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1 **ORIGINAL ARTICLE**

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

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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 Microbiological concordance between PF cultures of kidneys from the same donor

3 When kidney transplant was procured from deceased-donor and contralateral kidney was also  
4 transplanted, we could compare with microbiological data of contralateral kidney transplant  
5 PF cultures (Table 3). Microbiological concordance between kidney transplant PF and  
6 contralateral kidney transplant PF cultures were observed in 72.6% (2,674/3,681) of cases. A  
7 concordance between negative PF cultures was observed in 63.7% (2,345/3,681) of cases. In  
8 8.9% (329/3681) of cases positive kidney transplant PF cultures was completely concordant  
9 with positive contralateral kidney transplant PF cultures, the great majority of samples were  
10 culture-positive with coagulase-negative staphylococci and Enterobacteriaceae. Among  
11 them, 11.8% (39/329) cultures were also in concordance with donor samples, largely with UC  
12 (33/39 - 84.6%). In these concordance cases, microorganisms were mainly Enterobacteriaceae  
13 (37/39- 94.8%).

14

15 Microbiological concordance of kidney transplant PF cultures with donor samples

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

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**1 TRANSPARENCY DECLARATION**

2 All authors: no conflict of interest to declare.

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

	All (N=4487)	Living donors (N=725)	Deceased donors (N=3762)
<b>General characteristics</b>			
Year of transplantation			
2015	872 (19.4%)	149 (20.6%)	723 (19.2%)
2016	3615 (80.6%)	576 (79.4%)	3039 (80.8%)
<b>Kidney procurement activity</b>			
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
<b>Donors</b>			
Age <sup>a</sup> (year)	53.1±17.4	50.3±9.5	53.7±14.7
<b>Donor type</b>			
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 <sup>a</sup> (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
<b>Microbiological analysis in donors</b>			
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 <sup>b</sup>	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 <sup>a</sup> (in hours)	14.2 $\pm$ 7.4	2.2 $\pm$ 1.2	16.1 $\pm$ 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 <sup>a</sup> (years)	51.3 $\pm$ 16.1	45.7 $\pm$ 13.0	52.4 $\pm$ 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 (%). <sup>a</sup>mean  $\pm$  standard deviation. <sup>b</sup>commensal 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%) Enterobacteriae: 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%) Enterobacteriae: 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 <sup>a</sup>
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%)

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different microorganisms: 60/4327 (1.4%)	Enterococci: 48/629 (7.8%) 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%)	Positive blood culture and UC 85/1484 (5.7%)
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<sup>a</sup>: 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 <sup>a</sup>	
			Odds ratio	95%CI [Inferior-Superior]	Odds ratio	95%CI [Inferior-Superior]
<b>General characteristics</b>						
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			
<b>Donor</b>						
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]
<b>Recipient</b>						
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]

<sup>a</sup>: 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.