ORIGINAL ARTICLE

Iatrogenic retroperitoneal hematoma as an access-site complication of neurointervention

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Abstract

Background: To evaluate the clinical and imaging presentation, management, and outcome of iatrogenic retroperitoneal hematomas (IRPHs) during a series of neurointerventional procedures (NIPs).

Methods: Six IRPH patients with complications, including five renal subcapsular hematomas (RSH) and one retroperitoneal hemorrhage, were observed among 2290 NIPs performed at our hospital from 2000 through 2020. The medical records, neurointerventional techniques, imaging data, and management of these six IRPH patients were retrospectively reviewed. All six patients received preprocedural dual antiplatelet medication and intraprocedural heparinization.

Results: All patients underwent right femoral access. The guidewires were not handled under full course fluoroscopy monitoring. The most common symptom of IRPH was periprocedural flank/abdominal pain (6/6, 100%), including five on the left side (83.3%). Hypotension or shock was observed in three patients (50%). Two patients (33%) were diagnosed intraoperatively by sonogram and received on-site treatment, whereas the other four were diagnosed by postprocedural abdominal computed tomography. Active extravasation from a renal artery was diagnosed by angiogram in the five patients with RSH and was successfully treated with embolization. Multiple bleeders in the branches of the renal artery were noted in three RSH patients (60%). The patient with retroperitoneal hematoma was treated conservatively.

Conclusion: Unexplained periprocedural or postprocedural abdominal/flank pain, especially contralateral to the femoral access side of the NIPs, should raise the possibility of IRPH. To prevent IRPH, the authors suggest using full visual fluoroscopic monitoring for guidewire navigation during femoral catheterization of NIPs.

Keywords: Aneurysm; Angioplasty; Carotid artery disease; Complication; Retroperitoneal hematoma

1. INTRODUCTION

Vascular complications related to endovascular procedures are commonly observed at the puncture site, particularly in cardiac catheterization, which can account for 2.5% of all puncture site complications.[1] The overall access-site complication rate of neurointerventional procedure (NIP) can reach 5.1%, and the most common complications are groin hematoma and access-site hemorrhage.[2] Among access-site complications, retroperitoneal hematoma (RPH) is rare but severe, with an incidence rate of 0.57%. Iatrogenic RPH (IRPH) is often related to renal biopsy, extracorporeal lithotripsy, or endovascular procedures.

Although rare, IRPH can be life-threatening, with a mortality rate of 4%–12%.[3] Recognition of IRPH may be delayed during NIPs, because symptoms are usually nonspecific, which may be confusing when the patients are under or are recovering from general anesthesia, and are not related to symptoms of intracranial neurological insult. Application of NIP periprocedural antithrombotic medication can further aggravate IRPH and make it difficult to resolve spontaneously. Delayed recognition and management of IRPH can result in severe hypovolemic insult or mortality. Few cases of IRPH from NIPs and their management have been reported.[4–8] The present retrospective study evaluated clinical and imaging presentations and the management of IRPH after NIPs at the authors' institute. The anticipated results may facilitate early diagnosis of IRPH, thereby ameliorating the impact of this complication of neurointervention.

2. METHODS

2.1. Study population

This study was approved by our institutional review board and informed consent was obtained from all participants. All investigations were conducted according to the principles expressed in the Declaration of Helsinki. From 2000 through 2020, a total of 2290 patients received endovascular neurointerventional procedures at the authors' institute. The therapeutic objectives of these endovascular procedures included the management of neurovascular stenosis, carotid blowout syndrome, cerebral aneurysm,

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and arteriovenous malformation. Of these 2290 patients, six patients diagnosed with IRPH were included in this retrospective study (Table 1), consisting of five cases of renal subcapsular hematoma (RSH) and one case of hematoma extending along with the psoas muscle. No cases of coagulopathy were observed. The platelet count was within normal range for all six patients (range 196–375 K/μl).

2.2. Neurointerventional procedures

Regarding the indications for NIPs, two patients had carotid stenosis and one had intracranial vertebral artery dissection, who were treated with angioplasty and stenting; two patients had threatened carotid blowout syndrome and were treated with stent-graft placement; and one cerebral aneurysm patient treated with stent-assisted coiling. The six patients had received NIP-related preprocedural dual antiplatelet medication, including loading dose of 300 mg aspirin and 300 mg clopidogrel, at least 1-day pre-procedure. Following procedures, dual antiplatelet therapy, including 300 mg aspirin, q.d. and 75 mg Clopidogrel, q.d., was given for 1–3 months. All procedures were performed under local anesthesia, except for a patient with cerebral aneurysm who received general anesthesia.

A trans-arterial approach with Seldinger's technique was used to gain access to the right femoral artery. The wire used to perform the diagnostic angiogram, and to forward guiding sheaths, was 0.035Fr, 150 cm hydrophilic guidewire (Radifocus guidewire M, Terumo Medical Corporation, Tokyo, Japan; Merit Laureate, Merit Medical, UT, USA). A 5Fr femoral sheath (Radifocus Introducer II; Terumo Medical Corporation, Tokyo, Japan) was used initially when obtaining a complete neuroangiogram. After obtaining the diagnostic angiogram, a 6 or 8 Fr guiding sheath (Flexor Shuttle sheath, Cook Medical, Bloomington, IN, USA; Neuron MAX 088, Penumbra, CA, USA) was placed into the targeted artery using a 150 cm hydrophilic guidewire. For all six patients, episodes of wire resistance into branches of the abdominal aorta during manipulation of the guiding sheaths were experienced by the resident or fellow operators. All patients received an intravenous bolus of heparin, 50–70 IU/kg (approximately 3000–4000 IU/patient) before the procedure. Post-NIP, intravenous protamine 20 mg was administered to reverse the injected heparin. Technical success was achieved in all six patients without the occurrence of neurological deficit. Hemostasis for the femoral artery was achieved by manual compression with the hemostatic patch (Coreleader Hemo-Pad, BIOTECH CO., LTD., New Taipei City, Taiwan; Avitene Microfibrillar Collagen Hemostat, Becton, Dickinson and Company, NJ, USA; Clo-Sur PLUS P.A.D., Scion BioMedical, FL, USA).

2.3. Iatrogenic retroperitoneal hematoma

Clinical symptoms and onset time from the start of NIPs were evaluated for all six IRPH patients. The following were recorded and reviewed: procedural course reported by the operators, laboratory studies of IRPH, including platelet count and periprocedural hemoglobin; anatomical factors of lower abdominal aorta and branches related to the femoral access, wiring or catheterization feasibility; imaging tools to diagnose IRPH, including on-site sonography and computed tomography (CT); and management techniques of the IRPH and outcome.

3. RESULTS

3.1. Demographic features and neurointerventional procedures

The demographic features and NIPs were listed in Table 1. The average age of all six patients was 59.2 ± 14.5 (range: 42–83) years, with five males (83%) and one female. All NIPs were successfully completed without neurological sequelae. The preprocedural platelet counts were 279 ± 74.1 (range: 196–375) × 1000/μl. No history of bleeding tendency was found in all six patients.

3.2. Iatrogenic retroperitoneal hematoma, management and outcome

Periprocedural/postprocedural abdominal/flank pain or hypotension initiated further evaluation. The clinical symptoms of IRPH in all six patients began 7.3 ± 11.2 (range: 1.5–30) hours after NIPs. Clinical impression before abdominal sonography and/or CT was aortic dissection or acute abdomen. The most common symptoms of IRPH were abdominal fullness, nausea, and flank pain. Three patients (cases 2, 4 and 6) receiving local anesthesia complained of flank pain intraoperatively. Shock or hypotension was observed in cases 2 and 6. The diagnosis was made using on-site ultrasound or abdominal CT. The other three patients had symptoms after returning to the ward and were diagnosed by abdominal CT. One patient developed hypovolemic shock while in the post-anesthesia care unit (case 3).

Among the four patients who received an abdominal CT scan, case 1 had contrast extravasation from inter-polar and lower pole of the left kidney detected on CT, which is compatible with a later angiographic finding of three bleeders from interlobular arteries in upper and lower poles of the left kidney. Case 1 was then embolized with n-butyl cyanoacrylate (NBCA). Case 2 had several high-density foci in the subcapsular hematoma of the left kidney, but no active extravasation upon CT scan. Angiogram revealed no extravasation, other than multiple vascular leaks or small pseudoaneurysms at the left lower pole region. Case 3 had active contrast extravasation, left lower pole, with large hematoma extending into left iliac fossa and pelvis; angiogram confirmed the diagnosis of bleeding via an interlobar artery branching from the left lower segmental artery, which was embolized with coils (Fig. 1). Other than RSH, the only complication in case 3 was a pseudoaneurysm in the punctured femoral artery, treated with surgical repair. Case 5 had hematoma formation along the left psoas muscle with no extravasation and received conservative treatment. Cases 4 and 6 were diagnosed using on-site sonography and angiogram (Figs. 2, 3). All 5 cases of RSH received a total of 6 sections of endovascular treatment of the involved renal artery to achieve hemostasis (Table 1, Figs. 1–3).

Case 4 complained of left flank pain during the procedure. After a carotid stent was deployed, on-site ultrasound confirmed RSH. A renal angiogram showed two focal regions of extravasation from the left renal parenchyma (Table 1, Fig. 2). Two bleeders from interlobular arteries were successfully embolized with NBCA. About 6 hours post-procedure, case 4 complained of persistent abdominal pain. Abdominal CT showed extravasation from the lower pole of the left kidney. The renal angiogram was again performed and an additional bleeder from the left lower renal parenchyma was noted. An interlobar artery in the lower pole was embolized with NBCA and condition stabilized. The reasons why the 3rd bleeder was not found in the first angiogram might be attributed to: (1) It was too small to be detected at the first angiography. The bleeder can only be detected and correlated with computed tomography angiography of the abdomen and thus we found the bleeder. (2) After first embolization, the patient's blood pressure raised to the normal range, which made the small 3rd bleeder detectable. Follow-up abdominal sonography showed atrophy of involved kidney.

The clinical conditions of the six patients were stabilized soon after treatment. However, case 2 expired 11 days post-treatment due to progressive lung metastasis from thyroid cancer. The

Table 1

Demographic features of the six patients of iatrogenic retroperitoneal hematomas by neurointerventional procedures

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Age (Y/O)	83	51	65	51	42	63
Sex (M/F)	M	M	F	M	M	M
Indication for neurointervention	Right carotid stenosis	Threatened carotid blowout syndrome from left ICA	Aneurysm at right supra-clinoid ICA	Right carotid stenosis	Dissection of right intracranial vertebral artery	Threatened carotid blowout syndrome from right ICA
Brief history	Smoking	Thyroid cancer s/p operation 1 month ago	Nil	NPC for 10 years, s/p CCRT	Nil	Tongue cancer for 8 years
Neurovascular treatment	Angioplasty and stenting	Stent-graft placement	Stent-assisted coiling	Angioplasty and stenting	Angioplasty and stenting	Stent-graft placement
Procedural platelet count (1000/ul)	196	375	216	230	321	336
IRPH symptoms	Left flank pain, nausea	Left flank/back pain, shock	Left flank pain, shock	left flank pain	Left abdominal pain	Right flank pain, hypotension
IRPH onset time (hours)	4	1.5, Intraprocedural	5	2, Intraprocedural	30	1.5, Intraprocedural
CT or ultrasound findings	CT: RSH and contrast extravasation from left middle and lower kidney	CT: Hyperdense foci in the left RSH	CT: RSH and contrast extravasation from left lower kidney	US: left RSH CT: contrast extravasation from left lower kidney	CT: RPH along left psoas muscle	US: left RSH
Angiogrphic findings	Three bleeders from left renal interlobular arteries	Two bleeders from left upper and lower segmental arteries	A bleeder from left lower renal segmental artery	1st Angiogram: two bleeders from the left renal interlobar artery; 2nd angiogram: one bleeder from left lower renal interlobar artery	Nil	A bleeder from right lower interlobular artery
Management of IRPH	Embolization with NBCA	Embolization with NBCA	Embolization with coils	Both embolization with NBCA	Medical treatment	Embolization with NBCA
Hb (g/dl), preprocedural	12.5	10.9	13.9	14.2	16.7	9.2
Hb (g/dl), postprocedural	7.1	4.7	9.2	9.7	11.4	4.8
Received blood transfusion	Yes	Yes	Yes	Yes	Yes	Yes
Follow-up period (years)	13	0.04	6	4	0.4	0.4
Survival	Alive	Death (cancer progression)	Alive	Alive (atrophy of the involved kidney)	Alive	Death (cancer progression)

CCRT = concurrent chemoradiotherapy; CT = computed tomography; ICA = internal carotid artery; IRPH = iatrogenic retroperitoneal hematoma; NBCA= N-butyl cyanoacrylate; NPC = nasopharyngeal carcinoma; RSH= renal subcapsular hematoma; RPH= retroperitoneal hematoma; US= sonogram.

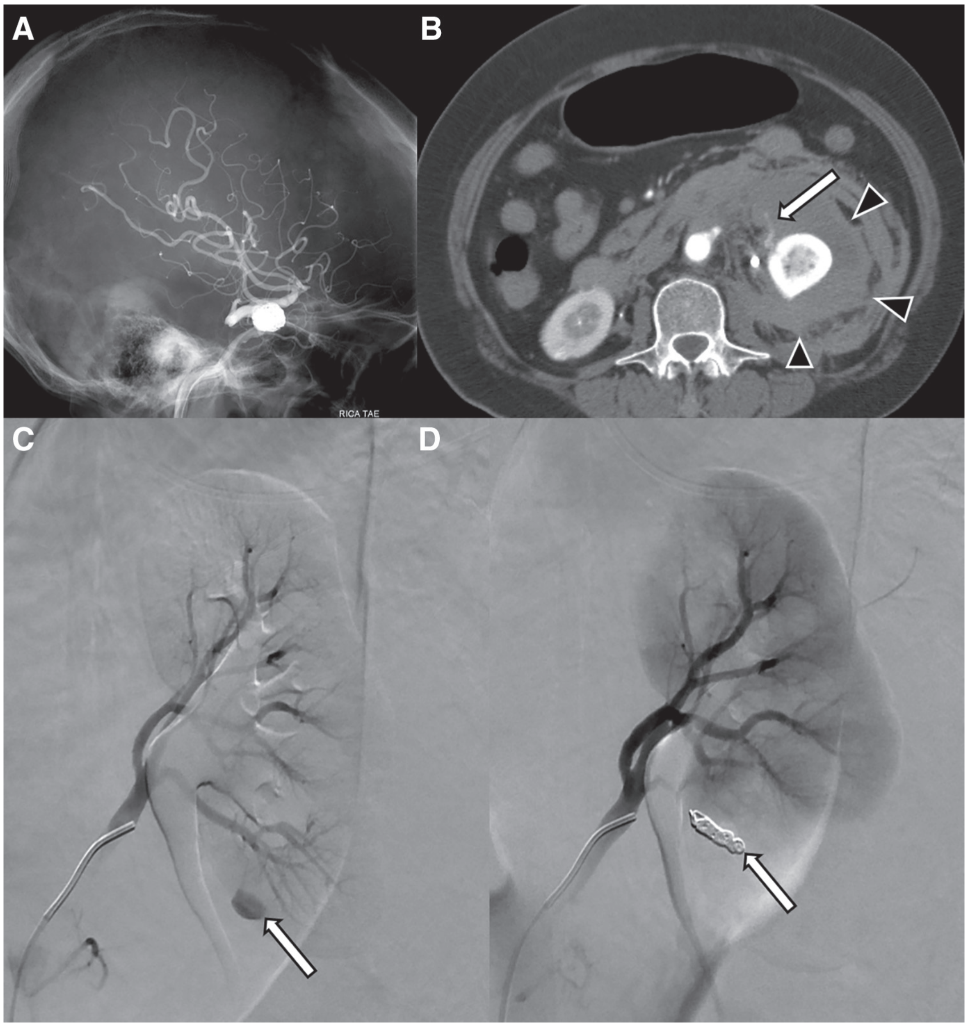

Fig. 1 Case 3. A 65-year-old female received stent-assisted embolization of the aneurysm at right supra-clinoid ICA (A). Pt. developed hypovolemic shock in the postanesthesia care unit. Contrast-enhanced abdominal CT showed a left RSH (B, arrowheads) with an active contrast extravasation from left lower renal pole kidney (B, arrow). Left renal angiogram disclosed a bleeder from a lower interlobular artery (C, arrow). Embolization of the bleeder was done by placement of fiber coils in the left inferior segmental artery (D, arrow). CT = computed tomography; ICA = internal carotid artery; RSH = renal subcapsular hematomas.

other five patients (cases 1, 3–6) were discharged in stable condition. Case 4, who received two courses of embolization, showed temporarily deteriorated renal function at 1-month follow-up, with creatinine 2.17 mg/dl (baseline 0.94 mg/dl); creatinine was normal at 1-year follow-up (1.14 mg/dl).

4. DISCUSSION

This study presents six cases with IRPH (including five RSH) following neurointerventional therapeutic procedures with stent placement. The incidence of IRPH was 0.3 % (6/2290) in this study. All six patients had episodes of hydrophilic wire forwarded blindly into the branches of the abdominal aorta with unusual resistance during femoral catheterization of guiding sheath, which was recorded in complication notes by the operators. The authors concluded that wire injury is the major cause of IRPH following NIPs. The use of preprocedural dual antiplatelet medication and in-procedural heparinization also contributed to these complication symptoms.

The incidence of peripheral vascular complications after the cardiac catheterization, such as pseudoaneurysm, arteriovenous fistula, thromboembolism, infection, and other bleeding complications, is between 0.3% and 6%, and bleeding with hematoma formation is the most frequent complication (0.9–1.27%).[9,10] Hematomas may be characterized into four location types: femoral puncture site, retroperitoneal space, intraperitoneal region, and abdominal wall.[10–12] Risk factors for hematoma include age greater than 60 years, female, hypertension, thrombocytopenia, large-bore catheter use, operator inexperience, poor groin compression following sheath removal, high puncture site, abnormal vessel or graft, peripheral vascular disease, and anticoagulant-thrombolytic therapy.[10,12,13] There is ample literature regarding cardiac angiography access-site complications; however, there are few reports focusing on access-site complications for NIPs. As indicated by a systemic review of access-site complications in transfemoral neuroendovascular procedures,[2] 8 out of 40 randomized clinical trials reported an incidence of retroperitoneal hemorrhage ranging from 0.32% to 1.77%, with an average of 0.57%. Treatment was mainly conservative with additional intervention performed if inadequate initial response; endovascular procedures were preferred over surgery.[2]

The causes of RPH may be traumatic and nontraumatic. Nontraumatic RPH includes spontaneous and iatrogenic.

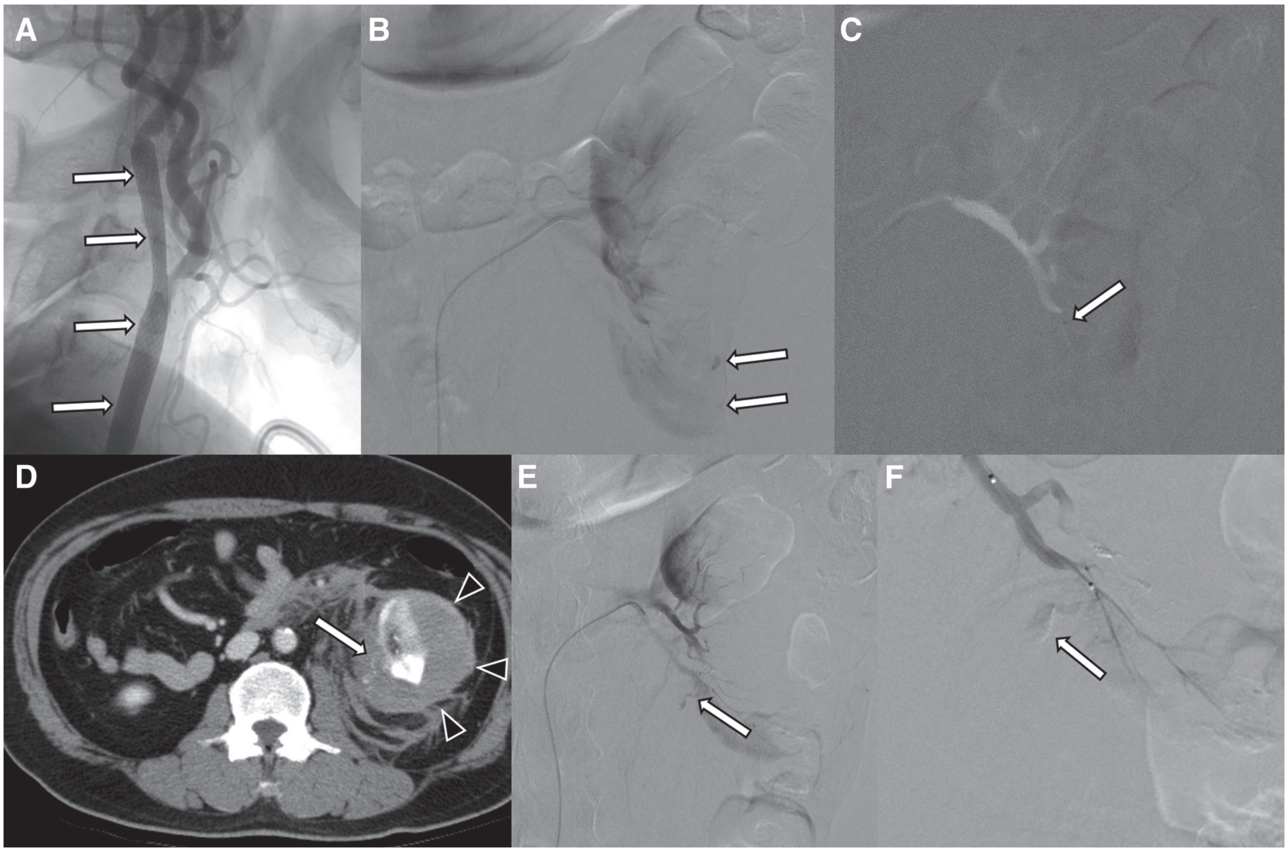

Fig. 2 Case 4. A 51-year-old male with nasopharyngeal carcinoma, postirradiation, with severe symptomatic right carotid stenosis. Angioplasty and stenting of the right carotid stenosis was successful (A, arrows). Pt. complained left flank pain intraoperatively. On-site sonogram showed left RSH. Left renal angiogram showed two bleeders from lower interlobular artery (B, arrows). The bleeders were successfully embolized with injection of NBCA (C, arrow). However, pt. continued to complain of left abdominal pain 6 hours after the embolization. CT of abdomen showed RSH (D, arrowheads) and contrast extravasation from lower pole of left kidney (D, arrows). Left renal angiogram found an additional bleeder from the left lower renal parenchyma (E, arrow). Bleeder was embolized with NBCA (F, arrow) and patient's condition stabilized. CT = computed tomography; NBCA = N-butyl cyanoacrylate; RSH = renal subcapsular hematomas.

Spontaneous RPH is frequently seen in the elderly, patients receiving anticoagulation therapy, and patients with underlying coagulopathy.[14] IRPH is often caused by renal biopsy, extracorporeal lithotripsy, percutaneous coronary intervention, or endovascular procedures. A retrospective study from the early 1990s demonstrated an incidence of 0.5% for post-cardiac catheterization IRPH.[15] A similar cardiovascular study spanning 2007–2014 showed a decline in incidence in RPH from 0.09% to 0.03%.[16] The rise in radial artery access may have contributed to declining RPH incidence. Femoral artery access remains the most common approach of NIPs due to the neurovascular anatomy, making awareness of IRPH is important for neurointerventionalists. Those who develop IRPH are still at significantly increased risk of mortality (crude 30-day mortality rate 8%; odds ratio 3.59) and adverse cardiac events (9%; odds ratio 5.76).[16] Of all IRPH resulting from endovascular procedures, RSH remains a unique entity. Compared with other RPH, for example, after percutaneous coronary intervention (PCI), RSH caused by endovascular treatment often needs more intensive treatment (Table 2), such as blood transfusion, embolization, or surgical intervention.[16]

Early diagnosis of IRPH was challenging because symptoms did not initially appear directly related to NIPs. IRPH presentation ranged from suprainguinal tenderness and fullness (most common) to severe back and lower quadrant abdominal pain, and lower extremity pain. These non-neurological symptoms were more confusing when presenting contralateral to the right femoral puncture site or when patients were in sedated status.[2,6,8,9,17] Authors suggest that when patients experience unexplainable abdominal pain or hypovolemic status during NIPs, the possible IRPH should be evaluated timely. In addition to clinical examination, on-site sonographic examination and flat-panel CT are valuable diagnostic tools. IRPH should be carefully differentiated from increased intracranial pressure caused by intracranial hemorrhage, the latter showing increased systolic blood pressure and reduced heart rate.

For the mechanisms of IRPH following NIPs, especially RSH, we suggest the following:

1. *Character of hydrophilic wire:* From the present angiographic findings of IRPH, wire-caused injuries during femoral sheath catheterization played a direct and important role. Our NIPs used Seldinger's method. A 150cm, 0.035 Fr, shapeable angled guidewire was forwarded through the puncture needle to the abdominal aorta to support the 5 Fr femoral sheath for the diagnostic angiogram. These wires are made of a super-elastic alloy consisting of nickel and a titanium core, with favorable traceability and pushability. The surface is coated with a hydrophilic polymer, facilitating smoother guidance.[7] The 0.035 Fr wire was used to support a 90–100 cm, 6–8 Fr guiding sheath to the target artery for performing the therapeutic procedure. Using a 150 cm guidewire to catheterize a 90–100 cm guiding sheath is sometimes difficult in cases of a tortuous abdominal aorta or iliac artery with a thick,

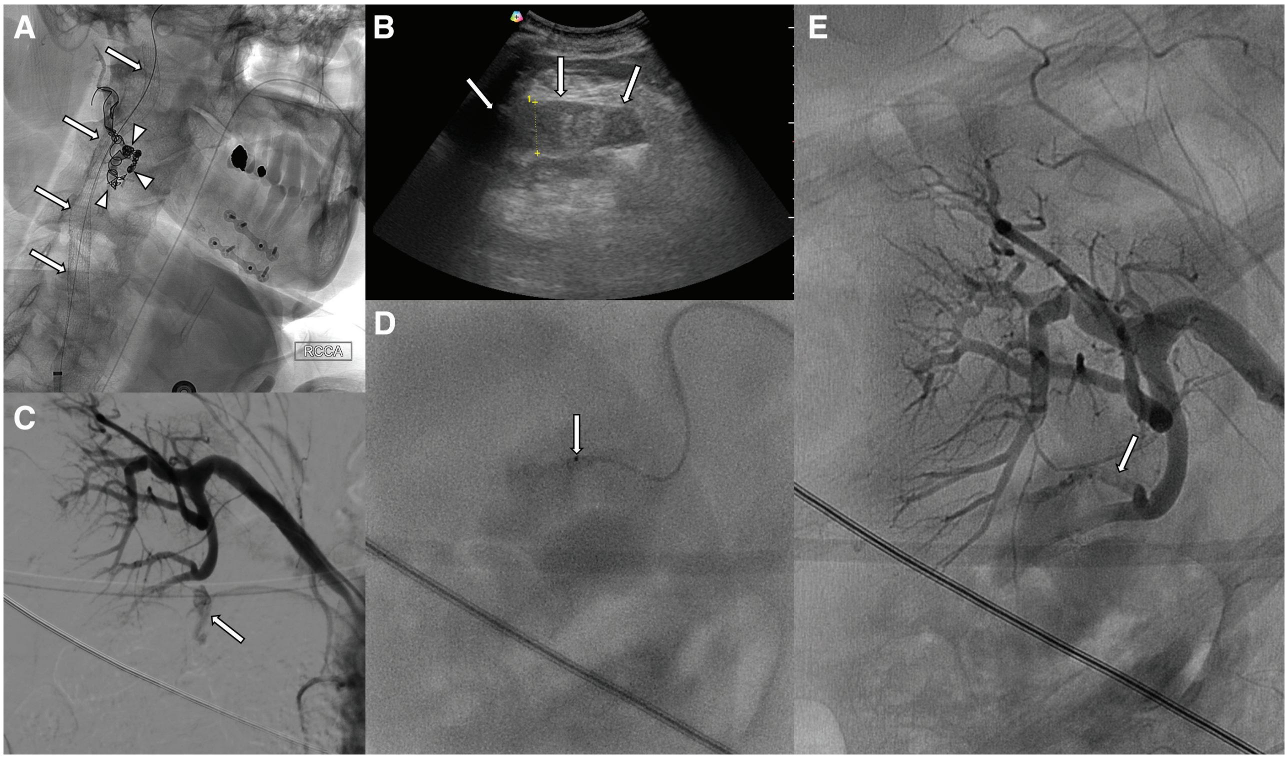

Fig. 3 Case 6. A 63-year-old male with tongue cancer complicated by threatened carotid blowout syndrome. Pt. received carotid stent-graft placement of the ICA to CCA (A, arrows) and embolization of the ECA (A, arrowheads). He complained right flank pain during the procedure. On-site sonogram showed right RSH (B, arrows). Right renal angiogram showed active bleeding from an interlobular artery in lower pole (C, arrow). We meticulously navigated a microcatheter to the interlobar artery (D, arrow) and did embolization with NBCA. Control angiogram showed obliteration of the bleeder (E, arrow). CCA = common carotid artery; ECA = external carotid artery; ICA = internal carotid artery; NBCA = N-butyl cyanoacrylate; RSH = renal subcapsular hematomas..

atherosclerotic, vascular wall. To improve the wire support during femoral sheath catheterization, the neurointerventionalist must push the 150 cm hydrophilic guidewire as distally as possible. It may be necessary to move the hydrophilic wire in and out during difficult femoral catheterization, to pass a thickened atherosclerotic vascular wall. Without full course fluoroscopy monitoring, wire movement is associated with multiple passages, and wire looping in the branches of renal arteries is more likely to cause multiple bleeders and even scattered renal parenchyma, as seen in our cases (Table 1).

2. *Anatomical character of renal artery and its branches:* The main stem of the renal artery divides into anterior and posterior divisions, before it enters the hilum of the kidney[18], so the renal artery has a relatively long and horizontal course before entering the renal parenchyma. The renal parenchyma is soft tissue. Without fluoroscopic monitoring, if an operator is not mindful of the tactile signals originating from subtle variations in resistance encountered by the wire as it passes into the distal renal arterial branches, renal parenchyma injury/perforation may occur, resulting in RSH.
3. *Anatomical factors of abdominal aorta and its branches:* Five of six patients had IRPH on their left side, contralateral to the right femoral access site. The right renal artery indicates a longer and more caudal course than the left renal artery because of the right kidney's location beneath the liver. The relatively higher location of the left kidney makes the left renal artery being more horizontal or of a cranial/upward orientation.[19] Thus, the angle of the left renal artery to the abdominal aorta is greater than that of the right renal artery (Fig. 4). The left side predilection for IRPH in patients with right femoral access may be explained by the facts: the hydrophilic wire is apt to become engaged with the left renal artery and less resistance to wire manipulation is offered by the distal branches of the left renal artery than the right one. When the wire goes to the orifice of the right renal artery, the unfavorable angle to the abdominal aorta may cause the wire to leave this aortic branch and drop back to the aorta. When an attempt is made to engage the renal artery by a femoral approach, intuitively, it would be easier via the renal artery on the contralateral side because the vector of the proximal part of the wire is somewhat more parallel (smaller angle) to the distal part, thereby making the route of the wire smoother and offering less resistance. As most femoral approaches are performed from the right side, it would be easier for the wire to go into the left renal artery.[20,21] Similar observation was also made in one case report;[5] however, in one systemic review of access-site complications in transfemoral neuroendovascular procedures,[2] most of the clinical trials it included did not specify right or left of lesions.
4. *Antithrombotic medication*: Because of stent placement protocols, all six patients were administered preprocedural dual antiplatelet medication and intraprocedural heparinization. Although heparinization is reversed at the end of the procedure, the patients were still vulnerable to iatrogenic vascular insult while in such antithrombotic medication status. IRPH became symptomatic intraoperatively in three cases (50%), including hypovolemic status in two cases. It had suggested that heparin, or anticoagulation-induced immune microangiopathy, may cause spontaneous RPH.[22]
5. *Operator's level of experience*: The first few steps of angiography and femoral access for guiding sheath placement to the target vessel are routinely performed by senior residents or first-year fellows at our institute. A relative lack of experience, for example, capacity to perceive subtle changes in wire

Table 2

Cases of iatrogenic renal subcapsular hematomas by neurointerventional procedures

	Yi, et al. 2014[5]	La, et al. 2016[4]	Nishiyama, et al. 2020[7]	Five Cases of Present Study
Age (Y/O)	54	74	65	62.6 ± 11.8 (51–83)
Sex (M/F)	F	F	F	4 M, 1 F
Indication for neurointervention	Aneurysms at ACOA and paraclinoid ICA	Right middle cerebral artery infraction	Aneurysm at ACOA	2 carotid stenosis, 2 carotid blowout, 1 cerebral aneurysm
Neurointerventional procedures	Diagnostic angiogram	Intra-arterial thrombectomy	Stent-assisted embolization	2 Angioplasty and stenting, 2 stent-graft placement, 1 Stent-assisted embolization
Femoral access side	Right	Right	Right	Right
Lesion side of RSH	Left	Right	Right	4 left, 1 right
IRPH symptoms	Left flank pain and hypotension	Vague right abdominal pain	Hypovolemic shock	Flank/abdominal pain, hypotension, shock
IRPH onset time (hours)	3	48	Presumed 1 hour	2.8 ± 1.6 (1.5–5)
Management	Medical treatment	Medical treatment	Embolization with NBCA	Embolization with NBCA or coils
Follow-up and outcome	Regression of hematoma 1 month later	Complete regression 6 months later	Recovery	Hemostasis after embolization of the renal arteries; All had recovered renal function in follow-up.

ACOA = anterior communicating artery; ICA = internal carotid artery; IRPH = iatrogenic retroperitoneal hematoma; NBCA = N-butyl cyanoacrylate; RSH = renal subcapsular hematomas.

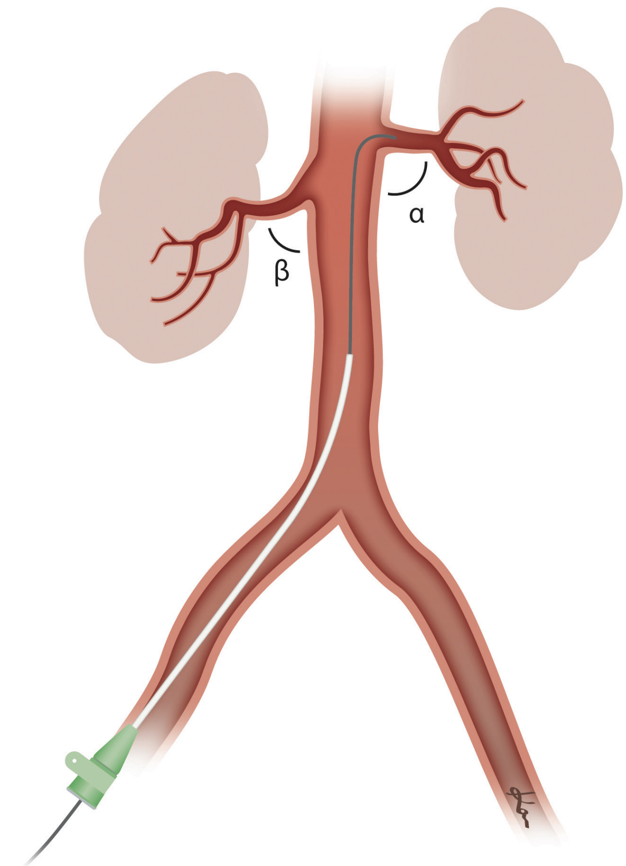

Fig. 4 The right renal artery typically demonstrates a longer and more caudal course than the left renal artery whereas the relatively higher location of the left kidney gives the left renal artery a more horizontal or even cranial/upward orientation. The left renal artery's angle to the abdominal aorta is wider than that of the right renal artery angle (α > β). These anatomical factors may explain the left side predilection of IRPH in patients with right femoral access: (A) the hydrophilic wire is apt to become engaged with the left renal artery; (B) less resistance to wire manipulation by the distal branches of left renal artery than the right side. In addition, when engaging the renal artery by a femoral approach, intuitively it would be easier via the renal artery on the contralateral side, because the vector of the proximal part of the wire is somewhat more parallel (smaller angle) to the distal part, which makes the route of the wire smoother. IRPH = iatrogenic retroperitoneal hematoma.

resistance during manipulation, or lack of knowledge, for example, ability to recognize RPH early, can sometimes lead to an unfavorable result. Less experienced operators may overlook the importance of full course fluoroscopic guidance. Hence, the benefits of using full course fluoroscopic guidance should be considered as part of practice guidelines on competent angiography for all neurointerventionalists.

Three prior cases of RSH were found in the literature (Table 2). The speculated causes of renal hematoma include recombinant tissue plasminogen activator (rTPA) use in stroke patients,[4] guidewire injury to the proximal portion of the left accessory renal artery,[5] and guidewire passing deeply into the right renal artery when the guiding sheath was navigated into the abdominal aorta.[7] One report directly observed guidewire piercing the renal artery,[7] and two reports attributed the renal hematoma to guidewire manipulation,[5,7] which correlates with observations in the present study. The case involving rTPA could be attributed to guidewire-related injury.[4] In the authors' experience, the renal artery can be highly vulnerable to puncture and an operator might experience only slight resistance as the guidewire pierces the wall of the renal artery.

There are some limitations to this study: (1) a relatively small number of cases; (2) retrospective design without standard treatment of this complication; (3) diverse neurointerventional procedures; and (4) the procedural course was reported retrospectively by the operators and there was no objective quantification of the resistance of the guidewire.

In conclusion, difficult-to-explain abdominal/flank pain during NIP may be an important early sign for IRPH. In patients with right femoral access, IRPH was apt to occur in the contralateral side due to the anatomy of the abdominal aorta. To achieve good outcomes, timely diagnostic imaging and endovascular treatment for cases with active bleeding are of paramount importance. The authors suggest using full visual inspection under fluoroscopy of femoral catheterization, to prevent the iatrogenic complication of femoral access.

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