

## Acute Renal Failure in Diabetes Mellitus (Prospective Study)

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### Abstract

**Objective:** To study the pattern and outcome of acute renal failure (ARF) in diabetes mellitus.

**Methods:** Outcome of variables like duration of renal failure, recovery of renal function and mortality were analyzed with parameters like age, sex, duration of diabetes mellitus, preexisting diabetic nephropathy, preexisting ischemic heart disease, cause of renal failure, dialysis requirement and number of organ systems involved.

**Results:** 70 patients with diabetes mellitus and acute renal failure were studied. Most common causes of acute renal failure were found to be sepsis and urinary tract obstruction. Most common cause of urinary tract obstruction was papillary necrosis. NSAID was most common cause of drug induced renal failure. Out of total 17 patients who underwent renal biopsy, 9 received steroid treatments had AIN, 1 had diffuse proliferative glomerulonephritis (DPGN). Out of 9 patients who had received steroid treatment, 6 patients had recovery of renal failure. Recovery of acute renal failure was found in 64.3% of the study group. Patients with urinary tract obstruction seemed to have better outcome of ARF recovery, when compared with other causes of acute renal failure, though it did not reach statistical significance. Duration of renal failure >10 days seemed to have poor outcome of ARF recovery, though it did not reach statistical significance. Surprisingly patients with sepsis appeared to have better outcome of ARF recovery, compared to other causes of renal failure with statistical significance.

**Conclusions:** Most common causes of renal failure in our study were found to be sepsis and urinary tract obstruction. Acute renal failure recovered in 64.3%. Patients with urinary tract obstruction and sepsis seemed to have favorable outcome in ARF recovery.

**Keywords:** Acute Renal Failure (ARF); Diabetes Mellitus (DM); Steroids

### Introduction

People with diabetes mellitus (DM) may be at increased risk of developing acute renal failure (ARF) [1]. Acute renal failure in diabetes mellitus may occur due to prerenal, renal and post renal causes like diabetic ketoacidosis, non ketotic hyperosmolar state, and hypotension, sepsis, or nephrotoxic agents. This condition carries high morbidity and mortality, and management may be more complicated by presence of diabetes mellitus and other comorbid factors [2]. A literature search however revealed few studies on this topic of acute renal failure in diabetes mellitus. Hence the study was planned.

### Objectives

To study the pattern and outcome of acute renal failure in diabetes mellitus.

**Study design:** A prospective clinical evaluation study with 70 patients with diabetes mellitus and ARF admitted to our hospital between 1.6.2008 to 31.12.2009 was undertaken to study the incidence and outcome of acute renal failure. NU Trust Hospital, Bangalore is a tertiary care nephro-urology centre. Characteristics of overall patients have been shown in master chart. During this period, total 360 acute renal failure patients and 24 acute on CRF patients were admitted to the hospital. Among them, 162 had diabetes mellitus. After considering exclusion criteria, only 73 patients were eligible for the study. But as three of them treated for urosepsis expired at their home before the completion of study period, they were not included for statistical analysis. Details of death could not be elicited, though initial documentation had shown these patients had associated ischaemic heart disease. Relevant parameters of history, clinical examination, biochemical and radiological investigations were collected and analyzed. Patients were followed up for 3 months. Outcome of variables like duration of renal failure, recovery of renal function and mortality were analyzed with parameters like age, sex, duration of diabetes mellitus, preexisting

diabetic nephropathy, preexisting ischemic heart disease, cause of renal failure, dialysis requirement and number of organ systems involved using Fischer exact test, Multivariate logistic model and Chi square test as the case warranted. Confounding factors like preexisting diabetic nephropathy, preexisting ischemic heart disease, and hypertension were adjusted.

**Inclusion criteria:** Diabetes mellitus patients presenting with:

- i. Fall in GFR by 50% from base line over the previous 3 months or,
- ii. Improvement of GFR by 50% after intervention if baseline value is not available.
- iii. Patients who have given consent for the study.

GFR was calculated by MDRD formula. The National Kidney Foundation's K/DOQI guidelines consider the MDRD equation a reliable measure for GFR in adults [3].

**Exclusion criteria:**

- i. CKD stage 5 patients.
- ii. Patients in whom acute renal failure could not be conclusively established or not available for required follow up.

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- iii. Patients who have fulfilled the inclusion criteria but have not given consent for the study.

Duration of renal failure was mainly grouped under 2 categories and was defined by duration of elevated serum creatinine level at the time of presentation, if baseline values were available. Category 'a' means  $\leq 10$  days and 'b' means  $>10$  days duration (indeterminate duration of renal failure was included in this category). Multiorgan dysfunction syndrome (MODS) was defined as dysfunction of more than 1 organ, requiring intervention to maintain homeostasis.

Serum creatinine was detected by employing a modification of the kinetic Jaffe reaction. Proteinuria is usually detected by dipsticks. With increasing concentrations of protein in urine, the dye indicators undergo sequential color changes from pale green to green to blue. The results are expressed on a scale from nil to +++ or +++++, at each of which level it corresponds to approximate protein concentrations varying according to the manufacturer. In our lab, sulfosalicylic acid method (Turbidometry) was used to diagnose proteinuria. 1+ proteinuria means an excretion of 30 mg/dl protein, 2+ means 300 mg/dl and 4+ means 2000 mg/dl.

For data analysis of urine protein, following scores were used:

- i. score 0 means traces/absent
- ii. score 1 means 1+
- iii. score 2 means 2+, 3+, 4+

Diabetic nephropathy was defined in our study as: Prior documentation of progressively increasing levels of proteinuria over a period of at least 3 months time in association with background to moderate non-proliferative diabetic retinopathy.

- i. Renal biopsy proven.
- ii. Presence of diabetic retinopathy, persistent urine protein  $\geq 1+$  without hematuria at the end of 3 months study period, after excluding confounding factors like UTI, febrile illness or CCF.

Indications of renal biopsy in our study were:

- i. Cause of ARF unclear.
- ii. Suspected drug induced AIN.
- iii. Incomplete renal failure recovery after relief of urinary tract obstruction and cure of infection.
- iv. Association with persistent hematuria and recent onset proteinuria.

Indications of steroid therapy in our study were:

- i. AIN on renal biopsy: worsening ARF despite withdrawal of offending drugs, and renal biopsy not showing significant interstitial fibrosis and tubular atrophy.
- ii. DPGN on renal biopsy: worsening ARF despite treatment of infection.

## Results

70 patients with diabetes mellitus and acute renal failure were studied. Most of the patients were in the age group of 51-60 years with 34.3% incidence. 70% of patient's duration of diabetes mellitus was  $<10$  years. Comorbid illness like hypertension was found in 82.9%, IHD was found in 11.4%. Majority of patients presented within  $\leq 10$  days of ARF onset. Most common symptom at the time of presentation was fever

(58.5%). Need of ICU admission was found in 17.1%. Among organ involvement, it was found that single organ involvement (with kidney 81.4%) was predominantly seen. Most common causes of acute renal failure were found to be sepsis (52.9%) and urinary tract obstruction (50%). NSAID was most common cause of drug induced renal failure in the study (40%). Most common organism isolated in urine culture was found to be *E. coli* (86%). Most common cause of urinary tract obstruction was papillary necrosis (37%). Diabetic nephropathy was found in 52.9%. Among patients with renal biopsy proven AIN, the causative factor was NSAID in 88.8%. Out of total 17 (24.3%) patients who underwent renal biopsy, 9 received steroid treatment (8 had AIN, 1 had DPGN). As 8 patients had chronic changes on renal biopsy, they were not treated with steroids. Out of 9 patients who had received steroid treatment, 6 patients (66.7%) had recovery of renal failure. Recovery of acute renal failure was found in 64.3% of the study group. Patients with urinary tract obstruction seemed to have better outcome of ARF recovery, when compared with other causes of acute renal failure, though it did not reach statistical significance (p value 0.032). Duration of renal failure  $>10$  days seemed to have poor outcome of ARF recovery, when compared to other variables studied, though it did not reach statistical significance (p value 0.038). Surprisingly patients with sepsis appeared to have better outcome of ARF recovery, compared to other causes of renal failure with statistical significance (p value 0.009). This could be because of early presentation, early detection, better management of patients with sepsis which was predominantly of urinary tract origin in our tertiary care nephro-urology centre, and hospital leading to greater recovery. Three of the patients expired at their home early during the study period.

## Discussion

Literature review to compare various studies from present study is shown in Table 1.

### Age and gender distribution

The minimum age of the patient in our study was 30 years and the maximum age was 82 years. The mean age of presentation was  $57.57 \pm 11.29$  years. Most of the patients were in the age group of 51-60 years with 34.3% incidence. Most patients appeared to have type 2 diabetes mellitus, except one patient who was 30 years age.

In the study by Prakash et al. [1], age ranged between 35-72 (mean 54.15) years. Kaaroud et al. [4] study included 20 cases of ARF induced by drugs in diabetic patients. Eleven men and 9 women with mean age of 55.2 years (17-71 years) were enrolled in the study. Males predominated in gender distribution with 61.4%.

### Symptoms at presentation

Most common symptom at the time of presentation was fever (58.5%) (Table 2).

### Clinical profile of patients studied

Comorbid illness like hypertension was found in 82.9%, IHD was found in 11.4% (Table 3).

Need of ICU admission was found in 17.1%. ICU admission was considered by presence of hypoxia, hypotension, needing ventilator support.

Duration of diabetes mellitus was  $<10$  years in 70% of patients.

Diabetic nephropathy was found in 52.9%. In the study by Prakash et al. [1], diabetic nephropathy was found in 10 (30%).

Study	No. of patients	Study period	Duration of diabetes >10years	Causes of ARF	Drug causes of ARF	AKI improvement
Prakash et al. [1]	260 type 2 DM Non diabetic renal disease in 12.3%	2 Years	31.2%		Tubulointerstitial disease-53% Non diabetic glomerulopathy-47%	47%
Kaaroud et al. [4]	20				Diuretics-7 ACEI-5 Gentamycin-2 NSAIDS-1 Colimycin-1 Contrast- 4	
Moger et al. [5]	26				DPGN-27%	
Lee et al. [6]	22				Non diabetic glomerulopathy-59% Tubulointerstitial disease-4%	
Soni et al. [7]					Non diabetic glomerulopathy-35% Tubulointerstitial disease-18%	
Woodrow et al. [11]	23 Type 1 DM			DKA-60%		
Our study	70 Type 2 DM	1½ years	30%	Sepsis-52.9%	Tubulointerstitial disease-76.4% Non diabetic glomerulopathy-17.6%	NSAIDS-40% 64.3%

Table 1: Literature review to compare various studies from present study.

Symptoms	Number (n)	%
Fever	41	58.5
Leg swelling	21	30
Vomiting	20	28.5
Diarrhoea	14	20
Loin pain	9	12.8
Dysuria	9	12.8
Decreased urine output	8	11.4
Pain abdomen	6	8.5
Breathlessness	5	7.1
Painful swelling of leg, or wound	4	5.7
Anorexia	4	5.7
Urinary incontinence	3	4.2
Increased urinary frequency	2	2.8
Hematuria	2	2.8
Facial puffiness	1	1.4
Hiccups	1	1.4
Cough	1	1.4
Multiple symptoms	56	80

Table 2: Symptoms at presentation.

In Kaaroud et al. [4] study, risk factors for ARF in diabetes mellitus were age more than 70 years, pre-existent renal failure in 17 cases, dehydration in 6 cases, and drug association in 20 cases.

### Duration of renal failure

Majority of patients presented within  $\leq 10$  days of ARF onset (indicated with clinical features or raised serum creatinine). This could be because in our study, most common causes of ARF were sepsis (52.9%) and urinary tract obstruction (50%), which could have made patients present with symptoms very early.

### Details of renal biopsy

Out of total 70 patients, 17 (24.3%) of them required renal biopsy. Among non diabetic renal disease, tubulo-interstitial renal disease was dominant than glomerular disease as in Prakash et al. study.

**Renal biopsy findings:** Multiple biopsy findings indicates patients who had >1 histopathological biopsy findings (Table 4).

Out of total 17 (24.3%) patients who underwent renal biopsy, 9 received steroid treatment (8 had AIN, 1 had DPGN). Steroid used was 1 mg/kg/day of prednisolone over 4 weeks, after which it was tapered and stopped. Among AIN group, 1 patient had associated myeloma cast nephropathy.

In our study, among renal biopsy proven AIN patients, NSAID related renal disease was found in 88.8%, possibly related to the high prevalence of NSAID usage. In Kaaroud et al. [4] study diuretics were the most common cause of drug-induced ARF in diabetic patients.

As 8 patients had chronic changes on renal biopsy, they were not treated with steroids.

Out of 9 patients who had received steroid treatment, 6 patients (66.7%) had recovered of renal failure.

Analysis of renal failure recovery was done in renal biopsy patients who were treated with steroid therapy with variables like duration of renal failure, duration of steroid treatment. It was found that these

	Number of patients (n=70)	%
<b>Hypertension</b>		
Yes	58	82.9
No	12	17.1
<b>Duration of Hypertension</b>		
Nil	12	17.1
1-5 years	18	25.7
6-10 years	24	34.3
>10 years	16	22.9
<b>IHD Pre-Existing</b>		
Yes	8	11.4
No	62	88.6
<b>ICU</b>		
Yes	12	17.1
No	58	82.9
<b>Duration of DM</b>		
<10 years	49	70.0
>10 years	21	30.0
<b>Diabetic Nephropathy</b>		
Yes	37	52.9
No	33	47.1

Table 3: Clinical profile of patients.

	Number of patients (n)	%
Diabetic nephropathy	12	70.5
AIN	8	52.5
DPGN	2	12
CIN	2	12
ATN	1	5.9
CGN	1	5.9
Myeloma cast nephropathy	1	5.9
Multiple biopsy findings	10	58

Table 4: Renal biopsy findings.

variables did not have an impact on renal failure recovery. Perhaps correction of hemodynamic instability and hypovolaemia could have contributed for ARF recovery.

**Comparison of renal biopsy findings with other studies showed:** In the study by Prakash et al. [1], with two hundred sixty type 2 diabetics with clinical renal diseases screened for evidence of non-diabetic renal disease (NDRD) and ARF, renal disease other than diabetic nephropathy was found in 32(12.3%) patients. It was found that primary isolated glomerulopathy was seen in 12(37.5%), mesangioproliferative nephropathy +diabetic nephropathy was seen in 3(9.3%), acute interstitial nephritis (AIN) was seen in 4(12%), chronic interstitial nephritis (CIN) was seen in 10(31.2%), and chronic pyelonephritis was seen in 3(10%).

In the study of Moger et al. [5] renal histology showed mixed lesions of diabetic nephropathy (DN) and NDRD in 11 cases, only DN in nine, and pure NDKD in six. Diffuse proliferative glomerulonephritis (DPGN) was the commonest NDRD (27% cases), all on a background of DN. The proportion of post-infectious glomerulonephritis in diabetics with rapidly progressive renal failure was over six times that of the non-diabetic adult RPRF population. Four patients had acute interstitial nephritis and three showed crescentic glomerulonephritis. Other lesions included atheroembolic disease, and renal papillary necrosis (one each). Conclusions were: about two-thirds of patients with type 2 diabetes presenting with rapid decline of renal function in a tropical environment show NDRD. The high incidence of post-

infectious glomerulonephritis in that group was possibly related to the high prevalence of skin and soft tissue infections.

In the study of Lee et al. [6], of 22 NIDDM patients who underwent biopsy and it was found that non diabetic renal disease with IgA nephropathy (n=6), minimal change disease (n=3), membranous nephropathy (n=3), membranous lupus nephritis (n=3), and acute interstitial nephritis (n=1) were present.

Soni et al. [7] studied 160 people with type 2 diabetes with clinically suspected NDRD underwent renal biopsy reported by a single pathologist. The most common NDRD were acute interstitial nephritis (18.1%), post-infectious glomerulonephritis (17.24%), membranous nephropathy (11.20%) and focal segmental glomerulosclerosis (7.75%). They concluded that prevalence of NDRD (either isolated or superimposed on underlying diabetic glomerulosclerosis) is very high in appropriate clinical settings.

Ulinski et al. [8] concluded that interstitial nephritis, another possible adverse effect of NSAIDs, might require steroid treatment. Although numerous drugs have been implicated in drug induced renal disease, antibiotics and non-steroidal anti-inflammatory drugs (NSAID) continue to be the drugs most involved.

Abdul Ghani et al. [9] concluded numerous drugs have been implicated as the offensive agents, the commonest being non-steroidal anti-inflammatory drugs (NSAIDs), angiotensin-converting-enzyme inhibitors and angiotensin-receptor blockers.

In Arrizabalaga [10] study, non-steroidal anti-inflammatory drugs were the most frequent etiology in 44% of cases of drug induced renal disease.

Arrizabalaga [10] analyzed the small number of patients not treated with steroids (9 out of 61) diagnosed to have DAIIN through renal biopsy, a noteworthy difference stood out: at the end of the follow-up, they had significantly higher creatinine ( $3.71 \pm 2.91$  vs.  $2.1 \pm 2.1$ ) and an incidence of chronic dialysis (44.4% vs. 3.8%) higher than the patients who received steroids.

In this study, initially it was found that there were no differences in final creatinine levels among those patients who received steroids and those managed conservatively. However, close inspection later, revealed that steroid treatment began late, and although there were no significant differences between the group receiving steroids and those managed conservatively, various patients in both groups had good renal function improvement initially, but later conservatively managed patients developed a degree of renal failure and chronicity on repeat biopsy.

### Organ involvement pattern

Multiorgan dysfunction syndrome (MODS) is defined as dysfunction of more than 1 organ, requiring intervention to maintain homeostasis [9].

Among organ involvement, it was found that single organ involvement (with kidney 81.4%) was predominantly seen.

### Causes of renal failure

Most common causes of renal failure in our study were found to be sepsis (52.9%) and urinary tract obstruction (50%). Among drug induced renal failure, NSAIDs were noted to be most common cause of renal failure with either as unifactorial in 40%, or together with other contributory factors as multifactorial in 54.5% (Table 5).

Most common cause of urinary tract obstruction was papillary necrosis (37%).

Contrary to study conducted by Woodrow et al. [11] where it was found that diabetic ketoacidosis was the most common cause of ARF in type 1 diabetes mellitus, in our study, ARF associated with diabetic ketoacidosis was not found, probably because majority of our patients appeared to have type 2 diabetes mellitus.

### Outcome of renal failure

Favorable outcome was defined as ARF recovery with improvement of GFR by 50% after intervention (Table 6).

In the study by Prakash et al. [1], 47% patients recovered from renal failure with appropriate institution of treatment. In our study, recovery was found in 64.3%.

The two renal transplant recipient patients who had ARF due to sepsis recovered.

Patients after relief of urinary tract obstruction seemed to have better outcome of ARF recovery, when compared with other causes of acute renal failure, though it did not reach statistical significance (p value 0.032). Duration of renal failure >10 days seemed to have poor outcome of ARF recovery, when compared to other variables studied, though it did not reach statistical significance (p value 0.038).

Surprisingly patients with sepsis appeared to have better outcome of ARF recovery, compared to other causes of renal failure with statistical significance (p value 0.009). This could be because of early presentation, early detection, better management of patients with sepsis which was predominantly of urinary tract origin in our tertiary care nephro-urology centre, and hospital leading to greater recovery. P value  $\leq$  0.01 was considered to have statistically very strong significance. P value between 0.01 to 0.05 was considered to have statistically moderate significance.

Gransden et al. [12] in 18 years prospective study involving 861 (23.9%) *E. coli* origin 3605 bacteremic patients predominantly with diabetes mellitus found that mortality was lesser in urinary tract origin *E. coli* sepsis compared to non-urinary tract origin *E. coli* sepsis (2.6% vs. 10.3% respectively). Similarly in our study, sepsis patients had better renal failure outcome as sepsis was predominately due to *E. coli* from urinary tract origin.

In a 1-year prospective cohort study which included all episodes of *Escherichia coli* bacteraemia in two French university hospitals, simultaneously the influence of host and bacterial determinants on the initial severity and outcome of *E. coli* sepsis was assessed. Clinical data (underlying disease, primary source of infection, severity sepsis scoring and outcome), phylogenetic groups (A, B1, D and B2), nine virulence factors (VFs) (papC, papGII, papGIII, sfa/foc, hlyC, cnf1, iucC, fyuA

Causes of renal failure	Number of patients (n=70)	%
Sepsis	37	52.9
Urinary tract obstruction	35	50.0
NSAID	28	40.0
Gastroenteritis	9	12.9
AIN	9	12.9
Cellulitis	4	5.7
Alternative medications	3	4.3
DPGN	2	2.8
Diuretic	1	1.4
Myeloma	1	1.4
Uncontrolled hypertension	1	1.4
Carcinoma cervix, radiation nephritis	1	1.4
Multiple causes	33	47.1

Table 5: Causes of renal failure.

Variables	Outcome of RF		Univariate			Multivariate		
	Recovered (n=45)	Not Recovered (n=25)	p value	OR	95%CI	p value	OR	95% CI
Age>60 years	22 (48.9%)	9 (36%)	0.298	0.58	0.21-1.61	0.105	0.23	0.04-1.36
Female	18 (40%)	9 (36%)	0.742	0.84	0.31-2.33	0.205	3.07	0.54-17.41
Hypertension	35 (77.8%)	23 (92%)	0.190	3.29	0.66-16.38	0.062	12.89	0.88-189.61
IHD	5 (11.1%)	3 (12%)	1.000	1.09	0.24-5.00	0.978	0.96	0.07-13.08
ICU	9 (20%)	3 (12%)	0.517	0.55	0.13-2.23	0.736	0.64	0.05-8.4
DN	18 (40%)	19 (76%)	0.004	4.75	1.59-14.19	0.352	3.44	0.26-46.42
Duration RF >10 days	10 (22.2%)	13 (52%)	0.011	3.79	1.32-10.87	0.038	7.40	1.12-49.11
MODS	9 (20%)	4 (16%)	0.759	0.76	0.20-2.78	0.944	0.92	0.08-10.7
NSAIDs	16 (35.6%)	12 (48%)	0.309	1.67	0.61-4.52	0.427	0.46	0.07-3.11
Sepsis	29 (64.4%)	8 (32%)	0.009	0.26	0.09-0.73	0.022	0.11	0.02-0.73
Gastroenteritis	7 (15.6%)	2 (8%)	0.474	0.47	0.09-2.47	0.326	0.23	0.01-4.31
AIN	4 (8.9%)	5 (20%)	0.265	2.56	0.62-10.59	0.959	0.92	0.03-25.74
Urinary tract obstruction	22 (48.9%)	13 (52%)	0.803	1.13	0.43-3.01	0.032	7.37	1.18-45.8
Others	5 (11.1%)	6 (24%)	0.183	2.53	0.68-9.33	0.959	0.95	0.11-7.98
RRT	16 (35.6%)	9 (36.0%)	0.429	1.01	0.36-2.87	0.416	1.54	0.54-4.42

Table 6: Univariate and multivariate analysis for outcome of renal failure.



and iron) and the antibiotic susceptibility of isolates were investigated. The non-B2 isolates were more frequently resistant to antibiotics than were B2 isolates ( $p < 0.05$ ). No bacterial or host determinants influenced the initial severity of sepsis. Multivariate analysis revealed that the presence of papGIII, a non-urinary tract origin of sepsis were associated independently with a fatal outcome ( $p$  value is 0.04, and 0.04, respectively). A multifactorial analysis of correspondence allowed two populations of isolates to be distinguished: those belonging to the B2 group were associated more frequently with susceptibility to antibiotics, a urinary tract origin and immunocompetent hosts. Those belonging to the A, B1 or D groups were associated more frequently with resistance to antibiotics, a non-urinary tract source. Although no influence of host or bacterial determinants on the initial severity of sepsis was detected, bacterial and host determinants both influenced the outcome of *E. coli* sepsis significantly [13].

In our study, the phylogenetics of *E. coli* which was the most common cause of organism isolated from urosepsis could have influenced the sepsis and hence ARF outcome.

Three of the patients expired at their home early during the study period, cause could not be assessed.

## Conclusion

- i. Most common causes of renal failure in our study were found to be sepsis and urinary tract obstruction.
- ii. Among drug induced renal failure, NSAIDs were noted to be most common cause.
- iii. Steroid treatment induced favorable results in ARF recovery (in majority of AIN, 1 patient of DPGN).
- iv. Acute renal failure recovered in 64.3%.
- v. Patients with urinary tract obstruction and sepsis seemed to have favorable outcome in ARF recovery.

## Merits of the Study

- i. It is a prospective study, where each etiology, causative factor of ARF in diabetes mellitus, and outcome of ARF were analyzed. Literature search revealed that there is paucity of data on this topic, hence the outcome of the study would have a great help.
- ii. With early detection, better management of ARF in diabetes mellitus due to sepsis, it can have favorable prognosis.
- iii. Renal biopsy in diabetes mellitus patients especially with incomplete recovery of ARF or features atypical of diabetic nephropathy will yield the underlying causative factor and upon appropriate treatment would lead to renal failure recovery.

## Limitations of the Study

- i. Selection bias in the study because of the fact that ours being basically a nephro-urology tertiary care centre, it was noticed that sepsis was predominantly of urinary tract origin. Sepsis due to other etiology was not represented. Early intervention, better management would have lead for better renal failure recovery. Similarly, ARF due to other etiology like cardiorenal syndrome, contrast induced nephropathy, post operative ARF were not represented in the study group.

- ii. Longer period of follow-up would probably throw more light on ARF recovery. Survival analysis could not be done due to fewer mortality, and deaths during early period of study.

## Recommendations

- i. Causes of acute renal failure in patients with diabetes mellitus like urinary tract obstruction, sepsis have favorable outcome, if treated appropriately.
- ii. Early detection, diagnosis and aggressive management of acute renal failure in diabetes mellitus should be carried out to attain renal failure recovery.
- iii. Nephrotoxic drugs like NSAIDs have to avoid especially in patients with diabetic nephropathy.
- iv. Renal biopsy in patients with diabetes mellitus with incomplete recovery of ARF or features atypical of diabetic nephropathy will yield the underlying causative factor and upon appropriate treatment would lead to renal failure recovery.
- v. Steroid treatment should be considered in patients with incompletely recovered acute renal failure due to drug induced AIN and DPGN which was adequately treated for infection.

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