



HAL
open science

Microbiological epidemiology of preservation fluids in transplanted kidney: a nationwide retrospective observational study

A. Corbel, M. Ladriere, N. Le Berre, L. Durin, H. Rousseau, L. Frimat, N. Thilly, C. Pulcini

► To cite this version:

A. Corbel, M. Ladriere, N. Le Berre, L. Durin, H. Rousseau, et al.. Microbiological epidemiology of preservation fluids in transplanted kidney: a nationwide retrospective observational study. *Clinical Microbiology and Infection*, 2019, 26 (4), pp.475-484. 10.1016/j.cmi.2019.07.018 . hal-02459139

HAL Id: hal-02459139

<https://hal.univ-lorraine.fr/hal-02459139>

Submitted on 20 May 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

1 **ORIGINAL ARTICLE**

2 **Microbiological epidemiology of preservation fluids in transplanted kidney: a nationwide**
3 **retrospective observational study**

4 Alice Corbel¹, Marc Ladrière¹, Nicolas Le Berre¹, Laurent Durin⁵ Hélène Rousseau², Luc
5 Frimat^{1,3}, Nathalie Thilly^{2,3}, Céline Pulcini^{3,4}

6

7 ¹ Nephrology Dialysis Transplantation Department, University of Lorraine, CHRU-Nancy,
8 Nancy, France

9 ² Plateforme d'Aide à la Recherche Clinique, University of Lorraine, CHRU-Nancy, Nancy,
10 France

11 ³ APEMAC, University of Lorraine, Nancy, France

12 ⁴ Infectious Diseases Department, Université de Lorraine, CHRU-Nancy, Nancy, France

13 ⁵ Agence de la Biomédecine, Saint Denis La Plaine, France

14 Corresponding Author: a.corbel@chru-nancy.fr

15 Adress:

16 Dr A. Corbel

17 Service de Néphrologie

18 Hopital Brabois Adultes

19 Allée du Morvan

20 54511 Vandoeuvre les Nancy

21 France

22 Tel : +33 383 15 36 55 / Fax : + 33 383 15 35 31

23 Abstract 204 words / Text 2801 words

24

1 **ABSTRACT**

2 Objectives: Kidney transplant recipients are at high-risk for donor-derived infections in the
3 early post-transplant period. Transplant preservation fluid (PF) samples are collected for
4 microbiological analysis. In case of positive PF cultures, the risk for the recipient is unknown
5 and prescribing prophylactic antibiotics is not consensual. This nationwide observational study
6 was aimed to determine the epidemiology of bacterial and fungal agents in kidney transplant
7 PF cultures and identify risk factors associated with positive PF cultures.

8 Methods: We performed a retrospective observational study on the following data collected
9 from a national database between October 2015 and December 2016: characteristics of
10 donor, recipient, transplantation, infection in donor, and PF microbiological data.

11 Results: Out of 4,487 kidney transplant procedures including 725 (16.2% 725/4,487) from
12 living-donors, 20.5% had positive PF cultures (living-donors: 1.8% -13/725; deceased-donors:
13 24.1% - 907/3,762). Polymicrobial contamination was found in 59.9% (485/810) of positive PF
14 cultures. Coagulase-negative staphylococci (65.8% - 533/810) and Enterobacteriaceae (28.0%
15 - 227/810) were the most common microorganisms. Factors associated with an increased risk
16 of positive PF cultures in multivariable analysis were (deceased-donor kidney transplant):
17 intestinal perforation during procurement (OR 4.4 [2.1;9.1]), multi-organ procurement (OR 1.4
18 [1.1;1.7]) and *en bloc* transplantation (OR 2.5 [1.3;4.9]) ; use of perfusion pump and donor
19 antibiotic therapy were associated with lower risk of positive PF cultures (OR=0.4 [0.3;0.5] and
20 OR=0.6 [0.5;0.7], respectively).

21 Conclusion: In conclusion, 24% of deceased-donor PF cultures were positive, and PF
22 contamination during procurement seemed to be the major cause.

23

- 1 **Key words:** kidney transplantation, preservation fluid, microbiological analysis, organ
- 2 procurement procedure, infectious risk
- 3

1 INTRODUCTION

2 Kidney transplantation is considered as the choice treatment for end-stage kidney disease
3 patients(1), and requires immunosuppressive therapy (2). As a result, kidney transplant
4 recipients (KTR) are prone to infectious complications, associated with significant
5 morbidity(3–6). Three at-risk periods after transplantation have been described(7): the early
6 post-transplant period in which predominate healthcare-associated infections and donor-
7 transmitted infections, the 6-month post-transplant period at high risk for reactivation of
8 latent infections and opportunistic infections, and the late post-transplant period (beyond the
9 sixth month) with an increased risk of community acquired infections(7). Today development
10 of multidrug-resistant bacteria (MDR-B) is a major concern(7–11).

11 Infectious disease screening of donor is systematically performed(12–14). The kidney
12 transplant preservation fluid (PF)(15) can also be a source of healthcare-associated infections.
13 According to the French Agency of Biomedicine (ABM) 2008 guidelines, kidney transplant PF
14 samples are systematically collected for microbiological (bacterial and mycological) analysis
15 through transplant procedure(14)(16). In case of positive fungal PF cultures, the risk of mycotic
16 pseudoaneurysm is well-known and its therapeutic management, as well as the patient's
17 surveillance are well-documented according to an international consensus(16,17). However,
18 in case of positive bacteriological PF culture, the infectious risk for KTR is unknown and
19 management of such cultures is not consensual(18). Previous studies suggest that a significant
20 number of KTR receives antibiotic treatment to prevent infections, but the benefit of such
21 prophylactic therapy has not been demonstrated (14,19,20). Microbiological epidemiology of
22 PF cultures is also not well-known. Few single-center, retrospective studies carried out in
23 France, Italy, UK and Canada between 1999 and 2012 reported that the prevalence of positive

1 PF cultures varies widely, ranging from 17.8% to 58.0%(18,19,21–25). Although coagulase-
2 negative staphylococci are the most common microorganism isolated in PF cultures,
3 Enterobacteriaceae, which are more virulent and more frequently multidrug-resistant, tend
4 to have a growing role in recent studies(18,19,23,24).

5 This nationwide observational study was aimed to determine the epidemiology of bacterial
6 and fungal agents in kidney transplant PF cultures and identify risk factors associated with
7 positive PF cultures.

8

9

1 **METHODS**

2 Data source

3 Exhaustive clinical information on all kidney transplant procedures carried out in France are
4 routinely and prospectively collected in national databases which are maintained by the ABM.
5 In this study, data were retrieved from these national databases of kidney transplantations,
6 and retrospectively analyzed. All kidney transplant procedures performed in France between
7 October 1, 2015 and December 31, 2016 were included. We double-checked that we comply
8 with the STROBE reporting guidelines for observational studies(26).

9

10 Data collection

11 Kidney transplantations are performed in 42 university hospital centers in France including 28
12 adult centers, 9 pediatric centers, and 5 both adult and pediatric centers(27). Furthermore,
13 157 healthcare institutions across France are authorized to perform kidney procurement
14 procedures(28).

15 Allocation and distribution of organ are coordinated by the ABM. All data prospectively
16 collected by the ABM are recorded in real time; clinical data are recorded by organ
17 procurement and transplant teams, and microbiological data by the ABM. Since 2008, ABM
18 recommends withdrawing twice 25 mL of PF at the opening of graft container (25mL for
19 mycological analysis and 25 mL for bacteriological analysis. After direct exam, PF is cultured
20 on solid media, aerobic blood culture bottle, anaerobic blood culture bottle and mycological
21 blood culture bottle. (16). Each microorganism was identified and antibiograms are performed
22 following standards of the French Microbiology Society(29). Data reporting is mandatory,

1 guaranteeing the exhaustive nature of information. Data anonymization, consistency and
2 completion are controlled by the data manager of the ABM.

3 The following data are routinely collected: (i) donor: clinical, biological and imaging
4 parameters; death cause and hospitalization process in intensive care when appropriate; (ii)
5 microbiological records of kidney transplant PF cultures; and (iii) recipient: pre-transplant
6 information, mandatory for the file creation process and registration on the national kidney
7 transplant waiting list, as well as post-transplant information on serious events occurring
8 within the first 30 days after transplantation, such as recipient death and graft non-function
9 (GNF).

10

11 Variables selection

12 All variables of interest and statistical analysis plan were *a priori* selected by the
13 interdisciplinary scientific committee of the study (kidney transplant specialists, infectious
14 disease physician, epidemiologist and medical expert of the ABM) based on literature data
15 (see supplementary data)(17,19,21,23,25,30,31).

16 Microbiological analyses of PF cultures included positivity of bacterial and fungal cultures, and
17 if appropriate, isolated agent(s) (only species because susceptibility testing results were
18 unavailable). These analyses were performed in kidney graft PF and contralateral kidney PF
19 when it was also transplanted. Microbiological species were grouped as follows: coagulase-
20 negative Staphylococci, *Staphylococcus aureus*, Streptococci other than *Streptococcus*
21 *pneumoniae*, Enterococci, Enterobacteriaceae, non-fermenting Gram-negative bacilli,
22 *Candida*, commensal bacteria of skin, naso-laryngeal sphere and gastrointestinal tract flora
23 (such as *Actinomyces*, *Propionibacterium*, *Clostridium*, *Haemophilus*, *Corynebacteriae*,

1 *Moraxella, Lactobacillus, Bacteroides, Bacillus, Neisseria, Streptococcus pneumoniae*) and
2 others.

3

4 Statistical analyses

5 Analysis of characteristics for donors, recipients, procurement and transplantation was first
6 descriptive. Data are expressed as frequency and percentages for categorical variables and as
7 mean and standard deviation for continuous variables.

8 Microbiological analysis (frequency, %) were performed for all positive kidney transplant PF
9 cultures, and across subpopulations (living-donor graft, deceased donor graft, *en bloc*, and
10 positive contralateral kidney PF cultures). To explore process leading to the positivity of PF
11 cultures, microbiological concordance was calculated according to the positivity or negativity
12 of cultures: (i) between kidney transplant and contralateral kidney PF cultures, (ii) between
13 kidney transplant PF cultures and donor's samples (blood cultures and UC). Kidney transplant
14 PF cultures were defined as concordant with contralateral kidney PF cultures or with samples
15 from donor if the same microbiological species were found. Complete concordance is defined
16 as exactly the same microbiological species found in both donor and PF culture, partial
17 concordance is defined as one or more identical microbiological species found among multiple
18 other species in both PF and donor cultures. Cultures for which the microbiological species
19 were not identified were excluded from the present analysis.

20 If contralateral kidney wasn't transplanted, no PF culture was performed; in this case, culture
21 was considered negative, representing less than 10% of transplantation according to ABM
22 data(27).

1 As risk factors associated with positive kidney transplant PF cultures are unknown, the
2 scientific committee selected them based on pathophysiology and their own experience
3 (18,31). The following variables were selected to assess their association with positive kidney
4 transplant PF cultures (bacteriological, and/or mycological): year of transplantation (2015 or
5 2016), transplant laterality (right, left, en bloc), donor's age, procurement activity of the
6 department (<25 *versus* ≥25 kidney procurements/year(28)), multiorgan or kidney alone
7 procurement surgery, length of donor stay in intensive care (≤2 *versus* >2 days - mean), cold
8 ischemia time (≤14 *versus* >14 hours, mean=16 hours), use of perfusion pump, antibiotic
9 therapy in donor, positive blood culture and/or positive UC in donor, and intestinal
10 perforation during procurement.

11 Bivariate and multivariable logistic regression models were used to identify factors associated
12 with positive PF cultures. Two distinct analyses were conducted according to clinical status of
13 donor (living *versus* deceased) because of disparity in donor selection criteria, surgical
14 procedures and graft distribution. Variables found to be significant with a p-value < 0.10 in the
15 bivariate logistic regression were entered into the multivariable logistic regression model for
16 which a p value <0.05 (bilateral) was considered statistically significant. As missing data were
17 observed for only four independent variables and their percentage was always < 5%, missing
18 values were not imputed. So, the analyses were performed on PF cultures for which there was
19 no missing data on these variables. Odds ratios (crude & adjusted) with 95% confidence
20 intervals (95% CI) and p-values were calculated. No collinearity was observed between
21 variables and the Hosmer-Lemeshow goodness of fit p-value was at 0.32. All statistical
22 analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, NC).

23

1 Ethical statement

2 The study protocol was submitted to the scientific committee of ABM who gave its approval
3 for data transmission on 17/10/2017. An authorization from the National Commission of
4 Informatics and Liberty (CNIL) was not required as French ABM performed data
5 anonymization.

6

7

1 RESULTS

2 Characteristics of kidney recipients and donors

3 Over the 15-month study period 4,487 kidney transplant procedures were performed in
4 France, 725 from living-donors (16.2% 725/4,487). Characteristics of kidney transplant
5 recipients, organ donors, procurement and transplantation are detailed in Table 1. Most
6 donors (3,449/4,487-76.9%) had neither bacteremia (negative blood cultures), nor bacteriuria
7 (negative UC) at the procurement time. No living donor had bacteremia or bacteriuria at
8 procurement time. Among the 64.9% (2,423/3,736) of donors who received an antibiotic
9 therapy before procurement, 76.6% (1,856/2,423) of them received monotherapy, the most
10 prescribed medications were beta-lactams, most commonly amoxicillin-clavulanic acid (68%-
11 1,641/2,423, data not shown).

12

13 Microbiology results of positive PF cultures

14 Throughout the study period, 920 (20.5% - 920/4,487) KTR received a kidney transplant with
15 positive PF cultures (bacteriological and/or mycological) (Table 2). Among them, 907 (98.6%
16 907/920) received a deceased-donor kidney transplant. Polymicrobial cultures were found in
17 the majority of positive PF cultures (59.9% - 485/810). Coagulase-negative staphylococci
18 (65.8% - 533/810) and Enterobacteriaceae (28.0% - 227/810) were the most common agents
19 isolated in these positive cultures; in 110 cases, the cultures were reported as positive without
20 details on the identified micro-organism. Living-donor kidney transplant PF cultures were
21 rarely positive (1.8% - 13/725) and always with coagulase-negative staphylococci, alone or
22 with other agents.

23

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

Microbiological concordance between PF cultures of kidneys from the same donor

When kidney transplant was procured from deceased-donor and contralateral kidney was also transplanted, we could compare with microbiological data of contralateral kidney transplant PF cultures (Table 3). Microbiological concordance between kidney transplant PF and contralateral kidney transplant PF cultures were observed in 72.6% (2,674/3,681) of cases. A concordance between negative PF cultures was observed in 63.7% (2,345/3,681) of cases. In 8.9% (329/3681) of cases positive kidney transplant PF cultures was completely concordant with positive contralateral kidney transplant PF cultures, the great majority of samples were culture-positive with coagulase-negative staphylococci and Enterobacteriaceae. Among them, 11.8% (39/329) cultures were also in concordance with donor samples, largely with UC (33/39 - 84.6%). In these concordance cases, microorganisms were mainly Enterobacteriaceae (37/39- 94.8%).

Microbiological concordance of kidney transplant PF cultures with donor samples

Comparison of microbiological analyses from donor samples and kidney transplant PF cultures are detailed in Table 4. Concordance between positive kidney transplant PF and positive donor sample cultures was complete in 0.5% (23/4,327) of cases and partial in 0.6% (24/4,327) of cases. Enterobacteriaceae, especially *Escherichia coli*, were the most common organisms found in both kidney transplant PF cultures and donor sample cultures (complete concordance: 78.3%, partial concordance: 91.7%). When the same pathogens were isolated in kidney transplant PF and donor sample cultures, it was mostly bacteria isolated in donor UC (complete concordance: 82.6%, partial concordance: 83.3%).

1

2 Risk factors associated with positive deceased-donor kidney transplant PF cultures (Table 5)

3 Only factors associated with positive deceased-donor kidney transplant PF cultures could be
4 explored. Factors associated with positive living-donor kidney transplant PF cultures could not
5 be explored because of low prevalence of positive PF cultures in this subpopulation (1.8% -
6 13/725).

7 Regarding deceased-donor kidney transplant procedures, 907/3,762 (24.1%) were performed
8 with positive PF cultures kidney transplant. The use of a perfusion pump and donor antibiotic
9 therapy reduced the risk of positive PF cultures by 2.5 (OR=0.4 [0.3-0.5] $p<0.0001$) and by 1.7
10 (OR=0.6 [0.5-0.7] $p<0.0001$) respectively, whereas intestinal perforation increased the risk of
11 positive PF cultures by 4.7 (OR=4.7 [2.2-9.8] $p<0.0001$). Multiorgan procurement and *en bloc*
12 transplant procedures also significantly increased the risk of positive kidney transplant PF
13 cultures (Respectively OR=1.4 [1.1-1.7] $p=0.0033$ and OR=2.5 [1.3-4.9] $p=0.028$).

1 **DISCUSSION**

2 Our study shows that 20.5% of KTR are exposed to microorganism *via* kidney transplant PF.
3 Coagulase-negative staphylococci and Enterobacteriaceae were the most common organisms
4 isolated in PF cultures. Our findings are consistent with those previously published in single-
5 center studies(19,21,23–25). However, the benefit of a systematic use of prophylactic
6 antibiotic therapy focusing on isolated bacteria is not demonstrated, although this practice is
7 a well-known risk factor for MDR-bacteria emergence(8–10,32,33).

8 PF contamination during procurement seemed to be the major mechanism. Indeed, majority
9 of PF cultures were positive with coagulase-negative staphylococci, illustrating a potential
10 contamination by donor skin flora. Agents present in the gut microbiota, such as
11 Enterobacteriaceae, Enterococci, some Streptococci, and *Candida* were also frequent, and
12 their presence in kidney transplant PF cultures was likely due to the contamination of graft by
13 intra-abdominal flora at procurement time. Positivity of PF cultures due to same bacteria as
14 found in donor culture was a rare event (1% of cases), mainly involving Enterobacteriaceae
15 isolated from donor urines.

16 The results of the multivariable analysis support these hypotheses. The presence of intestinal
17 perforation during the procurement procedure was a well-known risk factor for PF
18 contamination with *Candida*(16,17); our study shows that all infectious agents face the same
19 risk. Multiorgan procurement is a long and complex surgical procedure, requiring several
20 surgical teams around the donor, increasing contamination risk and sterile mistakes; *en bloc*
21 transplant procedure is also a potentially risky procedure (surgical kidney procurement
22 procedure can be different from separated kidney procurement and is not a common surgical
23 procedure). In addition, rare complete microbiological concordance (< 9% of cases) of positive

1 PF cultures of both kidneys from one donor and the very low prevalence of positive PF cultures
2 of living-donor kidney transplant (1.8% *versus* 24.1% in deceased-donor kidney transplants)
3 support that contamination during organ procurement and/or cantonment is the major factor
4 explaining positive PF cultures. It seems important to reinforce and standardize procedures
5 for limiting PF contamination during organ procurement.

6 In our study, using a perfusion pump for graft preservation was protective factor of positive
7 PF culture. Several hypotheses may explain this finding: procurement teams might pay more
8 attention to asepsia (34) and maintenance of homogeneous temperature (4°C) over the length
9 of preservation thanks to machine perfusion might limit the potential proliferation of
10 microorganisms.

11 Another factor associated with a lesser risk for positive PF cultures was donors having received
12 antibiotics. There are no guidelines recommending a systematic perioperative antibiotic
13 prophylaxis as a standard of care in organ donors, except for thoracic organ
14 procurements(34,35). Regarding kidney procurements, we believe it is essential: (i) to limit
15 perioperative contamination, as discussed above; and (ii) to assess impact of PF contamination
16 on the onset of infections in KTR during the early period post-transplant, and on emergence
17 of MDR-bacteria. Systematic antibiotic prophylaxis in donor has a potential interest only if
18 positive PF culture is a confirmed risk factor of infection in KTR, if these infections are frequent
19 or very severe, and overall if benefit-risk balance for antibiotic therapy is clearly
20 demonstrated.

21 In case of culture positive for *Candida* or of intestinal perforation, a systematic fungal
22 treatment is recommended in KTR because of the risk for mycotic pseudoaneurysm(16,17).

23 There is no evidence of complications related to PF cultures positive for bacteria. In contrast,

1 the risk for MDR-bacteria emergence in case of prophylactic antibiotic therapy is well-proven
2 for the latter situation(7–9,11,32). These findings lead us to question the need to
3 systematically share results of bacteriological (not mycological) analysis of PF cultures with
4 transplant teams, because it often leads to an antibiotic prescription (Le Berre et al.
5 Unpublished).

6 This study brings original findings and included a large number of observations (national
7 exhaustive data over a 1-year period) from data available for transplant teams in routine
8 clinical practice. Moreover, procurements and microbiological PF cultures were performed
9 using national standardized protocols(29).

10 However, our work has some limitations. The lack of data related to antibiotic susceptibility
11 profiles limits the validity of our findings on microbiological concordance. Our study also could
12 not assess the impact of positive PF cultures or tailored antibiotic prophylaxis, due to the lack
13 of detailed data on the management and outcomes of KTR.

14 In conclusion, this large observational nationwide study shows that about a quarter of
15 deceased-donor kidney transplant recipients are exposed to microorganisms via kidney
16 transplant PF. The presence of infectious agents in PF seems to be related to contamination
17 occurring during procurement procedures; there is an urgent need to reinforce and
18 standardize procedures in order to limit such contamination. Further studies are needed to
19 assess the impact of bacterial presence in PF, in order to propose a standardized and evidence-
20 based management in this situation and to limit the risk of MDR-bacteria infections in KTR.

21

22

1 **AUTHORS CONTRIBUTION**

2 AC, NLB, LF, NT and CP initiated the study and wrote the first draft of the protocol; all
3 remaining authors reviewed them. HR analyzed the data under the supervision of NT. AC and
4 CP wrote the first draft of the manuscript which was reviewed by all authors.

5

6 **FUNDING**

7 This work was conducted as part of our routine work and was not funded.

8

9 **ACKNOWLEDGMENTS**

10 We thank all the ABM and collaborators for providing data. We thank Brigitte Bourdillat for
11 editing the English translation.

12

13 **COLLABORATORS**

14 ALAMARTINE Eric (Saint Etienne, France), AMROUCHE Lucile (Paris, France), ANGLICHEAU
15 Dany (Paris, France), ATTIAS Philippe (Créteil, France), BACCHETTA Justine (Lyon, France),
16 BADET Lionel (Lyon, France), BARROU Benoit (Paris, France), BAUD HUIN Marc (Nantes,
17 France), BAUDOUIN Véronique (Paris, France), BENBOUZID Sabrina (Paris, France),
18 BENSADOUN Henri (Bordeaux, France), BERGIS Alexandre (Rouen, France), BERNHARD Jean-
19 Christophe (Bordeaux, France), BERTRAND Dominique (Rouen, France), BESSEDE Thomas (Le
20 Kremlin-Bicêtre, France), BILAND Guillaume (Saint Denis, La Réunion, France), BLANCHET
21 Pascal (Pointe à Pitre Abymes, France), BLANOT Stéphane (Paris, France), BOISSIER Romain
22 (Marseille, France), BOTTEREL Françoise (Créteil, France), BOUALI Ourdia (Toulouse, France),

1 BOUBNOVA Julia (Marseille, France), BOULAY Hugoline (Rennes, France), BOURTIN Jean
2 Michel (Tours, France), BOUVIER Nicolas (Caen, France), BRANCHEREAU Julien (Nantes,
3 France), BRUNET Philippe (Marseille, France), BRUYERE Franck (Tours, France), BUCHLER
4 Matthias (Tours, France), CAILLARD Sophie (Strasbourg, France), CHAKFE Nabil (Strasbourg,
5 France), CHAVENT Bertrand (Saint Etienne, France), CHEISSON Gaëlle (Le Kremlin Bicêtre,
6 France), CLAUDEON Joëlle (Pointe à Pitre, France), CLOAREC Sylvie (Tours, France), COLOSIO
7 Charlotte (Reims, France), CORMIER Luc (Dijon, France), CORNUAULT Mathieu (Nantes,
8 France), COUZI Lionel (Bordeaux, France), CULTY Thibault (Angers, France), DANTHU Clément
9 (Limoges, France), DEBETTE GRATIEN Maryline (Limoges, France), DECRAMER Stéphane
10 (Toulouse, France), DEL BELLO Arnaud (Toulouse, France), DELAPORTE Véronique (Marseille,
11 France), DELPECH Pierre-Olivier (Poitiers, France), DEMEDE Delphine (Bron, France),
12 DESCAZEAUD Aurélien (Limoges, France), DESGRANDCHAMPS François (Paris, France),
13 DOBREMEZ Eric (Bordeaux, France), DOUMERC Nicolas (Toulouse, France), DROUIN Sarah
14 (Paris, France), DUBE Laurent (Angers, France), DUCLOUX Didier (Besançon, France),
15 DURRBACH Antoine (Le Kremlin Bicetre, France), ELIAS Michelle (Le Kremlin Bicetre, France),
16 ESCHWEGE Pascal (Nancy, France), ESPOSITO Laure (Toulouse, France), FIGUERES Lucile
17 (Nantes, France), FOGERON Claire-Lise (Saint Etienne, France), GAME Xavier (Toulouse,
18 France), GARAIX Florentine (Marseille, France), GARANDEAU Claire (Nantes, France),
19 GARROUSTE Cyril (Clermont Ferrand, France), GAUDEZ François (Paris, France), GEORGET
20 Gilles (Toulouse, France), GLOTZ Denis (Paris, France), GOLBIN Leonard (Rennes, France),
21 GRALL-JEZEQUEL Anne (Brest, France), GREGOIRE Hélène (Nancy, France), GRIMBERT Philippe
22 (Créteil, France), HEBRAL Anne-Laure (Toulouse, France), HENG Anne-Elisabeth (Clermont
23 Ferrand, France), IRANI Jacques (Le Kremlin Bicêtre, France), JACOB Laurent (Paris, France),
24 JANBON Bénédicte (Grenoble, France), JOUVE Thomas (Grenoble, France), KAMAR Nassim

1 (Toulouse, France), KARAM Georges (Nantes, France), KERFORNE Thomas (Poitiers, France),
2 KLEINCLAUSS François (Besançon, France), KORMANN Raphaël (Nancy, France), LARDY Hubert
3 (Tours, France), LARRE Stéphane (Reims, France), LARRE Stéphane (Pointe à Pitre, France), LE
4 MEUR Yannick (Brest, France), LECHEVALLIER Eric (Marseille, France), LEGENDRE Christophe
5 (Paris, France), LEJAY Anne (Strasbourg, France), LLANAS Brigitte (Bordeaux, France), LUNELLI
6 Luca (Paris, France), LUQUE Yosu (Paris, France), MAILLARD Nicolas (Saint Etienne, France),
7 MAISIN Anne (Paris, France), MALVEZZI Paolo (Grenoble, France), MARTINEZ Franck (Paris,
8 France), MARTIN-LEFEVRE Laurent (La Roche sur Yon, France), MATIGNON Marie (Créteil,
9 France), MERVILLE Pierre (Bordeaux, France), MOAL Valérie (Marseille, France), MORANGE
10 Virginie (Tours, France), MORIN Marie Pascale (Rennes, France), MOTTOLA Clément (Nancy,
11 France), MOULIN Bruno (Strasbourg, France), MOUSSON Christiane (Dijon, France), NEAU-
12 CRANSAC Martine (Bordeaux, France), OUALI Nacéra (Paris, France), OUENDO Martial
13 (Amiens, France), PADILLA Marc (Grenoble, France), PFISTER Christian (Rouen, France),
14 PHILIPPONNET Carole (Clermont Ferrand, France), PICQUET Jean (Angers, France), PILLOT
15 Pierre (Poitiers, France), PONGAS Mario (Nancy, France), POULAIN Coralie (Amiens, France),
16 PRADERE Benjamin (Tours, France), PRIN Sébastien (Dijon, France), PRISO René-Hilaire (Lille,
17 France), RIOU Bruno (Paris, France), ROGIER Julien (Bordeaux, France), ROUSSIN France (Paris,
18 France), SAINT Fabien (Amiens, France), SALLUSTO Federico (Toulouse, France), SALOMON
19 Laurent (Créteil, France), SAMAILLE Charlotte (Lille, France), SBERRO-SOUSSAN Rebecca
20 (Paris, France), SCEMLA Anne (Paris, France), SCHIKOWSKI Johan (Nancy, France), SID-AHMED
21 Seddik (Brest, France), TERRIER Nicolas (Grenoble, France), THIERRY Antoine (Poitiers,
22 France), TILLOU Xavier (Caen, France), TOURRET Jérôme (Paris, France), VACHER-COPONAT
23 Henri (Saint Denis, La Réunion, France), VACHIERY Florence (Montpellier, France), VENHARD

1 Jean-Christophe (Tours, France), VIGNEAU Cécile (Rennes, France), VILLE Simon (Nantes,
2 France), VIQUESNEL Gérald (Caen, France), WOLF Philippe (Strasbourg, France)

3

4

1 TRANSPARENCY DECLARATION

2 All authors: no conflict of interest to declare.

1 REFERENCES

- 2 1. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LYC, et al. Comparison
3 of Mortality in All Patients on Dialysis, Patients on Dialysis Awaiting Transplantation, and
4 Recipients of a First Cadaveric Transplant. *New England Journal of Medicine*. 1999 Dec
5 2;341(23):1725–30.
- 6 2. Halloran PF. Immunosuppressive drugs for kidney transplantation. *N Engl J Med*. 2004
7 Dec 23;351(26):2715–29.
- 8 3. Bodro M, Sanclemente G, Lipperheide I, Allali M, Marco F, Bosch J, et al. Impact of
9 urinary tract infections on short-term kidney graft outcome. *Clin Microbiol Infect*. 2015
10 Dec;21(12):1104.e1-8.
- 11 4. Graversen ME, Dalgaard LS, Jensen-Fangel S, Jespersen B, Østergaard L, Søgaard OS.
12 Risk and outcome of pyelonephritis among renal transplant recipients. *BMC Infect Dis*. 2016
13 Jun 10;16:264.
- 14 5. Kroth LV, Barreiro FF, Saitovitch D, Traesel MA, d'Avila DOL, Poli-de-Figueiredo CE.
15 Acute Graft Pyelonephritis Occurring up to 30 Days After Kidney Transplantation:
16 Epidemiology, Risk Factors, and Survival. *Transplant Proc*. 2016 Sep;48(7):2298–300.
- 17 6. Kinnunen S, Karhapää P, Juutilainen A, Finne P, Helanterä I. Secular Trends in Infection-
18 Related Mortality after Kidney Transplantation. *Clin J Am Soc Nephrol*. 2018 Apr 5;
- 19 7. Fishman JA. Infection in Organ Transplantation. *Am J Transplant*. 2017;17(4):856–79.
- 20 8. Holmes AH, Moore LSP, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al.
21 Understanding the mechanisms and drivers of antimicrobial resistance. *Lancet*. 2016 Jan
22 9;387(10014):176–87.
- 23 9. Korth J, Kukalla J, Rath P-M, Dolff S, Krull M, Guberina H, et al. Increased resistance of
24 gram-negative urinary pathogens after kidney transplantation. *BMC Nephrol*. 2017 May
25 19;18(1):164.
- 26 10. Rodrigues Dos Santos BG, Amaral ES, Fernandes PFCBC, Oliveira CMC, Rodrigues JLN,
27 Perdigão Neto LV, et al. Urinary Tract Infections and Surgical Site Infections due to
28 Carbapenem-Resistant Enterobacteriaceae in Renal Transplant. *Transplant Proc*. 2016
29 Aug;48(6):2050–5.
- 30 11. Di Cocco P, Orlando G, Mazzotta C, Rizza V, D'Angelo M, Clemente K, et al. Incidence
31 of urinary tract infections caused by germs resistant to antibiotics commonly used after renal
32 transplantation. *Transplant Proc*. 2008 Aug;40(6):1881–4.

- 1 12. Fishman JA, Grossi PA. Donor-derived infection--the challenge for transplant safety.
2 Nat Rev Nephrol. 2014 Nov;10(11):663–72.
- 3 13. Fischer SA, Lu K, AST Infectious Diseases Community of Practice. Screening of donor
4 and recipient in solid organ transplantation. Am J Transplant. 2013 Mar;13 Suppl 4:9–21.
- 5 14. Jr CSK, Koval CE, van Duin D, de Morais AG, Gonzalez BE, Avery RK, et al. Selecting
6 suitable solid organ transplant donors: Reducing the risk of donor-transmitted infections.
7 World J Transplant. 2014 Jun 24;4(2):43–56.
- 8 15. Latchana N, Peck JR, Whitson BA, Henry ML, Elkhammas EA, Black SM. Preservation
9 solutions used during abdominal transplantation: Current status and outcomes. World J
10 Transplant. 2015 Dec 24;5(4):154–64.
- 11 16. Agence de la Biomédecine. Prévention de la transmission de bactéries et d'agents
12 fongiques aux receveurs d'organes. [Internet]. 2008. Available from: [https://www.agence-
13 biomedecine.fr/IMG/pdf/prevention-de-la-transmission-de-bacteries-et-d-agents-fongiques-
14 aux-receveurs-d-organes-texte-long.pdf](https://www.agence-biomedecine.fr/IMG/pdf/prevention-de-la-transmission-de-bacteries-et-d-agents-fongiques-aux-receveurs-d-organes-texte-long.pdf)
- 15 17. Matignon M, Botterel F, Audard V, Dunogue B, Dahan K, Lang P, et al. Outcome of renal
16 transplantation in eight patients with *Candida* sp. contamination of preservation fluid. Am J
17 Transplant. 2008 Mar;8(3):697–700.
- 18 18. Oriol I, Sabé N, Tebé C, Veroux M, Boin IFSF, Carratalà J. Clinical impact of culture-
19 positive preservation fluid on solid organ transplantation: A systematic review and meta-
20 analysis. Transplant Rev (Orlando). 2017 Dec 5;
- 21 19. Ranghino A, Diena D, Simonato F, Messina M, Burdese M, Piraina V, et al. Clinical
22 impact of bacterial contamination of perfusion fluid in kidney transplantation. Springerplus.
23 2016;5:7.
- 24 20. Yahav D, Manuel O. Clinical relevance of preservation-fluid contamination in solid-
25 organ transplantation: a call for mounting the evidence. Clin Microbiol Infect. 2019
26 May;25(5):536–7.
- 27 21. Yansouni CP, Dendukuri N, Liu G, Fernandez M, Frenette C, Paraskevas S, et al. Positive
28 cultures of organ preservation fluid predict postoperative infections in solid organ
29 transplantation recipients. Infect Control Hosp Epidemiol. 2012 Jul;33(7):672–80.
- 30 22. Audet M, Piardi T, Panaro F, Ghislotti E, Gheza F, Cag M, et al. Incidence and clinical
31 significance of bacterial and fungal contamination of the preservation solution in liver
32 transplantation. Transpl Infect Dis. 2011 Feb;13(1):84–8.

- 1 23. Sauget M, Verdy S, Slekovec C, Bertrand X, Talon D. Bacterial contamination of organ
2 graft preservation solution and infection after transplantation. *Transpl Infect Dis.* 2011
3 Aug;13(4):331–4.
- 4 24. Bertrand D, Pallet N, Sartorius A, Zahar JR, Soussan RS, Lortholary O, et al. Clinical and
5 microbial impact of screening kidney allograft preservative solution for bacterial
6 contamination with high-sensitivity methods. *Transpl Int.* 2013 Aug;26(8):795–9.
- 7 25. Wakelin SJ, Casey J, Robertson A, Friend P, Jaques BC, Yorke H, et al. The incidence and
8 importance of bacterial contaminants of cadaveric renal perfusion fluid. *Transpl Int.* 2005
9 Jan;17(11):680–6.
- 10 26. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The
11 Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) statement:
12 guidelines for reporting observational studies. *Lancet.* 2007 Oct 20;370(9596):1453–7.
- 13 27. Agence de la Biomédecine. Rapport médical et scientifique du prélèvement et de la
14 greffe en France . 2016. [Internet]. 2017. Available from: [https://www.agence-](https://www.agence-biomedecine.fr/annexes/bilan2016/accueil.htm)
15 [biomedecine.fr/annexes/bilan2016/accueil.htm](https://www.agence-biomedecine.fr/annexes/bilan2016/accueil.htm)
- 16 28. Agence de la Biomédecine - Direction juridique. Liste des établissements de santé
17 autorisés par les Agences régionales de santé. [Internet]. 2018. Available from:
18 https://www.agence-biomedecine.fr/IMG/pdf/11_20180727_liste_ets_prelevement_ot.pdf
- 19 29. Société Française de Microbiologie. Comité de l’antibiogramme de la Société Française
20 de Microbiologie (CA-SFM) [Internet]. 2015. Available from: [http://www.sfm-](http://www.sfm-microbiologie.org/UserFiles/files/casfm/CASFM_EUCAST_V1_2015.pdf)
21 [microbiologie.org/UserFiles/files/casfm/CASFM_EUCAST_V1_2015.pdf](http://www.sfm-microbiologie.org/UserFiles/files/casfm/CASFM_EUCAST_V1_2015.pdf)
- 22 30. Alangaden GJ, Thyagarajan R, Gruber SA, Morawski K, Garnick J, El-Amm JM, et al.
23 Infectious complications after kidney transplantation: current epidemiology and associated
24 risk factors. *Clin Transplant.* 2006 Aug;20(4):401–9.
- 25 31. Barba J, Algarra R, Romero L, Tienza A, Velis JM, Robles JE, et al. Recipient and donor
26 risk factors for surgical complications following kidney transplantation. *Scand J Urol.* 2013
27 Feb;47(1):63–71.
- 28 32. Origüen J, Fernández-Ruiz M, López-Medrano F, Ruiz-Merlo T, González E, Morales JM,
29 et al. Progressive increase of resistance in Enterobacteriaceae urinary isolates from kidney
30 transplant recipients over the past decade: narrowing of the therapeutic options. *Transpl*
31 *Infect Dis.* 2016 Aug;18(4):575–84.
- 32 33. Delmas-Frenette C, Dorais M, Tavares-Brum A, Frenette C, Yang B, Medani S, et al.

- 1 Epidemiology and outcome of antimicrobial resistance to gram-negative pathogens in
2 bacteriuric kidney transplant recipients. *Transpl Infect Dis.* 2017 Aug;19(4).
- 3 34. D. Tixier, B. Barrou. Recommandations techniques pour le prélèvement des organes et
4 des tissus sur donneurs en état de mort encéphalique. [Internet]. Agence de la Biomédecine;
5 2006. Available from: [https://www.agence-biomedecine.fr/IMG/pdf/recommandations-](https://www.agence-biomedecine.fr/IMG/pdf/recommandations-techniques-concernant-le-donneur-en-etat-de_mort-encephalique.pdf)
6 [techniques-concernant-le-donneur-en-etat-de_mort-encephalique.pdf](https://www.agence-biomedecine.fr/IMG/pdf/recommandations-techniques-concernant-le-donneur-en-etat-de_mort-encephalique.pdf)
- 7 35. Boulard G, Guiot P, Pottecher T, Tenaillon A. [Management of subjects in a state of
8 brain death and the preservation of organs]. *Ann Fr Anesth Reanim.* 2005 Jul;24(7):836–43.

TABLE 1 Characteristics of organ transplant recipients, donors, procurement and transplantation

	All (N=4487)	Living donors (N=725)	Deceased donors (N=3762)
General characteristics			
Year of transplantation			
2015	872 (19.4%)	149 (20.6%)	723 (19.2%)
2016	3615 (80.6%)	576 (79.4%)	3039 (80.8%)
Kidney procurement activity			
Departments with <25 kidney procurement/year	503 (11.2%)	0 (0%)	501 (13.3%)
Departments with ≥25 kidney procurement /year	3984 (88.8%)	723 (99.7%)	3261 (86.7%)
Missing data	0	2	0
Donors			
Age ^a (year)	53.1±17.4	50.3±9.5	53.7±14.7
Donor type			
Living donor	725 (16.2%)	725 (100%)	
Brain-death donor	3601 (80.3%)		3601 (95.7%)
Circulatory-death (M3) donors	94 (2.1%)		94 (2.5%)
Circulatory-death (M1 & M2) donors	67 (1.5%)		67 (1.8%)
Length of stay in intensive care for brain-death donors ^a (days)	3.3±3.8		3.3±3.8
Missing data	161		161
Antibiotics in donors	2423 (64.9%)	0 (0%)	2423 (64.4%)
Missing data	751	725	26
Microbiological analysis in donors			
Negative blood culture and UC	3449 (76.9%)	725 (100%)	2724 (72.4%)
Positive blood culture	264 (5.9%)	0 (0%)	264 (7.0%)
Positive UC	672 (15%)	0 (0%)	672 (12.8%)
Positive blood culture and UC	102 (2.3%)	0 (0%)	102 (2.7%)
Blood culture and UC in donors	911	0	911
Coagulase-negative staphylococci	206 (22.6%)		206 (22.6%)

Staphylococcus aureus	48 (5.3%)		48 (5.3%)
Streptococci (excluding pneumoniae)	33 (3.6%)		33 (3.6%)
Enterococci	201 (22.1%)		201 (22.1%)
Enterobacteriaceae	390 (42.8%)		390 (42.8%)
Non-fermenting gram-negative bacilli	26 (2.9%)		26 (2.9%)
Candida	93 (10.2%)		93 (10.2%)
Other commensal bacteria ^b	50 (5.5%)		50 (5.5%)
Others	53 (5.8%)		53 (5.8%)
<hr/>			
Procurement			
Multiorgan procurement	3016 (67.2%)	0 (0%)	3016 (80.2%)
Digestive wound during procurement procedure	33 (0.7%)	0 (0%)	33 (0.9%)
Machine perfusion for graft preservation	1383 (30.8%)	0 (0%)	1383 (37.8%)
<i>Missing data</i>	<i>108</i>	<i>0</i>	<i>108</i>
<hr/>			
Transplant surgery			
Cold ischemia time ^a (in hours)	14.2±7.4	2.2±1.2	16.1±4.7
<i>Missing data</i>	<i>182</i>	<i>113</i>	<i>69</i>
Combined organ transplantation (kidney and other organs)	200 (4.5%)	0	200 (5.3%)
Transplant laterality			
Right	1921 (42.8%)	72 (9.9%)	1849 (49.1%)
Left	2525 (56.3%)	653 (90.1%)	1872 (49.8%)
En bloc	41 (0.9%)	0 (0%)	41 (1.1%)
<hr/>			
Recipients			
Age ^a (years)	51.3±16.1	45.7±13.0	52.4±12.9
Death within 30 days after transplantation	35 (0.8%)	1 (0.1%)	34 (0.9%)
GNF within 30 days after transplantation	152 (3.4%)	20 (2.8%)	132 (3.5%)

Data are expressed as n (%). ^amean ± standard deviation. ^bcommensal flora in gastrointestinal tract, naso laryngeal tract and skin. Abbreviations: UC, urine culture; M, Maastricht (M1, M2, M3); GNF, graft non-function.

Table 2 Microbiological analysis of the kidney transplant preservation fluid (PF)

Type of sample	Positive kidney transplant PF cultures	Microorganisms isolated in culture-positive PF	Data in donor		Antibiotic therapy in donor		Clinical status of recipient at Day 30	
			Positive PF culture group	Negative PF culture group	Positive PF culture	Negative PF culture	Positive PF culture	Negative PF culture
Positive kidney transplant PF cultures: all grafts	920/4487 (20.5%)	Monomicrobial culture : 407/810 (50.2 %) Streptococci: 96/810 (11.9%) Coagulase-negative staphylococci: 533/810 (65.8%) <i>Staphylococcus aureus</i> : 98/810 (11.0%) Enterococci: 62/810 (7.7%) Enterobacteriaceae: 227/810 (28.0%) Non-fermenting gram-negative bacilli: 43/810 (5.3%) Candida: 78/810 (9.6%) Other commensal bacteria: 150/810 (18.5%) Others: 149/810 (18.3%)	Negative blood culture and UC: 653/920 (71.0%) Positive blood culture: 45/920 (4.9%) Positive UC: 199/920 (21.6%) Positive blood culture and UC: 23/920 (2.5%)	Negative blood culture and UC: 2796/3567 (78.4%) Positive blood culture: 219/3567 (6.1%) Positive UC: 473/3567 (13.3%) Positive blood culture and UC: 79/3567 (2.2%)	Yes: 410/820 (50%)	Yes: 1448/3567 (46.6%)	Death: 6/920 (0.7%) GNF: 32/920 (3.5%)	Death: 27/3082 (0.9%) GNF: 96/3082 (3.1%)
Positive kidney transplant PF cultures: living-donor grafts	13/725 (1.8%)	Monomicrobial culture: 8/10 (80%) Streptococci: 0/10 (0%) Coagulase-negative staphylococci: 10/10 (100%) <i>Staphylococcus aureus</i> : 0/10 (0%) Enterococci: 0/10 (0%) Enterobacteriaceae: 0/10 (0%) Non-fermenting gram-negative bacilli: 0/10 (0%) Candida: 1/10 (10%) Other commensal bacteria: 0/10 (0%) Others: 1/10 (10%)	Negative blood culture and UC: 10/10 (100%)	Negative blood culture and UC: 712/712 (100%)	Yes: 0/13 (0%)	Yes: 0/712 (0%)	Deaths: 0/13 (0%) GNF: 0/13 (0%)	Deaths: 1/712 (0.1%) GNF: 20/712 (2.8%)
Positive kidney transplant PF cultures: <i>en bloc</i>	16/41 (39.0%)	Monomicrobial culture: 5/14 (35.7%) Streptococci: 0/14 (0%) Coagulase-negative staphylococci: 4/14 (28.6%) <i>Staphylococcus aureus</i> : 0/14 (0%) Enterococci: 4/14 (28.6%) Enterobacteriaceae: 10/14 (71.4%) Non-fermenting gram-negative bacilli: 0/14 (0%) Candida: 0/14 (0%) Other commensal bacteria: 1/14 (7.1%) Others: 1/14 (7.1%)	Negative blood culture and UC: 8/16 (50.0%) Positive blood culture: 0/16 (0%) Positive UC: 7/16 (43.8%) Positive blood culture and UC: 1/16(6.3%)	Negative blood culture and UC: 16/25 (64.0%) Positive blood culture: 2/25 (8%) Positive UC: 7/25 (28%) Positive blood culture and UC: 0/25 (0%)	Yes: 3/16 (18.8%)	Yes: 14/25 (56%)	Deaths: 0/16 (0%) GNF: 0/16 (0%)	Deaths: 1/25 (4%) GNF: 0/25 (0%)

Positive contralateral kidney PF cultures	854/3721 (23.0%)	Monomicrobial culture: 369/753 (49.0%) Streptococci: 93/753 (12.4%) Coagulase-negative staphylococci: 495/753 (65.7%) Staphylococcus aureus: 89/753 (11.8%) Enterococci: 54/753 (7.2%) Enterobacteriae: 211/753 (28.0%) Non-fermenting gram-negative bacilli: 42/753 (5.6%) Candida: 76/753 (10.1%) Other commensal bacteria: 145/753 (19.3%) Others: 143/753 (19.0%)	Negative blood culture and UC: 602/854 (70.5%) Positive blood culture: 42/854 (4.9%) Positive UC: 190/854 (22.2%) Positive blood culture and UC: 20/854 (2.3%)	Negative blood culture and UC: 2098/2867 (73.2%) Positive blood culture: 220/2867 (7.7%) Positive UC: 468/2867 (16.3%) Positive blood culture and UC: 81/2867 (2.8%)	Yes: 389/756 (51.5%)	Yes: 1453/2409 (60.7%)	Deaths: 6/854 (0.7%)	Deaths: 28/2867 (1.0%)
							GNF: 27/854 (3.2%)	GNF: 99/2867 (3.5%)

Abbreviations: UC: urine culture; GNF, graft non-function; PF, preservation fluid.

Table 3 Microbiological concordance between kidney transplant and contralateral kidney preservation fluid (PF) cultures (deceased-donor kidney grafts excluding en bloc) in 3681 kidney transplant recipients

Clinical status	n/3681 (%)	Microorganisms isolated in positive PF cultures	Microbiological analysis in donor	Antibiotic therapy in donor	Clinical status of recipient at Day 30
Positive kidney transplant PF cultures: complete concordance with contralateral kidney PF cultures	329/3681 (8.9%)	Monomicrobial culture: 79/329 (24.0%) Streptococci: 55/329 (16.7%) Coagulase-negative staphylococci: 206/329 (62.6%) Staphylococcus aureus: 52/329 (15.8%) Enterococci: 40/329 (12.2%) Enterobacteriae: 131/329 (39.8%) Non-fermenting gram-negative bacilli: 12/329 (3.6%) Candida: 45/329 (13.7%) Other commensal bacteria: 67/329 (20.4%) Others: 120/329 (36.5%)	Negative blood culture and UC: 220/329 (66.9%) Positive blood culture: 18/329 (5.5%) Positive UC: 79/329 (24.0%) Positive blood culture and UC: 12/329 (3.6%)	Yes: 129/293 (44.0%)	Deaths: 2/329 (0.6%) GNF: 9/329 (2.7%)
Negative kidney transplant PF cultures: complete concordance with culture of contralateral kidney PF (negative culture or non-performed)	2345/3681 (63.7%)		Negative blood culture and UC: 1716/2345 (73.2%) Positive blood culture: 195/2345 (8.3%) Positive UC: 363/2345 (15.5%) Positive blood culture and UC: 71/2345 (0.3%)	Yes: 1199/1951 (61.5%)	Deaths: 25/2345 (1.5%) GNF: 76/2345 (3.2%)
Positive kidney transplant PF cultures: discordance with negative contralateral kidney PF cultures	522/3681 (14.2%)	Monomicrobial culture of kidney transplant PF: 233/457 (51.0%) Streptococci: 41/457 (9.0%) Coagulase-negative staphylococci: 313/457 (65.8%) Staphylococcus aureus: 37/457 (8.1%) Enterococci: 18/457 (3.9%) Enterobacteriae: 86/457 (18.8%) Non-fermenting gram-negative bacilli: 4/457 (0.9%) Candida: 32/457 (7.0%) Other commensal bacteria: 82/457 (17.9%) Others: 76/457 (16.7%)	Negative blood culture and UC: 382/522 (73.2%) Positive blood culture: 25/522 (4.8%) Positive UC: 105/522 (20.1%) Positive blood culture and UC: 10/522 (1.9%)	Yes: 255/459 (55.6%)	Deaths: 5/522 (1.0%) GNF: 22/522 (4.2%)

Clinical status	n/3681 (%)	Microorganisms isolated in positive PF cultures	Microbiological analysis in donor	Antibiotic therapy in donor	Clinical status of recipient at Day 30
Negative kidney transplant PF cultures: discordance with positive contralateral kidney PF cultures	485/3681 (13.2%)	Monomicrobial culture of contralateral kidney PF: 214/424 (50.5%) Streptococci: 38/424 (9.0%) Coagulase-negative staphylococci: 289/424 (68.2%) Staphylococcus aureus: 37/424 (8.7%) Enterococci: 14/424 (3.3%) Enterobacteriae: 80/424 (18.9%) Non-fermenting gram-negative bacilli: 4/424 (0.9%) Candida: 31/424 (7.3%) Other commensal bacteria: 78/424 (18.4%) Others: 72/424 (17%)	Negative blood culture and UC: 352/485 (72.6%) Positive blood culture: 22/485 (4.5%) Positive UC: 103/485 (21.2%) Positive blood culture and UC: 8/485 (1.6%)	Yes: 237/424 (55.9%)	Deaths: 5/485 (1.0%) GNF: 17/485 (3.5%)

Abbreviations: UC, urine culture; GNF, graft non-function; PF, preservation fluid.

Table 4 Microbiological concordance between kidney transplant preservation fluid (PF) cultures and samples from all donors (N=4327)

Clinical status	n/4327	Microorganisms isolated in positive PF cultures	Microbiological analysis in donors	Antibiotic therapy in donors	Clinical status of recipient at Day 30 ^a
Positive kidney transplant PF cultures: complete concordance with cultures of samples from donors	23/4327 (0.5%)	Monomicrobial culture: 23/23 (100%) Streptococci: 0/23 (0%) Coagulase-negative staphylococci: 2/23 (8.7%) Staphylococcus aureus: 0/23 (0%) Enterococci: 2/23 (8.7%) Enterobacteriae: 18/23 (78.3%) Non-fermenting gram-negative bacilli: 0/23 (0%) Candida: 0/23 (0%) Other commensal bacteria: 0/23 (0%) Others: 1/23 (4.3%)	Positive blood culture: 4/23 (17.4%) Positive UC: 19/23 (82.6%) Positive blood culture and UC: 0/23 (0%)	Yes: 5/23 (21.7%)	Deaths: 0/23 (0%) GNF: 0/23 (0%)
Negative kidney transplant PF cultures: complete concordance with donor sample culture	2796/4327 (64.6%)		Negative blood culture and UC: 2796/2796 (100%)	Yes: 1161/2456 (42.3%)	Deaths: 21/2796 (0.8%) GNF: 92/2796 (3.3%)
Positive kidney transplant PF cultures: partial concordance with donor sample culture	24/4327 (0.6%)	Monomicrobial culture: 0/24 (0%) Streptococci: 4/24 (16.7%) Coagulase-negative staphylococci: 16/24 (66.7%) Staphylococcus aureus: 2/24 (8.3%) Enterococci: 4/24 (16.7%) Enterobacteriae: 22/24 (91.7%) Non-fermenting gram-negative bacilli: 0/24 (0%) Candida: 4/24 (16.7%) Other commensal bacteria: 8/24 (33.3%) Others: 6/24 (25.0%)	Positive blood culture: 0/23 (0%) Positive UC: 20/24 (83.3%) Positive blood culture and UC: 4/24 (16.7%)	Yes: 7/21 (33.3%)	Deaths: 0/24 (0%) GNF: 0/24 (0%)
Kidney transplant PF cultures : discordance with samples from donors	Only PF or Donor sample positive culture: 1424/4327 (33.0%) Both positive cultures, but	Culture-positive kidney transplant PF: 713/1484 (48.0%) Monomicrobial PF culture: 237/629 (33.9%) Streptococci: 81/629 (12.9%) Coagulase-negative staphylococci: 425/629 (67.6%) Staphylococcus aureus: 75/629 (11.9%)	Negative blood culture and UC: 653/1484 (44.0%) Positive blood culture: 233/1484 (15.7%) Positive UC: 513/1484 (34.6%).	Yes: 628/1281 (49.0%)	Deaths: 15/1484 (1.0%) GNF: 47/1484 (3.2%)

different microorganisms: 60/4327 (1.4%)	Enterococci: 48/629 (7.8%)	Positive blood culture and UC 85/1484 (5.7%)
	Enterobacteriae: 153/629 (24.3%)	
	Non-fermenting gram-negative bacilli: 15/629 (2.4%)	
	Candida: 65/629 (10.3%)	
	Other commensal bacteria: 121/629 (19.2%)	
	Others: 104/629 (16.5%)	

^a: 30 days after transplantation; Abbreviations: UC, cytobacteriological examination of the urine; GNF, graft non-function; PF, preservation fluid.

Table 5 Factors associated with positive deceased-donor kidney transplant preservation fluid (PF) cultures

	N	Positive kidney transplant PF cultures n (%)	Bivariate logistic regression		Multivariable logistic regression ^a	
			Odds ratio	95%CI [Inferior-Superior]	Odds ratio	95%CI [Inferior-Superior]
General characteristics						
Year of transplantation						
2015	723	160 (22.1%)	1			
2016	3039	747 (24.6%)	1.1	[0.9 - 1.4]		
Kidney procurement activity						
Department with <25 procurement/year	501	123 (24.6%)	1.0	[0.8 - 1.3]		
Department with ≥25 procurement/year	3261	784 (24.0%)	1			
Donor						
Age						
≤ 54 years old	1813	486 (26.8%)	1		1	
> 54 years old	1949	421 (21.6%)	0.8	[0.6 - 0.9]	1.1	[0.9 - 1.3]
Length of stay in intensive care						
≤ 2 days	2114	551 (26.1%)	1		1	
> 2 days	1487	337 (22.7%)	0.8	[0.7 - 1.0]	0.9	[0.8 - 1.1]
Antibiotic therapy						
No	1313	395 (30.1%)	1		1	
Yes	2423	511 (21.1%)	0.6	[0.5 - 0.7]	0.6	[0.5 - 0.7]
Positive blood culture and UC						
Yes	2724	640 (23.5%)	1			
No	1038	267 (25.7%)	1.1	[1.0 - 1.3]		
Multiple organ procurement procedure						
No	746	137 (18.4%)	1		1	
Yes	3016	770 (25.5%)	1.5	[1.2 - 1.9]	1.4	[1.2 - 1.8]
Digestive wound during procurement						
No	3729	889 (23.1%)	1		1	
Yes	33	18 (54.5%)	3.8	[1.9 - 7.6]	4.7	[2.2 - 9.7]
Machine perfusion for graft preservation						
No	2271	668 (29.4%)	1		1	
Yes	1383	209 (15.1%)	0.4	[0.4 - 0.5]	0.4	[0.3 - 0.5]
Recipient						
Cold ischemia time						
≤ 14 hours	1573	387 (24.6%)	1			
> 14 hours	2120	508 (24.0%)	1.0	[0.8 - 1.1]		
Transplant laterality						
Right	1849	442 (23.9%)	1		1	
Left	1872	449 (24.0%)	1.0	[0.9 - 1.2]	1.0	[0.9 - 1.2]
En bloc	41	16 (39.0%)	2.0	[1.1 - 3.9]	2.5	[1.2 - 4.7]

^a: Only bivariate significant variables (p<0.10) were entered in the multivariate model (n=3499).

Hosmer - Lemeshow goodness of fit p-value = 0.32.

Abbreviations: UC, urine culture; CI, confidence interval; GNF, graft non-function; PF, preservation fluid.