EVALUACIJA DAVALACA KOMPJUTERIZOVANOM TOMOGRAFIJOM U SKLOPU PREOPERATIVNE PRIPREME ZA PRESAĐIVANJE BUBREGA SA ŽIVOG DAVAOCA

PREGLEDNI RAD

REVIEW ARTICLE

COMPUTED TOMOGRAPHY EVALUATION OF DONORS WITHIN PREOPERATIVE PREPARATION FOR LIVING-DONOR KIDNEY TRANSPLANTATION

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SAŽETAK

Transplantacija bubrega je terapijski metod izbora u slučaju završnog stadijuma bolesti bubrega. Preoperativna priprema podrazumeva brojne preglede, a radiolozi su odgovorni za adekvatnu procenu snimanjem (engl. *imaging evaluation*). Kompjuterizovana tomografija (engl. *computed tomography – CT*) je modalitet snimanja prvog izbora u preoperativnoj evaluaciji bubrega i predstavlja zlatni standard.

Radiološka procena obuhvata, kako uvid u sve fokalne i difuzne bolesti bubrežnog parenhima, tako i izveštavanje o anatomiji, anomalijama, sabirnom sistemu i vaskulaturi. Detaljni uvid u vaskularne strukture bubrega predstavlja verovatno najvažniji korak, zato što obezbeđuje pripremljenost hirurga na eventualne poteškoće pre početka operativnog zahvata, a samim tim smanjuje i rizik od potencijalnih komplikacija.

Stoga je radiološka procena potencijalnih živih davalaca bubrega od presudnog značaja za uspešnu transplantaciju. Ključ za dobar radiološki izveštaj jeste poznavanje hirurških tehnika i poteškoća sa kojima se hirurzi mogu suočiti tokom procesa presađivanja bubrega.

Ključne reči: kompjuterizovana tomografija, bubreg, transplantacija

ABSTRACT

Kidney transplantation is the therapeutic method of choice in end-stage kidney disease. Preoperative preparation includes a number of examinations, with the radiologists being responsible for accurate imaging evaluation. Computed tomography (CT) is the preferred imaging modality for preoperative renal evaluation and it is the gold standard.

Radiological evaluation includes insight into all focal and diffuse diseases of the renal parenchyma, as well as reporting about anatomy, anomalies, the collecting system, and vasculature. A careful insight into the vascular structures of the kidney is possibly the most important step because it helps the surgeon prepare for potential difficulties before the procedure, therefore reducing the risk of potential complications.

This is why radiological evaluation of the potential living kidney donor is essential for successful transplantation. The key to accurate radiological reporting is knowledge of surgical techniques and of the difficulties that surgeons may face during the kidney transplantation procedure.

Keywords: computed tomography, kidney, transplantation

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Primljeno • *Received*: November 17, 2022; **Revidirano • *Revised*:** January 30, 2023; **Prihvaćeno • *Accepted*:** March 8, 2023; ***Online first*:** May 25, 2023

DOI: 10.5937/smclk4-41246

UVOD

Transplantacija bubrega je terapijski metod izbora u slučaju završnog stadijuma bolesti bubrega. Transplantacija sa živog davaoca (engl. *living donor transplantation*) je bolja opcija od transplantacije sa kadavera zbog dužeg perioda preoperativne pripreme, kraćeg trajanja ishemije i dužeg preživljavanja grafta. Preoperativna priprema podrazumeva brojne preglede, uključujući analize krvi i urina, testove bubrežne funkcije, elektrokardiogram, analizu antigena specifičnog za prostatu, ili mamografiju, kao i kompletnu radiološku evaluaciju. Radiolozi su odgovorni za adekvatnu *imaging* evaluaciju koja se sastoji od izveštavanja o bubrežnoj anatomiji, vaskulaturi, sabirnom sistemu, kao i fokalnim ili difuznim bubrežnim bolestima. Pažljivo i precizno izveštavanje utiče na veći uspeh hirurških procedura i smanjuje broj potencijalnih komplikacija. Modalitet snimanja prvog izbora u preoperativnoj evaluaciji bubrega je kompjuterizovana tomografija (engl. *computed tomography – CT*) i ona je i dalje zlatni standard, uprkos teoretskim rizicima, o kojima ćemo govoriti kasnije u ovom radu [1–3].

CT PROTOKOL

U našem centru, potencijalni živi davaoci bubrega se evaluiraju 64-rednim multidetektorskim *CT* aparatom (*Siemens Medical Solution*) sa kolimacijom od 5 mm i retrorekonstrukcijom prilikom reformacije slika (engl. *post-processing*) od 1 mm. Naš protokol uključuje nativnu fazu pregleda za eventualnu detekciju nefrolitijaze, a potom se aplikuje 2 ml/kg intravenskog kontrastnog sredstva brzinom od 4 ml/s. Akvizicija se kod svih pacijenata čini u najmanje tri postkontrastne faze (arterijska, venska i ekskretorna faza) korišćenjem *bolus-tracking* tehnike sa ROI u nivou torakoabdominalne aorte i pragom (engl. *threshold*) od 150 HU, bez prethodne peroralne pripreme. Prilikom reformacije slika su korišćene multiplanarne rekonstrukcije i *volume-rendering* 3D tehnike.

Osim za detekciju kalkulusa, nativna faza služi i kao osnova za kasniju karakterizaciju lezija. Arterijska faza se koristi za prikaz vaskularne anatomije, kako arterijske, tako i venske, zbog različite opacifikacije [2]. Venska faza je idealna za evaluaciju renalnog parenhima i može adekvatno prikazati male vene kao što su adrenalne i gonadalne vene. Ekskretorna faza se obično dobija između četiri i osam minuta nakon administracije kontrastnog sredstva (u našoj ustanovi na 6 minuta) i u ovoj fazi se može izvršiti evaluacija sabirnog sistema bubrega, kao i evaluacija urotelne patologije [4].

Naša škola pretransplantacionog i posttransplantacionog snimanja je pod jurisdikcijom hrvatske tran-

INTRODUCTION

Kidney transplantation is the therapeutic method of choice in end-stage kidney disease. Living donor transplantation is a better option than cadaver transplantation due to a longer period of preoperative preparation, shorter duration of ischemia and longer graft survival. Preoperative preparation involves numerous examinations, including blood and urine tests, renal function tests, electrocardiogram, prostate-specific antigen analysis, or mammography, as well as a complete radiological evaluation. Radiologists are responsible for adequate imaging evaluation, which consists of reporting on renal anatomy, vasculature, the collecting system, as well as on focal or diffuse renal diseases. Careful and accurate reporting enables more successful surgical procedures and reduces the number of potential complications. In the preoperative evaluation of the kidney, the imaging modality of first choice is computed tomography (CT) and it is still the gold standard, despite the theoretical risks, which we will discuss later in this paper [1-3].

CT PROTOCOL

In our center, potential living kidney donors are evaluated with a 64-row multidetector CT scanner (Siemens Medical Solution) with 5 mm collimation and 1 mm retroreconstruction slices in post-processing. Our protocol includes a native phase of the examination for possible detection of nephrolithiasis, upon which 2 ml/kg of intravenous contrast agent is administered at a rate of 4 ml/s. Acquisition in all patients is done in at least three postcontrast phases (arterial, venous and excretory phase) using the bolus-tracking technique with the region of interest (ROI) at the level of the thoracoabdominal aorta and a threshold of 150 HU, without prior oral preparation. In postprocessing, multiplanar reconstructions and volume-rendering 3D techniques were used.

Apart from its role in the detection of calculi, the native phase also serves as a baseline for the subsequent enhancement of the lesions. The arterial phase is used to depict the vascular anatomy, both arterial and venous, due to their different opacification [2]. The venous phase is ideal for evaluating the renal parenchyma and can adequately depict small veins such as the adrenal and gonadal veins. The excretory phase is usually obtained between four and eight minutes after contrast administration (6 minutes in our institution), and evaluation of the renal collecting system as well as evaluation of urothelial pathology can be performed in this phase [4].

Our school of pretransplantation and posttransplantation imaging is under the jurisdiction of the Cro-

splantacione škole, te je obuka u medicinskim centrima u Zagrebu doprinela da i u našoj ustanovi zaživi ovaj *CT* protokol.

U nekim transplantacionim centrima, *CT* protokoli su modifikovani u cilju smanjenja doze zračenja. U svom protokolu, Kavamoto i saradnici ne koriste nativnu tehniku skeniranja, već se detekcija nefrolitijaze radi u arterijskoj fazi pregleda sa modifikacijama pri reformaciji snimaka [5]. U nekim protokolima, skeniranje u nativnoj fazi se čini sa smanjenim naponom (manjim od 100 kV) dok je ekskretorna faza zamenjena topogramom, što značajno smanjuje dozu zračenja, a ne utiče na dijagnostičku tačnost anatomije pijlokaliksnog sistema [6].

SNIMANJE KOMPJUTERIZOVANOM TOMOGRAFIJOM NASPRAM SNIMANJA MAGNETNOM REZONANCOM

I kompjuterizovana tomografija (*CT*) i magnetna rezonanca (MR) mogu prikazati vaskularnu i pelvikalicealnu anatomiju, ali MR omogućava evaluaciju bez jonizujućeg zračenja i rizika od kontrastom-indukovane nefropatije. Međutim, *CT* ima bolju prostornu rezoluciju i veću brzinu, za razliku od magnetne rezonance, koja je podložnija artefaktima usled pomeranja. Vaskularne kalcifikacije i nefrolitijaza se bolje detektuju *CT*-om, a neke studije su pokazale da to važi i za akcesorne renalne arterije. Rizik od kontrastom-indukovane nefropatije je zanemarljiv kod pacijenata sa normalnom renalnom funkcijom Prema tome, *CT* je i dalje zlatni standard uprkos ovim teoretskim rizicima [3,4].

EVALUACIJA BUBREŽNOG PARENHIMA

Radiološka procena renalnog parenhima uključuje informacije kao što su broj bubrega, njihova dužina, položaj, volumen i anatomske varijante, kao i anomalije i bolesti donorskog bubrega i njegova vaskulatura [2,3]. Ovi podaci imaju prognostički značaj i povezani su sa renalnom funkcijom kod primaoca, do 36 meseci nakon transplantacije [3]. Unilateralna agenezija, potkovičasti bubreg, kortikalna atrofija, policistična bolest, medularni sunđerasti bubreg i renalna papilarna nekroza isključuju donaciju [2].

Dužina bubrega je definisana kao maksimalni longitudinalni promer na koronalnom *CT* preseku, a 2 cm i veća razlika u dužini između dva bubrega generalno zahteva dalju proveru bubrežne funkcije (radioizotopsko ispitivanje) [3].

Volumen bubrega može biti meren manuelno ili pomoću poluautomatskih i automatskih segmentnih tehnika, ali su sve one zasnovane na merenju renalnog korteksa u većem broju preseka [3].

Bubrezi sa unilateralnim ožiljcima i normalnim renogramom su pogodni za transplantaciju [2]. Takođe,

atian transplantation school, so the training of our specialists in medical centers in Zagreb contributed to the adoption of this CT protocol in our institution.

In some transplant centers, CT protocols have been modified to reduce the radiation dose. In their protocol, Kawamoto et al. do not use the native scanning technique, rather the detection of nephrolithiasis is done in the arterial phase of the examination with modifications in postprocessing [5]. In some protocols, scanning in the native phase is done with a reduced voltage (less than 100 kV) while the excretory phase is replaced by a topogram, which significantly reduces the radiation dose and does not affect the diagnostic accuracy of the anatomy of the pelvicalyceal system [6].

COMPUTED TOMOGRAPHY VERSUS MAGNETIC RESONANCE IMAGING

Both CT and magnetic resonance (MR) imaging can show vascular and pelvicalyceal anatomy, but MRI enables the evaluation without ionizing radiation and the risk of contrast-induced nephropathy. However, CT has higher spatial resolution and speed, unlike MRI which is more susceptible to motion artifacts. Vascular calcifications and nephrolithiasis are better detected with CT, and some studies have shown this to also be true of accessory renal arteries. The risk of contrast-induced nephropathy is negligible in patients with normal renal function. Therefore, CT is still the gold standard despite these theoretical risks [3,4].

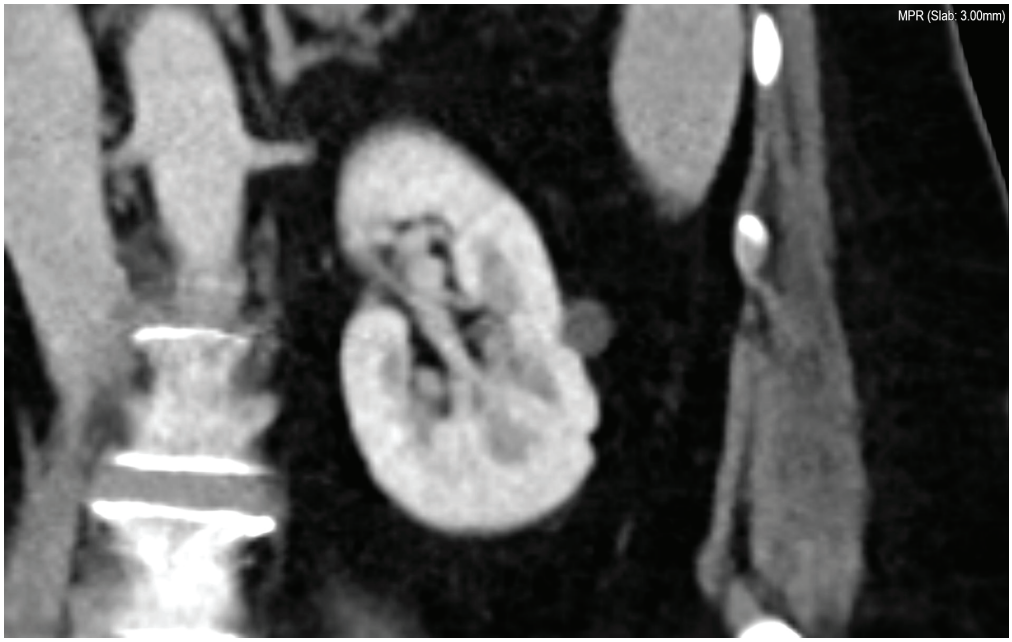
EVALUATION OF RENAL PARENCHYMA

Radiological assessment of the renal parenchyma includes information such as the number of kidneys, their length, position, volume and anatomical variants, as well as anomalies and diseases of the donor kidney and its vasculature [2,3]. These data have prognostic significance and are related to renal function in the recipient, up to 36 months after transplantation [3]. Unilateral agenesis, horseshoe kidney, cortical atrophy, polycystic disease, medullary sponge kidney and renal papillary necrosis exclude the possibility of donation [2].

Kidney length is defined as the maximum longitudinal diameter on a coronal CT section, and a two-centimeter or greater difference in length between two kidneys generally requires further testing of renal function (split function radioisotope scan) [3].

Kidney volume can be measured manually or using semi-automated and automated segmentation techniques, but all of them are based on measuring the renal cortex in a larger number of sections [3].

Kidneys with unilateral parenchymal scars and normal renograms are suitable for transplantation [2]. Also, kidneys with cysts of moderate size (less than 5



Slika 1. Kortikalna cista levog bubrega - Bosniak I
(slika pripada arhivi Urgentnog centra Univerzitetskog kliničkog centra Srbije).

Figure 1. Cortical cyst of the left kidney - Bosniak I (the image was taken from the records of the Emergency Department of the University Clinical Center of Serbia)

bubrezi sa cistama umerene veličine (manje od 5 cm) i broja, a bez povišene ehogenosti, mogu se smatrati dobrim graftom za transplantaciju (Slika 1) [7]. Karakteristike ciste treba proceniti da bi se isključilo prisustvo solidne mase. Takođe, bubrezi sa malim angiomiolipomima mogu biti presađeni bez rizika, s obzirom na njihov spor rast i odsustvo rizika od morbiditeta [2].

PROCENA RENALNE VASKULARIZACIJE

Nakon evaluacije renalnog parenhima, drugi obavezni korak je procena vaskularnih struktura. To je možda i najvažniji korak, jer zahteva široko znanje, ne samo radiologije, nego i hirurških pristupa, kako bi čitava transplantaciona procedura bila uspešna.

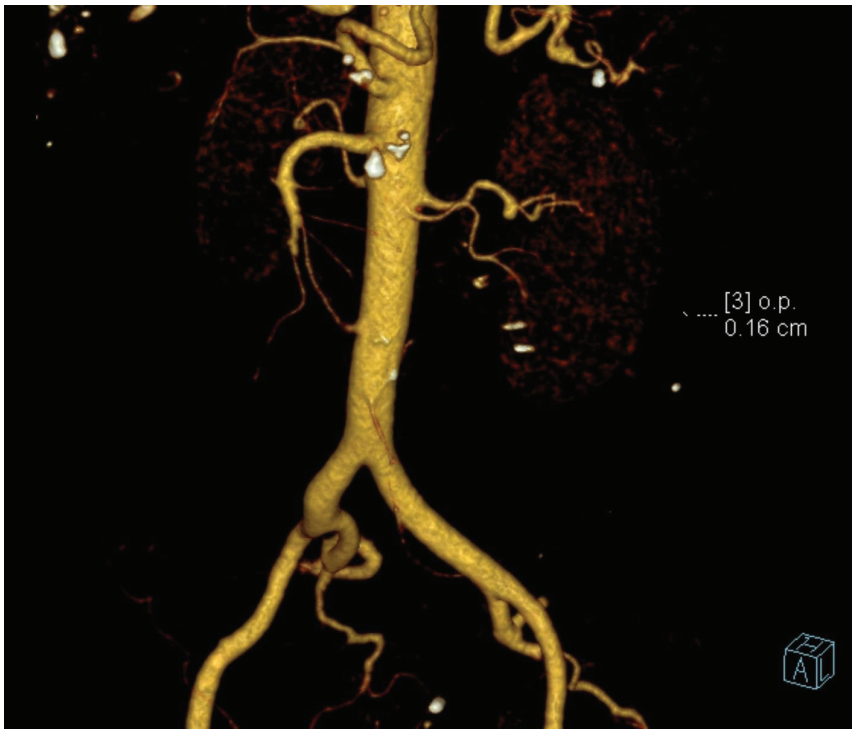
Kod najvećeg broja ljudi, renalna arterija polazi u nivou između gornje ivice L1 i donje ivice L2 pršljena, a desna renalna arterija je obično više položena od leve. Varijacije renalnih arterija se mogu podeliti u dve grupe: (1) rano grananje i (2) ekstrarenalne arterije [3,4]. Kod desnog bubrega, rano segmentno arterijsko grananje znači grananje iza *v. cavae inferior* (*VCI*), tj. retrokavalno grananje, koje se javlja 1 cm od desne ivice donje šuplje vene. Ovo može stvoriti poteškoće hirurzima zbog veće mogućnosti povređivanja velikih krvnih sudova kada rade iza *VCI*. Kod levog bubrega, rano segmentno arterijsko grananje je grananje unutar 1,5 cm od ishodišta leve renalne arterije [2–4]. Postoje tri tipa ekstrarenalnih arterija: (1) hilarne, (2) polarne i (3) kapsularne. Hilarne (akcesorne) arterije ulaze u bubreg u nivou hilusa, sa glavnom renalnom arterijom (Slika 2) [2–4]. Najveći broj akcesornih arterija ishodi iz

cm) and number, and without elevated echogenicity, can be considered good grafts for transplantation (Figure 1) [7]. Cyst characteristics should be evaluated to rule out the presence of a solid mass. Also, kidneys with small angiomyolipomas can be safely transplanted, given their slow growth and the absence of the risk of morbidity [2].

RENAL VASCULARIZATION ASSESSMENT

After the evaluation of the renal parenchyma, the second mandatory step is the evaluation of the vascular structures. This is perhaps the most important step, because it requires a broad knowledge, not only of radiology, but also of surgical approaches, in order to make the entire transplantation procedure successful.

In most individuals, the renal artery originates at the level between the upper margin of the L1 and the lower margin of the L2 vertebrae, and the right renal artery usually originates above the left. Variations of renal arteries can be divided into two groups: (1) early branching and (2) extrarenal arteries [3,4]. In the right kidney, early segmental arterial branching means branching behind the inferior vena cava (IVC), i.e., retrocaval branching, which occurs 1 cm from the right IVC margin. This can create difficulties for surgeons due to the greater possibility of injuring large blood vessels when working behind the IVC. In the left kidney, early segmental arterial branching is branching within 1.5 cm of the origin of the left renal artery [2–4]. There are three types of extrarenal arteries: (1) hilar, (2) polar, and (3) capsular. Hilar (accessory) arteries enter the kidney at the level of the hilus, with the main renal artery (Fig-



Slika 2. Akcesorna renalna arterija, levo
(slika pripada arhivi Urgentnog centra Univerzitetskog kliničkog centra Srbije)

Figure 2. Accessory renal artery, left (the image was taken from the records of the Emergency Department of the University Clinical Center of Serbia)

aorte, ali mogu polaziti i iz nekog drugog krvnog suda, kao što su ilijačne, gonadalne arterije, mezenterična vaskulatura, itd. [4]. Polarne (aberantne) arterije ulaze u bubreg direktno kroz renalnu kapsulu u nivou polova. Najzad, kapsularne arterije su tanki krvni sudovi koji okružuju bubreg i perfunduju renalnu kapsulu [2–4]. Prisustvo više od dve akcesorne renalne arterije može se smatrati kontraindikacijom za transplantaciju, zbog visokog rizika od tromboze i dužeg trajanja operacije [4]. Shodno tome, akcesorne arterije i njihov dijametar moraju biti pomenuti u izveštaju kako bi se prevenirala ne samo tromboza, već i nepotrebno operativno krvarenje [8]. Male arterije (dijametra manjeg od 2 mm) su prihvatljive, jer je, u tom slučaju, volumen infarktnog tkiva bubrega manji od 10% [4].

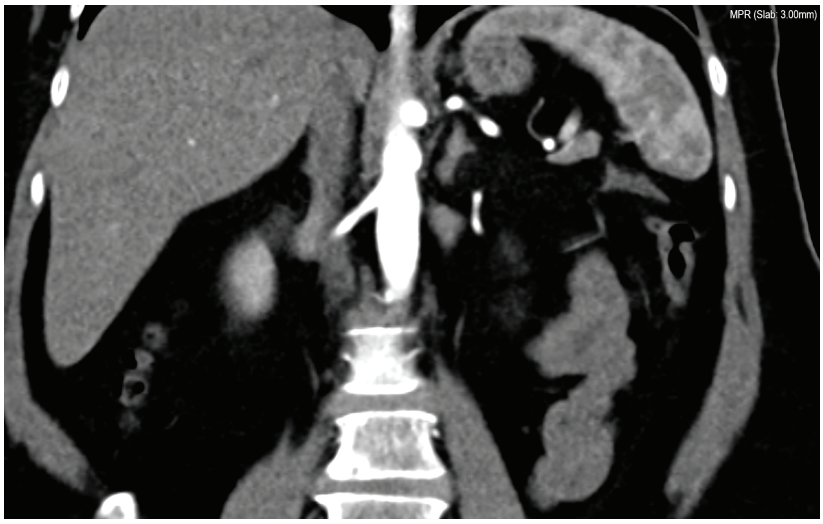
Postoje tri obavezna merenja renalnih arterija: (1) rastojanje između ishodišta desne renalne arterije i prvog segmentnog grananja, (2) rastojanje između desne ivice donje šuplje vene i prvog segmentnog grananja desne renalne arterije i (3) distanca između ishodišta leve renalne arterije i njenog prvog segmentnog grananja [2,3].

Najvažnije bolesti renalnih arterija koje moraju biti detektovane su ateroskleroza, fibromuskularna displazija, aneurizme, arteriovenske malformacije, disekcija i tromboza (Slike 3 i 4) [3]. Stenoza renalne arterije najčešće ima aterosklerotsku etiologiju i pogađa ishodišne i proksimalne segmente renalnih arterija kod starijih pacijenata. Prisustvo kalcifikovanih plakova je kontra-

ure 2) [2–4]. The largest number of accessory arteries originate from the aorta, but they can also originate from another blood vessel, such as the iliac, gonadal arteries, the mesenteric vasculature, etc. [4]. Polar (aberrant) arteries enter the kidney at the renal poles, directly through the renal capsule. Finally, capsular arteries are thin blood vessels that surround the kidney and perfuse the renal capsule [2–4]. The presence of more than two accessory renal arteries can be considered a contraindication for transplantation, due to a high risk of thrombosis and longer operative time [4]. Accordingly, accessory arteries and their diameter must be mentioned in the report, in order to prevent not only thrombosis, but also unnecessary operative bleeding [8]. Small arteries (diameter of less than 2 mm) are acceptable, because, in that case, the volume of infarcted kidney tissue is less than 10% [4].

There are three mandatory measurements of the renal arteries: (1) the distance between the origin of the right renal artery and the first segmental branching, (2) the distance between the right margin of the inferior vena cava and the first segmental branching of the right renal artery, and (3) the distance between the origin of the left renal artery and its first segmental branching [2,3].

The most important diseases of the renal arteries that must be detected are atherosclerosis, fibromuscular dysplasia, aneurysms, arteriovenous malformations, dissection, and thrombosis (Figures 3 and 4) [3]. Renal

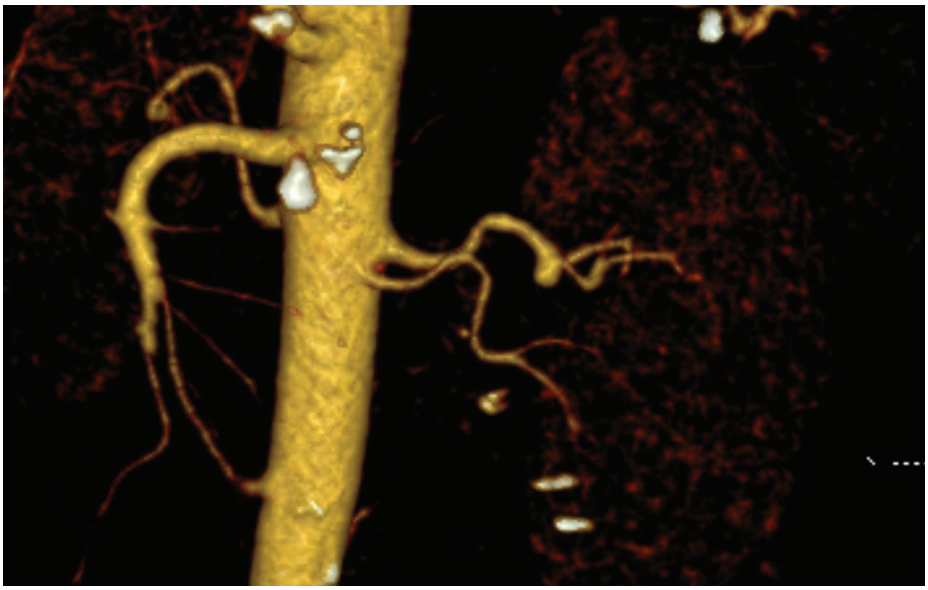


Slika 3. Stenoza stabla renalne arterije
(slika pripada arhivi Urgentnog centra Univerzitetskog kliničkog centra Srbije)

Figure 3. Stenosis of the renal artery (the image was taken from the records of the Emergency Department of the University Clinical Center of Serbia)

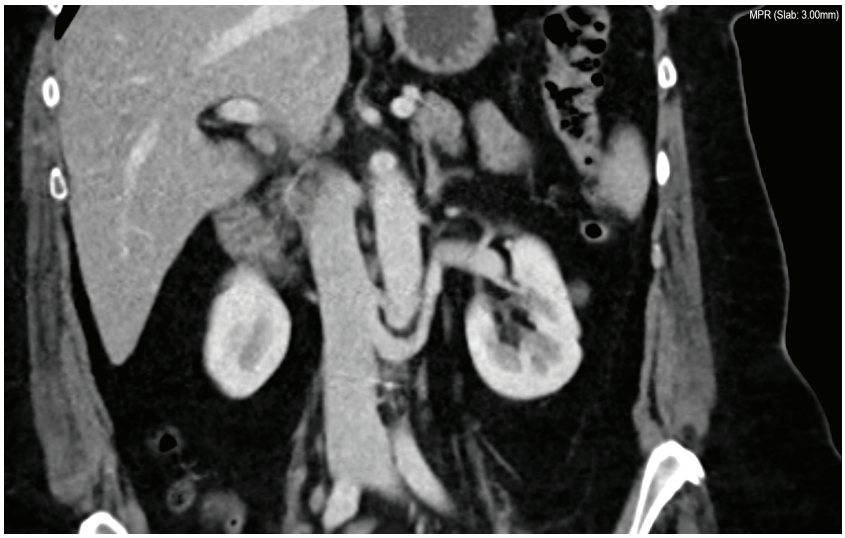
indikacija za transplantaciju, jer krvni sud ne može biti adekvatno zatvoren i to može posledično dovesti do laceracije intime renalne arterije i aorte i životno ugrožavajućeg krvarenja [1,2]. Fibromuskularna displazija (FMD) je drugi najčešći uzrok stenoze renalnih arterija i to je neaterosklerotska, neinflamatorna vaskularna bolest, nepoznate etiologije, koja zahvata srednje i velike arterije, tačnije srednje i distalne segmente renalnih arterija. Na *CT*-u se klasično prezentuje slikom „nanizanih perli", ali se može prezentovati i kao fokalna stenoza ili kao aneurizmatske promene [2,4,9,10]. Ako se nađe unilateralni segment fibromuskularne displazije, on može biti zamenjen graftom (biološkim ili sintetičkim) i bubreg se može koristiti kao graft. Međutim, bilateralna FMD isključuje mogućost donacije [2,10].

artery stenosis most commonly has an atherosclerotic etiology and it affects the origin and the proximal segments of the renal arteries, in elderly patients. The presence of calcified plaques is a contraindication for transplantation, because the blood vessel cannot be adequately clamped, which can subsequently lead to laceration of the intima of the renal artery and aorta and to life-threatening bleeding [1,2]. Fibromuscular dysplasia (FMD) is the second most common cause of renal artery stenosis and is a non-atherosclerotic, non-inflammatory vascular disease of unknown etiology that affects medium and large arteries, more precisely the middle and distal segments of the renal arteries. On CT, it typically presents as the 'string of beads' sign, but it can also present as a focal stenosis or as



Slika 4. Aneurizma glavnog stabla leve renalne arterije (slika pripada arhivi Urgentnog centra Univerzitetskog kliničkog centra Srbije)

Figure 4. Aneurysm of the main trunk of the left renal artery (the image was taken from the records of the Emergency Department of the University Clinical Center of Serbia)



Slika 5. Dve renalne vene, levo
(slika pripada arhivi Urgentnog centra Univerzitetskog kliničkog centra Srbije)

Figure 5. Two renal veins, left (the image was taken from the records of the Emergency Department of the University Clinical Center of Serbia)

Venska evaluacija je izuzetno važna, zato što je vensko krvarenje najčešći razlog odluke da se sa laparoskopske pređe na otvorenu hirurgiju, ali i zato što su anatomske varijacije renalnih vena češće nego varijacije renalnih arterija [4]. Trebalo bi navesti broj, tok i dužinu stabla glavnih renalnih vena i njihovih pritoka [2]. Kasni segmentni konfluens desne renalne vene je definisan kao segmentni konfluens na rastojanju manjem od 1 – 2 cm od donje šuplje vene. Obično je kratka desna renalna vena razlog zašto je levi bubreg poželjniji za transplantaciju. Kasni segmentni konfluens leve renalne vene se javlja 1,5 – 2 cm od leve ivice aorte [2]. Najčešće varijacije leve renalne vene su prekobrojne (akcesorne) i cirkumaortične renalne vene. Velike sistemske pritoke leve renalne vene, kao što su gonadalna, adrenalna, lumbalne i retroperitonealne vene, treba pažljivo opisati [4]. Desna renalna vena u najvećem broju slučajeva nema pritoke ili to mogu biti desna gonadalna vena i retroperitonealne vene [2]. Prisustvo multiplih renalnih vena je povezano sa većom incidencijom posttransplantacione tromboze (Slika 5) [4]. Tokom *CT* evaluacije, najvažnija merenja koja se moraju izvršiti su: (1) rastojanje između segmentnog konfluensa desne renalne vene i *VCI*, (2) rastojanje između segmentnog konfluensa leve renalne vene i *VCI* i (3) rastojanje između segmentnog konfluensa leve renalne vene i leve ivice aorte [2].

PROCENA SABIRNOG SISTEMA GORNJEG URINARNOG TRAKTA

Nefrolitijaza je prva među mogućim patologijama koje treba pomenuti, zbog njene velike učestalosti. Mali kalkulusi (manji od 4 mm) nisu prepreka za donaciju, ali multipli kalkulusi ili pojedinačni kalkulusi veći od 5 mm isključuju donaciju sve dok se kalkuloza ne tretira ili se

aneurysmal changes [2,4,9,10]. If a unilateral segment of fibromuscular dysplasia is found, it can be replaced with a graft (biological or synthetic) and the kidney can be used as a graft. However, bilateral FMD excludes the possibility of donation [2,10].

Venous evaluation is extremely important, because venous bleeding is the most common reason for the decision to switch from laparoscopic to open surgery, but also because anatomical variations of renal veins are more common than variations of renal arteries [4]. The number, course, and length of the trunk of the main renal veins and their tributaries should be reported on [2]. Late segmental confluence of the right renal vein is defined as segmental confluence at a distance of less than 1 – 2 cm from the inferior vena cava. Usually, a short right renal vein is the reason why the left kidney is preferred for transplantation. Late segmental confluence of the left renal vein occurs 1.5 – 2 cm from the left aortic margin [2]. The most common variations of the left renal vein are supernumerary (accessory) and circumaortic renal veins. Large systemic tributaries of the left renal vein, such as the gonadal, adrenal, lumbar, and retroperitoneal veins, should be carefully described [4]. In most cases, the right renal vein has no tributaries, or these tributaries can be the right gonadal vein and the retroperitoneal veins [2]. The presence of multiple renal veins is associated with a higher incidence of posttransplantation thrombosis (Figure 5) [4]. During CT evaluation, the most important measurements that must be made are: (1) the distance between the segmental confluence of the right renal vein and the IVC, (2) the distance between the segmental confluence of the left renal vein and the IVC, and (3) the distance between the segmental confluence of the left renal vein and the left margin of the aorta [2].

ne sprovede metaboličko ispitivanje [2]. Hidronefroza, papilarna nekroza, medularni sunđerasti bubreg, kao i tumori prelaznog epitela, podrazumevaju isključivanje iz donacije bubrega [2]. Bilo koji anatomski varijetet sabirnog sistema, kao što su duplikacija uretera, *ureter fissus*, ekstrarenalni pijelon, *pelvis bifidus*, opstrukcija ureteropijelične junkcije, i drugi, neophodno je pomenuti [2,3]. Treba istaći i da kompletna ili parcijalna duplikacija uretera nisu apsolutne kontraindikacije za donaciju, ali moraju biti pažljivo razmotrene [2].

ZAKLJUČAK

Transplantacija ostaje najbolja terapijska metoda kod pacijenata sa završnim stadijumom bubrežne bolesti, ali zahteva precizni multidisciplinarni pristup. Radiološka evaluacija potencijalnih živih davalaca bubrega je ključna za uspešnu transplantaciju, a *CT* ima presudnu ulogu u ovom procesu. Ključ za dobar radiološki izveštaj je poznavanje hirurških tehnika i poteškoća sa kojima se hirurzi mogu suočiti tokom procesa transplantacije bubrega.

Sukob interesa: Nije prijavljen.

ASSESSMENT OF THE UPPER URINARY COLLECTING SYSTEM

Nephrolithiasis is the first among the possible pathologies that should be mentioned, due to its high frequency. Small calculi (smaller than 4 mm) are not an obstacle for donation, but multiple calculi or single calculi larger than 5 mm preclude donation until they are removed, or until metabolic testing is performed [2]. Hydronephrosis, papillary necrosis, medullary sponge kidney, as well as transitional cell tumors, indicate exclusion from kidney donation [2]. Any anatomical variation of the collecting system, such as duplication of the ureter, ureter fissus, extrarenal pelvis, bifid renal pelvis, obstruction of the ureteropelvic junction, etc., must be reported [2,3]. It should also be noted that neither complete nor partial duplication of the ureter represent absolute contraindications for donation, however, they must be carefully considered [2].

CONCLUSION

Transplantation remains the best therapeutic method in patients with end-stage renal disease, but it requires a precise multidisciplinary approach. Radiological evaluation of potential living kidney donors is crucial for successful transplantation, and CT plays a crucial role in this process. The key to a good radiology report is knowing the surgical techniques and the difficulties that surgeons may face during the kidney transplant process.

Conflict of interest: None declared.

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