Original article

Bacterial infections and emerging resistance in renal transplant recipients

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Abstract:

Objective: Renal transplantation is frequently complicated by bacterial infections in the scenario of immunosuppression, altered metabolism and interventions resulting in prolonged morbidity. Subdued clinical presentation, antimicrobial resistance and toxicity question the outcome of transplantation. This retrospective study conducted at tertiary care apex transplant centre highlights colonization, clinical infection and antimicrobial resistance patterns in Renal Transplant Recipients (RTR). ***Materials and methods:*** Infection and antimicrobial resistance patterns in 130 RTR were studied. Clinico-demographic and transplant parameters were noted. Infection screening in the post transplant period along with antimicrobial susceptibility were used to analyze data in a post transplant time frame. ***Results and discussion:*** Culture positivity timeline was dominated by post surgical infections in the first week post transplant. Urinary infections followed by blood stream infections were noted. Infection profile included simultaneous polymicrobial, prolonged and widespread infections. Multi-resistant organisms producing beta lactamases and extended spectrum beta lactamases were isolated. ***Conclusion:*** Transplant recipients remain prone to bacterial infections with multi-resistant organisms which may persist due to immunosuppression, altered metabolism and toxicity, and contribute to nosocomial hazard. Infection control may be targeted at avoidance of donor derived infections, surgical complications, epidemiologic exposures, strengthening antimicrobial prophylaxis and anti-infection engineering. Antimicrobial stewardship, outbreak and epidemic preparedness should be ensured.

Key words: renal transplant; immunosuppression; bacterial infection; antimicrobial resistance; infection control

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Introduction

Renal transplantation for end stage renal disease (ESRD) has evolved as a major breakthrough since the first renal transplant in 1954 [1]. Improvement in graft survival with potent immunosuppressive regimens came at an expense of increased malignancies and infections. With 100,000 annual renal transplants conducted worldwide, infections remain major determinants in the outcome of transplants[2]. Transplantation increases host susceptibility to microbes due to immunosuppression (immunomodulating drugs, viruses), metabolic abnormalities (protein malnutrition, uremia, hyperglycemia), breach in mucocutaneous barriers and introduction of foreign bodies (tubes, lines, catheters, surgical procedures) [3]. Renal transplant recipients (RTR) are likely to acquire post transplant infections from community or nosocomial epidemiologic exposure via the allograft, transfusions, parenteral access, catheters, drains or activation of latent flora, resulting in prolonged morbidity and hospital stay, delayed recovery, reduced graft survival and complications such as bacteremia, sepsis and mortality [3, 4]. Bacterial infections account for up to 47% of all infections[3]. Urinary, blood stream, respiratory and wound infections are predominant [3, 5, 6]. Common isolates include coliforms, *Acinetobacter*, *Pseudomonas* and *Staphylococci.* Nosocomial bacteria can cause serious morbidity and mortality up to 30 days post transplant (phase of intensive immuno-

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suppression). *E. coli*, *Enterococci* and sometimes unusual bacteria are isolated from urine culture in RTR presenting with urinary infections [7]. Superinfections and co-colonizations with multiresistant bacteria such as *Pseudomonas aeruginosa, Stenotrophomonas maltophilia, Burkholderia cepacia* and methicillin-resistant *Staphylococcus aureus* (MRSA) is seen after prolonged exposure to broad spectrum antimicrobials and hospital stay. During second to six months, opportunistic and reactivated latent infections may reduce graft survival [8].

Clinical presentation is muted in the backdrop of immunosuppression, metabolic abnormalities, drug interactions and toxicities, presenting as a therapeutic challenge in severe polymicrobial multiresistant infections [9]. Infection prophylaxis, patient and environmental protection tend to reduce but not eliminate the risk of infections. Though infections have been characterized by various studies, data on resistance patterns is scanty. This retrospective study conducted at tertiary care apex transplant centre highlights colonization, clinical infection and antimicrobial resistance patterns in RTR.

Materials and Methods

A hundred and thirty RTR at an apex multispeciality centre at New Delhi, India were included in the retrospective study after approval from the Institutional Ethical Committee. Institutional pretransplant protocol included evaluation through relevant history, clinical profiling, HLA matching, infection screen and vaccination against tetanus and pneumococcus. Both donors and recipients underwent routine and intuitive infection screening in the pretransplant period by haematological, microbiological and imaging studies to select infection free donor-recipient pairs for transplantation. Immunosuppression was induced by thymoglobulin or interleukin-2 receptor antagonists (basiliximab, daclizumab) and maintained for life by combinations of mycophenolate mofetil (MMF), calcineurin inhibitors (tacrolimus, cyclosporin) and prednisolone. Empirical injectable cefoperazone-sulbactam or cefuroxime 24 hrs before surgery was continued till closure of drains, lines and catheters. Antimicrobials were escalated or deescalated as per antibiograms. Oral trimethoprim-sulfamethoxazole from day five to six months post transplant was given as *Pneumocystis jirovecii* prophylaxis. All patients underwent routine and intuitive infection screening in the post transplant period. Sex, age, indication for transplantation, graft sources, immunosuppressive regimen and prophylaxis protocol were noted. Samples were plated either directly on solid agar or after positive culture screen from BACTEC^{TM} 9120 (BD Diagnostics, 1 Becton Drive, Franklin Lakes, NJ USA 07417) and BacT/ALERT® 3D (bioMérieux SA, F-69280 Marcy l'Etoile, France) blood culture systems and incubated in O_2 at 37^0C for 18-120 hrs. Both manual and automated systems were used for identification and susceptibility. The organisms were identified manually by Gram staining, tests for motility, carbon source utilization, enzymatic activity and special characteristics, and antibiograms were obtained by Kirby-Bauer disc diffusion method on Mueller Hinton agar. MicroScan WalkAway 40 SI (Siemens Healthcare Diagnostics, Inc., West Sacramento, CA 95691 USA) automated system was used in parallel. Identification percentage >85% was taken as cutoffs for final validation and inbuilt standards for identification comparison were utilized [10]. Non repeat positive cultures with respective antibiograms were taken into account for profiling of bacteria and antimicrobial resistance. Urine and urinary catheter tip isolates were considered horizontally wherever applicable. Positive cultures were correlated with clinical presentation and leukocyte counts to delineate colonization and clinical infection in a post transplant time frame. Antimicrobial resistance patterns were studied. Descriptive statistics were done in terms of proportion for qualitative parameters, describing variables using 95% confidence interval (95% CI).

Results

The study comprised of 92 (70.77%) males and 38 (29.23%) females. Most RTR were between 15-50 years of age (118, 90.77%, 95% CI 85.79%-

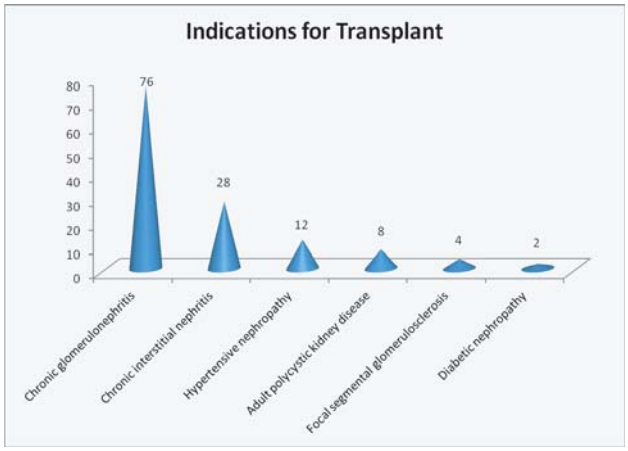

Fig 1 : Indications for Renal Transplants (n = 130)

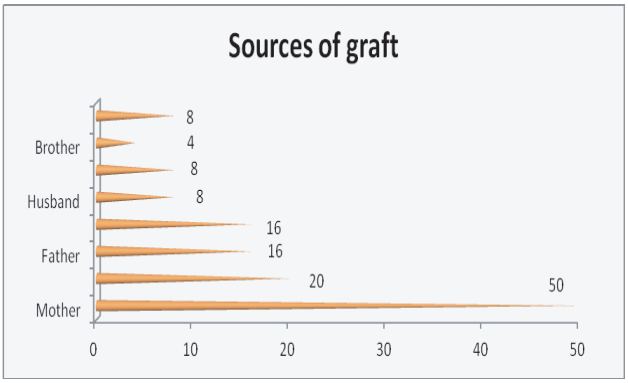

Fig 2 : Sources of grafts in Renal Transplant Recipients (n = 130)

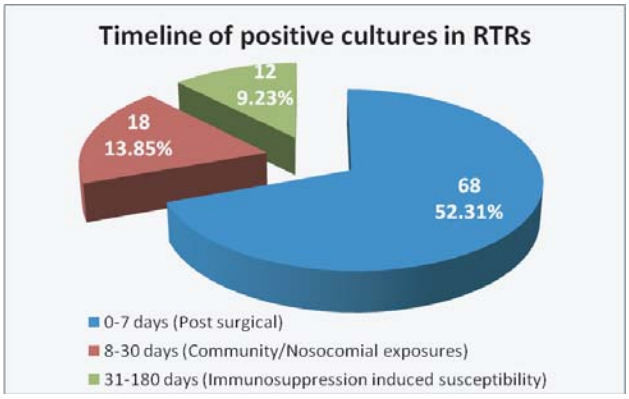

Fig 3 : Timeline of positive cultures in Renal Transplant Recipients (n = 130)

95.75%), four (3.1%) were between 1-15 years and eight (6.15%) were more than 50 years of age. Chronic glomerulonephritis was the most common indication for renal transplantation (Figure 1). Mothers outnumbered other first degree relatives as donors (Figure 2). Immunosuppressive regimen is depicted in Table 1. Culture positivity timeline was dominated by post surgical infections in the first week post transplant (Figure 3). Urinary isolates followed by blood stream isolates were predominant. Bacteremia secondary to infective foci, as observed by isolation of same organism from both samples, was seen in 30 (23.08%) cases with urinary tract being the most common focus. Simultaneous polymicrobial isolates were obtained in 16 (12.31%) cases. Multiple organisms were isolated from 12 (9.23%) during their stay in the hospital. Prolonged isolation of the same organism, as identified by same antibiogram was seen in eight (6.15%) recipients. Widespread colonization/infection with the same

Table 1: Immunosuppressive regimen in Renal Transplant Recipients (n = 130)

	Frequency	% age	95% Confidence Interval
Induction			
Thymoglobulin	26	20	13.12% – 26.88%
Basiliximab	40	30.77	22.84% - 38.7%
Daclizumab	16	12.31	6.66% - 17.96%
No induction given	48	36.92	28.62% - 45.22%
Maintenance			
MMF + Tacrolimus + Prednisolone	120	92.31	87.73% - 96.89%
Azathioprine + Tacrolimus + Prednisolone	6	4.62	1.01% - 8.23%
MMF + Everolimus + Prednisolone	2	1.54	-0.58% - 3.66%

Table 2: Profile of colonizations and infections in Renal Transplant Recipients (n = 130)

Profile of colonizations/infections	Colonizations			Clinical Infections		
	Frequency	% age	95% CI	Frequency	% age	95% CI
Urinary tract isolates	106	81.54	74.87% - 88.21%	6	4.62	1.01% - 8.23%
Blood stream isolates	36	27.69	20% – 35.38%	Nil	Nil	-
Miscellaneous isolates	26	20	13.12% - 26.88%	Nil	Nil	-
Simultaneous polymicrobial isolates	16	12.31	6.66% - 17.96%	6	4.62	1.01% - 8.23%
Multiple organisms in a patient spread in time (>30 days)	12	9.23	4.25% - 14.21%	Nil	Nil	-
Prolonged (>30 days) isolation of same organism	8	6.15	2.02% - 10.28%	Nil	Nil	-
Same pathogen isolated from multiple samples	2	1.54	-0.58% - 3.66%	6	4.62	1.01% - 8.23%
Pre transplant infections treated before surgery	4	3.1	0.12% - 6.08%	4	3.1	0.12% - 6.08%
Post transplant infections treated	6	4.62	1.01% - 8.23%	6	4.62	1.01% - 8.23%

Table 3 : Organisms isolated

Organisms	Renal Transplant Recipients (n=130)		
	Frequency	(% age)	95% CI
Escherichia coli	134	29.91	22.04% - 37.78%
Klebsiella pneumoniae	32	7.14	2.71% - 11.57%
Enterobacter cloacae	14	3.12	0.13% - 6.11%
Serratia marcescens	6	1.34	-0.64% - 3.32%
Citrobacter freundii	4	0.89	-0.72% - 2.5%
Proteus mirabilis	2	0.45	-0.7% - 1.6%
Morganella morganii	2	0.45	-0.7% - 1.6%
Providencia stuartii	2	0.45	-0.7% - 1.6%
Acinetobacter baumanii	56	12.5	6.81% - 18.19%
Pseudomonas aeruginosa	80	17.86	11.28% - 24.44%
Burkholderia cepacia	8	1.78	-0.49% - 4.05%
Strenotrophomonas maltophilia	6	1.34	-0.64% - 3.32%
Staphylococcus aureus	30	6.7	2.4% - 11%
Staphylococcus hemolyticus	34	7.59	3.04% - 12.14%
Staphylococcus epidermidis	10	2.23	-0.31% - 4.77%
Staphylococcus hominis	16	3.57	0.38% - 6.76%
Enterococcus faecium	6	1.34	-0.64% - 3.32%
Enterococcus faecalis	6	1.34	-0.64% - 3.32%
Total	448	100	

Table 4 : Cumulative susceptibility (%) of organisms in Renal Transplant Recipients (n = 130)

Antimicrobials	Frequency distribution (%)					
	Escherichia coli	*Klebsiella pneumoniae*	*Acinetobacter baumanii*	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Coagulase negative Staphylococci*
	RTR	RTR	RTR	RTR	RTR	RTR
Coamoxiclav	11.54	Nil	-	-	38.46	3.33
Pip-Tazobactam	100	Nil	-	100	100	Nil
Ticarcillin-K clav	30.77	20	26.92	18.52	-	-
Aztreonam	7.69	Nil	-	14.81	-	-
Imipenem	84.62	50	50	29.63	38.46	3.33
Meropenem	33.33	Nil	100	66.67	-	-
Ertapenem	76.92	33.33	-	-	-	-
Cefotaxime	7.69	Nil	15.38	7.41	38.46	3.33
Ceftazidime	7.69	Nil	19.23	22.22	-	-
Ceftriaxone	7.69	Nil	23.08	11.11	38.46	3.33
Cefipime	7.69	Nil	23.08	18.52	38.46	3.33
Amikacin	61.54	33.33	30.77	18.52	-	-
Trimeth-Sulfa	11.54	20	23.08	-	69.23	43.33
Erythromycin	-	-	-	-	15.38	33.33
Azithromycin	-	-	-	-	15.38	33.33
Tetracycline	7.69	10	23.08	-	76.92	63.33
Chloramphenicol	53.85	-	-	-	53.84	89.29
Ciprofloxacin	7.69	10	19.23	29.63	30.77	20
Ofloxacin	-	-	-	-	23.08	16.67
Levofloxacin	11.54	20	19.23	29.63	23.08	20
Rifampicin	-	-	-	-	76.92	63.33
Vancomycin	-	-	-	-	84.62	80
Linezolid	-	-	-	-	100	100
Polymyxin E (Colistin)	100	100	100	100	-	-

organism was noted in two (1.54%) cases. Four (3.1%) cases of urinary infection were promptly treated prior to transplant while six (4.62) cases of urinary infection were treated post transplant (Table 2).

Infections due to Gram negative bacteria outnumbered Gram positive infections. Majority of isolates from RTR cases were *E. coli* (29.91%), *Pseudomonas aeruginosa* (17.86%), *Acinetobacter baumanii* (12.5%), *Klebsiella pneumoniae* (7.14%), *Staphylococcus aureus* (6.7%) and *Staphylococcus hemolyticus* (7.59%) (Table 3). *E. coli* and *Klebsiella pneumoniae* were the most common organisms isolated from urine and catheter tip culture samples. Most common organisms responsible for blood stream infections were *Acinetobacter baumanii* (27.03%), *Pseudomonas aeruginosa* (13.51%), *E. coli* (13.51%) and coagulase negative Staphylococci (21.62%) (Table 3). All bacterial isolates except *Providencia stuartii* primarily exhibited multiresistance. Multiresistant *Pseudomonas aeruginosa, Stenotrophomonas maltophilia* and *Burkholderia cepacia* were seen. Antimicrobials not commonly used at our centre

Table 5 : Superbug profile

Superbugs	Renal Transplant Recipients (n = 130)		
	Frequency	% age	95% CI
ESBL producers/ Total *E coli*, *Klebsiella* and *Proteus*	62/168	36.9	29.6% - 44.2%
Beta lactamase producers/ Total Gram positive	76/86	88.37	81.59% - 95.15%
MRSA/Total *Staphylococcus aureus*	24/30	80	65.69% - 94.31%

such as cephamycins, tobramycin, tetracycline, chloramphenicol, rifampicin, quinupristin-dalfopristin were found to be potentially effective compared to others. The susceptibility profile is depicted in Table 4. Amongst *E.coli*, *Klebsiella* and *Proteus*, 36.9% were extended spectrum beta lactamase (ESBL) producers. More than 3/4th *E. coli* and *Klebsiella* isolated were found resistant to third generation cephalosporins and aztreonam demonstrating ESBL production. 88.37% Gram positive bacteria were β lactamase producers including 80% MRSA (Table 5). All isolates and antibiograms correlated well by manual and automated methods with minimal discordance. Infections were treated as per antibiograms with successful outcomes.

Discussion

The peritransplant work up, immunosuppressive regime, therapeutic, surgical, nursing procedures and infection control strategies followed at our transplant centre are in accordance with international guidelines. 75.38% RTR got colonized including 4.62% who developed clinical manifestations and were promptly treated. Immunocompromised state impairs inflammatory response which may contribute to predisposition to infections. The prevalence and incidence of both community and hospital acquired infections in tropical developing countries is likely to be higher than those of developed nations due to higher endemicity, overcrowding, substandard socioeconomic conditions, decaying public health infrastructures, higher antimicrobial resistance and growing HIV-AIDS population. Our centre follows trimethoprim-sulfamethoxazole prophylaxis for *Pneumocystis jirovecii* which may reduce the incidence/presentation of urinary infections and bacteremia [11, 12]. The incidence of bacterial infections varies widely [3, 5, 6, 10]. Most of the positive isolates were seen in the first week post surgery. Gram negative isolates outnumbered Gram positive isolates in this study, a preponderance noted in similar studies [3, 5, 6, 10], though predominant Gram positive isolates have also been reported [13]. Urinary infections were the most common infections, a fact reported by various studies [5, 10, 14, 15]. The predominance of urinary infections is partially attributable to prolonged catheterization. Deceased donor kidneys can also contribute to urinary infections as contamination rate of deceased donor kidneys may be up to 25% [14]. Independent positivity of urinary catheter samples without positive urine samples indicates biofilm formation on indwelling devices without planktonic surrounding growth. Blood stream isolates were second in frequency. Bacteremia after transplant surgery occurs from colonized foci in urinary, lower respiratory tracts and intravascular catheters. Both bacteremia without and with foci were seen. Urinary foci were the most common, delineating urosepsis as the predominant risk. Lower respiratory tract infections or surgical site infections were not seen. This may be attributable to usage of closed suction device attached to tracheostomies or endotracheal tubes and strict infection control measures during surgery. The profile of transplant associated infections varied in severity and presentation compared to other patient groups in the hospital setup. The organisms isolated in this study predominate transplant infections worldwide[3, 5, 6, 11]. Common organisms seen in hospital setups were frequently isolated amongst others. Multiple organisms were isolated simultaneously or at different times. Infections related to excessive nosocomial hazard were not seen. Positive isolates despite antimicrobial prophylaxis portray widespread and emerging antimicrobial resistance. Significant difference in beta lactamase positive isolates was seen (Table 5). Intra-class variation of susceptibility reinforces the need for antimicrobial susceptibility testing before antimicrobial administration. While the proportion of ESBL producing coliforms is comparable, the proportion of MRSA is in contrast with data from developed countries [16-19]. Though, the pattern of isolates is comparable to other studies [3, 5, 6, 10], resistance patterns observed may be alarming. Multiresistance was encountered in all organisms; however adequate susceptibility was preserved with reserve drugs. RTR form a special group of patients who may not have a control population which can be matched for age, sex, risk and prevalence of infec-

tions and antimicrobial resistance patterns.

Infections in transplant recipients

The omnipresence of infectious agents and lowered host resistance renders the transplant recipient vulnerable to infections for life. Immunocompromised states are conferred by immunosuppressive agents causing leucopenia and depression of cell mediated immunity and antibody responses, and immunomodulating viruses such as cytomegalovirus or HIV. The newer immunosuppressive agents score well on potency but remain nonselective for different components of the immune system, thereby interfering with cellular and humoral immunity and predisposing to infections. In addition, thymoglobulin depletes lymphocytes, calcineurin inhibitors render vaccines less effective, MMF causes neutropenia and steroids suppress inflammatory response. Renal failure induced by immunosuppressive drugs can attenuate response to vaccination [6]. Rejection episodes in varying frequency, intensity and chronicity are managed with augmented immunosuppressive therapy, thereby increasing host susceptibility and exposure to nosocomial agents and their antimicrobials. Perioperative nosocomial and community exposures are followed by lifestyle determined environmental exposures during occupation, avocation, travel and specific exposures due to sexual, drug and dietary habits [20]. A mild infection such as asymptomatic bacteriuria may progress to pyelonephritis, bacteremia and urosepsis and may compromise allograft function and survival [11]. Even when the infection is easy to treat, it exposes the recipient to repetitive courses of antimicrobials. Repeated simultaneous exposure from multiple sources in the setting of multiple antimicrobial exposures and immunosuppressive state leads to frequent, florid, disseminated, simultaneous and polymicrobial infections [9]. Both transplantation and microbial infections independently elicit a chronic inflammatory response which alters their presentation [21]. While a modeled infection timeline suits broad perspectives, it is influenced by various factors. Retransplant cases may not follow the classical infection timeline and often present atypically with infections increased in concurrence and severity [3]. Transplant centres in developing countries may face increased threat of infections and widespread multiresistance than developed countries, though bacterial infections remain significant determinants in developed country transplant centres even today [22].

Antimicrobial resistance

The magnitude of antimicrobial resistance in transplant centres is often four pronged which may exists as a vicious cycle. Firstly, nosocomial strains are inherently multiresistant, secondly, routine infection prophylaxis increases selection pressure for emergence of resistant strains, thirdly, antimicrobial resistance is increased in immunocompromised hosts and fourthly, transplant patients harbouring multiresistant organisms may contribute to nosocomial hazard in transplant centres. Bacteria with high intrinsic resistance and secondary resistance mechanisms participate in a complex interplay of clonal spread, persistence, transfer of resistance elements and cell-cell interaction, thereby plaguing transplant programs [23]. These resistance mechanisms, if simultaneously present in a bacterial host, can result in multiresistant phenotypes which are difficult to detect and treat. Even a small change in antimicrobial susceptibility of certain organisms can result in increased minimal inhibitory concentration (MIC) of a drug to a level that is greater than the clinically achievable level. Also, elevated MICs may remain within the susceptible range leading to disparity in breakpoint concentrations in vivo [8].

Transplant recipients continue to live under the threat of failure of antimicrobial therapy. The antimicrobial susceptibility profiles to commonly used first line drugs may be dismal. While polmyxins and tigecycline remain the last resort, there is no predictable timeline of development of resistance. Development of newer antimicrobials is exacting in time, expense and effort. A high index of clinico-microbiological suspicion and impeccable management through peritransplant infection screen and susceptibility testing for donors and recipients followed by post-transplant microbiological surveillance are quintessential for a successful transplant. Rapid bacteriological, immunological and molecular techniques for identification and susceptibility can aid early identification, susceptibility testing and resistance profiling. Optimization of therapy beginning with empirical antimicrobials to combination therapies based on combination antibiograms need to be established [24].

Infection risk management

Infection risk management revolves around infection prevention, control and reducing the emergence of resistance. Risk of infection in transplant recipients is interplay between donor and recipient exposures, net state of immunosuppression, prophylaxis and patient behaviour modification. With the

unavailability of mathematical models or assays to measure the risk/susceptibility of infections in transplant recipients, concerted efforts targeted towards antimicrobial prophylaxis, early diagnosis and prompt management are required to save grafts and recipients [12]. The risk of infections in transplant patients starts from first exposure to the hospital environment, continues during transplant surgery, post operative period, convalescence period and extends for the recipient's lifetime. Under the umbrella of more potent immunosuppressive agents, the risk of post transplant infections may have increased despite usage of antimicrobials resulting in more post transplant hospitalizations than any other cause [22]. Pretransplant evaluation should include history of past immunization, infectious diseases (including Rheumatic fever, tuberculosis, recurrent and childhood infections), antimicrobial therapy, surgical history (especially splenectomy and transplants), history of transfusions, immunosuppression, travel, occupation, specific exposures, lifestyle and dietary habits [20]. Patients who have received multiple or prolonged antimicrobials especially carbapenems are classified as high risk by most transplant centres. Pretransplant urinary infection, prolonged hemodialysis, diabetes mellitus, postoperative bladder catheterization and technical complications can increase risk of infections in RTR [11]. Preventive strategies can be targeted at avoidance of donor derived infections, surgical complications, epidemiologic exposures, strengthening antimicrobial prophylaxis, anti-infection engineering, prevention of nosocomial horizontal transmission and behavior modification. Prolonged post transplant antimicrobials may protect against a wide range of susceptible common and emerging organisms. Selective bowel decontamination prevents colonization by aerobic gram negative bacilli in oral cavity and gastrointestinal tract; and preserves colonization resistance conferred by anaerobic gut flora [3]. Invigorated efforts towards pretransplant donor infection screen, vaccination/boosters to recipient or household contacts, pre-emptive therapy, increasing patient safety, elective surgery, contact isolation, barrier precautions, comprehensive catheter care, adequate environmental sanitation, linen disinfection, universal prophylaxis, hand hygiene, equipment sterilization and routine and specific surveillance are required. Recipient should follow food, animal and environmental security. Transplant centres should be air conditioned with 15-20 HEPA filtered air changes per hour and maintain relative positive pressure gradient. An astute observation by transplant physician, surgeon, microbiologist and Infection Control Committee in a transplant program is quintessential to its success. Outbreak and epidemic preparedness should be kept standby. Measures to prevent the emergence of resistance such as empirical prescription austerity and antimicrobial cycling may preserve the susceptibility of organisms. Internal and external quality control measures should be incorporated.

The Future

Transplant recipients are vulnerable to infections due to immunosuppression, disturbed metabolic parameters, pharmacodynamic reactions and toxicity. Antigen specific immunosuppression targeted at exclusive graft alloantigens using antibodies or soluble ligands reactive to cell surface molecules have been found promising in animal experiments [21]. Immunotherapy is also being evaluated. Coupled with resolute efforts towards infection control, an infection free transplant may be the promise of the future.

Conclusion

Transplant programs, even with established protocols, remain prone to frequent, disseminated, simultaneous polymicrobial bacterial infections with emerging multiresistant organisms complicating transplant outcome. A subdued clinical presentation in the milieu of immunosuppression, altered metabolism and toxicity mounts a diagnostic and therapeutic challenge. Multiresistant organisms harboured by transplant recipients may contribute to nosocomial hazard. Infection control may be targeted at avoidance of donor derived infections, surgical complications, epidemiologic exposures, strengthening antimicrobial prophylaxis and anti-infection engineering. Antimicrobial stewardship, outbreak and epidemic preparedness should be ensured.

Conflicts of interest

None

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