

Renal mucormycosis presenting during the COVID-19 pandemic: A series of 11 cases from a tertiary care center in India

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ABSTRACT

Introduction: Renal mucormycosis has been documented to occur even in apparently immunocompetent individuals. Owing to the rarity of this disease, literature on its management is small. We present our experience of diagnosing and managing 11 cases of primary renal mucormycosis who presented during the second wave of the COVID-19 pandemic in India.

Methods: We reviewed the records of all patients presenting to our institute with a diagnosis of acute pyelonephritis from March 2021 to September 2021. All patients with a radiological, microbiological, or histopathological diagnosis of renal mucormycosis were included in the analysis and all demographic and clinical details, including a history of COVID-19 disease and its treatment, were noted. All patients were treated by a combination of intravenous antifungal therapy and aggressive surgical debridement including nephrectomy and multivisceral resection as required. Predictors of mortality were evaluated by statistical analysis.

Results: A total of 93 patients presented to our hospital with features of acute pyelonephritis of which 11 patients were suspected to have primary renal mucormycosis based on characteristic imaging features and confirmed on microbiological and histopathological examination. Of these, four patients had a history of COVID-19 infection. Only one patient had diabetes mellitus. Ten patients underwent nephrectomy and seven needed resections of surrounding organs. The colon was the most commonly involved organ. Five patients (45.5%) died of progressive sepsis. None of the predictors of mortality that were analyzed showed statistical significance.

Conclusion: A high index of suspicion, early cross-sectional imaging, prompt institution of antifungal therapy, and aggressive surgical extirpation are very important for achieving good outcomes in patients of primary renal mucormycosis.

INTRODUCTION

The causative agent in mucormycosis is a fungus of the order *Mucorales* and these fungi are ubiquitous in our surroundings and are of low virulence.^[1] Isolated or primary renal mucormycosis is a rare entity and renal involvement by systemic mucor infection is usually a part of disseminated mucormycosis in immunocompromised states.^[2] Although there are many case reports and series on primary renal mucormycosis

in immunocompetent individuals, in most cases, predisposing factors are apparent.^[3,4] There are multiple reports of craniofacial, rhinocerebral, and pulmonary mucormycosis in patients after Sars-CoV2 (COVID-19) infection.^[5] The first two cases of primary renal mucormycosis in post-COVID patients have also been from India.^[6,7] The most common predisposing factor associated with renal mucormycosis is poorly controlled diabetes.^[8] Other predisposing conditions

Access this article online	
Quick Response Code:	Website: www.indianjurol.com
	DOI: 10.4103/iju.iju_437_21

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Received: 20.11.2021, **Revised:** 27.02.2022,

Accepted: 15.03.2022, **Published:** 01.04.2022

Financial support and sponsorship: Nil.

Conflicts of interest: There are no conflicts of interest.

are immunosuppression, history of renal transplantation, and intravenous (IV) drug abuse. It has been postulated that the immune dysregulation caused by COVID-19 infection acts as a facilitator for invasive mucormycosis.^[9] By itself, renal mucormycosis is an aggressive disease and any delay in the diagnosis and treatment leads to high morbidity and mortality. Due to the limited amount of published data on this disease in apparently immunocompetent individuals, it is imperative that more reports on the experience of dealing with such cases be available to clinicians worldwide. We reviewed data patients of primary renal mucormycosis who presented to our institute during the second wave of the COVID-19 pandemic for possible predisposing factors and outcomes and present our algorithm for the diagnosis and management of these cases.

MATERIALS AND METHODS

We retrospectively reviewed the records of all patients presenting with history and clinical features suggestive of acute pyelonephritis to our institute from March 2021 to September 2021. All patients with radiological diagnosis of mucormycosis later confirmed by either microbiological or histopathological examination were included in this study. This study was approved by the Institutional Ethics Committee. We maintained a prospective database of all patients, including demographic data (age, sex, comorbidities, history of COVID-19 disease, treatment details during COVID-19 disease if any, status of COVID-19 vaccination, etc.), laboratory parameters (hemoglobin, total leukocyte count [TLC], platelet counts, renal function tests, glycosylated hemoglobin levels, etc.), and radiological investigations (contrast-enhanced computed tomography (CECT) of the abdomen and pelvis). All patients were managed as per the algorithm outlined in Figure 1. At presentation, all patients were assessed by the Quick Sequential Organ Failure Assessment Criteria and total score was calculated. Resuscitation was carried on as indicated and after drawing blood for laboratory parameters and cultures, empirical IV antibiotic therapy with cefoperazone sulbactam was instituted and radiological imaging (CECT abdomen) was carried out. The clinical diagnosis of renal mucormycosis was established based on characteristic imaging findings of renal infarction and vessel thrombosis on CT scan. The extent of renal involvement along with the involvement of the surrounding bowel, solid organs, great vessels, and the abdominal wall was also noted. Urine KOH mounts were then examined for the presence of mucus and a positive finding confirmed the diagnosis. However, the absence of characteristic findings on KOH mount did not rule out the diagnosis. Irrespective of the absence or presence of microbiological findings, IV liposomal amphotericin was instituted in all patients in the dose of 5–10 mg/kg/day.

Exploration of the abdomen through midline incision was done for all patients along with nephrectomy. This was

done preferably 24 h after initiation of antifungal therapy, but emergency laparotomy was done if there were signs of peritonitis, hemodynamic instability or radiological features suggestive of bowel involvement with perforation or ischemia. Nephrectomy of the affected kidney was done with cross clamping and mass ligation of the renal hilum because the tissues and vascular structures were friable and most of the cases had thrombus in the renal vein which could potentially migrate during dissection. Postsurgery, patients were managed in the intensive care unit. Repeat exploration of the abdomen and auxiliary procedures such as debridement of necrotic soft tissue was done as per requirement after multidisciplinary consultation. After stabilization, patients were shifted to the ward as per the protocol. Liposomal amphotericin B was continued up to a maximum cumulative dose of 5 g in each patient. Oral antibiotics were started only when the patient was afebrile with normal TLC, vitals were accepting oral diet, ambulatory and did not have any evidence of surgical site infections (SSIs) for at least 72 h. After the completion of the course of liposomal amphotericin B, all patients were started on oral Posaconazole, which was continued for 3 months. Length of hospital stay was noted for each patient. All the data about the patients collected from the hospital records are presented in Supplementary Table 1. Statistical analysis was done using Wizard for Mac version 2 ©Evan Miller (available at <https://www.wizardmac.com/>). Chi-squared and Mann–Whitney U test were used to assess the difference of various variables between the mortality and survival groups and *P* values were calculated. Multivariate analysis would then be done if any predictor showed a significant *P* value.

RESULTS

A total of 93 patients presented to the outpatient and emergency department of our institute with a clinical diagnosis of acute pyelonephritis. Of these, 63 patients had infected hydronephrosis/pyelonephrosis secondary to obstructing calculi, 11 had emphysematous pyelonephritis and 8 had acute pyelonephritis in a setting of uncontrolled diabetic mellitus with or without papillary necrosis. The remaining 11 patients had mucormycosis, and their details are mentioned in Supplementary Table 1. Nine (81.8%) out of 11 patients were <50 years of age, with the remaining 2 being in the age group of 50–70 years. Eight patients were male and 3 were female. Only one patient had uncontrolled diabetes mellitus. Another patient had a history of ulcerative colitis for the last 20 years and was on long-term oral steroid therapy. Fever was the most common presenting complaint, occurring in 10 out of the 11 patients and flank pain was the next most common (9 out of 11 patients). Two of the patients had discoloration and edema of the skin of the flank on the affected side at presentation and 2 developed it subsequently [Figure 2]. Two patients had symptoms suggestive of peritonitis.

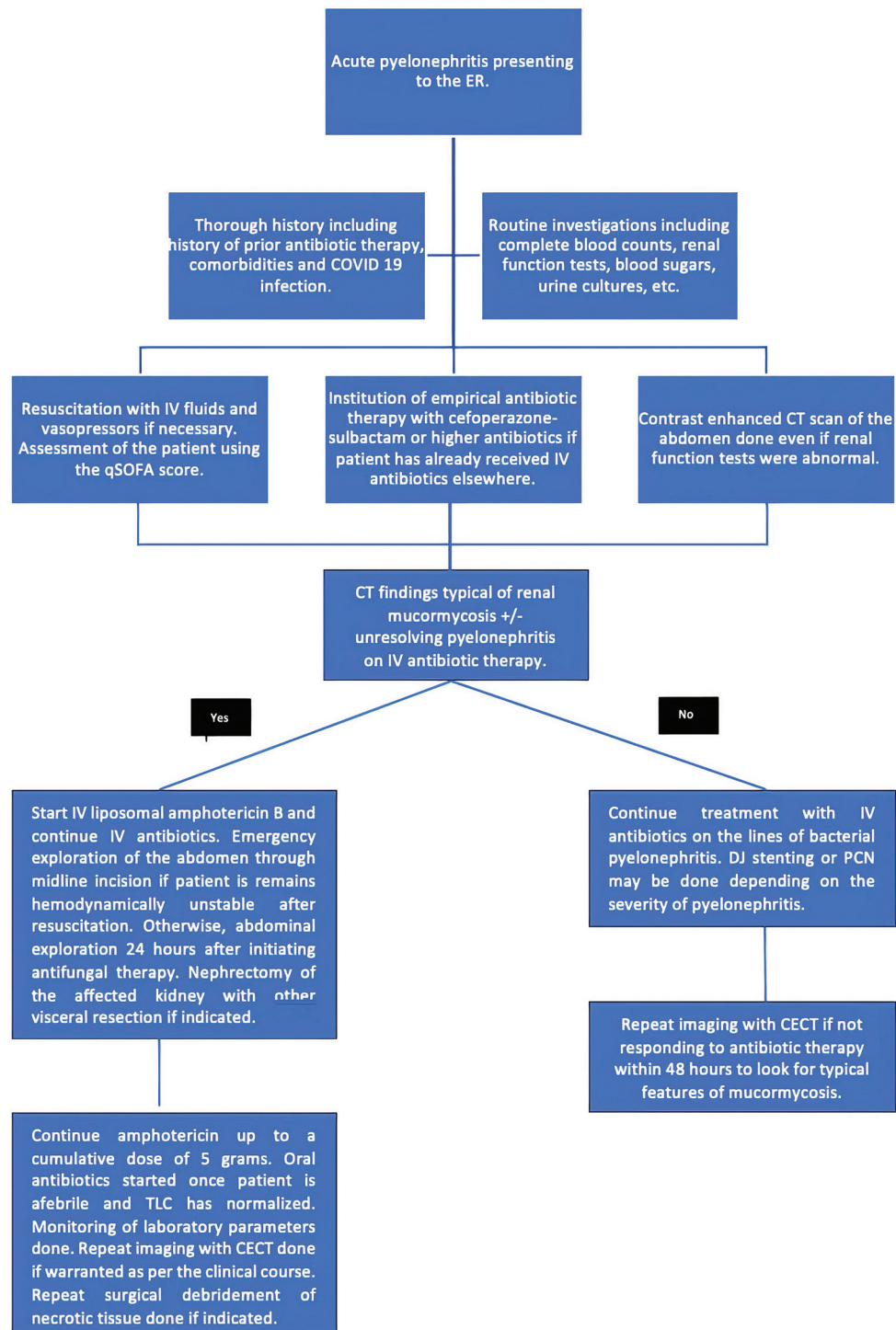


Figure 1: Algorithm showing diagnosis and management of renal mucormycosis cases presenting to us during the study

A total of 4 patients had a history of COVID-19 disease during the preceding 6 months, of which 2 patients had required treatment in the hospital setting and had been administered injectable and oral steroids along with inhalational oxygen therapy. The other two patients had received only oral steroids for a period of 4 weeks and 6 weeks, respectively. Two of the patients had received their first dose of the COVID vaccine within the last 6 weeks of their presentation,

of which one patient had developed post-vaccination fever requiring oral paracetamol for 2 days. The findings on CECT seen in the patients are enumerated in Supplementary Table 1 and Table 1. A typical CECT image is shown in Figure 3. One patient had KOH mount examination of the urine sample, positive for mucor. Only 3 of the 11 patients underwent nephrectomy alone. Seven patients needed resection of surrounding organs, most common of which

Table 1: Diagnostic signs of mucormycosis present in the patients as seen on cross sectional imaging

Imaging characteristic	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11
Enlarged kidney	+	+	+	+	+	-	+	+	-	+	+
Patchy/complete hypoenhancement or nonenhancement	+	+	+	+	+	+	+	+	+	+	+
Perinephric fat stranding	+	+	+	+	+	+	+	+	+	+	+
Thickened Gerota fascia	+	+	+	+	+	-	+	+	+	+	+
Perinephric collection	-	-	-	-	-	-	-	+	-	-	-
Renal abscess	-	-	-	-	-	-	-	-	-	-	-
Psoas involvement	-	-	+	+	-	-	+	-	+	-	+
Mesenteric stranding and thickening of bowel wall or hypoenhancement of bowel	+	-	+	+	-	-	+	+	+	+	+
Ischemic bowel or intraperitoneal perforation.	+	-	+	+	-	-	+	+	+	+	+
Reactive pleural effusion	-	+	-	-	-	-	-	+	-	-	-



Figure 2: Discolouration of the skin of the flank in a patient with renal mucormycosis



Figure 3: Contrast enhanced computed tomography section of the abdomen showing non enhancing kidney on the right side, typical of infarcted kidney seen in renal mucormycosis

was the colon, and debridement of necrotic material from the anterior and posterior abdominal wall. A total of two patients required re-operative surgery, of which one patient underwent peritoneal lavage and feeding jejunostomy and secondary suturing for burst abdomen. The other patient underwent debridement of necrotic tissue from the flank and split skin grafting at a later stage to cover the defect. The intraoperative findings are described in Supplementary Table 1. A total of five (45.5%) of the patients died, of which 4 died on postoperative days ranging from 2 to 37. One patient died before he could undergo surgery. The cause of death was systemic sepsis with multiorgan dysfunction syndrome in all five patients. Predictors of mortality on univariate analysis are shown in Table 2. None of these factors showed a significant *P* value.

DISCUSSION

To our knowledge, this is the largest series of primary renal mucormycosis recorded during the COVID-19 pandemic. The two largest series of primary renal mucormycosis from India documented details of 17 and 10 patients, over 6 and 13 years, respectively.^[3,4] In our series, there were 11 patients over a period of 7 months. Most human infections occur due to inhalation of fungal sporangiospores borne in the

air.^[10] Renal seeding can then occur during fungemia from a pulmonary or rhinocerebral focus. Many risk factors for rhinocerebral mucormycosis have been postulated. During the second wave of the COVID-19 pandemic, many patients were treated with industrial-grade oxygen inhalation therapy in hospitals and homes facing medical oxygen shortages. Contamination of this industrial grade oxygen by fungal spores and the attendant immune dysregulation caused by COVID-19 and its treatment can be postulated to be contributory factors toward the increased incidence of systemic mucormycosis.^[11,12] The use of steroids and anti-interleukin 6 directed therapies and other invasive procedures such as mechanical ventilation, extracorporeal membrane oxygenation, prolonged hospital stays along with poor nursing ratios and breaches in asepsis are the perfect setting for secondary fungal infections.^[13] Worldwide, the majority of systemic mycoses in the COVID setting comprises COVID-19-associated pulmonary aspergilloses. However, in India, the epidemiology reveals a significant burden of invasive mucormycosis.^[13] Invasive mucormycosis has been seen to occur even in patients with mild to moderate SARS-CoV-2 infections. Hyperglycemia further amplified by corticosteroid use and the attendant immunosuppression appears to be the strongest predisposing factor.^[8] This makes

Table 2: Predictors of mortality on univariate analysis

Variable	Mortality group (n=5)	Survival group (n=6)	P
Age	34	38	0.385
Sex	Male - 4, Female - 1	Male - 4, Female - 2	0.064
Diabetes	1	0	0.251
History of COVID-19 disease	2	2	0.082
History of steroid use	3	2	0.082
History of oxygen therapy as a part of treatment for COVID-19 disease	2	0	0.931
Total leukocyte count	17.8	17.5	0.866
Serum creatinine at presentation	1.7	1.69	0.329
qSOFA score	1.5	0.5	0.506
Bowel involvement	5	4	0.452
COVID-19 vaccination	2 (single dose)	0	0.9
Side	Left - 2, Right - 3	All left	0.197

qSOFA=Quick Sequential Organ Failure Assessment

the diabetic COVID-19 patient receiving corticosteroids or other immunosuppressants exceptionally vulnerable to the development of mucormycosis and this association has been definitely shown in rhinocerebral mucormycosis.^[14-16] In our series, there was no association between COVID-19 disease, use of industrial-grade oxygen therapy, steroid use, and the occurrence of primary renal mucormycosis.

Fever and flank pain usually for several days before a presentation is the most common presenting complaints. Local findings may include flank tenderness, pitting edema of the skin, and sometimes blackish discoloration or necrosis of the soft tissue of the flank.^[3] This is due to the extensive perinephric inflammation of the surrounding perinephric tissue and the nearby parietal wall. Many of these cases will be initially treated as bacterial pyelonephritis with IV antibiotics. Unrelenting fever not responding to treatment is an important pointer toward the diagnosis of renal mucormycosis. The algorithm we followed to diagnose and manage our patients ensured prompt initiation of antibiotic therapy and immediate cross-sectional imaging via CECT abdomen. Raised serum creatinine should not be a deterrent in getting a contrast-enhanced CT scan urgently for diagnostic purposes. A cautious approach to contrast-enhanced cross-sectional imaging in the face of renal failure may be a contributor to an adverse clinical outcome and we have published our experience on this in one of our patients.^[6] The findings on CT scan as enumerated in Table 1 are the strong pointers toward mucormycosis and combined with the clinical picture described, they make the need for preoperative tissue diagnosis redundant. A CT scan is also useful in estimating the extent of surrounding organ involvement and helps in preoperative planning. Certain findings on CT scan may also denote severity and be predictors of the clinical course and may help in management decisions. However, no such predictors were seen in our study and they need to be evaluated in larger studies. KOH mount examination of urine has low yield and only one out of the 11 patients in our series had a positive result.

The European Confederation of Medical Mycology and European Conference on Infections in Leukemia recommends

amphotericin B lipid in combination with surgery as the treatment of choice for mucormycosis.^[17] There are the reports of renal mucormycosis being treated entirely with IV amphotericin B without the need for surgery.^[18] However, theoretically, we are dealing with an infected kidney with a compromised blood supply due to the angioinvasive mucor. Adequate delivery of the blood-borne antifungal agent to such a kidney is questionable and therefore an aggressive surgical extirpation of the affected kidney and wide excision of the affected surrounding organs whenever necessary should be carried out as soon as possible after the institution of antifungal therapy. Therefore, we do not recommend conservative management and monitoring the patient for improvement after starting amphotericin B. We recommended early and aggressive surgical debridement. In our series, 7 out of the 10 patients who went on to have surgery had resection of surrounding organs also. A total of 5 out of the 11 patients (45.4%) died in our series. Of these one patient died before surgery and 4 died of progressive sepsis after surgery. Our mortality rate is similar to that published by Devana *et al.* and is significantly lower than the rates in older literature.^[3] We believe that early institution of IV liposomal amphotericin B at least 24 h before emergency nephrectomy and continuing the same during the perioperative period could be one of the reasons for the improved outcomes. This protocol ensures high serum levels of antifungal medication during surgery and it counteracts the possible fungemia occurring during intraoperative handling of the involved kidney. It is worthwhile to mention that in all our cases, the hilum was cross clamped as a whole and individual hilar structures were not dissected out. After dividing the hilum, it was oversewn using proline 2-0 sutures. There were two main reasons for the above step. First, the intense inflammation and ischemia in the area of the hilum had rendered all tissues friable and there was a risk of injuring the aorta or the inferior vena cava during dissection of the hilum. Second, most of these cases had thrombus in the renal vein which could have potentially migrated into the systemic circulation during the hilar dissection.

Our study has several limitations. First is the small sample size, which prevents us from identifying factors predictive

of mortality and morbidity with statistical significance. Although we did see 4 out of 11 patients with a history of previous COVID-19 disease and steroid use, the small sample size failed to show a statistically significant association. Second, the diagnosis of mucormycosis postoperatively was confirmed only on histopathology. The microbiological culture was not done and we have not identified the individual species of the offending fungi which would have better helped us to understand the aetiological agent and maybe tailor antifungal therapy accordingly.

CONCLUSION

We have presented our experience in the management of 11 cases of primary renal mucormycosis in apparently immunocompetent individuals who presented to us in a short time of 6 months. A high index of suspicion along with early cross-sectional imaging, prompt institution of antifungal therapy and abdominal exploration, and aggressive resection helped us to achieve good outcomes in most patients. The significant association of history of COVID-19 infection and steroid use observed with rhinocerebral and pulmonary mucormycosis was not seen in our series.

Acknowledgments

The authors wish to acknowledge the contributions of Dr Amit Aggarwal, Dr Raghav Nayar, Dr Kumar Madhavan, Dr Vaibhav Varshney, Dr Vidhi Jain, Dr Ponam Elhence and Dr Mahendra Singh for their valuable contributions toward the writing of this paper.

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How to cite this article: Madduri VK, Jena R, Baid G, Choudhary GR, Sandhu AS. Renal mucormycosis presenting during the COVID-19 pandemic: A series of 11 cases from a tertiary care center in India. *Indian J Urol* 2022;38:115-20.

Supplementary Table 1: Details of all patients included in the study

Serial number	Age	Sex	Presenting complaints	Comorbidities (DM, hypertension, immunosuppression, etc.)	Symptom duration (days)	History of COVID-19	Treatment taken for COVID-19 disease (hospital admission, steroid use, oxygen supplementation)	Status of COVID-19 vaccination	TLC ($\times 10^3$)	Serum creatinine
Case 1	31	Male	Fever, flank pain, flank edema, discoloration of skin, malena	None	5	Yes	Injectable and oral steroids, oxygen by ventimask in hospital setting	Unvaccinated	19.3	1.7
Case 2	62	Male	Fever, right flank pain	None	3	Yes	Injectable and oral steroids, oxygen by ventimask in hospital setting	Unvaccinated	27.3	2.32
Case 3	31	Female	Fever, flank pain, flank edema, discoloration of skin	None	10	No	No	Unvaccinated	31.2	1.74
Case 4	37	Male	Flank pain, fever	None	7	No	No	Unvaccinated	24.4	1.54
Case 5	35	Male	Flank pain, fever	None	15	No	No	Unvaccinated	10.6	1.64
Case 6	43	Female	Generalised weakness, fever, right flank pain	None	7	No	No	Unvaccinated	10.2	1.0
Case 7	39	Male	Fever, flank pain, abdominal distension	None	7	Yes	History of oral steroid intake, no oxygen supplementation	Unvaccinated	17.8	2.69
Case 8	60	Male	Left flank pain, black discharge from flank site	DM on oral hypoglycemics and poorly controlled	15	Yes	History of oral steroid intake, no oxygen supplementation	Unvaccinated	13.3	2.3
Case 9	34	Male	Right iliac fossa pain, weight loss, decreased appetite	Ulcerative colitis on long-term oral steroids.	8	No	History of long term steroid intake for ulcerative colitis	Unvaccinated	13.6	0.8
Case 10	31	Male	Right flank pain and fever	None	20	No	No	Received first dose	48.2	2.32
Case 11	45	Female	Fever and pain abdomen. Examination showed abdominal and right flank tenderness and edema and discoloration of the overlying skin	None	5	No	N/A	Received first dose	36	1.2
Serial number	qSOFA score	Imaging findings (unilateral/bilateral renal involvement. Surrounding organ involvement)	Preoperative diagnosis based on (radiology/microbiology/biopsy)	Surgery	Intraoperative findings	Histopathology	Auxiliary procedures	Days of hospital stay	Outcome	
Case 1	0	Nonenhancing enlarged left kidney with renal vein thrombosis with extensive perinephric and paranephric fat stranding. Left colon showed wall thickening with hypoenhancement with mesenteric and pericolic fat stranding	Microbiological examination of KOH mount specimen of urine confirmed presence of mucor	Left sided nephrectomy	Extensive subcutaneous and muscular edema. Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed. Left colon was gangrenous upto distal third of transverse colon along with gangrene of third part of the duodenum upto 40 cm distal to duodenojejunal flexure	Mucormycosis involving entire left kidney, perinephric fat, full thickness involvement of the resected colon and resected part of the duodenum end ileostomy	Left hemicolectomy with segmental resection of small bowel and duodenum with tube duodenostomy with feeding jejunostomy and end ileostomy	5	Died on postoperative day 1	
Case 2	2	Nonenhancing mid and lower pole of the right kidney with thrombosis of the lower pole segmental arteries with perinephric fat stranding. Thickened Gerota fascia	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Enlarged kidney with thickened fat. Hilar structures were thrombosed. Part of the duodenum overlying renal hilum appeared dusky, which was reversed with warm saline and 100% oxygen inhalation intra-operatively	Mucormycosis involving entire right kidney, perinephric fat, renal sinus	Secondary suturing of burst abdomen and exploratory laparotomy and peritoneal lavage and feeding jejunostomy	35	Discharged in stable condition	

Contd...

Supplementary Table 1: Contd...

Serial number	qSOFA score	Imaging findings (unilateral/ bilateral renal involvement/ Surrounding organ involvement)	Preoperative diagnosis based on (radiology/ microbiology/ biopsy)	Surgery	Intraoperative findings	Histopathology	Auxiliary procedures	Days of hospital stay	Outcome
Case 3	1	Enlarged right kidney with patchy, wedge shaped hypoenhancing areas on the upper and middle pole with extensive perinephric fat stranding with thickening of right colonic wall and mesenteric stranding	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Right kidney grossly enlarged, edematous with thickened gerotas and with purulent fluid all around Ascending colon necrosed	Mucormycosis involving entire right kidney, perinephric fat, renal sinus. Full thickness involvement of the bowel by mucor	Right hemicolectomy, debridement of necrotic area on right flank with split thickness skin graft at a later stage	37	Discharged in stable condition
Case 4	0	Enlarged, nonenhancing right kidney with dense inflammatory perinephric stranding. Inflammatory stranding seen involving the overlying bowel mesentery	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed Right side colon was gangrenous Second part of duodenum was dusky. Short segment of terminal ileum was ischemic	Mucor involving full thickness of ileum and colon, resected area of duodenum, psoas muscle and entire kidney	Segmental resection of small bowel and right colon with end to end anastomoses, duodenal wall biopsy and feeding jejunostomy	11	Discharged in stable condition
Case 5	0	Bulky nonenhancing right kidney with extensive perinephric fat stranding and thickening of gerota's fascia	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy.	Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed. Rest of the surrounding organs were unaffected	Mucormycosis involving entire right kidney, perinephric fat, renal sinus	None	7	Discharged in stable condition
Case 6	0	Right kidney shows perinephric fat stranding and shows nonenhancement of entire renal parenchyma. Hypodense thrombus seen in renal vein with extension into IVC	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed. Rest of the surrounding organs were unaffected	Mucormycosis involving entire right kidney, perinephric fat, renal sinus	None	7	Discharged in stable condition
Case 7	2	Enlarged bulky right kidney, nonenhancing, suggestive of infarcted kidney. Extensive mesenteric stranding. Ascending colon and caecum appear nonenhancing with thickened walls	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Enlarged kidney with thickened and saponified perinephric fat. hepatic flexure and entire right colon unhealthy invaded by mucor	Invasive mucormycosis involving entire kidney, full thickness of the colon and debrided issue from the iliopsoas muscle	Right hemicolectomy with end ileostomy with transverse colonic mucous fistula formation with feeding jejunostomy and debridement of necrotic iliopsoas muscle	2	Died on postoperative day 1
Case 8	3	Bilateral renal involvement. Multiple patchy areas of consolidation with cavitary lesions in right lung with microthrombi in subsegmental	Radiological diagnosis based on CECT findings. KOH mount of urine was negative but that of discharge from left flank showed mucor	Nil	Nil	Nil	Nil	2	Patient died before he could be taken for surgery

Contd...

Supplementary Table 1: Contd...

Serial number	qSOFA score	Imaging findings (unilateral/bilateral renal involvement. Surrounding organ involvement)	Preoperative diagnosis based on (radiology/microbiology/biopsy)	Surgery	Intraoperative findings	Histopathology	Auxiliary procedures	Days of hospital stay	Outcome
Case 9	1	vessels-likely fungal aetiology. Emphysematous pyelonephritis in left kidney with descending colon emphysematous colitis. Right renal infarcts/nephronia with focal areas of nonopacification in segmental branches of right renal artery. Right sided perinephric collection seen near inferior pole of the kidney	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Terminal ileum, ascending colon and caecum forming inflammatory phlegmon that was densely adherent to the abdominal wall and psoas muscle. Kidney was infarcted and enlarged with dense adhesions to the overlying phlegmon	Invasive mucormycosis involving entire kidney and full thickness of the colon and terminal ileum	Right hemicolectomy with ileotransverse anastomoses with feeding jenuostomy	28	Died on POD 28
Case 10	2	Hypo enhancing right kidney with delayed excretion. Patchy wedge shaped areas of nonenhancement were seen. Asymmetrical circumferential long segment ill-defined infiltrative thickening seen involving the proximal ascending colon, caecum, ileocecal junction, terminal ileum measuring ~30 cm in length	Radiological diagnosis based on CECT findings. KOH mount was negative	Right sided nephrectomy	Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed. Overlying part of the duodenum showed dusky patched. Entire colon was discolored and appeared ischemic	Invasive mucormycosis involving entire kidney and full thickness of resected bowel	Right hemicolectomy with ileotransverse anastomosis with loop ileostomy and feeding jejunostomy	2	Died on POD 1
Case 11		CECT showed nonenhancement of the enlarged right kidney with extensive perinephric fat stranding. Right sided colon was distended with nonenhancing walls with pericolonic stranding. Second part of duodenum showed decreased enhancement of the walls	Radiology and microbiological examination. KOH mount of the urine showed mucor	Right sided nephrectomy	Enlarged kidney with thickened and saponified perinephric fat. Hilar structures were thrombosed. Overlying part of the duodenum showed dusky patched. Entire colon was discolored and appeared ischemic	Invasive mucormycosis involving entire kidney and full thickness of resected bowel	Right hemicolectomy with end ileostomy and DMF and debulking of retroperitoneal necrosis and feeding jejunostomy	21	Discharged in stable condition

DM = Diabetes mellitus, CECT = Contrast-enhanced computed tomography, N/A = Not available, IVC = Inferior Vena Cava