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Renal emphysema in diabetic patients: CT evaluation

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ABSTRACT
Renal emphysema is a rare, fulminant, suppurative infection of pelvicaliceal system, renal parenchyma, perinephric tissues, and retroperitoneum. It is characterized by formation of gas. Invariably this condition is associated with diabetes mellitus and carries high mortality (40–90%). Renal emphysema can be classified into two distinct clinical entities: emphysematous pyelitis and emphysematous pyelonephritis. This classification has important prognostic and therapeutic implications. Herein we describe the computed tomographic findings in five unilateral cases of renal emphysema (two cases of emphysematous pyelitis and three cases of emphysematous pyelonephritis) in five insulin-dependent diabetic patients.

Key words: • *kidney* • *emphysema* • *computed tomography* • *diabetes mellitus*

Emphysematous pyelonephritis (EPN) and emphysematous pyelitis (EP) are rare gas-forming acute infections of the renal parenchyma. In EP the gas is limited to the pelvicaliceal system, whereas in EPN, gas extends further into the renal parenchyma, perinephric tissues, and the retroperitoneum. Ninety percent of patients with EPN have diabetes mellitus (DM), while EP is associated with DM in 50% of cases (1–5). The purpose of our study was to describe the computed tomography (CT) findings in five insulin-dependent diabetic patients with renal emphysema.

Case reports

Over a 4 year period (2003–2007), five insulin-dependent diabetic patients (four women, one man; age range, 36–87 years, mean age, 69.6 years) with renal emphysema (2 EP, 3 EPN) underwent CT examination in our department. All CT scans were obtained with a Picker PQ 5000 CT scanner device with a slice thickness of 5 mm, pitch of 2, reconstruction interval of 5 mm, field of view (FOV) ranging between 340–440 mm, depending on the patient's size. Images were obtained before and after contrast agent administration during nephrographic phase, while in one patient only unenhanced images were obtained because of impaired renal function. In three patients (2 of 2 with EP and 1 of 3 with EPN) obstruction of the urinary tract by calculi or tumor was demonstrated. All cases were unilateral (two right, three left).

Case 1

An 87-year-old woman with insulin-dependent DM presented in septic shock. Laboratory findings demonstrated normal renal function and signs of renal infection. CT demonstrated dilatation of the left pelvicaliceal system caused by obstruction by a large stone in the left ureter; CT also demonstrated gas in the collecting system and the left ureter above the level of obstruction. These findings were consistent with EP. The function of the affected kidney, however, was demonstrated normal and symmetric with the contralateral kidney. Reactive retroperitoneal lymph nodes and an aneurysm of the abdominal aorta were also observed (Fig. 1). Conservative management with antibiotics, insulin, and electrolytes, and percutaneous drainage (nephrostomy) were performed; the patient's condition improved within six days.

Case 2

An 85-year-old male with an 18-year history of insulin-dependent DM and a known history of bladder cancer and lithiasis of the collecting system of the right kidney and of the right ureter presented with symptoms of acute renal infection. CT demonstrated hydronephrosis of the right pelvicaliceal system, stones in the right pelvicaliceal system and

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Figure 1. a–c. Postcontrast axial CT images show emphysematous pyelitis with dilatation and gas in the left pelvicaliceal system **(a)** and left ureter **(b)** due to obstruction by a stone in the ureter **(***arrow,* **c)**. Reactive retroperitoneal lymph nodes and an aneurysm of the abdominal aorta are also observed.

ureter, and air in the collecting system and right ureter—findings consistent with EP (Fig. 2a–c). A large tumor of the bladder infiltrating the right ureteral orifice was also observed (Fig. 2d). The patient was managed conservatively with antibiotics, insulin, and electrolytes. Despite treatment, his condition deteriorated, and he died a month later.

Case 3

A 67-year-old female insulin-dependent DM patient presented with septic coma and acute renal failure. Her relatives reported a 48-hour history of fever and pain in the right renal area, where physical examination revealed a mass. Laboratory evaluation showed impaired renal function and signs of urinary infection. CT demonstrated gas within the parenchyma of right kidney, the collecting system, the right ureter, and the retroperitoneum (Fig. 3). The patient was managed conservatively but died of sepsis after six days.

Case 4

A 73-year-old female with a 15-year history of insulin-dependent DM presented with confusion, vomiting, high fever, and abdominal pain. A mass was palpable in the left upper abdominal quadrant. Laboratory evaluation showed signs of urinary infection. CT demonstrated a large amount of air in the renal parenchyma and the retroperitoneum. Much of the renal parenchyma was destroyed (Fig. 4). The patient was initially treated with antibiotics, insulin, and electrolytes; clinical condition improved over the next few days. Two months later, left nephrectomy was performed; the patient is in good condition 2.5 years later.

Case 5

A 36-year-old female insulin-dependent DM patient with a history of urolithiasis presented with high fever and abdominal pain. CT demonstrated multiple stones in the left pelvicaliceal system, gas within the renal parenchyma, a small amount of gas in the retroperitoneum, and a renal abscess (Fig. 5). The patient's condition improved within four days after conservative treatment, and urolithiasis was managed a few months later.

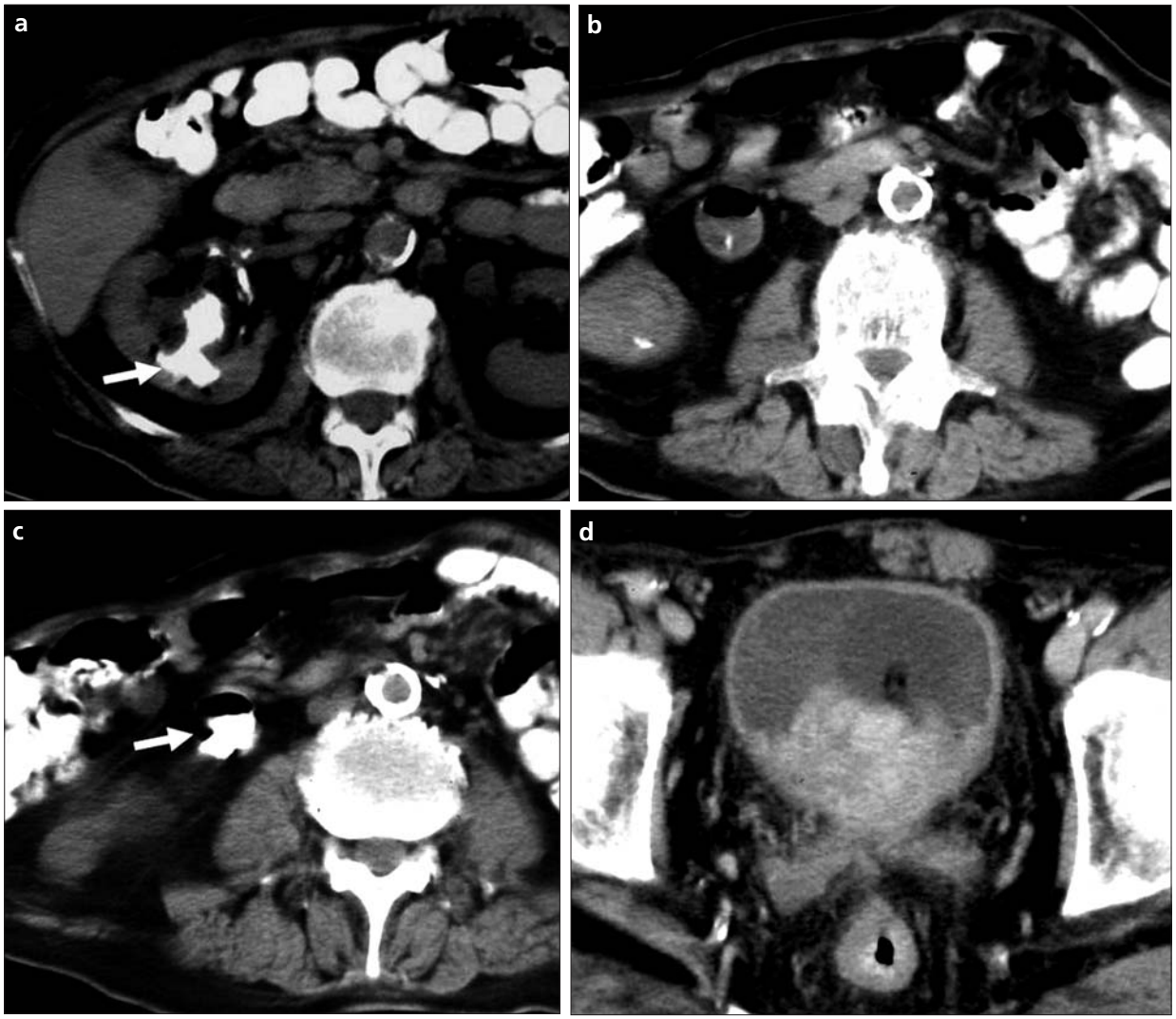

Figure 2. a–d. Unenhanced axial CT images **(a–d)** showing dilatation of the right pelvicaliceal system and gas in the collecting system **(***arrow,* **a)** and right ureter due to obstruction by stones **(***arrow,* **c)**. A large tumor of the bladder is also observed **(d)**.

Discussion

Renal emphysema is one of the most fulminant forms of upper urinary tract infection associated with necrosis and gas formation. Although it is a serious clinical entity, it is rarely reported in the medical literature. In the majority of cases it is unilateral (1–4).

Kelly and MacCallum initially described renal emphysema (gas in the kidney) in 1898. Renal emphysema is divided into two different clinical entities whose management and prognosis are different: EPN and EP (5).

EPN is a rare severe necrotizing gas-forming acute infection of the renal parenchyma, in which gas is present in the renal parenchyma, perinephric tissues, and even in the retroperitoneum. High rates of mortality and morbidity are seen in EPN. More than 90% of the patients have DM; in the remainder, it is related to obstruction. It is more common in females and usually affects the left kidney, although in 10% of the cases there is involvement of both kidneys. In addition to medical therapy, aggressive surgical management (nephrectomy) has been recommended to improve survival. EPN has also been reported in transplanted kidneys (1–5).

EP is a milder form of the disease with a better prognosis, in which gas is limited to the pelvicaliceal system. It is commonly associated with obstructive uropathy due to calculus, stricture, or neoplasm. It responds well to conservative therapy, with or without a drainage procedure (1–5).

In 75% of the cases, infection is caused by *Escherichia coli* (75%). In other cases, *Klebsiella pneumoniae*, *Enterobacter aerogenes*, *Proteus mirabilis*, *Pseudomonas* species, anaerobic streptococci, and *Candida* and other fungi have been isolated as the pathogenetic organisms (1–9). A case of amoebiasis has also been reported (10).

Renal emphysema may present with fever, nausea, vomiting, abdominal pain, shock, lethargy, confusion, and uncommonly with diabetic ketoacidosis. Laboratory findings include hyperglycemia, increased white blood cell counts, pyuria, and elevated levels of urea and creatinine (11). At the onset of the disease, clinical features of renal emphysema are similar to other forms of acute pyelonephritis. Renal emphysema should be suspected when renal infection has a prolonged or refractory course and is associated with a palpable renal lump, diabetes,

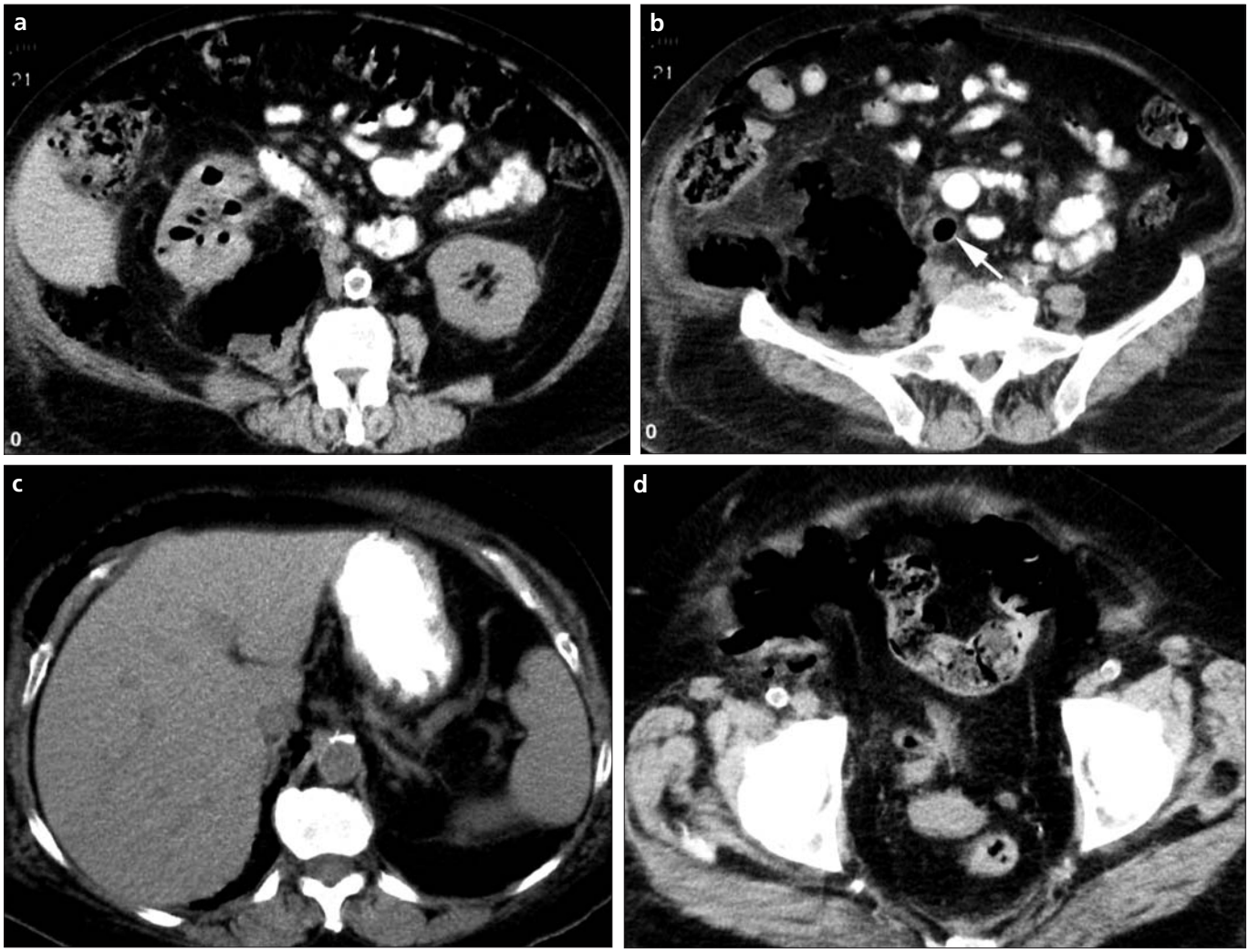

Figure 3. a–d. Unenhanced axial CT images **(a–d)**. Emphysematous pyelonephritis with gas within the parenchyma of right kidney, the collecting system, the right ureter *(arrow)* and in the right pararenal and perirenal space is seen **(a, b)**. Note the extension of the retroperitoneal air collection behind the abdominal wall, representing a potential extension of the posterior perirenal space **(c)**. Retroperitoneal air collection is also demonstrated in the pelvis **(d)**.

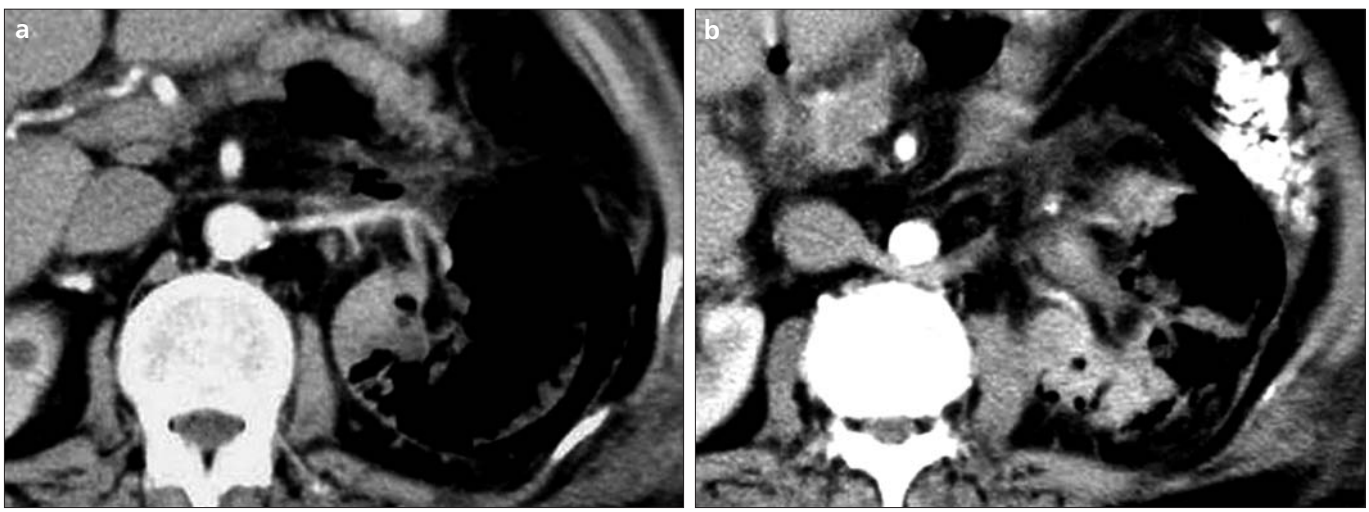

Figure 4. a, b. Postcontrast axial CT images show emphysematous pyelonephritis with destruction of much of the left renal parenchyma **(a)** with a large amount of gas within the renal parenchyma and the retroperitoneum **(b)**.

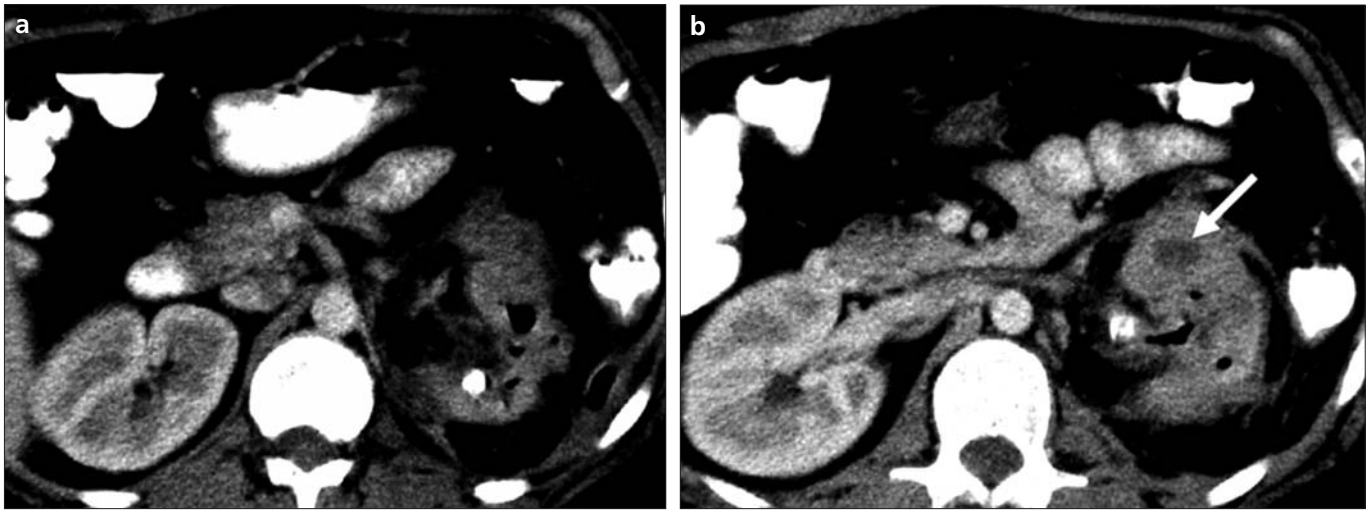

Figure 5. a, b. Postcontrast axial CT images show emphysematous pyelonephritis due to urolithiasis. There are calculi in the left pelvicaliceal system, gas within the renal parenchyma and the retroperitoneum **(a, b)**. A renal abscess is also demonstrated **(***arrow,* **b)**.

or obstruction. The dramatic finding of crepitation over the thigh or flank in a diabetic patient is infrequent; when present it should raise a high degree of suspicion for emphysematous pyelonephritis with extension into the perinephric space and retroperitoneum.

Four factors appear to be involved in the pathogenesis of EPN: gas-forming bacteria, high tissue glucose, impaired tissue perfusion, and defective immunity (2, 3, 12). The most important factor in the pathogenesis of gas formation appears to be high tissue glucose, employed as a growth medium for the microorganisms involved and fermentation of necrotic tissue. Analysis shows that the gas includes N_2 (60%), H_2 (15%), O_2 (8%), CO_2 (5%), and other gases in lesser concentrations (12). The pathogenesis of gas formation is not well understood; formation of CO_2 and H_2 by fermentation of sugar (at high levels in the tissue and urine of these patients) is one proposed mechanism. Gas bubble formation is initiated by rapid catabolism and impaired transportation of gas. The rapid catabolism may be caused by severe infection, tissue ischemia, and infarction. Another possibility is that poor circulation leads to sugar fermentation and impaired transportation (12).

CT is considered the best imaging technique for the diagnosis of the disease, for identification of gas (within the renal parenchyma, collecting system, ureter, urinary bladder, perinephric and paranephric spaces, and sometimes in the vascular system) and for evaluating severity of infection. Gas around the spinal cord and within the psoas muscle was reported in a fatal case of bilateral EPN (13).

In 1998, Wan et al. classified EPN into two types, based on CT findings: Type I is the classical form with renal parenchymal destruction and presence of diffuse gas in the parenchyma in a streaked or mottled pattern following the pyramids, with little or no fluid. Type II is characterized by the presence of fluid (renal and perirenal) with a bubbly or loculated gas pattern, or gas in the collecting system with acute bacterial nephritis or with renal or perirenal fluid-containing abscesses (14). Radiological diagnosis plays a major role in the prognosis of disease; type I EPN has a higher mortality rate than type II (14).

In 2000, Huang and Tseng categorized CT findings into the following 4 classes (class 1 being the mildest) (4):

Class 1: gas in the collecting system only (EP).
Class 2: gas in the renal parenchyma without extension to extrarenal space.
Class 3A: extension of gas or abscess to the perinephric space.
Class 3B: extension of gas or abscess to the paranephric space.
Class 4: bilateral EPN or solitary kidney EPN.

EPN (classes 2–4) must be differentiated from EP (class 1), in which gas is present in the collecting system of the kidney but not in the parenchyma.

It has been suggested that the term EPN should be only applied to gas formation within the renal parenchyma and perinephric space. Others have said that the infection of the renal parenchyma and perinephric tissue results in the presence of gas in the collecting system, parenchyma, and perinephric space. This is preferred because it includes all possible manifestations of acute renal infection with gas formation. EPN must be also differentiated from gas-forming renal abscess, in which gas is not found in the renal parenchyma. Gas in the renal parenchyma can also have traumatic or iatrogenic causes (Foley catheter or an enterorenal fistula).

The most important factor in management is early diagnosis and treatment. Treatment of EPN involves antibiotic therapy (15), followed, if necessary, by surgical intervention (nephrectomy). Recently, percutaneous drainage has been reported as a kidney-saving procedure. This alternative to nephrectomy is particularly important in solitary kidney patients, patients with bilateral EPN, and inoperable patients (16, 17). Transurethral retrograde drainage with stent placement has also been reported (18).

The mortality in untreated EPN is near 100%. With medical treatment alone, it decreases to 70%; with combined medical and surgical intervention, mortality can be reduced to 30% (19).

In conclusion, we believe that spiral CT is the examination of choice for evaluation of diabetic patients with signs and symptoms of renal em-

physema. This diagnostic modality is helpful in staging the disease and evaluating its severity, and it plays a critical role in selection of the treatment procedure.

References

1. Joseph RC, Amendola MA, Artze ME, et al. Genitourinary tract gas: imaging evaluation. Radiographics 1996; 16:295–308.
2. Rodriguez-de-Velasquez AR, Yoder IC, Velasquez PA, Papanicolaou N. Imaging the effects of diabetes on the genitourinary system. Radiographics 1995; 15:1051–1068.
3. Evanoff GV, Thompson CS, Foley R, Weinman EJ. Spectrum of gas within the kidney. Emphysematous pyelonephritis and emphysematous pyelitis. Am J Med 1987; 83:149–154.
4. Huang JJ, Tseng CC. Emphysematous pyelonephritis: clinicoradiological classification, management, prognosis, and pathogenesis. Arch Intern Med 2000; 160:797–805.
5. Kawashima A, Sandler CM, Goldman SM, Raval BK, Fisherman E. CT of renal inflammatory disease. Radiographics 1997; 17:851–866.
6. Langston CS, Pfister RC. Renal emphysema: a case report and review of the literature. AJR Am J Roentgenol 1970; 110:778–786.
7. Seidenfeld SM, Lemaistre CF, Setiawan H, Munford RS. Emphysematous pyelonephritis caused by Candida tropicalis. J Infect Dis 1982; 146:569.
8. Zaboo A, Montie JE, Popowniak KL, Weinstein AJ. Bilateral emphysematous pyelonephritis. Urology 1985; 25:293–296.
9. Kim DS, Woesner ME, Howard TF, Olson LK. Emphysematous pyelonephritis demonstrated by computed tomography. AJR Am J Roentgenol 1979; 132:287–288.
10. Guvel S, Kilinc F, Kayaselcuk F, Tuncer I, Ozkardes H. Emphysematous pyelonephritis and renal amoebiasis in a patient with diabetes mellitus. Int J Urol 2003; 10:404–406.
11. Jain SK, Agarwal N, Chaturvedi SK. Emphysematous pyelonephritis: a rare presentation. J Postgrad Med 2000; 46:31–32.
12. Yang WH, Shen NC. Gas-forming infection of the urinary tract: an investigation of fermentation as a mechanism. J Urol 1990; 143:960–964.
13. Sailesh S, Randeva HS, Hillhouse EW, Patel V. Fatal emphysematous pyelonephritis with gas in the spinal extradural space in a patient with diabsetes. Diabet Med 2001; 18:68–71.
14. Wan YL, Lo SK, Bullard MJ, Chang PL, Lee TY. Predictors of outcome in emphysematous pyelonephritis. J Urol 1998; 159:369–373.
15. Tahir H, Thomas G, Sheerin N, Bettington H, Pattison JM, Goldsmith DJ. Successful medical treatment of acute bilateral emphysematous pyelonephritis. Am J Kidney Dis 2000; 36:1267–1270.
16. Sacks D, Banner M, Meranze S, Burke D, Robinson M, McLean G. Renal and related retroperitoneal abscesses: percutaneous drainage. Radiology 1988; 167:447–451.
17. Mallet M, Knockaert DC, Oyen RH, Van Popple HP. Emphysematous pyelonephritis: no longer a surgical disease? Eur J Emerg Med 2002; 9:266–269.
18. Matsuda D, Irie A, Mizoguchi H, Baba S. A case of emphysematous pyelonephritis successfully treated by transurethral retrograde drainage. Hinyokika Kiyo 2004; 50:15–17.
19. Menif E, Nouira K, Baccar S, et al. Emphysematous pyelonephritis: report of 3 cases. Ann Urol 2001; 35:97–100.