—Case Reports—

Long-Term Outcomes of Endovascular Stenting for Blunt Renal Artery Injuries with Stenosis: A Report of Five Consecutive Cases

Ichiro Okada[1], Junichi Inoue[2], Hiroshi Kato[3],
Yuichi Koido[1], Nobuaki Kiriu[1], Takayuki Hattori[4],
Kohei Morimoto[5], Yoshiaki Ichinose[5] and Hiroyuki Yokota[6]

[1]Department of Critical Care Medicine and Trauma, National Hospital Organization Disaster Medical Center, Tokyo, Japan
[2]Emergency and Critical Care Medical Center, Yamanashi Prefectural Central Hospital, Yamanashi, Japan
[3]Department of Emergency Medicine, Minamitama Hospital, Tokyo, Japan
[4]Department of Radiology, Tokyo Metropolitan Health and Medical Treatment Corporation Ohkubo Hospital, Tokyo, Japan
[5]Department of Radiology, National Hospital Organization Disaster Medical Center, Tokyo, Japan
[6]Department of Emergency and Critical Care Medicine, Nippon Medical School Hospital, Tokyo, Japan

Background: Renal artery stenting is performed for renal artery injuries to preserve renal function and prevent renovascular hypertension. However, its indications are controversial and its long-term prognosis remains unknown. Here, we evaluate the characteristics and long-term outcomes of renal artery stenting for blunt renal artery injuries at our institution.

Methods: We retrospectively reviewed patients with blunt renal artery injuries who had been treated with stenting over a 12-year period at our institution. Five patients (three men and two women) were included.

Results: Trauma resulted from falls in three patients and motor vehicle accidents in two. All patients had experienced multiple injuries (median injury severity score, 24 [range, 16-48]; median revised trauma score, 5.9672 [4.0936-7.8408]; and median probability of survival, 0.689 [0.533-0.980]). All renal artery injuries involved stenosis because of traumatic arterial dissection or intimal tear; no cases of total occlusion were observed. No complications due to the intervention itself were observed. Although two patients developed reversible acute renal failure, none required long-term hemodialysis. One patient with renovascular hypertension was treated with antihypertensive agents for a month and subsequently became normotensive without further medication. All patients underwent postoperative computed tomography, which revealed no stent occlusion or renal atrophy. Renal scintigraphy for three patients demonstrated preserved differential renal function. All five patients survived.

Conclusions: Renal artery stenting for hemodynamically stable blunt renal artery injuries with stenosis is suggested to be safe and helps in avoiding long-term hemodialysis and renovascular hypertension.

(J Nippon Med Sch 2019; 86: 172–178)

Key words: blunt renal artery injury, stenosis, endovascular treatment, hemodialysis, renovascular hypertension

Introduction

Blunt renal artery injury is rare, accounting for 0.05% of blunt injuries[1]. These injuries can roughly be divided into two types, bleeding and stenosis/occlusion. For bleeding cases, emergent laparotomy or tans-catheter renal artery embolization is required for hemostasis[2]. In contrast, con-

Correspondence to Ichiro Okada, MD, Department of Critical Care Medicine and Trauma, National Hospital Organization Disaster Medical Center, 3256 Midoricho, Tachikawa, Tokyo 190–0014, Japan
E-mail: ichiroh1974@gmail.com
https://doi.org/10.1272/jnms.JNMS.2019_86-306
Journal Website (http://www2.nms.ac.jp/jnms/)

Table 1 Patients treated by simple observation

Case	Age	Sex	Cause of injury	Side	Degree of stenosis	Renal injury scale grade[a]	Associated injuries	ISS	RTS	Ps	Renovascular hypertension	Long-term hemodialysis	Change of stenosis	Survival	Follow-up (months)
1	72	M	Unknown	Left	<25%	Unclear[b]	Subdural hematoma, multiple rib fracture, hemopneumothorax, clavicle fracture	25	6.6132	0.744	No	No	No change	Alive	3
2	33	M	Motor vehicle accident	Right	<25%	Grade 2	Facial bone fracture, multiple rib fracture, hemopneumothorax, spine injury, liver injury	29	7.8408	0.97	No	No	No change	Alive	12
3	28	M	Fall	Left	75%	Unclear[b]	Subdural hematoma, multiple rib fracture, hemopneumothorax, spine injury, liver injury, abdominal aorta injury, pelvic fracture, clavicle fracture	48	5.9672	0.591	No	No	None	Dead (within 6 h)	No

ISS=injury severity score; RTS=revised trauma score; Ps=survival probability
[a]Renal injury scale grade according to the renal injury scale of the American Association for the Surgery of Trauma.
[b]It was difficult to evaluate contusion and subcapsular hematoma in renal parenchyma for ischemic change.

servative therapy is chosen for a renal artery injury with stenosis/occlusion in a state of shock because the treatments of other injuries are given priority. For a hemodynamically stable renal artery injury with stenosis/occlusion, there are various choices of treatment. Conservative therapy or surgical revascularization is generally chosen as the treatment for these hemodynamically stable injuries[1,3–6]. However, the incidence of complications with conservative therapy, such as acute renal failure or renovascular hypertension is as high as 19%-43%[3,7]. Furthermore, the success rate of surgical revascularization is poor, 25%-50%[3–7].

For these reasons, renal artery injuries have been treated with renal artery stenting since the mid-1990s to preserve renal function and prevent renovascular hypertension[8]. However, its indications are controversial. The long-term prognosis remains unknown, and its evaluation as a treatment has not yet been determined[9–11].

The aim of the present study was to evaluate the characteristics and long-term outcomes of renal artery stenting for blunt renal artery injuries at our institution.

Materials and Methods

This study involved a retrospective chart review at our institution. We examined medical records dated between January 2003 and December 2014. During this period, 6,360 trauma patients were admitted to the intensive care unit. Among these, patients with blunt renal artery injury were included. Patients who were under 15 years of age or with cardiopulmonary arrest on arrival were excluded. We diagnosed the main renal artery injuries of 12 patients with contrast computed tomography (CT). Four patients experienced bleeding from the main renal artery and were treated with either surgery or renal artery embolization. Eight of the patients showed stenosis/occlusion without bleeding from the main renal artery. Of these eight patients, two had only minor stenosis, less than 25%, and were simply kept under observation, and one patient died of massive hemorrhage within 6 h after injury (**Table 1**). The remaining five were treated with renal artery stenting and were included in this study (**Fig. 1**).

The data included age, sex, cause of injury, side and form of the renal artery injury, degree of renal artery stenosis, renal injury scale grade, associated injuries, injury severity score (ISS), revised trauma score (RTS), probability of survival (Ps), time between injury and stenting, complications associated with stenting, initiation of anticoagulation therapy, post-traumatic acute renal

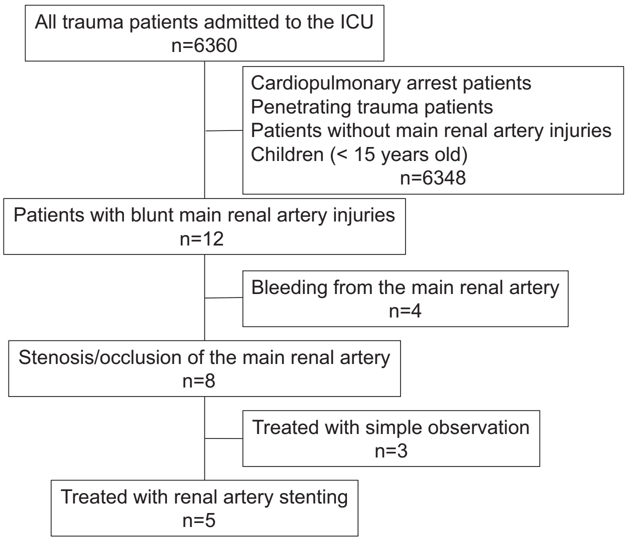

Fig. 1. Flow chart for the patients treated with renal artery stenting
ICU = intensive care unit

failure, post-traumatic renovascular hypertension, postoperative renal function, prognosis, and follow-up period.

Renal artery injuries were detected with contrast CT and performed when the patients had stabilized (i.e., they had recovered from shock and did not require continuous rapid infusion or transfusion). Using a multidetector row CT scanner, we obtained images for two phases, the arterial dominant phase and the parenchymal phase, and made sure there was no active bleeding in either phase. A maximum intensity projection image of the abdominal aorta was then created using the arterial dominant phase and the appearance of the injury was evaluated in detail. With no protocol specifying the indication for renal artery stenting, the role of stenting for each patient was decided by discussion between the attending surgeon and the radiologists.

The types of stent used were “Palmaz” (Cordis Corporation, Warren, NJ, USA) for two patients, “Palmaz genesis” (Cordis Corporation, Warren, NJ, USA) for two patients, and “Express SD” (Boston Scientific Corporation, Natick, MA, USA) for one patient. Renal artery stenting for renovascular trauma is off-label use with these devices.

When the general condition of the patient allowed the initiation of anticoagulation therapy, we administered enteral antiplatelet agents, specifically aspirin, or a continuous intravenous infusion of heparin, as early as possible after stenting. Subsequently, patients were administered antiplatelet agents at least for 3 months.

Renal parenchymal injuries were graded according to the renal injury scale of the American Association for the Surgery of Trauma[12]. We defined acute renal failure as renal function disorder equivalent to “Failure” according to the RFILE classification[13], and post-traumatic renovascular hypertension as acute onset secondary hypertension (systolic blood pressure ≥150 mmHg or diastolic blood pressure ≥90 mmHg) where the cause was not considered to be anything other than the renal artery injury[14].

Patients who had been treated with stenting underwent a follow-up contrast CT a few months later to check for complications. Within a year after stenting, their differential renal function was evaluated by renal scintigraphy. At least annually during the follow-up period, we checked renal artery blood flow and renal atrophy on ultrasonography or contrast CT, and measured renal function using laboratory data. The median follow-up period was 43 (3-110) months.

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Medicine’s Ethics Committee at our institution in January 2018 (approval number 2017-38).

Results

The characteristics of the patients with renal artery injuries treated with endovascular stenting are shown in **Table 2**. A total of five patients were included (three men and two women), of which two patients were aged less than 20 years and the others were aged 28, 37, and 62 years.

The cause of injury was falling from height in three patients and traffic accidents in the remaining two. All patients had experienced multiple injuries (median ISS, 24 [range, 16-48]). The median RTS was 5.9672 (4.0936-7.8408), and the median Ps was 0.689 (0.533-0.980). Renal artery injuries occurred on the right side in one patient, on the left side in three patients, and on both sides in one patient. All the renal artery injuries treated with stenting involved stenosis because of traumatic arterial dissection or intimal tear, and no cases of total occlusion were observed. The degree of stenosis was 99% in two patients, 75% in one, and 50% in two. Three patients (Cases 1-3) were in a state of shock on admission; before stenting, they were hemodynamically stabilized with resuscitation using transfusion or surgery. Four patients (Cases 1, 3, 4, and 5) underwent emergent thoracotomy or laparotomy before stenting.

The outcomes of endovascular stenting for renovascular trauma are shown in **Table 3**. The time between in-

Table 2 Characteristics of the patients with renal artery injuries treated with endovascular stenting

Case	Age	Sex	Cause of injury	Side	Degree of stenosis	Renal injury scale grade[a]	Associated injuries	ISS	RTS	Ps
1	37	M	Fall	Bilateral (right-sided stenting) [b]	50%	R: unclear[c] L: grade 4	Hemopneumothorax, spine injury, liver injury, mesenteric injury, pelvic fracture, femur fracture	48	5.6764	0.533
2	19	M	Fall	Left	99%	R: grade 1 L: grade 2	Hemopneumothorax, spine injury, liver injury, spleen injury, bilateral renal injuries	32	4.0936	0.547
3	62	F	Fall	Right	75%	Unclear[b]	Rib fracture, spine injury, pancreas injury, mesenteric injury	22	5.9672	0.689
4	19	M	Motor vehicle accident	Left	50%	Grade 2	Pancreas injury, fracture of tibia and fibula	24	7.8408	0.98
5	28	F	Motor vehicle accident	Left	99%	Unclear**	Pancreas injury, spine injury	16	7.8408	0.922

ISS=injury severity score; RTS=revised trauma score; Ps=survival probability

[a]Renal injury scale according to the renal injury scale of the American Association for the Surgery of Trauma.

[b]Arterial embolization for left renal artery injury with active bleeding.

[c]It is difficult to evaluate contusion and subcapsular hematoma in renal parenchyma for ischemic change.

Table 3 Outcomes of endovascular stenting for renal artery injuries

Case	Interval (h) [a]	Renal failure	Complications[b]	Renovascular hypertension	Long-term hemodialysis	Renal scintigraphy: differential renal function	Survival	Follow-up (months)
1	3.5	Yes	None	No	No	Not performed	Alive	3
2	8	Yes	None	Yes (temporally)	No	44.5%	Alive	110
3	7	No	None	No	No	41.6%	Alive	43
4	7	No	None	No	No	Not performed	Alive	55
5	8	No	None	No	No	25.2%	Alive	20

[a]Time between injury and stenting.

[b]Complications associated with stenting.

jury and stenting varied from 3.5 h to 8 h. No complications due to the intervention itself, such as bleeding or stent thrombosis, were observed. Two patients (Cases 1 and 2) developed reversible acute renal failure. In Case 1, we performed arterial embolization for bleeding from the left renal artery and performed stenting on the stenosed right renal artery. Two days later, we performed a left nephrectomy because of infection. This patient initially became dependent on a single kidney and required hemodialysis. However, hemodialysis was successfully weaned off on day 52 after stenting. Case 2 had experienced bilateral renal injuries and became anuric. He also required hemodialysis, but this was weaned off on day 8. Neither patient required long-term hemodialysis. Case 2 also developed renovascular hypertension (systolic blood pressure >200 mmHg) on day 3, which did not respond to analgesics or sedatives. We diagnosed this as post-traumatic renovascular hypertension, because this acute-onset hypertension was observed after trauma in a young patient with high plasma renin activity (PRA) and plasma aldosterone concentration (PAC) levels at rest (PRA, >20 ng/mL/h; and PAC, 230 pg/mL). He was successfully treated with antihypertensive agents (enalapril maleate 5 mg/day) for a month and subsequently became normotensive without requiring further medication. PRA and PAC levels also normalized within a month (PRA, 0.6 ng/mL/h; and PAC, 37 pg/mL).

Anticoagulation therapy was initiated for all five patients after stenting. We initiated the therapy for one patient (Case 4) on day 1 and for three patients (Case 1, 3, and 5) on day 3. The timing was unknown for Case 2.

Postoperative CT was performed on all patients, demonstrating no stent occlusion or renal atrophy. Renal scintigraphy was performed for three patients between 1 and

8 months after their injury. In all these cases, differential renal function was preserved at a level of >25%. All five patients survived.

Discussion

The results of our study suggest that stenting for renal artery injury with stenosis could preserve renal function and prevent renovascular hypertension even if significant time was taken for stenting after injury. A good long-term prognosis could be expected. Additionally, we were able to avoid complications associated with the procedure itself.

Indications for stenting in this study were hemodynamically stable blunt renal artery injuries with stenosis and no active bleeding from the renal parenchyma on contrast CT. With penetrating trauma, some arterial injuries with transection or avulsion have an appearance similar to stenosis/occlusion on contrast CT[15,16]. We therefore consider stenting to be contraindicated for penetrating trauma. In hemodynamically unstable patients, diagnosis and treatment of the cause is the main concern. We suggest that stenting is contraindicated for patients with extravasation from the renal parenchyma or blood vessels on contrast CT because the stenting can promote bleeding. The presence of a hematoma in the para-renal space, outside Gerota's fascia, is also a contraindication because bleeding can be expected imminently[17]. Conversely, we would not necessarily consider a small hematoma in the peri-renal space, inside Gerota's fascia, to be a contraindication for this treatment[18]. However, renal parenchymal injuries with renal artery injuries are sometimes unclear on contrast CT because of malperfusion caused by vessel injuries. This malperfusion can mask parenchymal injuries. Consequently, promoting hemorrhage by recanalization with stenting should be a concern even in cases without either injury or active bleeding in the renal parenchyma on contrast CT[19]. In addition, general stenting should not be performed for contraindicated patients (e.g., those with severe blood vessel meandering, allergy, or selected anticoagulation therapies). Stenting for total renal artery occlusion had not been attempted at our institution because of complications, such as perioperative bleeding[19].

Differences in the degree of stenosis did not significantly influence the outcomes of this study. In our opinion, total occlusion influences the outcome to a greater extent than stenosis. Irreversible changes in renal parenchyma occur when total occlusion of a renal artery continues for ≥1 h[20–22]. In a total renal artery occlusion, multiple thrombi in the distal renal arteries are likely to progress rapidly within 3 h, as was observed by Kushimoto et al.[23] Stenting at >3 h after an injury for the total occlusion could prevent renovascular hypertension but would not preserve adequate differential renal function in most cases[10,19,23,24]. Renal blood flow is mainly dependent on the renal arteries, but there is also a collateral arterial supply (e.g., from the renal capsular arteries or adrenal arteries)[25,26]. In a case of total occlusion, collateral supply does not keep sufficient renal blood flow; however, collateral supply may work in a case of stenosis. Indeed, our cases with severe 99% stenosis (Case 2 and 5) were able to preserve adequate differential renal function although Case 2 required temporary hemodialysis. In contrast, Springer et al. reported a case of stenosis for which stenting on day 25 after injury successfully resolved renovascular hypertension but did not preserve adequate differential renal function[27]. This report shows that stenting as early as possible is desirable to preserve differential renal function even in a case of stenosis.

Both bleeding and stent thrombosis are direct complications of renal artery stenting. Although bleeding may be controlled by endovascular treatment, such as arterial embolization, stenting should be performed under the care of stand-by surgeons, particularly if the risk of urgent nephrectomy is present. We did not experience bleeding during the procedure of stenting, but every stenting procedure was performed under the supervision of stand-by surgeons. The risk of stent thrombosis or re-stenosis is generally low because renal artery stents are large in diameter and short in length[28,29]. If stent thrombosis develops, endovascular treatments can be effective[10]. Postoperative antiplatelet or anticoagulation therapies to prevent stent thrombosis cannot be performed for patients who are in a poor general condition. However, we consider that it is important for the prevention of thrombosis and re-stenosis to administer enteral antiplatelet agents or a continuous intravenous infusion of heparin, as early as possible after stenting[28,29]. In this study, patients were initiated for anticoagulation therapies immediately after hemostasis. We believe this management would prevent thrombotic complications.

Because renal artery injuries are often associated with damage to the renal parenchyma, both renal blood flow and differential renal function should be assessed during the follow-up period[30]. In addition, the side where renal function is affected should be comprehensively evaluated for changes in kidney size, laboratory data, and clinical symptoms, including renal scintigraphy. After stenting, it is desirable to evaluate differential renal function with renal scintigraphy at least once. Regular ultrasonography is useful for follow-up[29]. In our study, renal scintigraphy was performed on three of five cases, and an adequate differential renal function was preserved in these three cases. Long-term follow-up after stenting revealed no renal atrophy in all the five cases. An endovascular stent with patency would be effective in preserving long-term renal function.

The largest study to date on stenting for blunt renal artery injuries included eight cases from three institutions in Texas, USA[19]. Intraoperative bleeding developed in two of these cases, and another two patients developed renovascular hypertension. The final renal function of the affected side was preserved in four of the eight cases. Stenting was performed in seven total occlusion cases in their study. In contrast, we performed stenting only for stenosis cases. This potentially accounts for any differences observed between the two studies with respect to success and complication rates.

The present study has some limitations. It was a retrospective observational study including a small number of patients. Because we did not follow a specific protocol for indications and procedures for renal artery stenting, there were no uniformity patient indications and the procedures that they underwent. Moreover, there was no control group, so we cannot accurately determine the effectiveness and safety of renal artery stenting for blunt renal artery injuries.

We reviewed five hemodynamically stable patients with blunt renal artery injuries and stenosis, who were treated with stenting at our institution. All the patients survived and no complications due to the intervention itself were observed. Furthermore, all preserved renal function without irreversible renovascular hypertension. Renal artery stenting for hemodynamically stable blunt renal artery injuries with stenosis is suggested to be safe and helps in avoiding long-term hemodialysis and renovascular hypertension. We therefore consider renal artery stenting to be a favorable treatment option for blunt renal artery injuries with stenosis.

Acknowledgements: We reported four of these five cases in the Journal of Japanese Association for Acute medicine (JJAAM) in January 2014 in Japanese. We added one more case with new data and revised the JJAAM report to produce this manuscript. The committee of Japanese Association for Acute Medicine permitted this submission. We thank Daizo Saito, MD, editor in chief of JJAAM for his help and advice.

Conflict of Interest: The authors declare no conflict of interest.

References

1. Sangthong B, Demetriades D, Martin M, Salim A, Brown C, Inaba K, Rhee P, Chan L: Management and hospital outcomes of blunt renal artery injuries: Analysis of 517 patients from the National Trauma Data Bank. J Am Coll Surg 2006; 203: 612–617.
2. Loffroy R, Chevallier O, Gehin S, Midulla M, Berthod PE, Galland C, Briche P, Duperron C, Majbri N, Mousson C, Falvo N: Endovascular management of arterial injuries after blunt or iatrogenic renal trauma. Quant Imaging Med Surg 2017; 7: 434–442.
3. Haas CA, Dinchman KH, Nasrallah PF, Spirnak JP: Traumatic renal artery occlusion: a 15-year review. J Trauma 1998; 45: 557–561.
4. Clark DE, Georgitis JW, Ray FS: Renal artery injuries caused by blunt trauma. Surgery 1981; 90: 87–96.
5. Elliott SP, Olweny EO, McAninch JW: Renal arterial injuries: a single center analysis of management strategies and outcomes. J Urol 2007; 178: 2451–2455.
6. Haas CA, Spirnak JP: Traumatic renal artery occlusion: a review of the literature. Tech Urol 1998; 4: 1–11.
7. Knudson MM, Harrison PB, Hoyt DB, Shatz DV, Zietlow SP, Bergstein JM, Mario LA, McAninch JW: Outcome after renovascular injuries: A Western Trauma Association Multicenter Report. J Trauma 2000; 49: 1116–1122.
8. Whigham J, Bodenhamer Jr, Miller JK: Use of the Palmaz stent in primary treatment of renal artery intimal injury secondary to blunt trauma. J Vasc Interv Radiol 1995; 6: 175–178.
9. Memon S, Cheung BY: Long-term results of blunt traumatic renal injury dissection treated by endovascular stenting. Cardiovasc Intervent Radiol 2005; 28: 668–669.
10. Chabrot P, Cassagnes L, Alfidja A, Mballa JC, Nasser S, Guy L, Diop AN, Ravel A, Boyer L: Renovascularization of traumatic renal artery dissection by endoluminal stenting: three cases. Acta Radiol 2010; 51: 21–26.
11. Schwartz JH, Malhotra A, Lang E, Sclafani SJ: One-year follow-up of renal artery stent graft for blunt trauma. J Urol 2008; 180: 1507.
12. Moore EE, Shackford SR, Pachter HL, McAninch JW, Browner BD, Champion HR, Flint LM, Gennarelli TA, Malanqoni MA, Ramenofsky ML, Trafton PG: Organ injury scaling: spleen, liver, and kidney. J Trauma 1989; 29: 1664–1666.
13. Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P: Acute renal failure - definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative Group. Crit Care 2004; 8: R204–R212.
14. Montgomery RC, Richardson JD, Harty JI: Posttraumatic renovascular hypertension after occult renal injury. J Trauma 1998; 45: 106–110.
15. Inaba K, Potzman J, Munera F, McKenney M, Munoz R, Rivas L, Dunham M, DuBose J: Multi-slice CT angiography for arterial evaluation in the injured lower extremity. J Trauma 2006; 60: 502–507.
16. Pieroni S, Foster BR, Anderson SW, Kertesz JL, Rhea JT, Soto JA: Use of 64-row multidetector CT angiography in blunt and penetrating trauma of the upper and lower extremities. Radiographics 2009; 29: 863–876.

17. Fu CY, Wu SC, Chen RJ, Chen YF, Wang YC, Chung PK, Huang HC, Huang JC, Lu CW: Evaluation of need for angioembolization in blunt renal injury: Discontinuity of Gerota's fascia has an increased probability of requiering angioembolization. Am J Surg 2010; 199: 154–159.
18. Charbit J, Manzanera J, Millet I, Roustan JP, Chardon P, Taourel P, Capdevila X: What are the specific CT scan criteria that can predict or exclude the need for renal angioembolisation after high grade renal injury in conservative management strategy? J Trauma 2011; 70: 1219–1228.
19. Lopera JE, Suri R, Kroma G, Gadani S, Dolmatch B: Traumatic occlusion and dissection of the main renal artery: Endovascular treatment. J Vasc Interv Radiol 2011; 22: 1570–1574.
20. Evans A, Mogg RA: Renal artery thrombosis due to closed trauma. J Urol 1971; 105: 330–334.
21. Magilligan DJ, DeWeese JA, May AG, Rob CG: The occluded renal artery. Surgery 1975; 78: 730–736.
22. Culp DA: Renal artery block. Surg Gynecol Obstet 1969; 129: 114–115.
23. Kushimoto S, Shiraishi S, Miyauchi M, Tanabe S, Fukuda R, Tsujii A, Masuno T, Kim S, Kawai M, Yokota H, Tajima H: Traumatic renal artery occlusion treated with an endovascular stent- The limitation of surgical revascularization: Report of a case. Surg Today 2011; 41: 1020–1023.
24. Abu-Gazala M, Shussman N, Abu-Gazala S, Elazary R, Bala M, Rozenberg S, Klimov A, Rivkind AI, Arbell D, Almogy G, Bloom AI: Endovascular management of blunt renal artery trauma. Isr Med Assoc J 2013; 15: 210–215.
25. Brolin I, Stener I: Collaterals in obstruction of the renal artery. Acta Radiol 1966; 4: 449–467.
26. Love L, Bush IM: Early demonstration of renal collateral arterial supply. Am J Roentgenol Rad Ther Nucl Med 1968; 104: 296–301.
27. Springer F, Schmehl J, Heller S, Claussen CD, Brechtel K: Delayed endovascular treatment of renal artery dissection and reno-vascular hypertension after blunt abdominal trauma. Cardiovasc Intervent Radiol 2011; 34: 1094–1097.
28. Rocha-Singh K, Jaff MR, Rosenfield K: Evaluation of the safety and effectiveness of renal artery stenting after unsuccessful balloon angioplasty: the ASPIRE-2 study. J Am Coll Cardiol 2005; 46: 776–783.
29. Rocha-Singh K, Jaff MR, Lynne KE: Renal artery stenting with noninvasive duplex ultrasound follow-up: 3-year results from the RENAISSANCE renal stent trial. Catheter Cardiovasc Interv 2008; 72: 853–862.
30. Wessells H, Deirmenjian J, McAninch JW: Preservation of renal function after reconstruction for trauma: quantitative assessment with radionuclide scintigraphy. J Urol 1997; 157: 1583–1586.

(Received, March 10, 2017)
(Accepted, December 12, 2018)