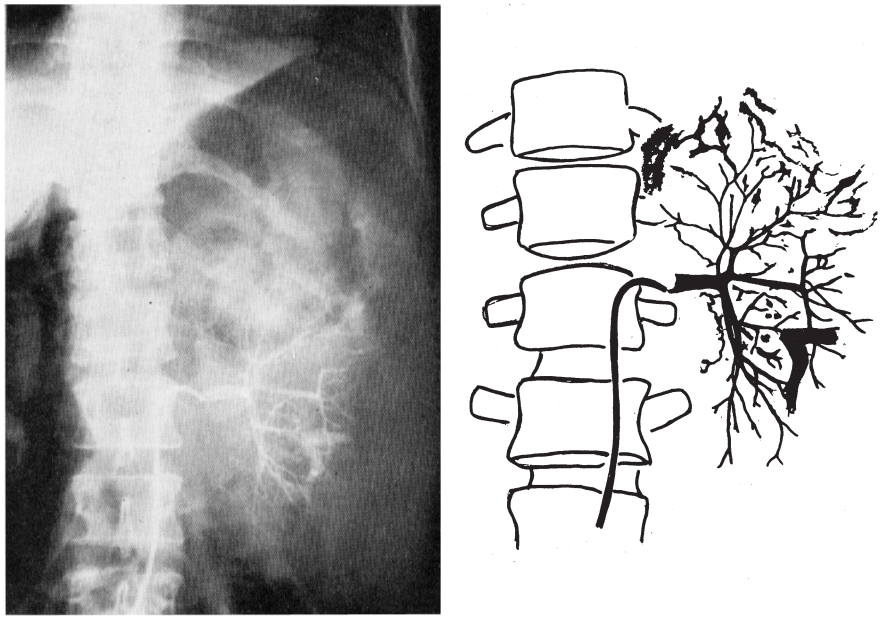


FIG. 25 (Case 7). Transitional cell carcinoma of the kidney. Left renal artery is irregular. Interlobar arteries are irregular and stretched with arteriovenous fistula.

RENAL CYST

On the renal cyst, intrarenal arteries are displaced, stretched, curved, and partly blocked by the cyst. In the nephrographic phase, the translucent and demarcated defect in the parenchyma is characteristic. When the cyst is located medially indentations on the renal pelvis and calyces are present[63]. If the cyst is located in the central portion of kidney, some lateral vessels may be curved and displaced by the lesion, but other vessels lying in front or behind may give a false impression on the films. If the cyst is placed laterally, a hump like bulging of the renal contour may be visible in the nephrogram[64)65)66)].

*Case 8*

A 42 years old man was admitted to the hospital with hematuria. He had intermittent hematuria 3 months ago. He had episodes of fever, initial pain of micturition, and continous hematuria for 3 days. Excretory urogram and retrograde pyelogram illustrated a curved, stretched upper calyces on the left side (Fig. 26). Selective left renal angiogram revealed a radiolucent oval area in the middle portion of the left kidney (Fig. 27). Operation disclosed a humping by the cyst on the middle portion of dorsal surface of the left kidney.

*Case 9*

A 59 years old man was admitted to the hospital with hematuria and back

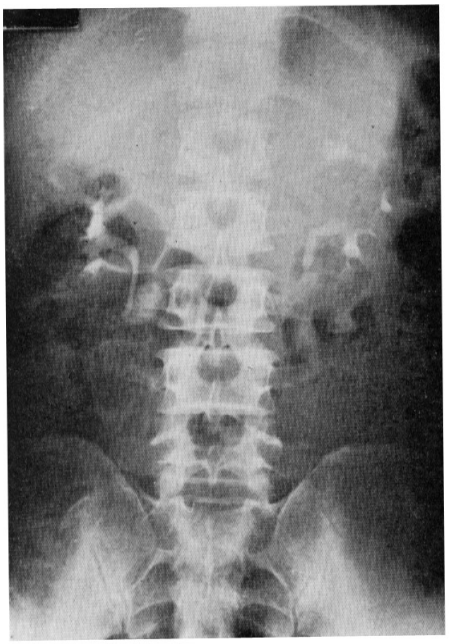
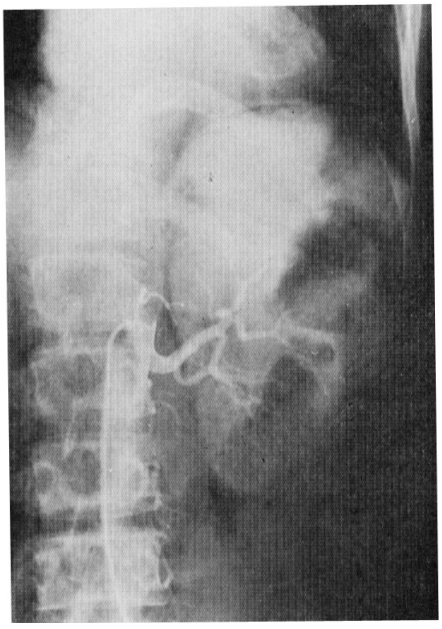


FIG. 26 (Case 8). Renal cyst (Medial renal cyst). Excretory urogram illustrated a curved stretchness of one of upper calyces on the left side.



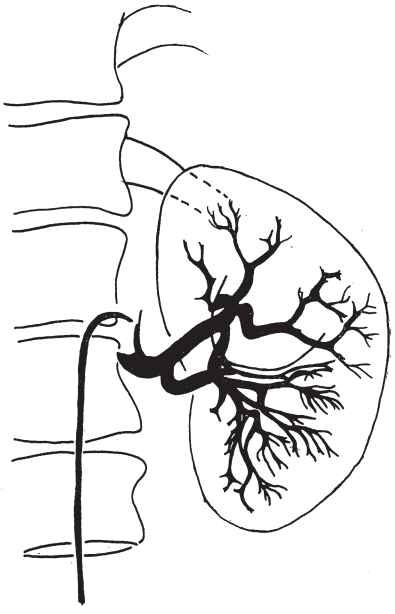


FIG. 27 (Case 8). Arteriogram shows the curved and stretched arteries at the middle portion of the left kidney.

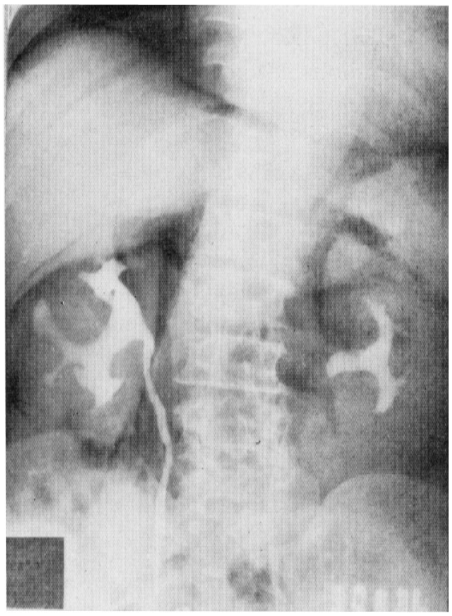


FIG. 28 (Case 9). Renal cyst (Lateral cyst). Excretory urogram shows a deformity and elongation of middle calyces in the right side.

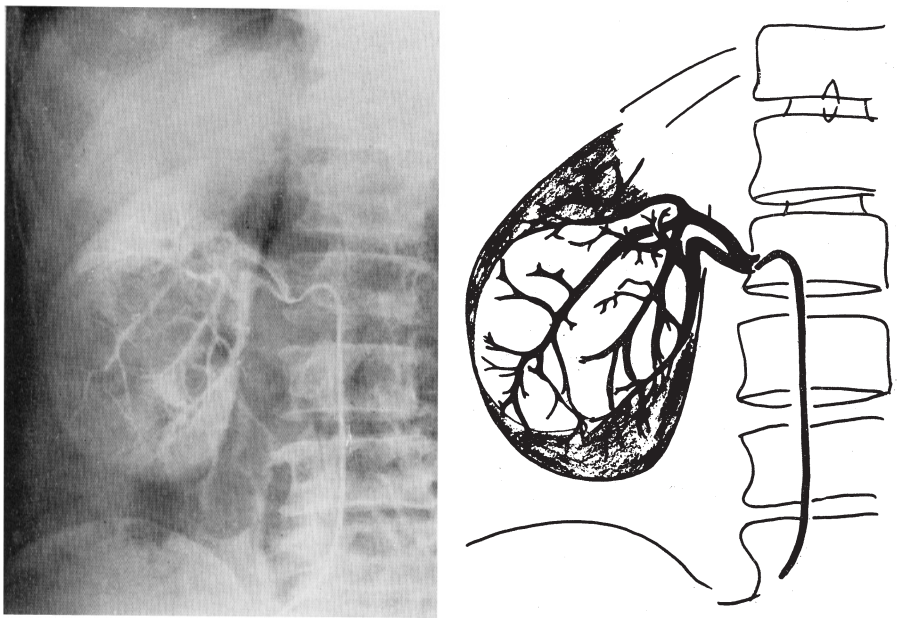


FIG. 29 (Case 9). Arteriogram shows curved and displaced arteries surrounding a radiolucent area by cyst.

pain for two days. Excretory urogram demonstrated a deformity and elongation of middle calyces (Fig. 28). Retrograde pyelogram showed the compressed middle calyces by round radiolucent mass. Right selective renal angiogram revealed a large cyst in lateral portion of the right kidney (Fig. 29).

POLYCYSTIC KIDNEY

Angiography of polycystic diseases can be affected depending upon how much parenchyma is left. The arteriographic pattern of the polycystic kidney at early stage is characterized by displacement and stretching of the arterial branches. These vessels are located around the many translucent areas, corresponding to cysts of various size. In the nephrographic phase, the kidney has a peculiar mottled appearance. At the progressed stage, the kidney has a thin parenchyma, angiogram shows withered tree like appearance, irregular spreading, and marked displacement of arterial branches. In the nephrographic stage, the kidney has irregular and soft nephrogram[67)68)].

*Case 10*

A 33 years old man was admitted to the hospital with fullness of the left flank. He has had weakness, headache, and craving for thirst for 6 years. Blood pressure was 155/100 mmHg. BUN was 31.0 mg/dl. Fishberg's concentration test was 1007, 1007, and 1005. Excretory urogram demonstrated

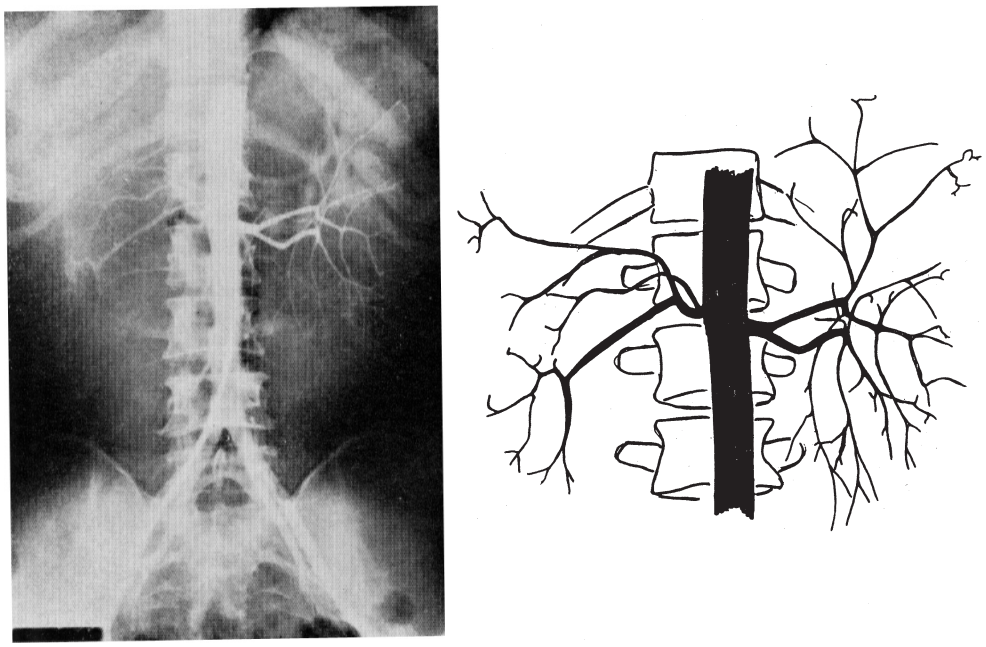


FIG. 30 (Case 10). Polycystic kidney. Renal arteries are thin, stretched and displaced.

nonvisualzation. Retrograde pyelogram showed enlarged and bended calyces as spider deformity. Aortogram was performed to see the status of the parenchyma. Renal arteries were thin, stretched, and displaced by the surrounding the multiple cysts (Fig. 30).

### HYDRONEPHROSIS

In hydronephrosis, thin stretched, bow-shaped arterial branches spring from the main renal artery[69]. The caliber of the main renal artery follows the progress of hydronephrosis. In the nephrographic and venous phase, angiography estimates the functional ability and thickness of the remaining parenchyma[70]. Another value of angiography in hydronephrosis is visualization of aberrant vessels crossing the ureter, pelvis, or the neck of the calyx[71)72].

*Case 11*

A 46 years old man was admitted to the hospital with albuminuria. He was completely asymptomatic until this admission. Physical and laboratory examinations were normal. Excretory urogram failed to demonstrate the functioning right kidney. The right ureter catheterization revealed an obstruction in the right lower ureter. Selective renal angiogram showed the uniform symmetrical stretching of the interlobular arteries (Fig. 31). Diagnosis

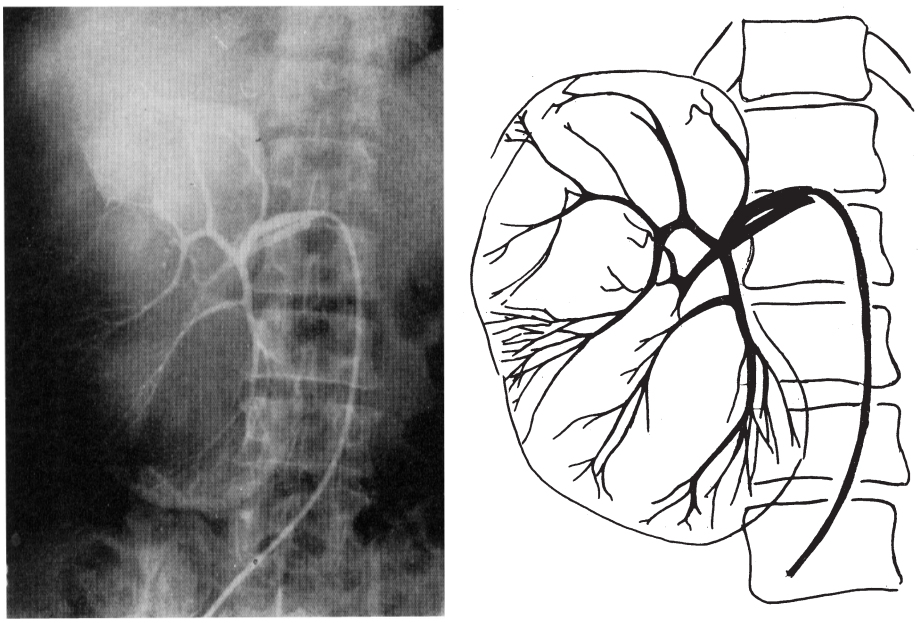


FIG. 31 (Case 11). Hydronephrosis. Arteriogram shows spread of interlobular arteries with loss of finer branches and shell of functioning parenchyma.

of hydronephrosis was made.

PYELONEPHRITIS

Pyelonephritis is characterized by the peripheral reduction of kidney due to parenchymal scarring and atrophy. The peripheral intrarenal arterial branches are often tortous and shorten with increased spiraling. In the nephrographic phase, the obscure border between medulla and cortex is best shown and the parenchyma may show marked defects and scarring that result in the lateral border to be irregular and lobulated[73)74)].

*Case 12*

A 41 years old man admitted to the hospital with fever and terminal hematuria for past six months. The urine was turbid with many red and pus cells, and gram-negative bacilli. Cystoscopy showed the hyperemic and edematous mucosa and golf-hole like appearance of both ureteral orifices. Catheterization of both ureters was impossible. Cystogram revealed vesico-ureteral reflux and dilatation of upper urinary tracts (Fig. 32). Selective left renal angiogram showed parencymal scarring by pyelonephritis. The intrarenal arteries are tortous and shorten (Fig. 33).

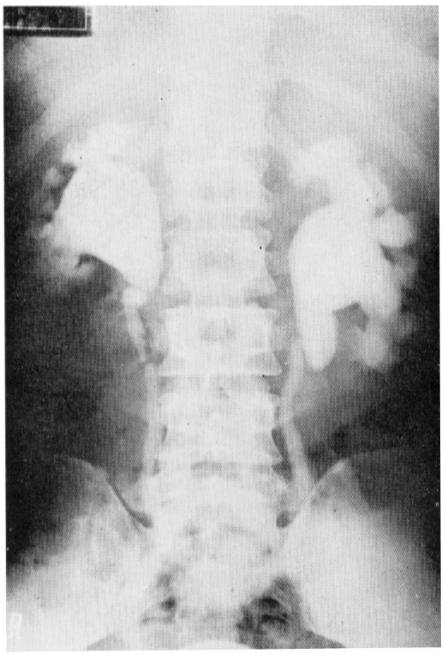


FIG. 32 (Case 12), Pyelonephritis. Pyelogram following retrograde cystogram revealed destructed and dilated pelvi-calyceal system.

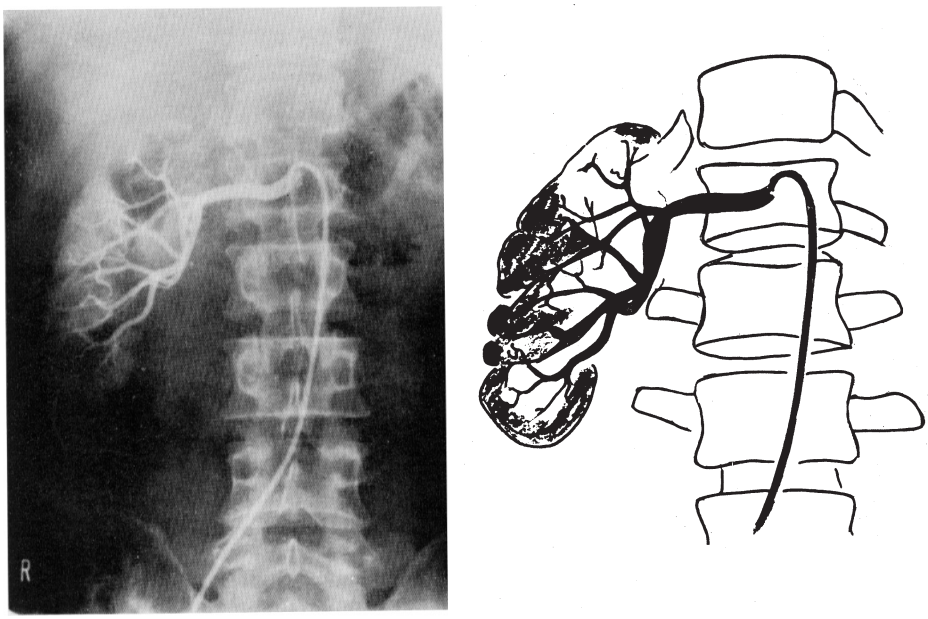



FIG. 33 (Case 12). Renal angiography reveals shorten and tortous arteries and irregular renal contour.

RENAL TUBERCULOSIS

Small cavity localized to one papilla may show very small vascular changes. If the change is recognizable, small branches are seen to be shorten and blocked close to the cavity. Large cavities may have cystlike appearance representing a rounded translucent area in the angiogram. The arteries may show blocking of adjacent branches and displacement of peripheral branches. In far advanced tuberculous kidney, thin main artery, and irregular arteries surrounding many avascular areas are shown in the angiogram[75)76)].

*Case 13*

A 37 years old woman was admitted to the hospital for suspected renal tuberculosis. She had a slight fever and a fullness in the right flank six months prior to admission. A routine examination showed that there was nothing abnormal. Cystoscopy revealed neither tubercle nor ulcer but the left ureteral orifice was gapped and rigid. Excretory urogram demonstrated absence of function of the left kidney. Retrograde pyelogram revealed a huge cavernous destruction of the lower calyces, and dilatation and moth-eaten appearance of the other calyces of the left kidney. The ureter and pelvis of the left side had irregular stricture and shortening. Right selective renal angiogram visualized thin main artery and irregular arteries surrounding many avascular areas (Fig. 34).

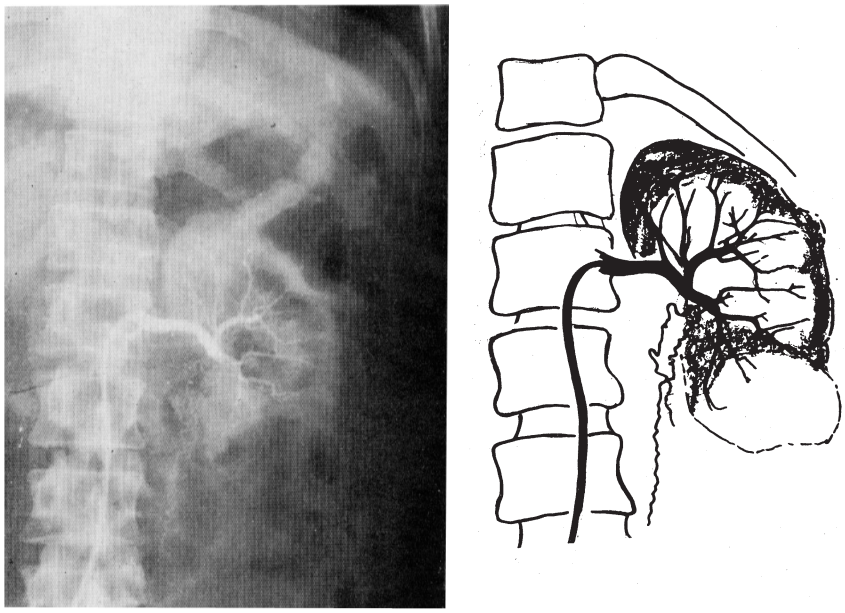


FIG. 34 (Case 13). Arteriogram shows irregular and stretched arteries of the upper and middle portion, and shorten arteries surrounding large a vascular area on the lower portion.

## DISCUSSION

The role of selective renal angiography in urology is different from reno-aortography. Aortography is required for renovascular hypertension, renal malformation, hydronephrosis, and nephroptosis. In these diseases there may be some transformations at origin of the renal arteries and main renal arteries themselves[77]. Aortography in the erect position has several advantages. The renal arteries in the erect position are better delineate than in the spine or prone position. In the upright position, the renal arteries are stretched in ptotic kidneys, and other vessels, which are overlaid and obscured the renal artery, are pulled down and filled with less contrast medium. Lesions of the main renal artery are disclosed more clearly in this condition[78)79)].

Mass of the kidney may be clarified by selective renal angiography. The differential diagnosis between cyst and tumor is of utmost importance in urological diagnosis. Usually in cysts, the contour is smooth and even, but in tumors, irregular or lobulated. Tumors have irregular vascular distributions and capillary net-work in the space occuping masses. However, the cysts have translucent avascular spaces in them. Peripheral arteries adjacent to the tumor are shortend or ended abruptly, but the cyst is surrounded by thin stretched arteries[80)~84)]. Distributions of intrarenal arteries in renal tuberculosis, pyelonephritis, and hydronephrosis were characteristic. The large part of the

intrarenal arteries is limited to the medulla and only some of them reach to the cortex in renal tuberculosis. Pyelonephritis has small arteries in the thin cortex. And intrarenal arteries of hydronephrosis are stretched and curved, and reach to the renal capsula. Thus, renal angiography may be a valuable adjunct to the conventional urologic tests, especially since the kidneys having non-visualized pyelogram are only diagnosed by renal angiography, and many patients will not need further explorations.

## SUMMARY AND CONCLUSION

Percutaneous transfemoral catheterization is the first choice for renal angiography in urology. A modification of procedure for safe and reliable arterial puncture was described. Damage to arterial wall were avoided using a modified catheterization technique with a catheter fitted to thin guide wire. There was no serious complication by contrast medium in this series. Various angiograms of renal diseases were demonstrated with some case reports from 104 experiences. Renal angiography has unquestionably superior value to differentiate renal tumor from other urological diseases. Especially, non-visualizing kidney is only diagnosed by renal angiography. Urological diagnosis became more exact by using renal angiography.

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