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KIDNEY AUTOTRANSPLANTATION IN PATIENTS WITH RENAL ARTERY PATHOLOGY

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Abstract*. We have experience of 11 kidney autotransplantations in patients with various vascular pathologies (9 cases - renal artery stenosis caused by atherosclerosis, fibromuscular dysplasia and nonspecific Takayasu aortoarteriitis), 7 of which came back after previously performed stenting of the renal artery, 1 case - stenosis of the right renal artery with a poststenotic aneurysm). All patients suffered from renovascular hypertension. In all patients, the hypertension crisis exceeded the mark of 200/100 mmHg, with normal blood supply to the contralateral kidney. With long-term arterial hypertension, there is a high risk of developing hypertensive nephroangiosclerosis, with the level of systolic blood pressure (BP) playing a decisive role. Hypertensive nephroangiosclerosis often manifests itself later than damage to other target organs. Kidney pathology may remain unrecognized for a long time, however, with ineffective blood pressure control, manifestations of chronic heart failure increase and cardiovascular complications develop, often with fatal outcomes. Kidney autotransplantation with renal artery reconstruction has advantages when reconstructing the RA with an autovenous vein, in most cases there is an aneurysmal expansion of the autovenous vein. Kidney autotransplantation with renal artery reconstruction has advantages when using a synthetic linear prosthesis, due to neointimal hyperplasia at the anastomotic site, stenosis of the anastomotic orifice is possible. Reconstructions of the right renal artery are considered by technical difficulty due to the anatomical location of the aorta and inferior vena cava.*

Keywords*: kidney autotransplantation, Renal artery stenosis, Renal artery restenosis nonspecific aortoarteritis, blood pressure.*

Introduction. Kidney autotransplantation is an operation aimed to removing various organic lesions of the vascular pedicle or ureter of a functional kidney nephrectomy, followed by its reimplantation, most often in a heterotopic position.

If we look at history, we can find evidence that the first autotransplantation was reported on March 7, 1902 at a meeting of the Vienna Medical Society, where 41 years old Hungarian-born surgeon Imre Ullmann, presented a report titled "Experimental kidney transplantation", who reported autotransplantation of a kidney in a dog, using the recipient's carotid artery and jugular vein for vascular implantation. The transplanted organ produced urine for 5 days. That same year, he also performed successful kidney allotransplants in dogs and xenotransplantations on dog-to-goat. In 1912, Nobel Prize winner A. Carrel, who developed the technique of vascular anastomosis, repeated the experiments of I. Ullmann. At that time, scientists and doctors were not aware of the problems of ischemia and reperfusion injury. In 1963James Hardy has performed an autotransplantation of the right kidney in the right iliac region due to an extensive stenosis of the ureter caused by traumatic injury. Interestingly, J. Hardy used moderate whole-body hypothermia (32-36°C), rather than the graft, to minimize ischemic damage [15, 3]. Subsequently, with the

development of therapeutic and diagnostic capabilities, there was a parallel development in the field of autotransplantation for various indications. Thus, a number of indications for performing kidney autotransplantation have been formed, including various lesions of the vessels of the renal pedicle, ureter and renal parenchyma of an infectious-inflammatory neoplastic nature.

The most common indications for kidney autotransplantation (KAT) are pathology of the renal arteries (22.7%), pathology of the ureter (17%) and malignant neoplasms (14.9%).

Vascular indications - recently, vascular pathology was the most common indication for kidney autotransplantation. Currently, modern endovascular technologies started to replace autotransplantation in the treatment of arterial hypertension caused by renal artery pathology, such as stenosis of kidney artery by atherosclerosis or fibro – muscular disease and also aortoarteritis having clear advantages in the form of low invasiveness and the possibility of reintervention without significant trauma for the patient. The same technologies are used almost routinely in the treatment of renal venous hypertension. But in some cases, for example, with a large sac-shaped renal artery aneurysm, autotransplantation remains the method of choice [3, 11].

Many publications report the successful use of CT in the treatment of various renal artery pathologies [9]. Such pathologies include renal artery aneurysm, fibromuscular hyperplasia, atherosclerosis and dissection. Although renal artery disease is currently treated with endovascular techniques [24, 12], back table repair and CT are the preferred open techniques due to their superior exposure, vessel dissection, and microvascular restoration compared with renal artery surgery. traditional renal artery bypass [8]. Previous studies of bench-scale reconstruction of renal artery aneurysms with renal allografts have demonstrated positive results [2]. Moghadamiegane and her colleagues studied 817 patients from the National Inpatient Specimen Database (NIS) who underwent CT between 2002 and 2012. Renal artery pathology was the most common indication for CT (22, 7%). Postoperative bleeding was the most common complication (13.4%) in renal artery reconstruction, followed by ileus (11.9%). In this cohort, 97.8% of patients maintained good renal function and no patient developed renal vascular thrombosis [18].

Causes related to neoplasms -Malignant tumors of the kidney and its surroundings are other indications for kidney autotransplantation, which occurs in 14.9% of cases [18]. Several publications have reported the advantages of performing KAT for tumor resection [1, 27]. Backtable surgery may be necessary in complex renal anatomy with centrally located tumors, especially in patients with single kidneys. KAT can protect renal function in appropriately selected patients and prevent the need for dialysis [9]. In a large cohort study of patients undergoing KAT for malignancies, 47.5% of patients developed complications. Novick et al. [20] suggest that excision of renal lesions should begin with nephrectomy and removal of Gerota's fascia. After flushing the kidney with hypothermic perfusion, the kidney should be wrapped in gauze and placed in a hypothermic solution. The vascular access supplying the neoplasm should be ligated after hilar dissection and the tumor should be removed centripetally. This excision should include a 2 cm margin of disease-free tissue. Frozen section biopsy can be used to confirm negative margins. Ligation of the renal parenchyma and collecting ducts must be performed to secure the sectioned components and vessels. The surgeon should evaluate vascular integrity by checking pulsatile perfusion before reimplantation.

Local tumor recurrence or distant metastasis is the main concern associated with the long-term outcome of CT after cancer resection. Stormont et al described their experience with ex vivo excision and autotransplantation of 20 patients with renal cell carcinoma over a 10-year period

[26]. Although the procedure was successful in 16 patients, 4 patients had renal vein thrombosis or renal vein injury due to tumor lesions that could not be used for anastomosis. In this cohort, 25% of patients experienced recurrence of renal cell carcinoma after a median follow-up of 35 months. The authors recommended performing a CT scan of the autograft site every 3 to 6 months to monitor for possible recurrence of malignancy. Due to the rarity of the procedure, there is no consensus on surveillance; However, we recommend following guidelines for monitoring in situ resections of renal malignancies.

Urological indications - represents 17% of KAT procedures. Patients undergoing KAT for ureteral diseases had the lowest morbidity rate (29.5%) [18]. The presence of tumors, trauma, tuberculosis, and fibrosis are reported as factors leading to extensive ureteral leakage that may benefit from KAT. It is performed in cases where a ureteral prosthesis is necessary and plastic surgery such as ureteroneocystostomy, ureteroureterostomy, pyelocystostomy, ipsilateral ureteroureterostomy, inferior nephropexy, Boari operation or psoas pull maneuver is not possible due to tissue deficiency [4]. An alternative solution may be to replace the affected ureter with a portion of the small intestine. However, the use of the small intestine carries a greater likelihood of complications of varying severity.

The widespread use of endoscopic methods of lithoextraction and endourological treatment of urothelial tumors in recent decades has led to an increase in the number of extended lesions and proximal ureteral avulsions [10]. This leads to the need for temporary urine diversion (nephrostomy) to preserve kidney function and multi-stage treatment. In such cases, performing kidney autotransplantation can be considered as a method that allows solving the problem of restoring the urinary tract in the shortest possible time and avoiding complications associated with additional diversion of urine from the damaged kidney and subsequent late reconstructive intervention. [28, 4].

If conservative treatment, including immunosuppressive therapy, or progression of urinary tract obstruction is ineffective, performing bilateral renal autotransplantation in a heterotopic position allows preserving the functional renal parenchyma, preventing the progression of chronic kidney disease [16].

Oncological indications - Malignant tumors of the kidney and its surroundings are other indications for kidney autotransplantation, which occurs in 14.9% of cases [18]. Several publications have reported the advantages of performing KAT for tumor resection [1, 27].

In the last decade, there has been a rapid increase in the proportion of combined and extended operations in the treatment of locally advanced retroperitoneal sarcomas. In more than half of the cases there is a need for traumatic multivisceral resections, of which 35-39% require nephrectomy [25]. However, according to large studies, it was found that when a histological study was carried out on the removed macroscopic sample, which consists of the "tumor-kidney" organic complex, only in 21.5-27% a true infiltrative growth of the retroperitoneal sarcoma in the kidney. [22].

For patients whose tumor has not spread beyond the kidney, organ-sparing treatment improves life expectancy [17]. This fact is of particular importance in the treatment of patients with tumor lesions of a single kidney, where all efforts should be directed to preserving the organ to avoid the need for chronic renal replacement therapy. In such conditions, performing kidney autotransplantation with ex vivo resection or enucleation of the tumor seems to be a completely applicable technique, but in the last decade interest in this operation has decreased significantly

[19]. This is because minimally invasive “nephron-sparing” surgery for renal malignancies, such as laparoscopic or robotic partial nephrectomy with super selective parenchymal ischemia, as well as ablative techniques, provide equivalent cancer-specific survival compared with radical nephrectomy. [6].

On the other hand, performing an autotransplant for a kidney tumor can cause a fairly wide range of complications, including hemorrhages (3.3-5% of cases), urinary tract infections (7.4%), renal vein thrombosis (4.1%), loss of graft function (12.3%). Although it is necessary to take into account that the autotransplant group includes patients with an initially more anatomically complex dissemination of the tumor process [9].

T. Bolling described a casuistic case of kidney autotransplantation in a patient with Young's tumor, which covered the area of the eleventh rib on the left. To avoid radiation damage, the kidney was displaced to the left iliac region before the start of radiotherapy [14].

In complex anatomical and topographic conditions of the retroperitoneal space, the use of transplants and extracorporeal surgical techniques expands the possibilities of organ-preserving treatment without reducing the radical nature of the intervention. Prolonged involvement of the ureter in the process in giant sarcomas of the retroperitoneal space may lead to the need to remove the block with the surrounding tumor tissues. The ureteral length deficit in such cases is almost impossible to compensate by standard urological approaches. Performing an autotransplant in a heterotopic position as a second stage after tumor removal allows preserving renal function and the integrity of the urinary tract [7,5].

Purpose of the work. Improving the results of surgical treatment of renovascular hypertension by introducing organ-sparing surgery.

Methods. Since April 2022 to April 2024 we performed 11 kidney autotransplantations in patients with renovascular hypertension. The Department of Vascular Surgery and Kidney Transplantation has, in a very short period of time, started to carry out operations such as kidney transplantation from a living related donor, and from 2018 to the present, we have performed 1,300 kidney transplants. Thanks to the extensive experience of the department’s team in performing kidney transplantations from a living donor and vascular surgery, it became possible to introduce the Automatic Kidney Transplantation operation into practice.

Here we present our first clinical cases of performing KAT.

Clinical case No. 1

Patient X., 19 years old, was admitted as planned with a diagnosis of: “Fibromuscular dysplasia of the right renal artery, after stent-graft implantation to the right renal artery (March 2015). Restenosis of the stented renal artery. Vasorenal hypertension”.

Has been sick for many years. Blood pressure is 220/110 mmHg, not amenable to drug antihypertensive therapy. In 2015, stenosis of the right renal artery (90%) was detected. An attempt was made to stent the right renal artery. Intraoperatively, there was under expansion of the middle third of the stent, with residual stenosis of 80%. Blood pressure stabilized on antihypertensive drugs. Since 2018, the patient again began to notice an increase in blood pressure to 220/110 mmHg. antihypertensive therapy without effect. According to MSCT: Condition after stenting of the right renal artery, with a narrowing of the lumen in the middle third up to 90%.

The patient was hospitalized for surgical correction of VA stenosis on the right. (pic.1)

Picture 1. – Patients left kidney artery after stenting and restenosis of middle third up to 90%.

According to clinical and laboratory data, the indicators are within normal limits. The patient underwent radioisotope scintigraphy with the Tc 99m MAG 3 isotope, dose 2mCi. Time of maximum accumulation of the drug: Left kidney - 3.6 minutes, Right kidney - 3.3 minutes (normal 3-7 minutes). Half-life of the drug: Left kidney - 7.2 minutes, Right kidney - 8.2 minutes (normal up to 21 minutes). Total renal plasma flow is 663.8 ml/min/m2 (normal range is 400-700 ml/min/m2), right kidney is 349.9 ml/min/m2, left kidney is 313.9 ml/min/m2. Relative functional participation of the kidneys: left kidney – 52.1%, right kidney – 47.9%, with a norm of 50±5% for each kidney, proportionally. Scintigraphically, the kidneys have smooth, clear contours and uneven accumulation of radiopharmaceuticals in them; the relative functional parameters of both kidneys are within normal limits.

After a consultation with the participation of vascular surgeons and interventionalists, it was decided to perform autotransplantation of the right kidney. In the patient, through a pararectal incision on the right, the first stage of nephrectomy was performed on the right. It is worth noting the technical difficulty of performing a left-sided nephrectomy for transplantation, due to the anatomy of the location of the great vessels (aorta and inferior vena cava). The renal vein of the left kidney is short, creating difficulties in forming a new ostium with the iliac vein. The stented renal artery was resected immediately, at the level of the distal end of the stent. The ureter was resected at the level of the iliac arteries, in the lower third, on the right. The kidney was removed, the Backtable was washed with a preservative, cold (4°C) Custadiol solution, and the renal artery stenosis was eliminated. The next step was to implant the kidney into the right iliac region. The renal artery and vein are anastomosed end-to-side with the common iliac artery and vein, respectively. The ureter is anastomosed with the bladder, and an extravesical neoureterocystoanastomosis is formed according to the Lich method. In order to prevent failure of neoureterocystoanastomosis, a 5FR-26cm seahorse stent was installed.

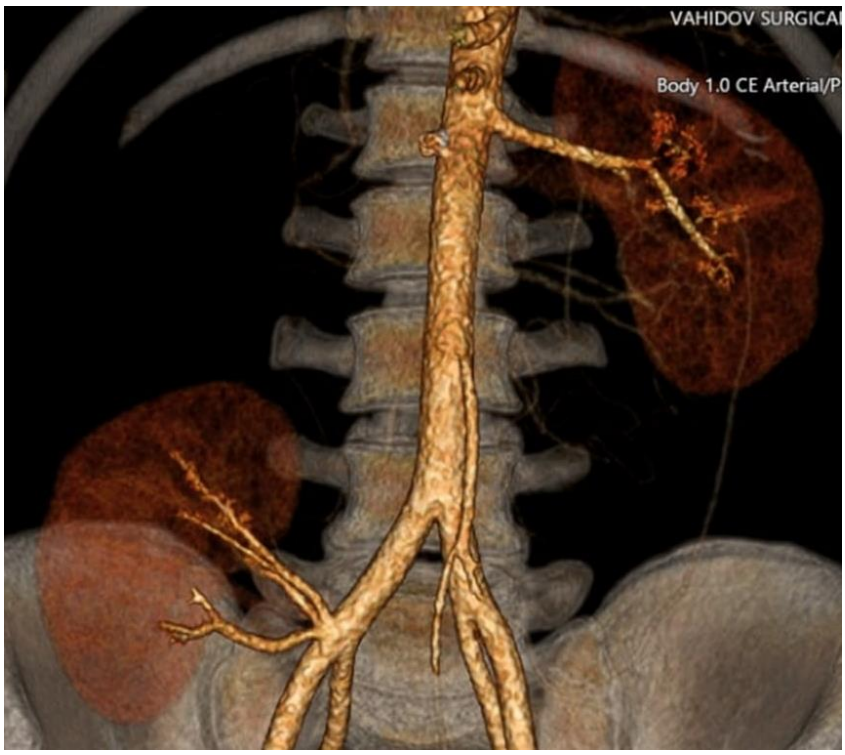
The patient was transferred to the intensive care unit after the operation. According to observation, blood pressure at entrance was 170/100 mmHg, the next day, at the time of transfer

to the department: blood pressure 120/60 mmHg, diuresis 2100 ml, drainage 200 ml. According to clinical and laboratory tests, the indicators are within normal limits.

In the postoperative period, he received anticoagulant, antibacterial, infusion and symptomatic therapy. The postoperative wound healed by primary intention, without any peculiarities; the drainage was removed on the 4th day after surgery. The Foley urinary catheter was removed on the 5th day after surgery. Diuresis is about 2.0-3.0 liters per day. BP-130/90, 110/70 mmHg. Pulse 75-88 beats/min, rhythmic.

On the 8th day, MSCT angiography of the abdominal aorta and renal vessels was performed.

Renal artery of an autotransplanted right kidney. The diameter at the mouth is 7.3 mm, then immediately branches into branches of 4 and 7 mm.



Picture 2. The CT angiography on 5th month of surgery.

On the 10th day after the operation, control radioisotope scintigraphy was performed with the Tc 99m MAG 3 isotope, dose 2mCi. Time of maximum accumulation of the drug: Left kidney - 7.0 minutes, Right kidney - 3.6 minutes (normal 3-7 minutes). Half-life of the drug: Left kidney - 8.7 minutes, Right kidney - 9.7 minutes (normal up to 21 minutes). Total renal plasma flow is 574.9 ml/min/m2 (normal range is 400-700 ml/min/m2), right kidney is 390.7 ml/min/m2, left kidney is 184.2 ml/min/m2. Relative functional participation of the kidneys: left kidney – 76.2%, right kidney – 23.8%, with a norm of 50±5% for each kidney, proportionally. Scintigraphically, the right kidney is reduced in size, with reduced accumulation of radiopharmaceuticals in it. The relative functional participation and plasma flow of the right kidney is reduced.

The patient was discharged from the hospital in satisfactory condition with normal clinical and laboratory parameters and normalized blood pressure.

The patient underwent repeat MSCT 5 months after surgery (pic.2). The concentration and excretory function of the kidneys is not impaired.

Clinical case No. 2

Patient A., 22 years old, was admitted as planned with the diagnosis: “Fibromuscular dysplasia of the left renal artery. Condition after surgery for stenting of the left renal artery from 2014. Restenosis of the stented renal artery. Condition after surgery for balloon dilatation of the left stented renal artery from 2015. Vasorenal hypertension”.

Has been suffering for many years with blood pressure 200/100 mmHg also does not respond to drug antihypertensive therapy. In 2014, stenosis of the left renal artery (85%) was detected. An attempt was made to stent the left renal artery. Blood pressure stabilized on antihypertensive drugs, not just for a few weeks. The examination revealed stenosis of the stented area. In 2015, an attempt was made to balloon dilatation of the left renal artery. The patient's blood pressure stabilized. By 2022, episodes of hypertension of 200/100 mmHg began to be observed again. Antihypertensive therapy is ineffective. According to MSCT: Condition after stenting of the left renal artery, with a narrowing of the lumen in the middle and proximal third to 85%. The patient was hospitalized for surgical correction of left KA stenosis.

According to clinical and laboratory data, the indicators are within normal limits. The patient underwent radioisotope scintigraphy with the Tc 99m MAG 3 isotope, dose 2mCi. Time of maximum accumulation of the drug: Left kidney - 2.5 minutes, Right kidney - 2.5 minutes (normal 3-7 minutes). Half-life of the drug: Left kidney - 6.5 minutes, Right kidney - 6.0 minutes (normal up to 21 minutes). Total renal plasma flow – 564.8 ml/min/m2 (normal 400-700 ml/min/m2), right kidney – 245.6 ml/min/m2, left kidney – 319.2 ml/min/m2. Relative functional participation of the kidneys: left kidney – 43.5%, right kidney – 56.5%, with a norm of 50±5% for each kidney, proportionally. Scintigraphically, the kidneys have smooth, clear contours and uneven accumulation of radiopharmaceuticals in them, the relative functional parameters of the left kidney are slightly reduced, the renal plasma is within normal limits.

And in this case, after a consultation with the participation of vascular surgeons and intervention cardiologists, it was decided to perform autotransplantation of the left kidney. The patient underwent the first stage of nephrectomy on the left, through a pararectal incision on the left. The stented renal artery was resected immediately, at the level of the distal end of the stent. The ureter was resected at the level of the iliac arteries, in the lower third, on the right. The kidney was removed, the backtable was washed with a preservative, cold (4°C) Custadiol solution, and the renal artery stenosis was eliminated. The next step was to implant the kidney into the left iliac region. The renal artery and vein are anastomosed end-to-side with the common iliac artery and vein, respectively. The ureter is anastomosed with the bladder, and an extravesical neoureterocystoanastomosis is formed according to the Lich method. In order to prevent failure of neoureterocystoanastomosis, a 5FR-26cm seahorse stent was installed.

The patient was transferred to the intensive care unit after the surgery. According to observation, blood pressure at entrance was 160/82 mmHg., the next day, at the time of transfer to the department: blood pressure 103/61 mmHg., diuresis 2200 ml, drainage 150 ml. According to clinical and laboratory tests, the indicators are within normal limits.

In the postoperative period, she received anticoagulant, antibacterial, infusion and symptomatic therapy. The postoperative wound healed by primary intention, without any peculiarities; the drainage was removed on the 4th day after surgery. The Foley urinary catheter was removed on the 5th day after surgery. Diuresis is about 2.0-3.0 liters per day. BP-120/90, 100/70 mmHg. Pulse 75-88 beats/min, rhythmic.

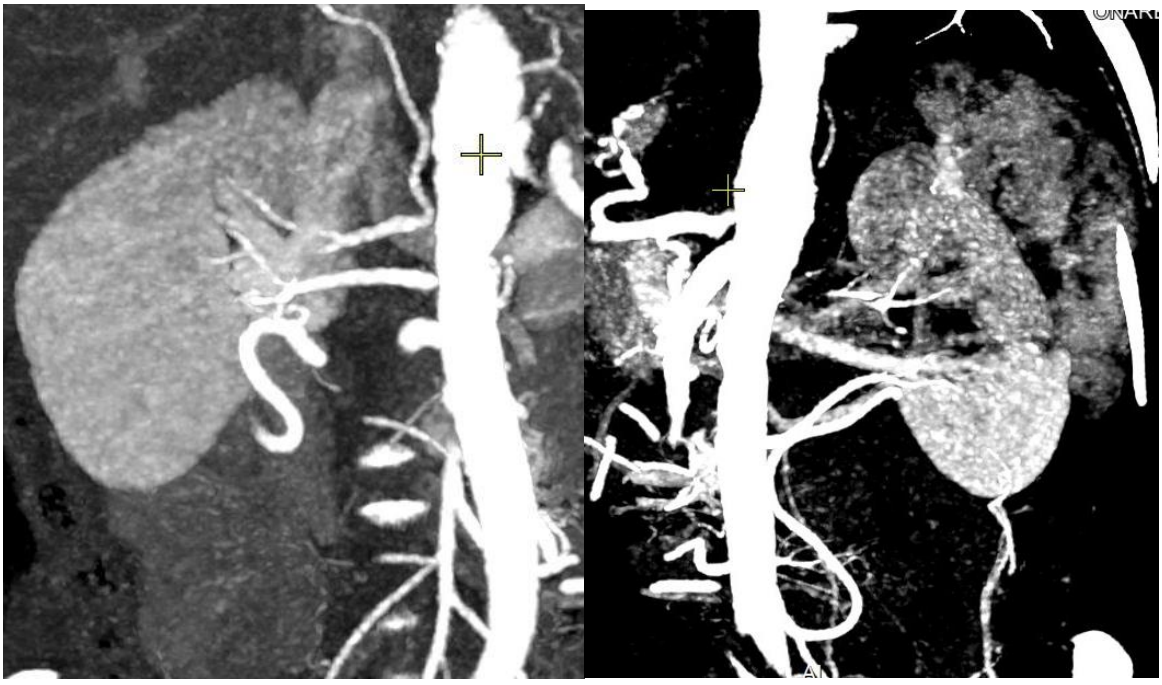
On the 7th day, MSCT angiography of the abdominal aorta and renal vessels was performed.

Renal artery of an autotransplanted left kidney: the mouth is at the level of c/3 of the left RA. The diameter at the mouth is 5.8 mm, in the middle third 3.5 mm.

On the 10th day after the operation, control radioisotope scintigraphy was performed with the Tc 99m MAG 3 isotope, dose 2mCi. Time of maximum accumulation of the drug: Left kidney - 7.0 minutes, Right kidney - 3.6 minutes (normal 3-7 minutes). Half-life of the drug: Left kidney - 8.7 minutes, Right kidney - 9.7 minutes (normal up to 21 minutes). Total renal plasma flow is 574.9 ml/min/m2 (normal range is 400-700 ml/min/m2), right kidney is 390.7 ml/min/m2, left kidney is 184.2 ml/min/m2. Relative functional participation of the kidneys: left kidney – 76.2%, right kidney – 23.8%, with a norm of 50±5% for each kidney, proportionally. Scintigraphically, the right kidney is reduced in size, with reduced accumulation of radiopharmaceuticals in it. The relative functional participation and plasma flow of the right kidney is reduced.

The patient was discharged from the hospital in satisfactory condition with normal clinical and laboratory parameters and normalized blood pressure.

The following clinical cases were performed in a similar manner; a staged bilateral autotransplantation of the kidney was also performed in a patient with bilateral damage to the renal arteries by the cause of Takayasu arteritis (nonspecific aortoarteriitis - NAA) (pic 3., pic 4.)

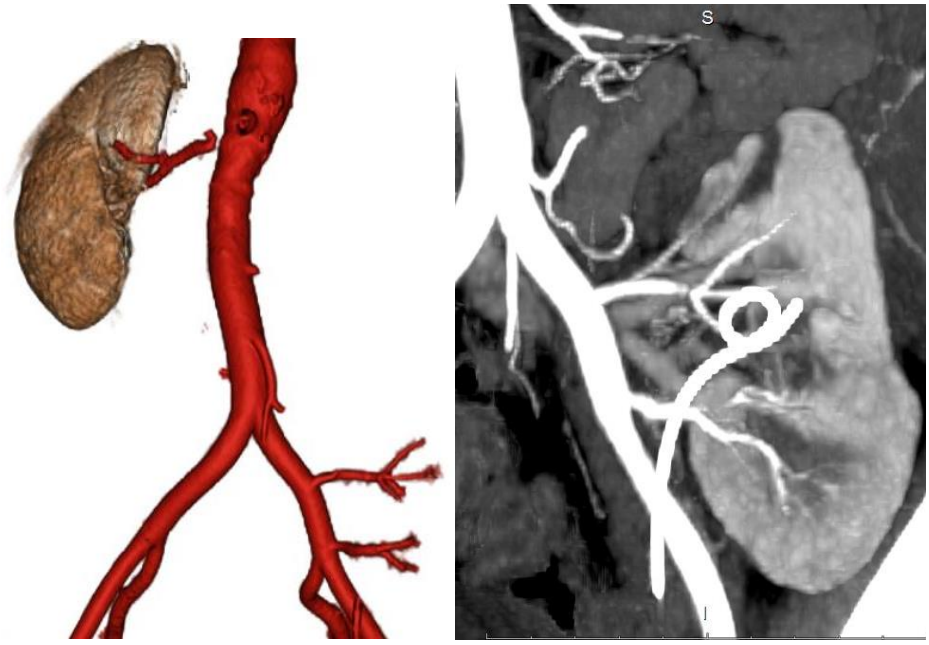


Picture 3. Bilatheral stenosis of renal arteries at a 21 years old woman with nonspecific aortoarteritis.

Patient N., 21 years old, chronic stage of NAA, bilateral renal arteries stenosis, blood pressure 190/110 mmHg before surgery. Surgery was performed in 2 stages. Left kidney autotransplantation at September 2023, right kidney autotransplantation - at March 2024, blood pressure 110/80 after second stage of surgery.

Discussion. With long-term arterial hypertension, there is a high risk of developing hypertensive nephroangiosclerosis, with the level of systolic blood pressure (BP) playing a decisive role. Hypertensive nephroangiosclerosis often manifests itself later than damage to other target organs. Kidney pathology may remain unrecognized for a long time, however, with

ineffective blood pressure control, manifestations of chronic heart failure increase and cardiovascular complications develop, often with fatal outcomes.



Picture 4. First step of surgery – autotransplantation of left kidney to left iliac region to the woman with aortoarteritis.

In all operated patients, blood pressure levels began to decrease on the first and second days after surgery. On the 10th day, the average blood pressure was 128/85 mmHg. The patients were discharged without complications. Today, we are periodically observed by a vascular surgeon, and our first patients with AT have been living a full life for 4 years without episodes of increased Arterial pressure.

Of course, for Kidney artery stenosis, due to their low-traumatic and minimal invasiveness, balloon angioplasty and (or) stenting are the primary method of choosing treatment for this group of patients. But as practice shows, 1 year after endovascular interventions, renal artery restenosis occurs in 25% after balloon angioplasty and in 10% after stenting [12, 24]. A stable increase in blood pressure and a high level of angiotensin II in the circulating blood in patients with unilateral renal artery stenosis causes damage to the contralateral kidney in the form of diffuse arteriolar damage and glomerulosclerosis [8]. In this case, correction of stenosis or nephrectomy of a stenotic kidney does not normalize blood pressure. If blood pressure has been elevated for five years or more, correction of stenosis is effective only in 25% of cases. The therapeutic effect is provided only by interventions at an early stage of the disease, when the function of the contralateral kidney is not yet impaired.

Conclusions

1. Kidney autotransplantation with renal artery reconstruction has advantages when reconstructing the RA with an autovenous vein, in most cases there is an aneurysmal expansion of the autovenous vein.

2. Kidney autotransplantation with renal artery reconstruction has advantages when using a synthetic linear prosthesis, due to neointimal hyperplasia at the anastomotic site, stenosis of the anastomotic orifice is possible.

3. Reconstructions of the right renal artery are considered by technical difficulty due to the anatomical location of the aorta and inferior vena cava.

4. We consider the advantage of the KAT to be the same type of anastomosis of vessels (artery to artery, vein to vein); intimal hyperplasia is not observed in the iliac artery.

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