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Surgical Intervention for Emphysematous Pyelonephritis – Our Experience

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Abstract:

Introduction: *Emphysematous pyelonephritis (EPN) is considered a rare renal infection. It is an acute severe necrotizing infection resulting in the production of gas in the renal parenchyma, collecting system or perinephric tissue. In this report, we describe the clinical, laboratory and imaging findings and in-hospital outcomes of EPN patients who underwent different surgical procedures.*

Method: *This prospective observational study was carried out at BIRDEM General Hospital, Dhaka, Bangladesh between January 2018 and November 2021.*

Result:*A total of 29 patients were recruited to the study (mean age 52.18 + 8.352 year; range 40 – 68 year) including female predominance (89.7%). Comorbidities includes diabetes (96.55%), hypertension (58.6%), acute kidney injury (58.6%), chronic kidney disease (37.9%), renal stones (20.7%), associated hydronephrosis (HDN) or hydroureteronephrosis (HDUN) (27.6%) and multiple comorbidities (93.1%). Neutrophilic leucocytosis with poor glycaemic status was common laboratory findings. CT scan used to confirm the diagnosis and classify EPN. Class 2 EPN (17%), class 3A EPN (26%), class 3B EPN (46%) and class 4 EPN (11%). Escherichia coli was the most common organism identified on urine culture (62%). Along with medical management, intervention includes DJ stenting (24.1%), incision drainage (I/D) with primary closure (65.5%), I/D with open wound (6.9%) and nephrectomy (3.4%). Mean + SD duration of drain tube was 12.36 + 4.83 days. Wound infection rate in I/D with primary closure was 15.8%. No patient died in our series.*

Conclusion: *Multidisciplinary team approach with aggressive medical management and timely interventions are key to decrease mortality in management of EPN. The result of incision drainage with primary wound closure along with a drain tube in situ is promising.*

Keywords: Emphysematous pyelonephritis (EPN); surgical intervention; Incision and drainage; nephrectomy; CT classification of EPN, outcome.

Introduction:

Emphysematous pyelonephritis (EPN) is considered a rare renal infection. It is an acute severe necrotizing infection resulting in the presence of gas in the renal parenchyma, collecting system or perinephric tissue.[1] Kelly and MacCullum,[2] described a case of gas-forming necrotizing renal infection with pneumaturia in 1898. Multiple eponyms had been used for this gas forming infective condition such as "pneumonephritis," "renal emphysema," and "emphysematous pyelonephritis".[3]

Diabetes mellitus (DM) is the most common associated factor [4] as is the presence of urinary tract obstruction in

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20-45%.[1] There is a higher predilection for females.[5,6] Escherichia coli is the most encountered organism, others being- Klebsiella, Proteus, Pseudomonas, Clostridium, Streptococcus, Candida, Aspergillus and Cryptococcus species and sometimes polymicrobial infections.[8,9]

Various imaging modalities can find gas in the affected reno-ureteral units. Abdominal X-ray may suggest the presence of gas within the renal outlines and prompt a computed tomography (CT) scan. Ultrasonography may reveal hypoechoic kidneys with echogenic components and dirty shadows in the renal parenchyma, calyces and pelvis. However, the CT scan is most reliable for establishing the diagnosis of EPN.[6] According to the classification system of Huang and Tseng,[10] which is based on the extent of air seen on computed tomography (CT), EPN is categorized in five classes: class 1, gas in the collecting system only; class 2, gas in the renal parenchyma without extension to the extrarenal space; class 3A, extension of gas or abscess to the perinephric space; class 3B, extension of gas or abscess to the pararenal space; and class 4, bilateral EPN or a solitary kidney with EPN.

Treatment options for EPN have evolved over the years, from invasive surgery to more conservative approaches. Until the late 1980s, the management of EPN usually involved emergency nephrectomy,[11] however this approach was associated with a mortality rate of 40% to 50%.[12] Over the last two decades, improvements in management techniques have resulted in a decrease in the mortality rate to 21%.[13] Patients are managed differently in different centres, although some treatment protocols and management algorithms have been proposed by different researchers and investigators.[10,11,13] The principles of treatment include resuscitation, intravenous antibiotics, glycaemic control (in diabetics), interventions aiming to release obstructions and nephrectomy (in selected cases).[6]

In this report, we describe the clinical, laboratory and imaging findings and in-hospital outcomes of EPN patients who underwent different urological procedures.

Methods:

This prospective observational study included 29 patients diagnosed with EPN who were managed in the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) General Hospital in Dhaka, Bangladesh between January 2018 and November 2021.

The participants were evaluated by a team consisting of physicians and/or nephrologists, radiologists, and urologists after undergoing a CT scan to decide whether urologic intervention required. Case records were completed during discharge (or would be after death, but none occurred) and had selected sociodemographic, laboratory and imaging characteristics, and in-hospital treatment outcomes. Exclusions included patient undergoing a recent genitourinary procedure and who were treated conservatively.

Statistical Package for Social Scientists (SPSS version 20) was used to analyse the data, comparing different demographic, laboratory parameters, CT classes and outcome variables among patients. A p value of < 0.05 was taken as significant.

Result:

A total of 29 patients were recruited to the study (mean age 52.18 + 8.352 year; range 40 – 68 year) including 26 females (89.7%) and 3 males (10.3%). Most of the patients were diabetic except one. Other common comorbidities [figure: 1] were hypertension (17 patients; 58.6%), AKI (17 patients; 58.6%), chronic kidney disease (11 patients; 37.9%), renal stones (6 patients; 20.7%), associated hydronephrosis (HDN) or hydroureteronephrosis (HDUN) (8 patients; 27.6%) and multiple comorbidities on 27 patients (93.1%).

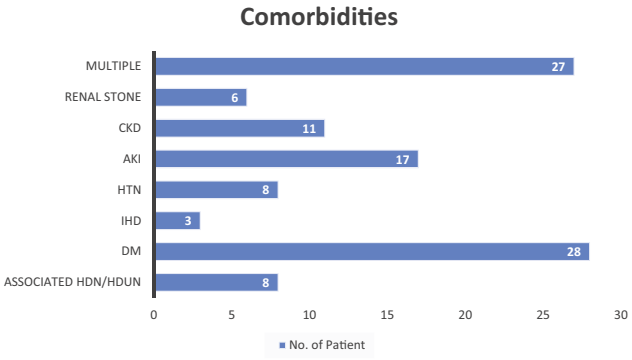

Figure 1: *Comorbidities of patients in this study with EPN (n = 29)*

The common clinical features were fever (100%), loin pain and/or renal angle tenderness (25 patients; 86.2%), vomiting (23 patients; 79.3%), dysuria (15 patients; 51.7%) and dehydration (6 patients; 30%). One patient (5%) presented with altered sensorium.

Neutrophilic leucocytosis was common with high erythrocyte sedimentation rates (ESR). Overall, glycaemic status was poor (Table 1). Other features were pyuria (21 patients; 72.4%), and microscopic haematuria (15 patients; 51.72%). 21 patients (72.4%) had hyponatremia and 3 patients (10.3%) had hypokalaemia. The laboratory characteristics are shown in Table I.

Table 1 *Parameters of patients with emphysematous pyelonephritis (n = 29)*

Parameter (n= 29)	Values
Age (yr) (mean ± standard deviation; range)	52.18 + 8.352 (40 – 68)
M/F	3/26 (10.3%/89.7%)
Haemoglobin gm/dl (mean ± standard deviation; range)	8.018 + 1.67 (5.0 - 10.2)
ESR (mm) (mean ± standard deviation; range)	70.64 + 20.67
Total white cell count/cmm (mean ± standard deviation; range)	16.7131 + 4.10106
Thrombocytopaenia (< 150.0 x 109/L)	5 (17.24%)
Neutrophil (%) (mean ± standard deviation; range)	80.759 + 7.6200
Random blood glucose at admission, mg/dl (mean ± standard deviation; range)	18.43 ± 4.78 (12.6–24.3)
Glycated haemoglobin (HbA1c %) (mean ± standard deviation; range)	11.827 + 1.9334
Blood urea, mg/dl (mean ± standard deviation; range)	49.36 + 31.525 (13-101)
Serum creatinine, mg/dl (mean ± standard deviation; range)	3.262 + 2.3815
Hyponatraemia (<135 mmol/L)	21 (72.4%)
Hypokalaemia (<3.5 mmol/L)	3 (10.3%)
Hypoalbumianemia (< 34 g/L)	19 (65.52%)
Pyuria	21 (72.4%)
Haematuria	15 (51.72%)
Total hospital stays, days (mean ± standard deviation; range)	8.14 + 1.903

The diagnosis of EPN was confirmed by abdominal CT scan. The right kidney was involved in 10 patients (34.5%), left in 16 patients (55.2%) and bilateral in 3 patents (10.3%). EPN classified from the features of CT findings according to Huang and Tseng. In this classification; class 1, gas in the collecting system only; class 2, gas in the renal parenchyma without extension to the extrarenal space; class 3A, extension of gas or abscess to the perinephric space; class 3B, extension of gas or abscess to the pararenal space; class 4, bilateral EPN or a solitary kidney with EPN. According to CT findings, 6 patients (17%) had class 2 EPN, 9 patients (26%) had class 3A EPN, 16 patients (46%) had class 3B EPN and 4 patients (11%) had class 4 EPN.

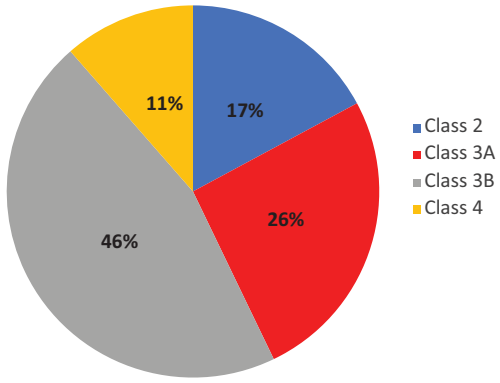

Figure 2: *CT classification of patients in this study with EPN*

Urine culture [figure 3] revealed the growth of microorganisms in 25 patients (86.2%). *Escherichia coli* was the most common organism found on urine culture (16; 62%). Blood appeared to be sterile except in 4 cases (13.8%) where culture revealed growth of *Escherichia coli* 1 X 10^5. Less common microorganisms in urine were *Enterococcus, Klebsiella pneumoniae, Candida.*

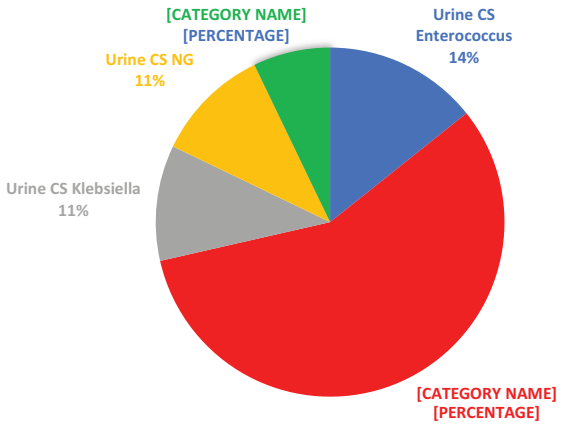

Figure 3: *Urine culture findings of patients in this study with EPN*

All patients were treated with intravenous antibiotics and other supportive measures including fluid resuscitation. Procedure done was summarized in figure

4. Most of the patients suffered from class 3A and class 3B diseases underwent incision and drainage (I/D) of EPN with primary wound closure (19 patients; 65.5%) with a wide drain tube (24 Fr) kept inside. The patients were discharged when stable (no fever, decreased total WBC count and acceptable pain) with the drain tube. The tube was removed when pus and or discharge stopped to drain. Mean + SD duration of drain tube was 12.36 + 4.83 days. The wound was kept open in two patients (6.9%) who underwent incision and drainage. Those suffered from class 2 and one of class 4 disease underwent DJ stenting (7 patients; 24.1%). One patient with class 3B EPN required nephrectomy (3.4%). Among those underwent I/D of EPN with primary closure; 3 patients (15.8%) developed wound infection.

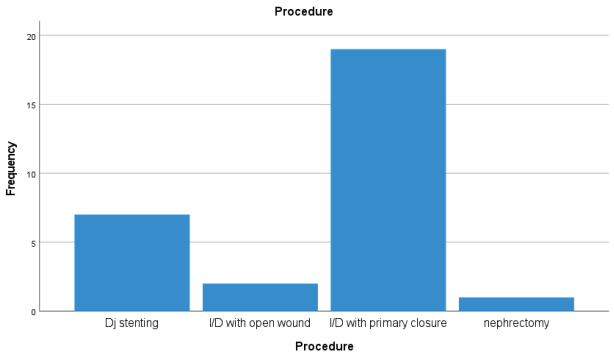

Figure 4: *Procedures performed in patients of this study with EPN*

During open procedure pus was collected and sent for culture sensitivity [figure 5]. *Esch. coli* was most common organisms isolated (12 samples, 43%). Pus cannot be collected from those underwent DJ stenting (N/A =25%).

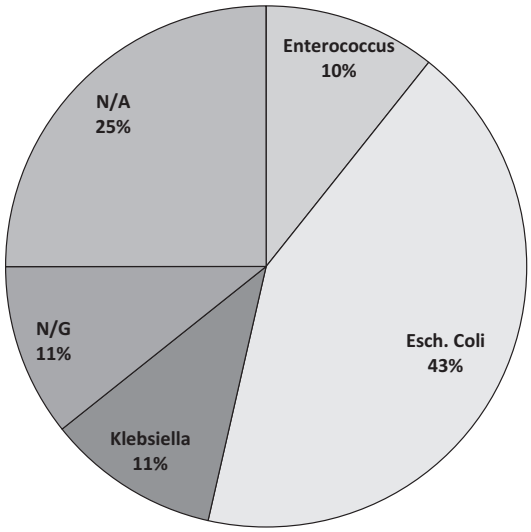

Figure 5: *Pus culture findings of patients in this study with EPN*

The mean + SD of total hospital stays of the patient underwent different procedure was 8.140 + 1.903 days. AKI resolved in 14 patients before discharge and there were no deaths.

Some photographs of CT imaging of different cases of EPN are shown in figure 6-9.

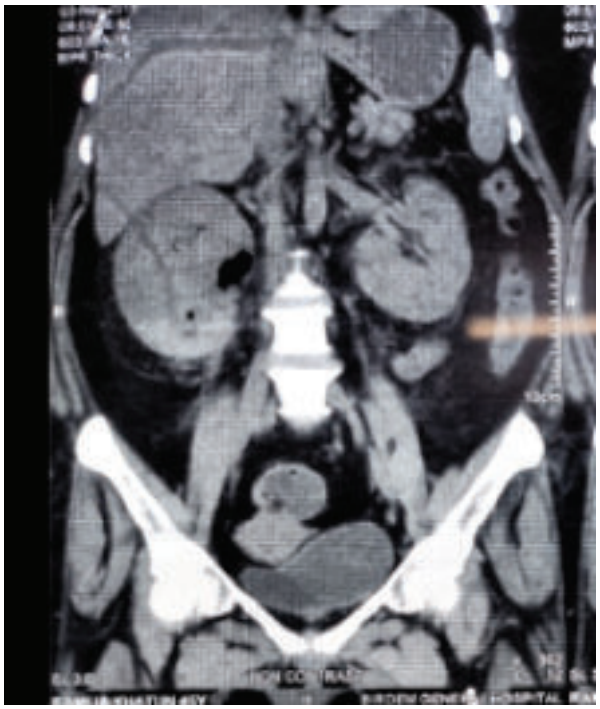

Figure 6: *Class 2 EPN on noncontract CT*

Figure 7: *Class 3A EPN on noncontract CT*

Figure 8: *Class 3B EPN on noncontract CT*

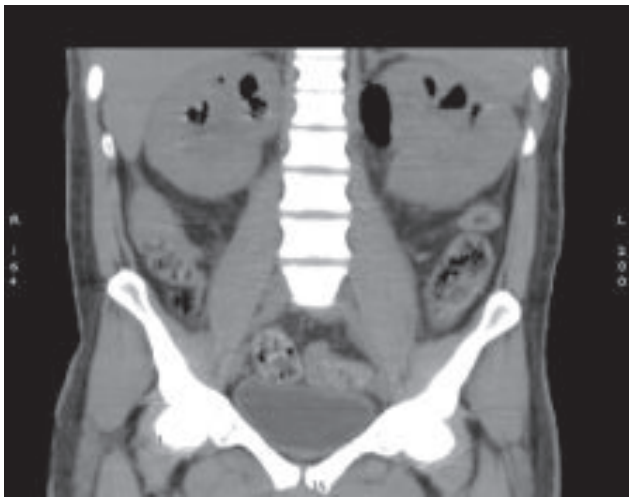

Figure 9: *Class 4 EPN on noncontract CT*

Discussion:

EPN is caused by a process of gas formation which requires a pathogenic organism proficient of acid fermentation in local necrotic tissue in the presence of hyperglycaemic environment.[14] Hence, diabetes mellitus has been known to be the most common associated factor with up to 95% of patients with EPN having uncontrolled diabetes mellitus at the time of presentation.[4,15] In our study most of the patients were diabetic except one. The mean age of our study population was 52.18 + 8.352 year (range 40 – 68 year) which was comparable with the age group of patients in other studies.[10,16] EPN predominantly occurs in females, and most commonly involves the left kidney, followed by the right kidney; bilateral involvement is the least common.[6] However in the study of Misgar et al. a third of their EPN patients had bilateral involvement.[17] In our study there were 26 females (89.7%) and 3 males (10.3%). Like other studies left kidney was involved in 34.5% patients and bilateral disease found in 10.3% patients. It is not known why EPN predominantly involves the left kidney.

Patients with EPN present with the typical features of an upper urinary tract infection (e.g., fever, renal-angle pain or tenderness, and vomiting). Occasionally they have altered consciousness and shock. Virtually no feature is diagnostic of EPN.[6] The clinical presentation of fever, loin pain and vomiting in our series is comparable with other published series.[6, 7, 17] Asymptomatic cases are occasionally identified during investigation for some other reasons.[18]

Neutrophilic leucocytosis, high ESR, and poor glycaemia status are consistent features as most EPN cases have DM.[6] EPN is commonly associated with *Esch. coli* organisms and was isolated in nearly 70% of the reported cases.[19,20] *Proteus mirabilis, Klebsiella pneumonia,* Group D *Streptococcus*, and coagulase-negative *Staphylococcus* have also been isolated in patients with EPN. In our study, urine culture revealed the growth of microorganisms in 25 patients (86.2%). *Escherichia coli* was the most common organism found on urine culture (16; 62%). Less common microorganisms were *Enterococcus, Klebsiella pneumoniae, Candida*. 11% of our patients had no urine isolates, which is not unusual, especially in patients who receive antibiotics before seeking medical care,[21] or who are transferred from other centres where they had been treated. Bacteraemia, AKI and electrolyte imbalances were important complications in our series. In other studies, up to 75% of EPN cases were complicated by AKI.[6] None of our patients required transfer to the intensive care unit (ICU).

We use CT scan as a diagnostic tool for EPN and classify it according to the Huang and Tseng classification.[10] The treatment of EPN has evolved over the years from emergency nephrectomy to more conservative approaches. The mortality rate in a series by Ahlering et al. advocating emergency nephrectomy was 42%.[12]

According to Lu et al. patients received antibiotics alone had mortality rate of 20%.[21] In our series no patient died. Patients were treated in a multidisciplinary approach involving urologist, nephrologist, endocrinologist, and internist. All were treated with intravenous antibiotics and other supportive measures including fluid resuscitation and haemodialysis as needed. Our study includes only those patients with EPN who needed some form of procedures. The procedures include DJ stenting, incision and drainage with primary wound closure keeping a drain tube in situ, incision and drainage with open wound and nephrectomy. For class 2 diseases with hydronephrosis and or hydroureteronephrosis DJ stenting was done with medical treatment. Par cutaneous drainage (PCD) though becoming popular for class 2 and class 3 diseases we did not do any PCD. Problem with PCD is, its inability to drain a multiloculated abscess cavity associated with class 3A and 3B diseases. According to Lu et al. PCD is associated with 37.5% failure rate and 13.5% mortality rate.[21] Instead, we prefer incision and drainage with primary wound closure keeping a drain tube in situ in most cases of class 3A and 3B diseases. Only those with grossly contaminated class 3B cases, the wound kept open and underwent regular dressing. Though, the usual norm in draining an abscess cavity is to keep the wound open, our strategy has a good outcome. We drain the EPN and break the loculi and wash the wound thoroughly with normal saline and closed the wound anatomically with 24 Fr drain tube in situ. The drain kept as long as any purulent discharge noted. Mean + SD duration of drain tube was 12.36 + 4.83 days. Patients were discharged with the drain tube when became stable. This avoids regular painful dressing with decreased hospital stay and early recovery. Only 3 patients (15.8%) developed wound infection.

Mortality associated with EPN has reduced largely in the last two or three decades.[6] In a literature review, many prognostic factors for mortality were identified, however none of the trials studied a large population. Khaira et al.[20] also reported that shock was an independent poor prognostic risk factor in a case series of 19 patients with EPN. Huang and Tseng,[10] reported that thrombocytopenia, altered mental status, severe proteinuria, and acute renal failure at the presentation of EPN were associated with a poor outcome. Similarly, a study conducted in India of 39 patients with EPN showed that altered mental status, thrombocytopenia, renal failure, and severe hyponatremia at presentation were also associated with higher mortality rates.[12] In a meta-analysis, systolic blood pressure less than 90 mmHg, serum creatinine greater than 2.5 mg/dL, and impairment of consciousness were also found to be associated with increased mortality.[23] Our series had zero mortality, although some risk factors were present, such as low platelet count, hypoalbuminemia, altered sensorium, uraemia and the requirement for haemodialysis.

Many factors contribute to the improved outcomes in EPN, including wide availability of CT scan facilities, early detection, early urological intervention along with aggressive resuscitative measures, rapid glycaemic control using intravenous insulin, early administration of effective, broad-spectrum intravenous antibiotics and a multidisciplinary team approach.[6]

Limitation:

This study done in a single institution with a small number of patients. This may account for the lack of significance of some of the factors analysed. Second, we mostly used data acquired at the initial presentation to identify the risk factors for mortality. Factors that varied over the time of treatment may also have influenced outcomes. A larger prospective multicentre cohort study is required to support our findings.

Conclusion:

Treatment options for EPN evolved over years. Multidisciplinary team approach with aggressive medical management and timely interventions are key to decrease mortality. Appropriate intervention varies according to CT classification and patients' overall status. The result of incision drainage with primary wound closure along with a drain tube in situ is promising as it is associated with avoidance of painful dressing, short hospital stays and early recovery along with nonsignificant wound infection rate.

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