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ORIGINAL PAPER

Colon perforation related to percutaneous nephrolithotomy: from diagnosis to treatment

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Abstract We present our experience with the largest series of colon perforation (CP) as complication of percutaneous nephrolithotomy (PNL). From January 1998 to August 2014, 22 cases that presented with PNL-related CP from seven referral centers were retrospectively reviewed. The patients with CP were evaluated in terms of probable risk factors. Peri-operative and postoperative findings, timing of diagnosis, and treatment modalities of the CP were reviewed. Of the 22 patients, previous ipsilateral renal surgery (*n*:2) and retrorenal colon (*n*:5) were the risk factors for CP. The CP was directly visualized via nephroscopy during the surgery in 3 (13.6 %) and with nephrostography at the end of the procedure in 4 patients (18.2 %). In two patients, perforation was realized via the passage of contrast into the colon with nephrostography on the postoperative second day. Postoperative passage of feces through the nephrostomy tube was seen in six patients. The clinical signs in 13 cases directed CP diagnosis. The confirmation of the CP was achieved with a CT scan in all the patients. The patients with extraperitoneal perforation were primarily managed conservatively. Open surgical treatment was performed in cases with intraperitoneal perforation (*n*:5) and those with extraperitoneal perforation resistant to conservative treatment (*n*:5). Meticulous evaluation of the risk factors preoperatively is the initial step in the prevention of CP. Timely diagnosis plays essential role in the management of this PNL complication. Although extraperitoneal CP may be managed conservatively, surgery is required for intraperitoneal CPs.

Keywords Colon perforation · Percutaneous nephrolithotomy · Complication · Diagnosis · Treatment

Introduction

Percutaneous nephrolithotomy (PNL) is the primary recommended treatment modality for kidney stones larger than 2 cm and an optional treatment for stones between 1 and 2 cm [1]. Although PNL is a reliable method with a high stone clearance rate and shorter recovery time, it may lead to bothersome complications. The most frequent complications are hemorrhage requiring transfusion and infections [2]. The rare but most feared complication of PNL is injury to adjacent organs of the kidney, such as colon, lung, or spleen [3].

Colon perforation (CP) is a very rare complication of PNL, which was observed at a rate of 0.3 % in the largest published study to date [4]. CP usually occurs during the creation of a percutaneous renal tract. Early diagnosis and prompt treatment play key role in the management of CP following PNL. The diagnosis of CP might be delayed due

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to nonspecific signs and symptoms [4]. Although detected at the time of surgery or several days later, if it is not diagnosed quickly, peritonitis, nephron-colonic or colocutaneous fistula may occur [5, 6].

There are some case reports and a limited number of patient series in the literature that evaluate the risk factors and present diagnosis and treatment modalities of CP related to PNL [4, 7–9]. Herein, to the best of our knowledge, we present our experience with the largest series of CPs as complication of PNL and discuss the diagnosis and management of this complication in light of the current literature.

Methods

From January 1998 to August 2014, 6375 PNL were performed and 22 cases that presented with PNL-related CP from 7 referral centers were retrospectively reviewed. The patients with CP were evaluated in terms of probable risk factors, such as age, sex, side of surgery, history of previous abdominal and/or retroperitoneal surgery, kidney anomalies, percutaneous access site and access technique. Peri-operative and postoperative findings, timing of diagnosis, and treatment modalities of the CP were reviewed.

All patients were routinely evaluated with kidney, ureter and bladder plain radiography (KUB), intravenous urography, and/or computed tomography (CT) preoperatively. The patients were also preoperatively assessed with complete blood count, serum biochemistry, coagulation parameters, and urine cultures.

A standard PNL procedure was applied to all patients using fluoroscopy and/or US guidance. Foley urethral and ureteral catheters were removed on the second day after surgery. Postoperative complications were classified with the Clavien Classification system [10].

Results

Of the 22 patients, 17 (77.3 %) were male and 5 (22.7 %) were female, and the mean age was 40.5 ± 20.0 years (2–70). The access was made through the left or right side in 17 (77.3 %) and 5 (22.7 %) patients, respectively.

Risk factors

Two of the patients had previous ipsilateral renal surgery (PNL and open pyelolitotomy). The procedure was performed through a single lower calix puncture in all the cases. Kidney abnormalities were not detected in any cases. In the preoperative CT imaging, retrorenal colon was noted in five patients as a defined risk factor. Whereas fluoroscopy-guided percutaneous access was performed in 16 patients, ultrasonography was used adjacent to fluoroscopy for percutaneous renal access in 6 patients. Patient demographics and risk factors for colon perforation are given in Table 1.

Table 1 Patients' demographics and risk factors of colon injury during percutaneous nephrolithotomy

Parameter	
Age (years)	40.5 ± 20.0 (2–70)
Sex	
Male	17 (77.3 %)
Female	5 (22.7 %)
Side	
Right	5 (22.7 %)
Left	17 (77.3 %)
Previous ipsilateral renal surgery	2 (9.1 %)
Congenital anomalies	0
Retrorenal colon	5
Punctured calyx	
Upper calyx	0
Middle calyx	0
Lower calyx	22 (100 %)
Stone localization	
Lower calyx	2 (9 %)
Renal pelvis	7 (32 %)
Multiple calyx	13 (59 %)

Diagnosis

The CP was directly visualized via nephroscopy during the surgery in 3 (13.6 %) and with nephrostography at the end of the procedure in 4 patients (18.2 %). In 2 patients, perforation was realized via the passage of contrast into the colon with nephrostography on the postoperative second day. Postoperative passage of feces through the nephrostomy tube was seen in six patients.

On the other hand, five patients presented with findings such as fever, vomiting, elevated white blood cells or peritonitis after the operation. Fecaloid material drainage from the tract was observed in 2 patients following nephrostomy tube removal. The CP diagnosis was confirmed with CT in all the patients.

Management

According to the CT findings, an intraperitoneal perforation was seen in 5 patients, whereas an extraperitoneal perforation was observed in 17 patients. The patients with extraperitoneal perforation were primarily managed conservatively. Transcolonic nephrostomy was withdrawn outside

of the kidney and repositioned into the colon under fluoroscopic guidance. Total parenteral nutrition and intravenous antibiotics (3rd generation cephalosporin and metronidazole) were administered. Retrograde ureteropyelography was performed, ureteral double j and urethral catheters were placed to prevent the risk of fistula formation between the renal collecting system and colon.

Fecaloid material drainage gradually decreased through the nephrostomy tube. After 7–10 days, the drainage tube was removed after the exclusion of a colorenal fistula under fluoroscopy. The ureteral double j stent was removed after 4 weeks. In 2 of the 17 patients, an extraperitoneal perforation was noticed after the removal of the nephrostomy tube. A Penrose drain was inserted to pericolonic area. Oral nutrition was restricted, and total parenteral nutrition and intravenous antibiotics (3rd generation cephalosporin and metronidazole) were started. Ureteral double j and urethral catheters were placed for urinary drainage. Then, low flow fistulas gradually decreased and closed. These two patients were discharged at 7 and 9 days. No colocutaneous fistulas were seen after the conservative treatment. During the conservative treatment, 5 of the 17 patients had persistent fever, tachycardia and leukocytosis. They underwent open surgical repair. Either primary repair of the colon (3/5) or colostomy (2/5) was performed. Two patients who required colostomy underwent closure of colostomy within 2 months. Five patients who had an intraperitoneal perforation were treated with open surgery. Three patients underwent primary repair, and 2 patients underwent colostomy.

Discussion

The PNL procedure is a safe, reliable, minimally invasive technique for the treatment of large kidney stones and has replaced open surgery [11]. Even though PNL has high success rates, it sometimes has life-threatening complications, such as hemorrhage requiring transfusion and adjacent organ perforation. CP is a very rare complication of PNL that was seen in at a rate of 0.3 % in 15 cases in the largest study to date [4]. In the other case series study CP was observed in 11 (0.2 %) out of 5260 PNL cases [9]. To the best of our knowledge, our study is the largest one to date, which includes 22 patients.

Some risk factors for CP are described in the literature [2, 4, 8, 9]. The most important risk factor for colonic injury is an abnormal localization of colon. Abnormal colon localization in the retrorenal space is very rare and has a risk of CP during the PNL procedure. Hopper et al. reported that retrorenal colon was found in 1.9 % of 500 patients who underwent abdominal CT scan in a supine position, whereas it was seen in 10 % of 90 patients in a prone position [12]. In the larger series study, retrorenal colon was detected in 2 and 6.8 % of patients in supine and prone position, respectively [13]. Despite this, a recently published meta-analysis showed that the risk of colon injury in prone or supine PNL is comparable [14]. The PNL procedure was performed in the prone position in all the cases in our series.

The descending colon is located more posteriorly of the lower pole of the kidney on the left side. Therefore, the CP risk is higher in a lower pole access of the left kidney [12]. In the present study, CP occurred in 17 patients (77.3 %) with left kidney stones. The procedure was performed through the lower pole access in all the patients in our series.

Retrorenal colon is seen at a higher rate in horseshoe kidneys (3–19 %) [15]. In thin and elderly patients, the colon may displace to the retrorenal area because of reduced perinephric fat. El-Nahas et al. reported that advanced patient age and presence of a horseshoe kidney were independent risk factors for CP in PNL surgery [4]. Additionally, a history of colonic distention due to chronic constipation, previous abdominal surgery, megacolon, and neurologic disorders of the gastrointestinal tract increase the risk of CP [15]. The other risk factor is an excessively lateral access to the kidney, which may increase the risk of CP. The colon is normally positioned anteriorly or anterolaterally to the kidney. To decrease the risk of CP, excessively lateral access (lateral to the posterior axillar line) should be avoided. Although patients with renal abnormalities were not detected in our series, retrorenal colon was the most common risk factor (*n*:5, 22.7 %) in the preoperative CT scan. In addition, 2 patients (9.1 %) had a history of renal surgery that was regarded as a risk factor for CP. The reported risk factors for CP and summary of the literature are listed in Table 2.

Early diagnosis is the most important step of the management of CP related to PNL. According to a review of the literature, 24.1 % of the patients were diagnosed intraoperatively, whereas 75.9 % of the patients were diagnosed in the postoperative period (mean 2.9 days) [16]. In our study, 31.8 % of the patients were diagnosed during the PNL procedure, whereas 68.2 % of the patients were diagnosed after the operation. In the intraoperative period, colon injuries can be diagnosed with a visualization of the bowel content or mucosa during nephroscopy, visualizing colonic contrast during antegrade nephrostography and observation of the bowel content in the operation area [16]. In the postoperative period, colon injuries are generally present as the drainage of feces and gas through the nephrostomy/nephrostomy tract, hematochezia, diarrhea, fever, signs of peritonitis, sepsis [15]. In our series, CP was intraoperatively detected with direct visualization in three patients and nephrostography in four patients. Colonic injury was postoperatively diagnosed with antegrade nephrostography in two patients, fecaloid drainage through the nephrostomy

Table 2 The summary of the literature presenting CP-related PNL over five cases

References	*n*	Mean age[a]	Accompanying risk factors (*n*)	Side (*n*)	Positioning (*n*)	Access side (*n*)	Time of diagnosis (*n*)	Diagnosis method (*n*)	Intra/extraperitoneal (*n*)	Treatment (*n*)
Gerspach et al. [5]	5	31	Lean (3)	Left (3)	Prone (5)	Lower (3)	3rd day (2)	Nephrostography (3)	Extraperitoneal (5)	Conservative
							2nd day (1)			
				Right (2)		Middle (2)	Early postoperative (1)	NA (1)		
								Direct vision (1)		
							Intraoperative (1)			
Kachrilas et al. [8]	5	56.4	NA	Left (3)	Prone (1)	Lower (4)	3rd day (2)	CT urography (4)	Extraperitoneal (5)	Conservative
					Supine (4)		2nd day (1)			
				Right (2)		Middle (1)	First day (1)	Direct vision (1)		
							Intraoperative (1)			
AslZare et al. [9]	11	40.4	Open surgery (5)	Left (5)	Prone (11)	Lower (11)	Postoperative (8)	NA	Extraperitoneal (11)	Conservative
			Laparotomy (1)	Right (6)			Intraoperative (3)			
			Horseshoe kidney (1)							
El-Nahas et al. [4]	15	57	Horseshoe (3)	Left (10)	Prone (15)	Lower (12)	Postoperative (10)	Nephrostography (5)	Extraperitoneal (15)	Conservative (12)
				Right (5)		Others (3)	Intraoperative (5)	CT (15)		Colostomy (3)
Present Study	22	40.5	Previous renal surgery (2)	Left (17)	Prone (22)	Lower (22)	Postoperative (15)	Direct vision (3)	Extraperitoneal (17)	Conservative (12)
								Nephrostography (6)	Intraperitoneal (5)	Primary repair (6)
			Retrorenal colon (4)	Right (5)			Intraoperative (7)	Clinical signs and CT (13)		Colostomy (4)

NA non-available, *CT* computed tomography

[a] Years

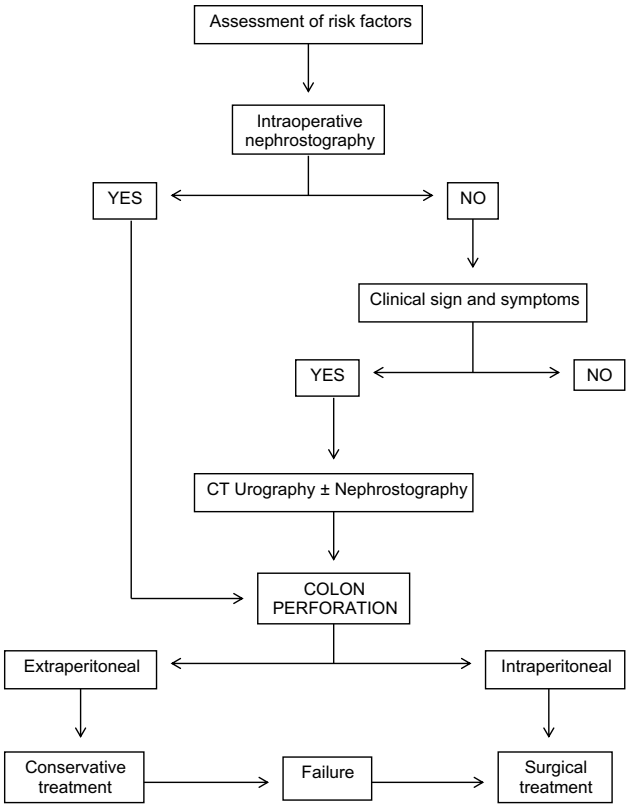

Fig. 1 A diagram for the diagnosis and treatment of colon injury related to percutaneous nephrolithotomy

tube in six patients and septic signs in five patients. In addition, the fecaloid material drainage was observed through the tract following tube removal in two patients.

The delay in diagnosis may lead to life-threatening complications such as abscess, peritonitis or sepsis. For this reason, El-Nahas et al. advised performing an antegrade nephrostography at the end of the every PNL surgery to identify any unnoticed CP. Secondly, surgeons consider CP in patients who develop abdominal tenderness, unexplained fever or findings of sepsis, especially in patients who have increased risk of colonic injury [4]. The best diagnostic tool for a suspected CP is an abdominal CT. Additionally, CT gives additional information such as abscess, fluid collection and injury to other organs. CT imaging may guide the management of the CP. If an intraperitoneal CP is present, surgical management (either primary repair or colostomy) should be performed. If an extraperitoneal perforation of the colon is diagnosed using a CT scan, conservative management may be chosen provided that the patient is stable and does not have sepsis [15, 16]. According to the literature and our experience, we suggest an algorithm for the diagnosis and treatment of CP (Fig. 1).

During conservative management of CP, the initial step is separating the nephron-colonic communication. Urinary drainage can be provided by the insertion of a ureteral double j stent and urethral catheter. The nephrostomy tube is withdrawn from kidney and repositioned into colon under fluoroscopy guidance [15]. We performed a withdrawal of the nephrostomy tube from kidney into colon in ten patients. Alternatively, the nephrostomy tube may be removed and a Penrose drain may be replaced into the pericolonic area under fluoroscopy guidance [5]. Additional steps include total parenteral nutrition, bowel rest and intravenous broad-spectrum antibiotics (7–14 days) [4, 16]. After 7–10 days, a contrast agent is given through the nephrostomy tube, and if no nephron-colonic fistula is seen, the tube may be removed [13, 17–19]. The ureteral double j stent is removed after 4–6 weeks [20]. If persistent fever, tachycardia, hypotension and leukocytosis are seen with an extraperitoneal CP, surgical management is the mandatory treatment. In our study, five patients had persistent fever, tachycardia and leukocytosis during the conservative treatment and we performed surgery for them.

The limitations of our study include the retrospective design and a lack of a statistical analysis for assessment of risk factors. Despite the limitations, we believe that our study included the largest case sample size and may contribute to the literature about the management of this dangerous complication.

Conclusion

Colonic injury is a rare and bothersome complication of PNL. Meticulous evaluation of the risk factors preoperatively is the initial step in the prevention of CP. Timely diagnosis plays essential role in the management of this PNL complication. Although extraperitoneal CP may be managed conservatively, surgery is required for intraperitoneal CPs.

Conflict of interest The authors declare that they have no conflict of interest.

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