

## Endovascular repair of renal artery aneurysm with the multilayer stent – a short report

Znotrajžilno zdravljenje anevrizme ledvične arterije z novo večslojno mrežasto žilno opornico – kratko poročilo

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### Abstract

**Background:** Complex renal artery aneurysms (RAA) involving major branches of renal artery are difficult to treat. Surgery may be associated with extensive invasiveness and morbidity in the context of major intra-abdominal surgery. Stent-grafts or selective coil embolization are contraindicated when large branches are involved in the aneurysmal sac. A case of the patient with complex renal artery aneurysm involving all major arterial branches treated with a new type of multilayer stent is described.

**Case report:** A 56-year old woman whose right kidney had been removed five years before because of renal cell carcinoma was incidentally found to have a large (22x26 mm) saccular aneurysm in the main left renal artery involving all three major branches of the renal artery. Via a percutaneous femoral approach a multilayer stent was deployed without complications. Blood flow inside the sac was immediately and significantly reduced. All the renal branches remained patent.

**Conclusion:** New multilayer fluid modulating stent concept appears to be a very useful and attractive alternative to surgery or other endovascular techniques for those RAA involving or very close to major branch vessels, especially in patients with very high risk of losing the only viable kidney, as in our case.

### Razširjen povzetek

**Uvod:** Anevrizme ledvične arterije so redke. Pojavljajo se v približno enem odstotku vseh klinično ugotovljenih anevrizem. Običajno so asimptomatske in praviloma jih odkrijemo po naključju. Indikacije o zdravljenju so protislovne. Večina zdravnikov se strinja, da je invazivno zdravljenje smiselno, ko anevrizma po premeru preseže dva centimetra, s čimer narašča tveganje za razpok, trombozo ali disekcijo. Zdravimo jih lahko kirurško ali znotrajžilno. Poseben primer so zapletene anevrizme ledvične arterije, ki zajemajo področje razcepišča poglavitnih vej za parenhim. Znotrajžilno zdravljenje z oplačnimi opornicami ali z embolizacijo pri takih anevrizmah ni možno. Kirurško zdravljenje pa je tvegano in povezano z večjo pojavnostjo zapletov. Prikazan je primer bolnice z eno samo ledvico, ki je imela zapleteno anevrizmo leve ledvične arterije. Uporabili smo novo vrsto znotrajžilne opornice. Gre za posebno opornico, sestavljeno iz več slojev pletene mreže in brez zunanega plašča. Posebnost opornice je njena zmožnost, da ohrani pretok krvi v tistih vejah arterije, ki jih prekrije, hkrati pa povzroči trombozo anevrizme.

**Prikaz primera:** Osemindesetletna bolnica je bila napotena iz druge ustanove, kjer je bila na običajnem kontrolnem pregledu trebušne votline z ultrazvokom. Kontrolne preglede so ji opravljali enkrat letno, saj so ji pred petimi leti odstranili desno ledvico zaradi ledvičnega karcinoma. Med pregledom so našli veliko anevrizmo v hilusu leve ledvične arterije. Napravljena je

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bila CT preiskava s kontrastom, ki je ultrazvočni izvid potrdila. Najdena je bila velika aneurizma (22x26 mm) na razcepišču glavne veje leve ledvične arterije. Iz aneurizme so izhajale tri veje za ledvični parenhim. Zdravljenje z oplašeno znotrajžilno opornico ni bilo možno. Prav tako ni bila možna embolizacija. Kirurški poseg je bil ocenjen kot tvegan predvsem zaradi zarastlin po prvi operaciji. Bolnici smo predstavili vse možnosti zdravljenja, tudi možnost z vstavitvijo nove vrste večslojne mrežaste žilne opornice. Privolila je v vstavitve nove vrste opornice. Tri dni pred posegom je pričela dobivati klopidrogel (75mg/dan). Poseg je bil opravljen v lokalni ommi skozi desno skupno stegensko arterijo. Med in po posegu ni bilo zapletov. Opornica je ane-

vrizmo izključila iz krvotoka in pri tem ohranila odprte vse arterijske veje za parenhim. Bolnica je bila iz bolnišnice odpuščena dan po posegu. Mesec in šest mesecev po posegu kontrolna CT preiskava kaže popolno izključitev aneurizme iz krvotoka, laboratorijske preiskave pa kažejo normalno ledvično funkcijo.

**Zaključek:** Nova vrsta mrežaste večslojne žilne opornice, ki lahko ohrani prehodne tudi tise arterijske veje, ki jih prekriva, je videti izvrstna alternativa kirurškemu zdravljenju zapletenih aneurizem ledvične arterije, še posebej v primerih, ko je tveganje invazivnega zdravljenja visoko, tako kot pri predstavljeni bolnici z eno samo ledvico.

## Introduction

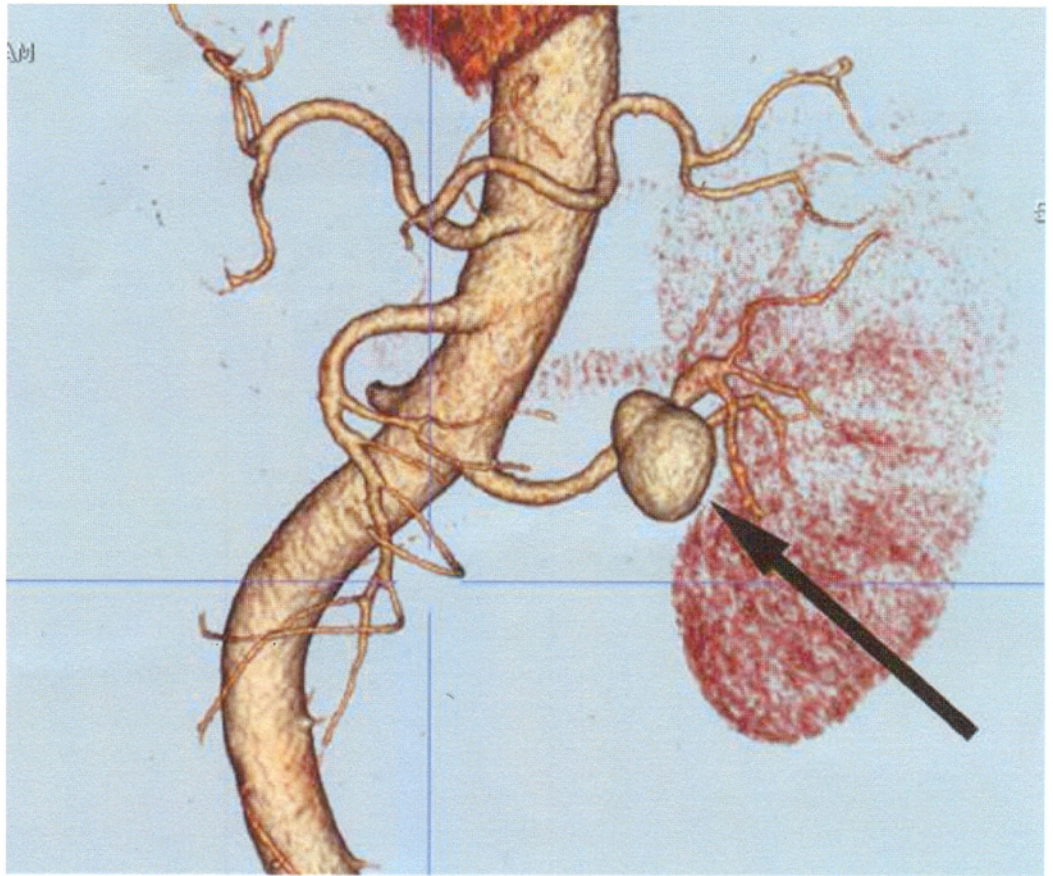
Renal artery aneurysms (RAA) are relatively rare occurrence in contemporary clinical practice. They have an estimated incidence from 0.1–1 %, <sup>1,2</sup> although the trend for more widespread investigation of the renal arteries with noninvasive methods has in some series resulted in an incidence up to 10 %. <sup>3,4</sup> In most cases the clinical relevance of the aneurysm is uncertain, as patients have no symptoms directly related to the aneurysm. Some patients may present with arterial hypertension, renal ischemia, hematuria, or flank pain, but the cause-and effect relationship is hard to establish. <sup>4-6</sup> The natural history of RAA is poorly documented. <sup>2,3</sup> RAA are usually incidentally detected in patients during various diagnostic procedures. Although rupture is not common, the risk of RAA rupture is significantly increased in pregnancy and polyarteritis nodosa (PAN) and is also related to the aneurysm size. <sup>6,7</sup> The accepted indications for RAA treatment include symptomatic patients, women who are pregnant, or those contemplating pregnancy, PAN, and enlarging lesions. <sup>4,8,9</sup> Most physicians would advocate invasive treatment when the aneurysm is larger than 2 cm or causing renal compromise. <sup>4,5</sup> Treatment of RAA involves surgical repair and endovascular techniques, depending on the size of RAA, morphologic characteristics of aneurysm and its location along the renal artery. <sup>4-7</sup> Endovascular treatment of renal

artery aneurysms was initially introduced for patients at a high risk with significant comorbidities or aneurysms of parenchymal branches with difficult surgical access. Yet, the high technical success with low procedural morbidity and mortality rates has made this approach the treatment of choice for most RAA in many centers. <sup>10,11</sup> However, for complex RAA located at the renal artery bifurcation, and for those involving distal branches, open surgical repair by *in situ* or *ex vivo* repair respectively, was suggested to be the gold standard of treatment. <sup>5,8,9,12</sup> But a new type of multilayer self-expanding stent technology has been developed that may offer an endovascular alternative in complex RAA where stent-grafts or embolotherapy could not be applied. <sup>13</sup> Stent-grafts are contraindicated when large branches must be covered, such as in our patient. The fluid modulating multilayer stent is a new technology that allows treatment of RAA without the risk of branch occlusion or renal infarction. <sup>13</sup>

## Case presentation

A 56-year old woman was referred from another hospital. Her right kidney had been removed because of renal carcinoma five years before. During regular follow-up examination with ultrasound a large left renal artery aneurysm was detected. Ultrasound showed slightly enlarged left kidney with normal shape, no signs of hydronephrosis

**Figure 1:** 3D CTA reconstruction of the abdominal aorta and left renal artery before endovascular treatment. The right renal artery is absent after removal of the right kidney years ago because of renal cell carcinoma. Arrow is denoting the aneurysm of the left renal artery. *D CTA rekonstrukcija abdominalne aorte in leve ledvične arterije pred znotrajžilnim zdravljenjem. Desne ledvične arterije ni. Desna ledvica je bila pred leti odstranjena zaradi ledvičnega carcinoma. Puščica označuje anevrizmo.*

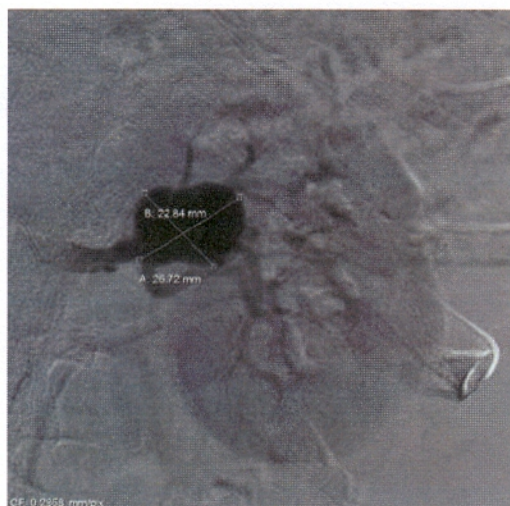


and normal echotexture. Interlobar artery resistance index was below 0.7. On admission, the patient was asymptomatic. She was taking medications for high blood pressure for five years (angiotensin-converting enzyme inhibitor ramipril and diuretic hydrochlorothiazide). Her average blood pressure during hospital stay before invasive treatment was 160/100 mmHg. Her serum urea and creatinine levels were normal. Her glomerular filtration rate calculated by MDRD equation was 71 ml/min.<sup>14</sup> The urine test showed no blood, protein or bacteria in her urine. CTA examination confirmed a large saccular aneurysm of the left hilum of the kidney (Fig. 1). On digital subtraction angiography the aneurysm measured 2.3 x 2.7 cm (Fig. 2). Three large terminal branches were involved in the aneurysm, which precluded the use of stent-graft or coils (Fig. 1 and 2). Surgical procedure was considered to be associated with high risks due to adhesions from the previous surgery. The option of an endovascular procedure with a new stent was explained to the patient, who con-

sented to the procedure. Three days prior to procedure the patient started taking clopidogrel (75 mg/dl).

Under local anesthesia, the right common femoral artery was catheterized and 5000 units of heparin were given intra-arterially. The left renal artery was selectively catheterized with a 7F RDC guiding catheter (Cordis, Warren, NJ, USA). An angiogram confirmed the size and location of the aneurysm. A stiff 0.018-inch guidewire (Boston Scientific, Natick, MA, USA) was placed in the left renal artery. Over this wire, a 6x30 mm Multilayer stent (Cardatis, Isnes, Belgium) protected by a 6-F delivery catheter was advanced and easily deployed across the neck of aneurysm, covering the main renal artery trunk and medium renal artery. All the branches remained intact (Fig 3.). The patient was discharged the next day with instruction to continue taking clopidogrel for 1 month and the acetylsalicylic acid indefinitely. At discharge, the patient's renal function was normal. Her glomerular filtration rate calculated by MDRD equation was

**Figure 2:** Digital subtraction angiography of the left renal artery. Renal artery aneurysm measures 22 x 26 mm along its long axes. *Digitalna subtrakcijska angiografija leve ledvične arterije. Aneurizma meri 22 x 26 mm, izmerjeno po dolgih oseh.*



83 ml/min. The urine test showed no blood, protein or bacteria in her urine.

After one month, the control CTA showed shrinkage of the aneurysmal sac. All major renal artery branches remained patent (Fig 4.). The patient remained in excellent condition, with normal blood pressure (130/60 mmHg) and renal function and no antihypertensive medication.

## Discussion

There is controversy regarding the indications for repair of RAA, but may include risk of rupture, rapid growth, hypertension, hematuria, dissection and symptomatic disease.<sup>4,5,8-11</sup> Our patient met multiple indications for repair of her renal artery aneurysm. She was hypertonic and it was considered that there was a significant risk for rupture. Primarily, the patient was left with only one viable kidney and the diameter of

aneurysm exceeded two centimeters. The risk of losing the remaining kidney due to rupture of RAA could not be neglected. The second indication for repair was blood pressure control.<sup>5</sup> Henke and coworkers suggested that patients who had successful repair of aneurysm had improved blood pressure control compared to controls.

For complex RAA located at the renal artery bifurcation, such as in our patient, and for those involving distal branches, open surgical repair by *in situ* or *ex vivo* repair respectively, was suggested to be the gold standard of treatment.<sup>5,8,9</sup> However, the open surgical approach for complex RAA is associated with extensive invasiveness and morbidity due to major intra-abdominal surgery.<sup>5</sup> In complex lesions, intentional nephrectomy occurs in up to 20 % of cases and unplanned nephrectomy in 5 % of cases.<sup>9</sup> In an effort to reduce invasiveness and morbidity associated with open surgical RAA repair, the laparoscopic and robot-assisted laparoscopic approach has been proposed as a possible alternative.<sup>8</sup> Minimally invasive robot-assisted laparoscopic surgery has been applied recently in the field of vascular surgery to reduce operative trauma and to improve the technical limitations of classic laparoscopy.<sup>8</sup> However, even with robotic system the total operation time with patient under general anesthesia exceeds 300 minutes and during the procedure surgeon is not able to work without total warm renal ischemia thus increasing the risk of procedure.<sup>8</sup>

Among endovascular techniques, stents represent a possible alternative to surgical repair of visceral aneurysms because they allow for organ flow preservation with minimal tissue trauma and warm ischemia time.<sup>4,10,11</sup> The current use of stents was restricted to RAA involving the main renal artery trunk, with edges located at least 15 mm away from the renal bifurcation and renal ostium.<sup>4,10,11,15</sup> Stent-grafts, selective coil embolization, stent-assisted coiling or use of liquid embolic agents are contraindicated when large branches are involved in aneurysmal sac, such as in our patient.<sup>4,10,11</sup>

The recent advent of a new type of stent offered a potential endovascular alternative to manage RAA involving one or more

**Figure 3:** Angiography immediately after new multilayer endovascular stent placement. Aneurysm is excluded from the blood flow and all distal branches are patent. *Angiografija takoj po vstavitvi znotrajžilne opornice. Aneurizma je izključena iz krvotoka, vse veje ledvične arterije pa so prehodne.*



**Figure 4:** 3D CTA one month after multilayer stent placement. There is no blood leakage into the aneurismal sac and all renal branches are patent.

*D CTA mesec dni po posegu. Aneurizma se ne polni s krvjo, vse veje ledvične arterije pa so normalno prehodne.*



branching vessels.<sup>13</sup> The fluid modulating multilayer stent has been available in Europe since 2006, and the first successful use in humans was reported for popliteal aneurysm in 2007.<sup>16</sup> The main advantage of three dimensional multilayer stent is that it reduces flow velocity and vortex into the sac, while improving laminar flow in the main artery and the surrounding vital branches. Without collateral branch, the multilayer stent eliminates the damaging flow vortex pressure and redirects its flow along the wall in the same directions as the systemic pressure leading to a physiological organized thrombus. If there is collateral branch, the multilayer stent laminates the flow in the aneurysm and the branch, directs the flow to the branch, and thus increased flow in the branch leads to a progressive collapse of the aneurismal wall. One of the major advantages of the multilayer stent is suggested to be its effect on collateral branches. Placed in front of collateral branches, a multilayer stent laminates the flow in these collaterals and improves the inflow into collateral circulation, keeping different size collateral arteries patent. All of these characteristics may help to reduce the shear stress on the

diseased arterial wall and increase the formation of an organized thrombus in aneurismal sac.<sup>13,16</sup>

Tests on animals have shown a significant difference in the flow to collaterals before and after implanting a multilayer stent. Better flow circulation in the branches was observed after a multilayer stent had been placed. All explants after one month showed that flow in the collaterals was maintained regardless of the size of the branch.<sup>13</sup> This sustained permeability is associated with the fact that the multilayer stent, unlike classical stents, becomes lined with endothelium except in the area of collaterals.<sup>13</sup>

To date only few cases of renal or visceral aneurysms treated with this new stent have been reported. Henry and coworkers first reported successful exclusion of a large renal artery aneurysm and also suggested its application for peripheral aneurysms.<sup>13</sup> Baldieri and coworkers excluded a large hepatic aneurysm and Carrafiello and coworkers successfully treated a patient with celiac trunk aneurysm.<sup>16,17</sup>

To date Henry and coworkers have treated more than 32 patients with new multilayer stent.<sup>18</sup> There were no short- and medium-term complications. In 30-month follow up all the side branches remained patent. All aneurysms thrombosed with diameter reduction in some patients.<sup>18</sup>

## Conclusion

A new concept of stent, the multilayer stent without any covering was developed to treat aneurysms. First midterm results show that this new technology could be a very useful and attractive alternative to surgery or other endovascular techniques for those RAA involving or situated very close to major branch vessels, especially in patients with very high risk of losing the only viable kidney, as in our case.

## Conflict of interests

Michel Henry is consultant for Cardiatis, producer of new multilayer stents. The other authors have no commercial, proprietary, or financial interest in any products connected with Cardiatis.

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