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Percutaneous drainage for non-operative management of emphysematous pyelonephritis: Clinical characteristics and predictors of success

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ABSTRACT

Emphysematous pyelonephritis (EPN) is a necrotizing renal infection that can rapidly progress without urgent intervention. The purpose of this study was to evaluate the safety and efficacy of percutaneous nephrostomy (PN) in the management of EPN, as well as the relationship of outcomes with initial classification by the Huang-Tseng classification system and other prognostic factors such as thrombocytopenia. A retrospective review of medical records revealed seven patients with EPN treated with PN. Thirty-day survival rate was 86%, with the only mortality due to an arrhythmia secondary to underlying cardiomyopathy rather than a complication from EPN or PN. A single nephrostomy procedure served as definitive treatment in 3 patients (43%). Reintervention due to recurrence of EPN symptoms was required in 4 patients (57%), all of which initially presented with Class 3 disease or higher. Two of these four patients required nephrectomy, while the other two were successfully managed with a second drainage procedure without further recurrence of symptoms. PN appears to be a safe and generally effective management option for EPN, especially in patients who are considered poor surgical candidates. PN may serve as definitive treatment in hemodynamically stable patients with lower class of disease. In patients with higher class of disease, PN may be definitive treatment in patients who lack additional risk factors such as thrombocytopenia or serve as an effective bridge to nephrectomy.

Keywords: Emphysematous pyelonephritis, Gangrenous pyelonephritis, Percutaneous nephrostomy, Nephrostomy, Upper urinary tract infection

INTRODUCTION

Emphysematous pyelonephritis (EPN) is a rare and gas-producing necrotizing infection of the renal parenchyma with occasional involvement of adjacent structures. It is most commonly caused by *Escherichia coli*, as well as other gas-producing species such as *Klebsiella* and *Clostridium*.[1] Mortality associated with EPN is most commonly related to septic complications.

The clinical features of EPN are largely indistinguishable from those present in severe and acute pyelonephritis, with patients often complaining of flank pain, fever, and vomiting. However, EPN is a much more aggressive entity with a higher mortality rate. Laboratory tests in affected patients often show hyperglycemia, leukocytosis, pyuria, and elevations in serum creatinine levels.[2]

EPN has been traditionally treated with nephrectomy or open drainage along with systemic antibiotics. More recently, it has been shown that treatment with percutaneous nephrostomy (PN) is

a viable option, eliminating the need for surgical intervention. A systematic review of 10 retrospective studies including 210 patients showed that the mortality rate in patients treated with percutaneous drain placement (13.5%) was lower than that seen in patients treated with nephrectomy (25%)[3] or medical management alone (50%). All patients were treated with systemic antibiotics regardless of other interventions.

EPN may be categorized into four classes by CT scan findings.[4] Class 1 is characterized by gas in the collecting system only (i.e., emphysematous pyelitis), which may be associated with severe obstruction at the site of the pyelitis. Class 2 is characterized by gas in the parenchyma without extension to the extrarenal space. Class 3A is characterized by extension of gas or abscess to the perinephric space (the area between the renal capsule and Gerota's fascia). Class 3B is characterized by extension of gas or abscess into the pararenal space (the space beyond the renal fascia and/or extension into adjacent tissues such as the psoas muscle). Class 4 is characterized by bilateral EPN or a solitary functioning kidney with EPN. The four-category system is generally preferred over the two-type system.

Patients with Class 1 or 2 disease have been shown to have better outcomes compared to those with Class 3 or Class 4 disease. PN has been shown to be effective in patients with Class 1 or 2 disease, with limited mortality rates (6.7%) or need for subsequent nephrectomy. Among patients with Class 3 disease, mortality rates are higher (21%) as are the percentage of PN procedures deemed to be unsuccessful (39%) with requirement for subsequent nephrectomy. Patients with Class 4 have been shown to have even higher rates of mortality and unsuccessful percutaneous drainage, although sample size is limited on this cohort.

Factors that confer a worse prognosis and mortality increase among patients with EPN include bilateral disease, presence of renal parenchymal necrosis on imaging, thrombocytopenia, and treating conservatively without percutaneous drainage.[5] Hyponatremia has also been shown to predict mortality.[6]

The aim of this retrospective study is to evaluate the safety and efficacy of PN in patients with EPN and to discuss the predictors of outcome.

MATERIAL AND METHODS

The Institutional Review Board exemption was obtained for this Health Insurance Portability and Accountability Act compliant retrospective study. The requirement for informed consent was waived for this retrospective chart review.

Patient selection

A search in the electronic medical records database of our tertiary care teaching hospital for all patients that underwent percutaneous renal and/or perinephric drainage procedures performed by interventional radiology was conducted, revealing a total of 83 cases between January 2017 and September 2021. Patients with radiologic evidence of gas within the renal collecting system, renal parenchyma, or perinephric space with a concurrent diagnosis of urosepsis were collected for inclusion in the study, leaving seven total cases.

CASE REPORT

A 60-year-old female with a medical history of hypertension and diabetes presented with flank pain, dysuria, and confusion for 1-week duration. CT scan showed a gas and fluid collection within the posterior perinephric space extending to the diaphragm, consistent with EPN [Figure 1]. A 12 Fr locking pigtail drain was placed on admission day 2, with removal of 15 cc of purulent fluid at the time of procedure [Figure 2]. She tolerated the procedure well with no periprocedural or immediate post-procedural complications. Her hospital stay was complicated by acute hypoxic respiratory failure secondary to community-acquired pneumonia. She was discharged on day 15 with nephrostomy in place and instructions to follow-up with urology in 2 weeks. She was seen by urology at her 2 weeks follow-up and subsequently had the drain removed as her symptoms had resolved. However, she experienced recurrence of symptoms requiring repeat percutaneous drainage 1 week later. The second drain remained in place for 28 days and was removed after the patient had resolution of symptoms. Repeat drainage resulted in interval decrease in the size of the fluid collection [Figure 3], and follow-up CT 6 months later showed continued improvement [Figure 4].

RESULTS

Seven patients were included in the study. The mean age of the patients was 48.9 ± 12.2 years, including two men and five women. The most common comorbidity was diabetes (86%, 6/7) followed by hypertension (57%, 4/7). All seven patients presented with hyperglycemia at admission with

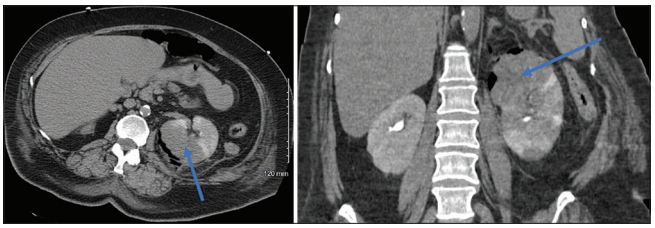

Figure 1: A 60-year-old woman with diabetes who presented with flank pain, dysuria, and confusion. CT scan (left: Axial and right: Coronal) shows foci of gas with a fluid collection component (arrows) within the posterior perinephric space, consistent with emphysematous pyelonephritis.

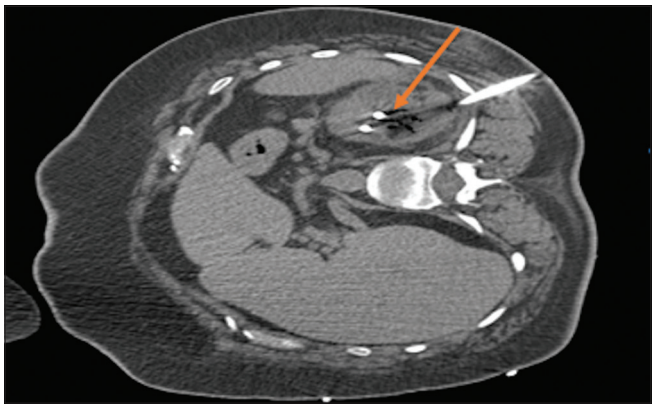

Figure 2: A 60-year-old woman with diabetes who presented with flank pain, dysuria, and confusion, undergoing percutaneous nephrostomy tube placement for emphysematous pyelonephritis. CT obtained during drain placement procedure shows catheter placement (arrow) in the above-noted gas and fluid collection in the left kidney.

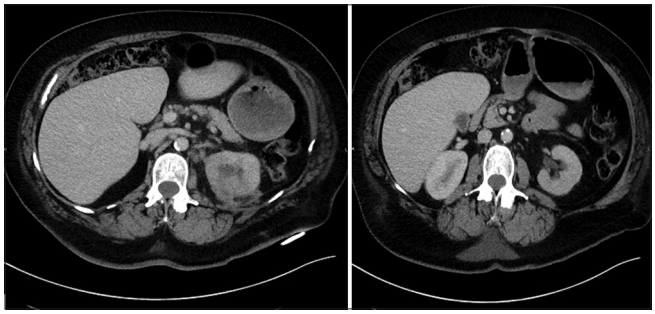

Figure 3: A 60-year-old female who required repeat drainage due to recurrence of flank pain and dysuria 1 week after removal of the initial nephrostomy tube, which was placed due to emphysematous pyelonephritis. CT abdomen with contrast performed following removal of the second drain shows interval improvement with resolution of gas foci and decreased perinephric fluid. Perinephric stranding is still present. More cranial slice is pictured on the left with more caudal slice on the right.

mean glucose levels of 336.9 ± 97.2 mmol/L [Table 1]. Hyponatremia and leukocytosis were also present in all seven patients. Thrombocytopenia (normal platelet count: 150–400 × 10^9/L) was present in 5 patients (71%, 5/7). Four patients (57%) presented with Class 3 disease assessed by CT findings, two patients presented with Class 2 disease, and one patient presented with Class 1 disease. Two patients (28.7%, 2/7) were found to have renal parenchymal necrosis on imaging. Zero patients had bilateral disease.

The procedure was technically successful and uneventful in all patients. All procedures were done under local anesthesia using the Seldinger technique with a 12 Fr locking pigtail drain. There were no periprocedural or immediate post-procedural complications in all patients. Aspirated fluid was purulent in 6 patients (86%) and bloody in 1 patient (14%).

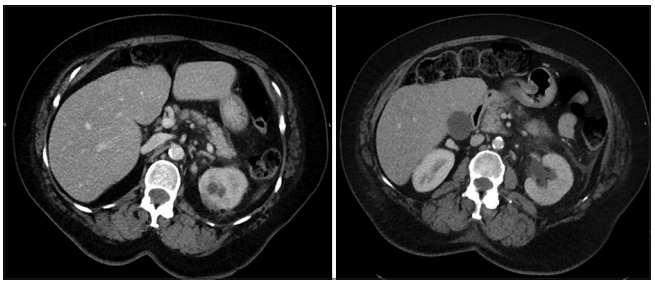

Figure 4: A 60-year-old female who presented for follow-up imaging 6 months after the removal of a second drain placed for recurrent emphysematous pyelonephritis. CT abdomen with contrast shows resolution of emphysematous pyelonephritis findings. Perinephric stranding is less conspicuous and represents chronic scarring. More cranial slice is pictured on the left with more caudal slice on the right.

Fluid culture was positive for *E. coli* in all seven patients, with 6 patients (86%) found to also have positive blood cultures for *E. coli*.

Survival rate at 30 days after the procedure was 86% (6/7), with the only mortality due to an arrhythmia secondary to underlying ischemic cardiomyopathy and heart failure with ejection fraction <40%, rather than a complication from EPN or nephrostomy placement. Survival rate remained 85.7% (6/7) at 60 and 90 days. The survival rate was 83.3% (5/6) at 180 days, as one patient was lost to follow-up before this interval.

One patient required nephrectomy at 26 days post-drainage for recurrence of symptoms with persistence of renal liquefactive necrosis on CT imaging. Another patient underwent elective nephrectomy 295 days post-drainage after multiple repeat drainage procedures for persistence of clinical symptoms. Complete resolution of symptoms was achieved in the remaining 4 out of 7 patients (57%) with drain removal occurring at a mean of 21.5 days post-nephrostomy placement (21.5 ± 5.7 days). Two of these patients did require repeat drainage for recurrence of symptoms at 10 and 71 days following removal of the initial drain, respectively. Both patients experienced resolution of symptoms and interval decreased in size of gas and fluid collections on CT imaging after repeat drainage. The largest fluid collection drained in our case series was 588 cm^3, with the smallest collection drained being 333 cm^3.

DISCUSSION

Diabetes mellitus is a known predisposing factor for the development of EPN. It has been proposed that up to 95% of cases of EPN occur in patients with underlying uncontrolled diabetes.[7] Hyperglycemia provides gas-producing bacteria with an environment that is more favorable for growth and gas formation, while compromised distal vascular perfusion

Table 1: Laboratory results at the time of initial presentation, class of disease by CT scan, and outcomes following PD.

Case	WBC count ($\times 10^9$/L)	Glucose (mmol/L)	Serum Na (mmol/L)	Platelet count ($\times 10^9$/L)	Class of disease by CT	Recurrence of symptoms	Outcome after recurrence
Case 1	23.5	283	132	136	3A	Yes	Resolution after repeat drainage
Case 2	23.5	280	130	353	3B	Yes	Resolution after repeat drainage
Case 3	10.2	259	126	103	3B	Yes	Nephrectomy
Case 4	12.4	276	131	24	3B	Yes	Nephrectomy
Case 5	18.0	425	134	431	2	No	N/A
Case 6	38.9	235	122	293	2	No	N/A
Case 7	20.1	>600	128	19	1	No	N/A

commonly seen in diabetic patients further facilitates anaerobic metabolism.[8] All seven of our patients had either a history of diabetes or presented with hyperglycemia, providing further support for this theory. EPN has also been shown to be more common in females[9,10] as they are more susceptible to urinary tract infections. In our case series, we saw a similar female preponderance (2.5:1).

E. coli was the most common pathogen cultured from aspirated fluid in our patients. This is consistent with prior studies that have shown *E. coli* as the most common microbe involved in the pathogenesis of EPN. One of our patients grew cultures positive for *Candida albicans*, which has been described as a cause of EPN in the past.[11]

The clinical approach to the management of EPN traditionally involved broad-spectrum antibiotics and nephrectomy. However, with recent advancements in medical technology, patients with EPN can now be treated less invasively with PN rather than nephrectomy. If patients are hemodynamically stable, nephrectomy can be deferred in place of drain placement. PN has been shown to be especially successful as definitive treatment in patients who present with lower class of disease. In our study, all three patients who presented with Class 1 or Class 2 disease were treated with a single PN procedure without recurrence of symptoms. However, all four of our patients who presented initially with more severe disease of Class 3 or above required either nephrectomy or a repeat drainage procedure. The results of our study are consistent with the previous literature suggesting that more severe disease at initial presentation is associated with recurrence of symptoms and failure of initial drain placement, requiring repeat percutaneous drainage or surgical intervention.

Thrombocytopenia is a known predictor of poor prognosis in EPN and may be a marker of severe sepsis in these patients. In our case series, we had five such cases of patients presenting with thrombocytopenia. PN was less successful in patients presenting with the combination of thrombocytopenia and Class 3 disease, with two of these patients requiring nephrectomy and the other patient requiring repeat drain placement. In patients who presented with thrombocytopenia alone in combination with a lower class of disease, a single PN procedure was definitive treatment for EPN. Thrombocytopenia seems to be a more important predictor of adverse outcomes in patients with more severe (Class 3 or Class 4) disease, while serving as a less important risk factor in patients with milder disease. In patients with renal involvement limited to the collecting system, PN may be definitive treatment regardless of platelet count.

In our case series, there was one mortality reported. The mortality rate in patients treated with medical management and PN has been estimated to be 13.5%, which is consistent with our study (14.3%). In addition, the death seen in our case series was caused by an acute cardiac event rather than complications of EPN. Mortality has been shown to be significantly higher in patients treated with medical management alone (50%) or medical management combined with nephrectomy (25%).

Our case series provides further support that PN should be part of initial management for EPN, especially in patients with Class 1 or Class 2 disease. PN is a viable option for patients with more severe disease as well (Class 3 and Class 4), assuming that the patient is hemodynamically stable. A nephrectomy may still be required in some patients but proceeding with drain placement first can stabilize clinical condition ahead of potential nephrectomy. Early broad-spectrum antibiotics remain a mainstay of treatment regardless of whether nephrectomy or drainage is employed, which all our patients received. This study is limited by small sample and single-center retrospective nature without comparison group. A comparison group would be very difficult task to achieve, as other options carry serious mortality rates.

CONCLUSION

Our case series provide further support that early management of EPN with broad-spectrum antibiotics

and fluid resuscitation combined with percutaneous drain placement can be an effective treatment option, especially in patients who are not deemed strong surgical candidates. Although there is still a role for nephrectomies in more severe cases of EPN, percutaneous drainage combined with medical management is a viable initial management strategy and may serve as an effective bridge to nephrectomy. The severity of the disease course of EPN is determined by an interplay of many clinical findings including the extent of renal and perirenal involvement, presence of renal necrosis, thrombocytopenia, and hemodynamic instability. These findings play a major role in the likelihood of successful treatment of EPN with PN.

Declaration of patient consent

Patient's consent not required as patient's identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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