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Nationwide survey of infection prevention protocols in solid organ transplantation in South Korea

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Background: Infections are a major cause of morbidity, graft failure, and mortality in solid organ transplant recipients. Preventive measures have greatly reduced the burden of posttransplant infections. However, little is known about the practice patterns of infection prevention in South Korea.
Methods: A questionnaire-based cross-sectional survey was conducted. The questionnaire was developed by a multidisciplinary discussion. From the Korean Network for Organ Sharing data, a list of hospitals that performed kidney, liver, heart, and lung transplantations in 2019 was selected. We invited participants to respond to the questionnaire via email from January to March 2022.
Results: The response rates for each organ were as follows; 41% (31/76 hospitals) for kidney, 49% (25/51) for liver, 40% (8/20) for heart, and 89% (8/9) for lung transplantations. The median duration of antibacterial prophylaxis after transplant ranged from 5 to 7 days. Prophylaxis was commonly applied in cytomegalovirus (CMV) D+/R– recipients. For non-lung CMV R+ recipients, a preemptive strategy was the most common method. The duration of viral load monitoring for preemptive or hybrid strategies varied. All lung transplant programs used mold-active antifungal agents for a median of 6 months. An interferon-gamma release assay was most commonly used to screen for latent tuberculosis infections.

Conclusions: The infection prevention protocols in most transplant programs in Korea were generally in accordance with the guidelines. However, some variability was observed regarding antibacterial prophylaxis and CMV prevention. Our results provide useful insights into practice patterns and will assist in the development of national guidelines.

Keywords: Transplantation; Prevention and control; Opportunistic infections; Surveys and questionnaires

HIGHLIGHTS

- The protocols at most centers in South Korea are in accordance with widely accepted guidelines.
- The duration of posttransplant antibacterial prophylaxis ranges from 5 to 7 days.
- A preemptive strategy is most commonly used for cytomegalovirus D+ recipients, except in lung transplantation.
- All lung transplant programs use universal anti-mold prophylaxis.
- Most centers screen for and treat latent tuberculosis infections.

INTRODUCTION

In patients with terminal dysfunction of an organ, solid organ transplantation (SOT) is the final treatment modality. In South Korea (hereafter, Korea), after the first kidney transplant was successful in 1969, liver transplantation was successful in 1988, pancreas transplantation and heart transplantation in 1992, and lung transplantation in 1996. Various SOTs are now common in Korea, and according to data from the Korean Network for Organ Sharing (KONOS), about 4,200 SOTs were performed in 2019 [1]. The development of immunosuppressants to reduce rejection has greatly contributed to the improvement of the long-term survival rate after SOT. However, at the same time, the occurrence of various infectious diseases remains a problem to be overcome.

Transplant centers around the world are using various prevention protocols to reduce the incidence of infectious diseases after SOT. In the meantime, there have been some national or international surveys on these protocols [2-10]. The international guidelines for post-SOT infection prevention have recently been updated [11-19]. In Korea, there has not yet been a nationwide survey on these protocols, and national guidelines have not been established. Therefore, the Korean Society for Transplantation formed the Transplant Infection Control Committee and conducted this nationwide survey on post-SOT infection prevention protocols.

METHODS

Ethics approval and written consent were not applicable to this study because it did not report on or involve the use of any animal or human data or tissue.

This questionnaire-based cross-sectional study was conducted on behalf of the Transplant Infection Control Committee of the Korean Society for Transplantation. The questionnaire (Supplementary Material 1) was peer-reviewed and a pilot version was trialed by the committee members. It was prepared for kidney, liver, heart, and lung transplantations, respectively. These included (1) the respondent's medical department and e-mail address; (2) the prophylactic antibacterial agents and duration of use; (3) cytomegalovirus (CMV) prevention in donor-seropositive/recipient-seronegative (D+/R–) and recipient-seropositive (R+) settings: universal prophylaxis, preemptive strategy, and hybrid (prophylaxis and preemptive) method; (4) herpes zoster prevention; (5) Epstein-Barr virus (EBV) monitoring for the prevention of posttransplant lymphoproliferative disease; (6) BK virus (BKV) monitoring in kidney transplantation; (7) *Pneumocystis jirovecii* pneumonia (PCP) prevention; (8) prophylactic antifungal agents and duration of use; and (9) treatment criteria for latent tuberculosis infection (LTBI). Universal prophylaxis entails the administration of an antiviral drug to all at-risk patients for a defined period of time after SOT. In contrast, preemptive therapy is the administration of antiviral drugs only to asymptomatic patients with evidence of early subclinical CMV replication with the aim of halting its progression to CMV disease. An additional strategy is a hybrid method wherein antiviral prophylaxis is followed by CMV surveillance and preemptive therapy during the period of CMV risk.

From the KONOS data, a list of hospitals that per-

formed kidney, liver, heart, and lung transplantations in 2019 was selected. We sent an e-mail to the person in charge of the transplant center in each hospital to explain the purpose of the project, and asked them to specify who would respond to the survey for each organ. Respondents were asked to complete the survey based on their routine management for post-SOT infection prevention. We received replies from January 21 to March 11, 2022. If the answer was insufficient, a personal email was sent to the respondent to request a supplementary answer.

RESULTS

According to KONOS data, 2,293 kidney transplantations at 76 hospitals, 1,579 liver transplantations at 51 hospitals, 194 heart transplantations at 20 hospitals, and 157 lung transplantations at 9 hospitals were performed in 2019 [1]. The response rates for each organ were as fol-

Table 1. Prophylactic antibacterial agents in solid organ transplantations

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
First-generation cephalosporins	10 (32)	0	1 (13)	0
Second-generation cephalosporins	1 (3)	0	1 (13)	0
Cephamycins	5 (16)	0	0	0
Third-generation cephalosporins	12 (39)	3 (12)	1 (13)	0
Cefepime	0	1 (4)	0	3 (38)
Ampicillin/sulbactam	2 (7)	4 (16)	0	0
Piperacillin/tazobactam	1 (3)	5 (20)	1 (13)	0
Cefotaxime+ampicillin	0	2 (8)	0	0
Cefoperazone/sulbactam+ampicillin	0	2 (8)	0	0
Cefotaxime+ampicillin/sulbactam	0	6 (24)	0	0
Ceftriaxone+metronidazole	0	1 (4)	0	0
Ceftazidime+moxifloxacin	0	1 (4)	0	0
Ceftazidime+vancomycin	0	0	2 (25)	0
Ceftazidime+teicoplanin	0	0	2 (25)	5 (63)
Duration of antibacterial agents (day)	5 (0.3–7)	5 (2–14)	7 (2–7)	6 (5–14)

Values are presented as number (%) or median (range).

Table 2. Strategies for CMV prevention in CMV D+/R– transplant recipients

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
None	3 (10)	2 (8)	0	0
Prophylaxis	10 (32)	7 (28)	5 (63)	3 (38)
Valacyclovir (oral)	3 (10)	0	0	0
Valganciclovir (oral)	7 (23)	7 (28)	5 (63)	3 (38)
Duration of prophylaxis (mo)	3 (2–6)	3 (1–3)	3 (1–3)	6 (3–6)
Prophylaxis+preemptive strategy	12 (39)	7 (28)	3 (38)	5 (63)
Valacyclovir (oral)+qPCR monitoring	4 (13)	0	0	0
Ganciclovir (intravenous)+qPCR monitoring	0	1 (4)	0	0
Valganciclovir (oral)+qPCR monitoring	7 (23)	6 (24)	2 (25)	5 (63)
Cut-off value of qPCR for preemptive therapy initiation (copies or IU/mL)	1,000 (34.5–10,000)	1,000 (34.5–10,000)	10,000 (10,000–10,000)	3,500 (1,000–10,000)
Valganciclovir (oral)+antigenemia monitoring	1 (3)	0	1 (13)	0
Cut-off value of antigenemia for preemptive therapy initiation (no./200,000 WBC)	25	0	1	0
Duration of prophylaxis (mo)	3 (3–6)	2 (0.5–6)	3 (3–3)	6 (3–6)
Duration of preemptive monitoring (mo)	8 (5–24)	9 (1–12)	12 (6–12)	12 (6–48)
Preemptive strategy	6 (19)	9 (36)	0	0
Preemptive strategy based on qPCR	6 (19)	6 (24)	0	0
Cut-off value of qPCR for preemptive therapy initiation (copies or IU/mL)	1,000 (34.5–1,000)	1,000 (500–10,000)	0	0
Preemptive strategy based on antigenemia	0	3 (12)	0	0
Cut-off value of antigenemia for preemptive therapy initiation (no./200,000 WBC)	0	4 (1–5)	0	0
Duration of preemptive monitoring (mo)	12 (3–12)	3 (1–12)	0	0

Values are presented as number (%) or median (range).

CMV, cytomegalovirus; qPCR, quantitative polymerase chain reaction; WBC, white blood cell.

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Table 3. Strategies for CMV prevention in CMV R+ transplant recipients

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
None	5 (16)	2 (8)	0	0
Prophylaxis	3 (10)	3 (12)	0	2 (25)
Valganciclovir (oral)	3 (10)	3 (12)	0	2 (25)
Duration of prophylaxis (mo)	3 (3–6)	3 (1–3)	0	3 (3–3)
Prophylaxis+preemptive strategy	3 (10)	4 (16)	2 (25)	5 (63)
Valacyclovir (oral)+qPCR monitoring	2 (7)	0	0	0
Ganciclovir (intravenous)+qPCR monitoring	0	1 (4)	1 (13)	0
Valganciclovir (oral)+qPCR monitoring	1 (3)	3 (12)	1 (13)	5 (63)
Cut-off value of qPCR for preemptive therapy initiation (copies or IU/mL)	1,000 (100–10,000)	86 (34.5–10,000)	10,000 (10,000–10,000)	3,500 (1,000–10,000)
Duration of prophylaxis (mo)	3 (3–3)	1 (0.25–2)	1, 3	6 (3–6)
Duration of preemptive monitoring (mo)	6 (5–24)	7 (1–12)	12 (12–12)	12 (6–48)
Preemptive strategy	20 (65)	16 (64)	6 (75)	1 (13)
Preemptive strategy based on qPCR	19 (61)	11 (44)	4 (50)	1 (13)
Cut-off value of qPCR for preemptive therapy initiation (copies or IU/mL)	1,000 (34.5–1,000)	1,500 (500–10,000)	1,000 (400–10,000)	10,000 (10,000–10,000)
Preemptive strategy based on antigenemia	1 (3)	5 (20)	2 (25)	0
Cut-off value of antigenemia for preemptive therapy initiation (no./200,000 WBC)	25	5 (1–5)	1, 5	0
Duration of preemptive monitoring (mo)	12 (3–24)	3 (0.5–12)	3 (3–12)	3

Values are presented as number (%) or median (range).
CMV, cytomegalovirus; qPCR, quantitative polymerase chain reaction; WBC, white blood cell.

Table 4. Preventions of viruses other than cytomegalovirus in solid organ transplantations

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
Herpes zoster prevention				
None	24 (77)	18 (72)	2 (25)	1 (13)
Prophylaxis	7 (23)	7 (28)	6 (75)	7 (88)
Acyclovir (oral)	0	4 (16)	6 (75)	0
Valacyclovir (oral)	2 (7)	0	0	0
Valganciclovir (oral), included in CMV prophylaxis	5 (16)	3 (12)	0	7 (88)
Duration of prophylaxis (mo)	3 (1–6)	3 (1–6)	1 (1–6)	6 (3–6)
EBV monitoring				
None	25 (81)	18 (72)	7 (88)	5 (63)
qPCR monitoring	2 (7)	0	0	0
qPCR monitoring, if EBV D+/R–	3 (10)	5 (20)	1 (13)	0
qPCR monitoring, if pretransplant EBV qPCR+	1 (3)	2 (8)	0	3 (38)
Duration of prophylaxis (mo)	12 (3–12)	12 (6–48)	12	12 (12–24)
BK virus monitoring				
None	3 (10)	0	0	0
qPCR monitoring	28 (90)	0	0	0
Blood	14 (45)	0	0	0
Urine	4 (13)	0	0	0
Blood+urine	10 (32)	0	0	0
Duration of qPCR monitoring (mo)	12 (3–60)	0	0	0

Values are presented as number (%) or median (range).
CMV, cytomegalovirus; EBV, Epstein-Barr virus; qPCR, quantitative polymerase chain reaction.

lows: 41% (31/76 hospitals) for kidney, 49% (25/51) for liver, 40% (8/20) for heart, and 89% (8/9) for lung transplantations. Of the total number of transplantation procedures, the proportions of transplantations for each organ performed by the respondents' hospitals were as follows: 70% (1,611/2,293) for kidney, 83% (1,307/1,579) for liver, 76% (148/194) for heart, and 99% (155/157) for lung transplantations.

The respondents answered that third-generation (39%, 12/31) and first-generation (32%, 10/31) cephalosporins were often used as prophylactic antimicrobial agents in kidney transplantation (Table 1). Cefotaxime plus ampicillin/sulbactam (24%, 6/25) was most commonly used in liver transplantation. Characteristically, ampicillin containing regimens (56%, 14/25) were commonly used in liver transplantation. The median durations of prophylactic antimicrobial agents were 5 days for kidney, 5 days for liver, 7 days for heart, and 6 days for lung transplantations (Supplementary Fig. 1).

Table 2 shows CMV prevention protocols for CMV D+/R− transplant recipients. In kidney transplantation, a hybrid method (39%, 12/31) was most commonly used. Universal prophylaxis was applied for a median of 3 months, and then a preemptive strategy was applied up to a median of 8 months after kidney transplantation in the hybrid method (Supplementary Fig. 2A-C). A preemptive strategy (36%, 9/25) was most commonly used for a median of 3 months after liver transplantation. Universal prophylaxis (63%, 5/8) was the most common method for heart transplantation, and the hybrid method (63% 5/8) was the most common method for lung transplantation. Table 3 and Supplementary Fig. 2D show CMV prevention in CMV R+ transplant recipients. Preemptive strategies were most commonly used for kidney (65%, 20/31), liver (64%, 16/25), and heart (75%, 6/8) transplantations. For lung transplantation, the hybrid method (63%, 5/8) was used the most often in the CMV R+ setting. As a prophylactic antiviral drug, valacyclovir was used at some kidney transplant centers, but most of the other centers used valganciclovir.

Most often, no method was used to prevent herpes zoster in kidney (77%, 24/31) and liver (72%, 18/25) transplantations (Table 4). Acyclovir prophylaxis (75%, 6/8) was most commonly used in heart transplantation. In lung transplantation, valganciclovir prophylaxis (88%, 7/8) for CMV prevention also prevented herpes zoster. Although most hospitals did not use any method to monitor EBV, it was monitored in situations such as EBV D+/R− or pretransplant quantitative polymerase chain reaction positivity. BKV was monitored at most hospitals (90%, 28/31)

Table 5. Strategies for preventing fungal infections in solid organ transplantations

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
Pneumocystis jirovecii prevention				
None	1 (3)	1 (4)	0	0
Prophylaxis	30 (97)	24 (96)	8 (100)	8 (100)
Trimethoprim/sulfamethoxazole (oral)	30 (97)	24 (96)	8 (100)	8 (100)
Duration of prophylaxis (mo)	6 (3–12)	6 (2–12)	12 (6–12)	Lifelong (12–lifelong)
Fungus prevention				
None	18 (58)	6 (24)	3 (38)	0
Prophylaxis	13 (42)	19 (76)	5 (63)	8 (100)
Nystatin (oral)	7 (23)	0	4 (50)	0
Fluconazole (oral)	6 (19)	10 (40)	0	0
Itraconazole (oral)	0	5 (20)	1 (13)	4 (50)
Itraconazole (oral)+LAMB (intravenous) (1 mg/kg)	0	1 (4)	0	0
LAMB (intravenous) (1 mg/kg)	0	3 (12)	0	0
Itraconazole (oral)+sGM monitoring	0	0	0	1 (13)
Itraconazole (oral)+AMB nebulizer+sGM monitoring	0	0	0	1 (13)
Voriconazole (oral)+sGM monitoring	0	0	0	2 (25)
Duration of prophylaxis (mo)	1 (0.5–6)	1 (0.13–3)	1 (1–6)	6 (3–6)
Duration of sGM monitoring (mo)	0	0	0	12 (3–12)

Values are presented as number (%) or median (range).

LAMB, liposomal amphotericin B; sGM, serum galactomannan; AMB, amphotericin B.

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Table 6. Treatment criteria for latent tuberculosis infections in solid organ transplantations

Characteristic	Kidney (n=31)	Liver (n=25)	Heart (n=8)	Lung (n=8)
None	3 (10)	7 (28)	1 (13)	0
IGRA+	21 (68)	16 (64)	6 (75)	5 (63)
IGRA+ and clinical risk factors[a)]	0	1 (4)	1 (13)	0
IGRA+ and donor chest X-ray	0	0	0	1 (13)
IGRA+ and TST+	2 (7)	0	0	0
IGRA+ and TST+ and clinical risk factors[a)]	1 (3)	0	0	0
IGRA/TST, any+	4 (13)	1 (4)	0	2 (25)

Values are presented as number (%).

IGRA, interferon-gamma release assay; TST, tuberculin skin test.

[a)]History of inadequate treatment or old tuberculosis lesion on a chest X-ray examination, or recent exposure to active tuberculosis.

up to a median of 12 months after kidney transplantation.

Most often, no method was used to prevent fungal infections in kidney transplantation (58%, 18/31) (Table 5). Antifungal prophylaxis was applied at 76% (19/25) of hospitals after liver transplantation and at 63% (5/8) after heart transplantation. In lung transplantation, all hospitals used mold-active antifungal prophylaxis for a median of 6 months, and 50% (4/8) of hospitals monitored serum galactomannan for a median of 12 months. The most common method used to screen for LTBI was an interferon-gamma release assay (Table 6).

DISCUSSION

This study is the first survey on infection prevention after SOTs in Korea. While the centers that responded to our survey comprised 40%–50% of all transplant centers in Korea, the respondents conducted ≥70% of transplants in the country.

The most remarkable finding about antibacterial prophylaxis was its duration. The median duration of postoperative antibacterial prophylaxis was 5 days for the kidney and the liver, and longer for the heart and the lung. This practice pattern is not in accordance with the latest American Society of Transplantation (AST) guidelines [19], where the general recommendation is 24 (kidney) to 48 (liver and heart) hours, except for lung transplantation (≤72 hours) and high-risk conditions (≤14 days). A recent Eurotransplant survey (n=65) also reported that the majority of centers used a single dose (45%) or ≤72 hours (22%) of prophylaxis [20]. Regarding the choice of antibiotics, 39% of kidney transplant centers used third-generation cephalosporins while the guidelines recommend first-generation cephalosporins. This suggests room for potential improvement, considering that kidney transplantation is usually performed as a non-emergent clean surgery and the surgical site infection rate is low. Based on the results of this study, it is hoped that multi-center research led by the Korean Society for Transplantation will be conducted to reduce the duration of antibacterial prophylaxis.

Most centers employed prophylaxis or a hybrid strategy for the prevention of CMV disease in CMV D+/R– recipients. Three months of valganciclovir was the most commonly used regimen for prophylaxis alone; however, the duration of prophylaxis and subsequent monitoring was not consistent for the hybrid strategy. One interesting finding is the use of acyclovir in three centers. Oral acyclovir for prevention was reported to be effective in a 1989 study, but a high dose was used and the study size was small (n=104) [21]. A small randomized controlled study on liver transplant recipients showed the lack of effectiveness of oral acyclovir [22]. As acyclovir is not recommended for CMV prophylaxis and oral valganciclovir is covered by the National Health Insurance Service (NHIS) in Korea, there seems to be no reason to use acyclovir in CMV D+/R– recipients.

For the more common setting of CMV R+ recipients, most centers used a preemptive strategy except for lung transplant programs. There is no clear evidence that either prophylaxis or a preemptive strategy is superior in low-risk settings (e.g., CMV R+ kidney, liver, and heart recipients). Prophylaxis is supported by more data from large clinical trials and is logistically convenient; however, higher drug costs and the potential side effect of cytopenia are of concern. There seems to be a regional difference in the selection of CMV prevention strategies. Centers in the United States more commonly used prophylaxis, while those in Europe employed either prophylaxis or hybrid strategies [4]. Asian centers have favored preemptive strategies. This regional variability might arise from differences in the seroprevalence of CMV. The geographical environment may also affect the choice of strategy, as a preemptive strategy requires more frequent monitoring with blood tests. In Korea, the reimbursement from the NHIS must be another strong factor in the decision, as valganciclovir is currently not covered by the NHIS for preventive use in CMV R+ recipients.

Most centers used a preemptive strategy for CMV R+

recipients. A notable exception was lung transplant programs, 63% of which used a hybrid strategy. The duration of prophylaxis in a hybrid strategy varied from 0.5 to 6 months, as did the duration of post-prophylaxis monitoring. However, most centers discontinued monitoring within 12 months after the end of prophylaxis. Preemptive monitoring for CMV mostly lasted for 6–12 months in kidney transplant programs and for 1–6 months in liver and heart transplants. The optimal duration of prophylaxis is yet unclear. A randomized clinical trial demonstrated the superiority of 200 days of prophylaxis compared to 100 days in CMV D+/R– kidney transplant recipients [23]. However, there have been no similar comparative studies in liver and heart transplant recipients, while 12 months of valganciclovir was shown to reduce the risk for CMV disease compared to 3 months of prophylaxis in CMV D+/R– and D+/R+ lung recipients [24]. The duration of prophylaxis in our survey was generally in line with the AST guidelines [17]. However, post-prophylaxis monitoring was considerably longer than suggested, with most centers continuing monitoring for 3–12 months. Three months of monitoring for preemptive treatment is generally suggested, albeit without firm evidence [17]. Interestingly, 26% of kidney transplant programs continued CMV monitoring up to 12 months posttransplant. However, it is unknown how often CMV monitoring was performed and whether patients were tested weekly for this prolonged duration.

Quantitative nucleic acid amplification was used for monitoring in most programs. The most commonly used viral load thresholds for antiviral treatment were either 1,000 or 10,000 copies or IU/mL. There is no universal viral load threshold to guide preemptive therapy, and programs are recommended to establish site- and assay-specific thresholds [17,25].

This survey did not examine whether the selection of CMV prevention methods differs by the use of lymphocyte-depleting agents. A report suggested that maintaining a preemptive strategy might be a viable option among patients who experience acute rejection within 6 months after kidney transplantation [26]. Furthermore, we could not collect credible responses on the conditions for the discontinuation of preemptive antiviral therapy. The AST guidelines suggest two consecutive weekly tests using a less sensitive assay and a single negative result from a highly-sensitive assay as a discontinuation threshold [17]. However, a report from a single transplant center suggested the safety of discontinuation after one negative test [27].

Screening and treatment for LTBI are widely implemented at most centers. However, 28% of liver transplant programs reported that they did not screen or treat for LTBI. This is probably due to the potential for hepatotoxicity of anti-tuberculosis drugs and the high prevalence of LTBI in Korea. An interferon-gamma release assay was the most common diagnostic method for screening, although a tuberculin skin test was used in combination with an interferon-gamma release assay at a minority of centers.

Our study has some strengths. First, this is the first nationwide survey on the prevention of opportunistic infections in solid organ recipients in Korea. The respondents in this survey performed the majority of transplants in Korea. Thus, our results provide useful insights into the current practice in most active transplant programs. Second, we developed our questionnaire through a discussion with a multidisciplinary team including infectious disease physicians, transplant surgeons, and internists.

However, there are some limitations. There were some transplant centers, mostly mid-size, which did not respond to our survey. Our results may not reflect practices at those centers with a relatively small volume of transplantation procedures. Some important issues regarding prevention strategies were either absent or insufficiently detailed to collect meaningful information. Future studies are warranted to fill the gaps in this survey.

The Transplant Infection Control Committee of the Korean Society of Transplantation conducted a nationwide survey on the infection prevention protocols in SOT programs in Korea. The protocols in most programs were in accordance with widely accepted guidelines, but some variability was observed regarding postoperative antibacterial prophylaxis and the prevention of CMV disease. Our results will assist in the development of national guidelines for the prevention of infectious complications in SOT recipients.

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Conflict of Interest

Jong Man Kim is an editorial board member of the journal but was not involve in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflict of interest relevant to this article was reported.

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Supplementary Materials
Supplementary materials can be found via https://doi.org/10.4285/kjt.22.0036.

REFERENCES

1. Korean Network for Organ Sharing (KONOS). 2019 Annual data report [Internet]. Seoul: KONOS; 2020 [cited 2022 Jun 7]. Available from: https://www.konos.go.kr.
2. He SY, Makhzoumi ZH, Singer JP, Chin-Hong PV, Arron ST. Practice variation in Aspergillus prophylaxis and treatment among lung transplant centers: a national survey. Transpl Infect Dis 2015;17:14-20.
3. Hodowanec AC, Simon DM. BK virus screening and management practices among US renal transplant programs: a survey. Transpl Int 2015;28:1339-41.
4. Le Page AK, Jager MM, Kotton CN, Simoons-Smit A, Rawlinson WD. International survey of cytomegalovirus management in solid organ transplantation after the publication of consensus guidelines. Transplantation 2013;95:1455-60.
5. Navarro D, San-Juan R, Manuel O, Giménez E, Fernández-Ruiz M, Hirsch HH, et al. Cytomegalovirus infection management in solid organ transplant recipients across European centers in the time of molecular diagnostics: an ESGICH survey. Transpl Infect Dis 2017;19:e12773.
6. Neoh CF, Snell GI, Kotsimbos T, Levvey B, Morrissey CO, Slavin MA, et al. Antifungal prophylaxis in lung transplantation--a world-wide survey. Am J Transplant 2011;11:361-6.
7. Pennington KM, Yost KJ, Escalante P, Razonable RR, Kennedy CC. Antifungal prophylaxis in lung transplant: a survey of United States' transplant centers. Clin Transplant 2019;33:e13630.
8. San-Juan R, Manuel O, Hirsch HH, Fernández-Ruiz M, López-Medrano F, Comoli P, et al. Current preventive strategies and management of Epstein-Barr virus-related post-transplant lymphoproliferative disease in solid organ transplantation in Europe. Results of the ESGICH questionnaire-based cross-sectional survey. Clin Microbiol Infect 2015;21:604.
9. Tan CS, Gabardi S, Pavlakis M. Survey of BK virus screening practices by American Society of Transplantation members. Clin Transplant 2019;33:e13620.
10. Zuk DM, Humar A, Weinkauf JG, Lien DC, Nador RG, Kumar D. An international survey of cytomegalovirus management practices in lung transplantation. Transplantation 2010;90:672-6.
11. Allen UD, Preiksaitis JK; AST Infectious Diseases Community of Practice. Post-transplant lymphoproliferative disorders, Epstein-Barr virus infection, and disease in solid organ transplantation: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13652.
12. Aslam S, Rotstein C; AST Infectious Disease Community of Practice. Candida infections in solid organ transplantation: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13623.
13. Fishman JA, Gans H; AST Infectious Diseases Community of Practice. Pneumocystis jiroveci in solid organ transplantation: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13587.
14. Hirsch HH, Randhawa PS; AST Infectious Diseases Community of Practice. BK polyomavirus in solid organ transplantation-guidelines from the American

Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13528.
15. Husain S, Camargo JF. Invasive aspergillosis in solid-organ transplant recipients: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13544.
16. Pergam SA, Limaye AP; AST Infectious Diseases Community of Practice. Varicella zoster virus in solid organ transplantation: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13622.
17. Razonable RR, Humar A. Cytomegalovirus in solid organ transplant recipients: guidelines of the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13512.
18. Subramanian AK, Theodoropoulos NM; Infectious Diseases Community of Practice of the American Society of Transplantation. Mycobacterium tuberculosis infections in solid organ transplantation: Guidelines from the Infectious Diseases Community of Practice of the American Society of Transplantation. Clin Transplant 2019;33:e13513.
19. Abbo LM, Grossi PA; AST ID Community of Practice. Surgical site infections: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. Clin Transplant 2019;33:e13589.
20. Bachmann F, Adam T, Friedersdorff F, Liefeldt L, Slowinski T, Budde K, et al. Perioperative antibiotic prophylaxis in renal transplantation: a single-center comparison between two regimens and a brief survey among the Eurotransplant renal transplantation centers. World J Urol 2019;37:957-67.
21. Balfour HH Jr, Chace BA, Stapleton JT, Simmons RL, Fryd DS. A randomized, placebo-controlled trial of oral acyclovir for the prevention of cytomegalovirus disease in recipients of renal allografts. N Engl J Med 1989;320:1381-7.
22. Singh N, Yu VL, Mieles L, Wagener MM, Miner RC, Gayowski T. High-dose acyclovir compared with short-course preemptive ganciclovir therapy to prevent cytomegalovirus disease in liver transplant recipients: a randomized trial. Ann Intern Med 1994;120:375-81.
23. Humar A, Lebranchu Y, Vincenti F, Blumberg EA, Punch JD, Limaye AP, et al. The efficacy and safety of 200 days valganciclovir cytomegalovirus prophylaxis in high-risk kidney transplant recipients. Am J Transplant 2010;10:1228-37.
24. Palmer SM, Limaye AP, Banks M, Gallup D, Chapman J, Lawrence EC, et al. Extended valganciclovir prophylaxis to prevent cytomegalovirus after lung transplantation: a randomized, controlled trial. Ann Intern Med 2010;152:761-9.
25. Razonable RR, Hayden RT. Clinical utility of viral load in management of cytomegalovirus infection after solid organ transplantation. Clin Microbiol Rev 2013;26:703-27.
26. Lee YM, Kim YH, Han DJ, Park SK, Park JS, Sung H, et al. Cytomegalovirus infection after acute rejection therapy in seropositive kidney transplant recipients. Transpl Infect Dis 2014;16:397-402.
27. Park SY, Kim YH, Han DJ, Park SK, Park JS, Sung H, et al. Efficacy of a strategy for discontinuing pre-emptive ganciclovir therapy after a negative cytomegalovirus antigenaemia test result in seropositive kidney transplant recipients. J Antimicrob Chemother 2013;68:1209-11.

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