Clinical Microbiology and Infection xxx (xxxx) xxx

Contents lists available at ScienceDirect

Clinical Microbiology and Infection

journal homepage: www.clinicalmicrobiologyandinfection.org

Original article

Association between unrecognized donor bloodstream infection and outcomes in solid organ transplant recipients: a prospective observational cohort study

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ARTICLE INFO

Article history:
Received 1 August 2025
Received in revised form
11 March 2026
Accepted 19 March 2026
Available online xxx

Editor: M. Paul

Keywords:
Active surveillance system
Bloodstream infection
Carbapenem-resistant Enterobacterales

ABSTRACT

Objectives: The study aimed to evaluate the association between unrecognized donor bloodstream infection (BSI), unknown at organ procurement, and recipient 1-year survival. Incidence of donor-derived infections (DDIs) was assessed as a secondary outcome.
Methods: Prospective study including all solid organ transplant recipients conducted at Mediterranean Institute for Transplantation and Advanced Specialized Therapy from 2016 to 2022. Recipients from donors with unrecognized BSI were compared with unexposed recipients. Data were prospectively collected within our active surveillance system, implemented to promptly recognize donor BSI and manage recipients to mitigate unexpected DDIs. The association between donor unrecognized BSI and recipient 1-year survival was evaluated using survival curves adjusted for confounders at multivariable analysis with Cox proportional-hazard models.
Results: A total of 968 solid organ transplant recipients were included (472 livers, 330 kidneys, 86 hearts, and 80 lungs); 136 (14%) recipients had a donor with unrecognized BSI. Among 150 blood culture

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https://doi.org/10.1016/j.cmi.2026.03.026

Donor-derived infection
Solid organ transplantation

isolates, 67% (100 of 150) were susceptible, whereas 33% (50 of 150) were multidrug-resistant (MDR). Ninety skin contaminants were excluded from analysis. Carbapenem-resistant Enterobacterales (CRE) were the most common MDR microorganisms (20 of 50, 40%). One-year survival probability was comparable between recipients from donors with and without unrecognized BSI (adjusted hazard ratio, 1.32; 95% CI, 0.86–2.03, p 0.12). However, after stratification by microorganism type, recipients from donors with unrecognized MDR BSI had lower 1-year survival probability compared with recipients from blood culture–negative donors (adjusted hazard ratio, 2.29; 95% CI, 1.08–4.87, p 0.04). Five DDIs caused by CRE occurred, all in liver recipients. CRE transmission rate was 25% (5 of 20). These cases were promptly treated with no deaths attributable to the infection.

Conclusions: In our cohort, 14% of recipients received organs from donors with BSI but only five CRE DDIs were observed. Receiving organs from donors with unrecognized MDR BSI may adversely affect recipient outcomes; further studies are needed to determine whether newer antimicrobial agents can mitigate this risk. **Andrea Cona, Clin Microbiol Infect 2026;▪:1**

Introduction

Bloodstream infection (BSI) in donors poses a potential risk of transmission to recipients, but discarding these organs could worsen the donor shortage. Approximately 5–7% of donors have bacteraemia at organ procurement [1]. Guidelines suggest considering organs from bacteraemic donors after 24–48 hours of effective therapy, provided that the recipient is also treated [1–3]. In some cases, donor BSI is unknown at organ procurement. However, transmission risk is relatively low, primarily occurring when surgical prophylaxis does not cover the pathogen identified in donor blood cultures (BCs) [4–6].

In 2015, at the Mediterranean Institute for Transplantation and Advanced Specialized Therapy (ISMETT), we described a cluster of carbapenem-resistant Gram-negative bacteria (GNB) donor-derived infections (DDIs) from unrecognized infection/colonization in donors [7]. To mitigate this risk, a local active surveillance system (LASS) was implemented in December 2015, which optimizes donor testing, data sharing, and recipient management [8].

This study was designed to assess the association between unrecognized BSI in donors and recipient outcomes. The primary aim was to compare 1-year survival probability of recipients from donors with unrecognized BSI as compared with recipients from donors without unrecognized BSI. The secondary aim was to assess the incidence of DDI in recipients from donors with unrecognized BSI.

Methods

Study design and setting

This prospective, single-centre, cohort study was conducted from January 2016 to December 2022 at ISMETT, a solid organ transplant (SOT) centre in Palermo (Italy), which performs heart, lung, liver, kidney, and pancreas transplant (Tx). Recipients from donors with unrecognized BSI were compared with recipients from donors without unrecognized BSI during the same time period. The results are reported following Strengthening the Reporting of Observational Studies in Epidemiology guidelines [9]. The study was conducted according to the Declaration of Helsinki guidelines and was approved by our Institutional Research Review Board (IRRB/06/18; protocol code 001-17612). Consent for organ procurement was obtained from donors or their next of kin, and recipients gave consent for use of their anonymized data for research purposes.

The LASS in our centre consists of:

a) Collection of donor samples (blood and preservation fluid for all donors, urine for kidney donors, and respiratory samples for lung donors) at procurement by our surgical team, and analysed at ISMETT.
b) Rapid communication of preliminary positive results to the on-call infectious diseases physician.
c) Early introduction of targeted therapy after collection of recipient's surveillance culture (blood and surgical drainage fluid for all recipients, respiratory samples for lung Tx, and urine for kidney Tx).
d) Daily reassessment of therapy.

In case of positive donor BC, urgent Gram stain and molecular analyses for rapid identification are performed, using the Vitek MS MALDI-TOF system (VITEK® MS PRIME), and resistance genes detection (Xpert Carba-R assay, Cepheid) for Gram-negatives.

If Gram stain reveals gram-negatives, extended-spectrum prophylaxis is started (since 2019: ceftazidime/avibactam + amikacin or intravenous fosfomycin).

For Gram-positive cocci (GPC), recipients are monitored; daptomycin is initiated if rapid identification (usually within 3 hours) confirms *Staphylococcus aureus* or *Enterococcus faecium*. Caspofungin is started for yeasts.

After final donor strain identification:

- If covered by surgical prophylaxis and recipient's BC are negative, antimicrobials are discontinued.
- If not covered and the recipient's BC results are pending, targeted prophylaxis is continued.
- If DDI is confirmed, therapy is continued for at least 7 days.

All infectious episodes are collected prospectively. Microbiological methods and ISMETT standatd peri-operative prophylaxis section in the supplementary materials.

Participants

All consecutive patients who underwent SOT during the study period were included.

Exposure

SOT recipients from donors with unrecognized BSI, defined as a BSI in a donor that was not identified or diagnosed at organ

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procurement when BC is collected. The unexposed groups comprised of recipients from donors without BSI or BSI that was treated prior to Tx.

Outcome

The primary outcome was survival up to 1 year after Tx.

Data collections and definitions

We collected donor characteristics and recipient demographic and clinical data, including age, gender, Tx reason, days on waiting list, pre-Tx infections and intensive care unit (ICU) stay, Tx type, post-Tx length of ICU stay, microbiological data, rate of infections, antimicrobial therapies, duration of hospitalization, rate of rejection, retransplantation, and mortality.

DDI was defined as 'proven' in case of: (1) absence of pre-Tx infection in the recipient, (2) same microorganism in donor and recipient cultures, and (3) confirmed identity of donor and recipient strains by whole genome sequencing (WGS) [10].

Multidrug-resistant (MDR) organism refers to isolates non-susceptible to at least one agent in three or more antimicrobial categories [11]. MDR organisms included extended-spectrum β-lactamases–producing Enterobacterales (ESBL), carbapenem-resistant Enterobacterales (CRE), carbapenem-resistant *Acinetobacter baumannii* (CRAB), difficult-to-treat *Pseudomonas aeruginosa*, methicillin-resistant *S. aureus*, vancomycin-resistant Enterococci, and azole-resistant *Candida* spp. (defined as strains resistant to fluconazole).

Statistical analysis

Transmission rate was calculated as the number of recipients with proven DDI divided by the number of recipients from donors with unrecognized BSI. Continuous variables were summarized as medians (interquartile range) or mean (standard deviation) and categorical variables as frequencies. Group comparisons were made with nonparametric Wilcoxon rank-sum test and Fisher's exact test. The median follow-up time was estimated using the Kaplan–Meier method, which accounts for censoring of patients lost to follow-up or without events at the end of observation. To evaluate the association between receiving Tx from donors with unrecognized BSI and 1-year recipient survival, adjustment for confounders was performed. Multivariable analysis of the time to events (i.e. all causes death) was performed using Cox proportional-hazard models with demographic, clinical, and laboratory variables (donor BC positive for multisensitive strains, donor BC positive for MDR

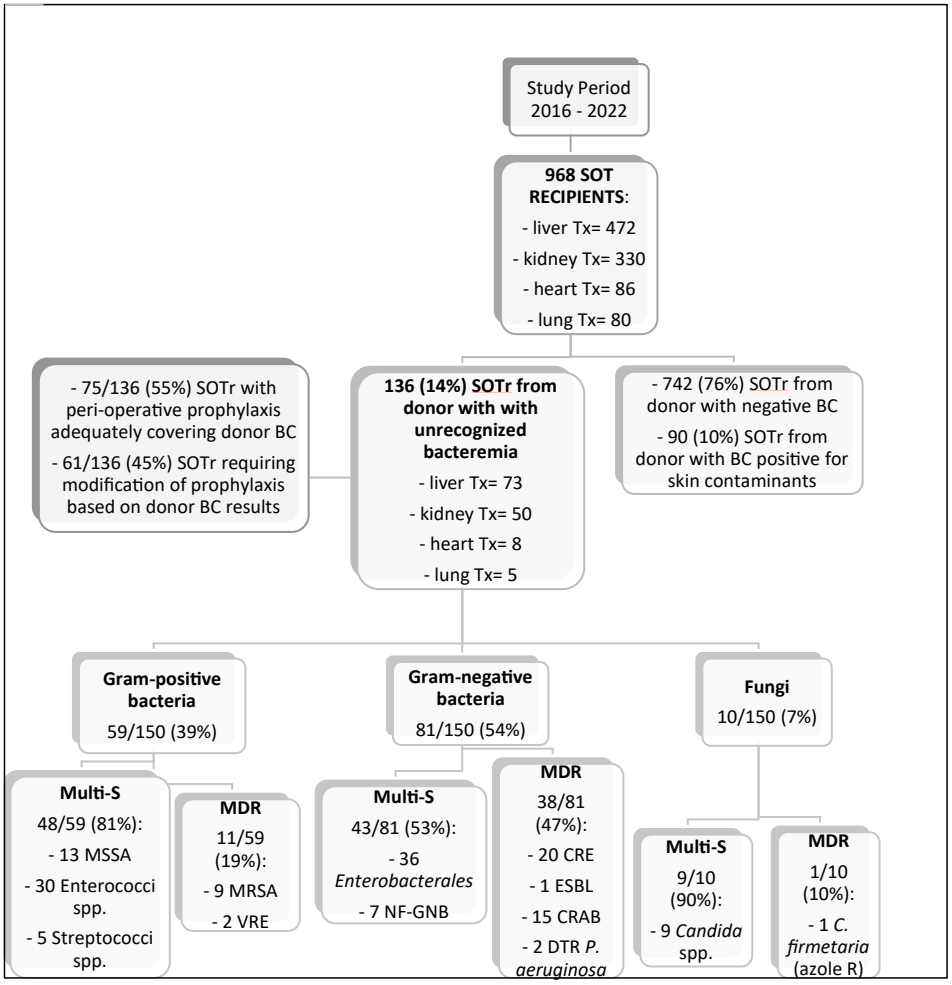

Fig. 1. Study population. BC, blood culture; CRAB, carbapenem-resistant *Acinetobacter baumannii*; CRE, carbapenem-resistant Enterobacterales; DTR, difficult-to-treat; ESBL, extended-spectrum β-lactamases; MDR, multidrug-resistant microorganism; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *Staphylococcus aureus*; NF-GNB, nonfermenting Gram-negative bacteria; Multi-S, multisensitive microorganism; SOT, solid organ transplant; SOTr, Solid Organ Transplant Recipients; Tx, transplant; VRE, vancomycin-resistant Enterococci.

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organisms, recipient age, gender, type of Tx, pre-Tx infections and ICU stay, post-Tx infections, rectal CRE colonization, and retransplantation) as independent variables and stratifying analysis by donor BC results. Final multivariable model was created using a stepwise mixed (i.e. both forward and backward) model selection technique with p value for selection and retention of 0.05. Age was incorporated into the model as a surrogate measure of recipient frailty, given that the Charlson Comorbidity Index was not developed for Tx candidates and thus may fail to fully capture frailty and functional impairment of this population. Statistical significance was set at p value of <0.05. Analyses were performed with a commercially available software program (SAS software version 9.4, and STATA 18.1, MP version, StataCorp. Ltd, College Station, TX).

Table 1
Demographic and clinical characteristics of population

Characteristics	Recipients from donors with positive BC	Recipients from donors with negative BC	All recipients	p value
Recipients, *n* (%)	136 (14.1)	832 (85.9)	968	
Recipient age (y), median (IQR)	53.2 (44–60)	55.5 (45–62)	55 (45–63)	0.23
Recipient gender–male, *n* (%)	86 (63.3)	543 (65.3)	629 (64.9)	0.65
Recipient cause of Tx, *n* (%)				0.59
HCC and other hepatic malignancies	39 (28.7)	188 (22.6)	227 (23.5)	
Metabolic/alcoholic liver disease	12 (8.8)	77 (9.3)	89 (9.2)	
Viral hepatitis	8 (5.9)	46 (5.5)	54 (5.6)	
Biliary tract diseases	4 (2.9)	34 (4.1)	38 (3.9)	
Fulminant hepatitis	1 (0.7)	7 (0.8)	8 (0.8)	
Other liver diseases	4 (2.9)	34 (4.1)	38 (3.9)	
Glomerular or tubulointerstitial kidney diseases	14 (10.3)	59 (7.1)	73 (7.4)	
Polycystic kidney diseases	8 (5.9)	47 (5.7)	55 (5.7)	
Vascular kidney disease	5 (3.7)	25 (3.0)	30 (3.1)	
Unknown-aetiology chronic kidney disease	17 (12.5)	130 (15.6)	147 (15.2)	
Cystic fibrosis	3 (2.2)	20 (2.4)	23 (2.4)	
Interstitial lung disease	1 (0.7)	31 (3.7)	32 (3.3)	
COPD	1 (0.7)	24 (2.9)	25 (2.6)	
Ischaemic heart disease	1 (0.7)	18 (2.2)	19 (2)	
Nonischaemic cardiopathy	7 (5.1)	60 (7.2)	67 (6.9)	
Graft failure	11 (8.1)	32 (3.9)	43 (4.4)	
Recipient infections before Tx, *n* (%)	13 (9.6)	83 (10.0)	96 (9.9)	0.88
Recipient ICU stay before Tx, *n* (%)	8 (5.9)	56 (6.7)	64 (6.6)	0.71
Type of Tx, *n* (%)				0.08
Liver	73 (53.7)	399 (47.9)	472 (49.8)	
Kidney	50 (36.8)	280 (33.7)	330 (34.1)	
Lung	5 (3.7)	75 (9.0)	80 (8.3)	
Heart	8 (5.8)	78 (9.4)	86 (8.8)	
Year of Tx, *n* (%)				0.18
2016	8 (5.8)	107 (12.9)	115 (11.9)	
2017	21 (15.5)	146 (17.5)	167 (17.3)	
2018	20 (14.7)	116 (13.9)	136 (14.1)	
2019	16 (11.9)	114 (13.7)	130 (13.4)	
2020	25 (18.4)	108 (13.0)	133 (13.7)	
2021	27 (19.9)	139 (16.7)	166 (17.1)	
2022	19 (13.8)	102 (12.3)	121 (12.5)	
Recipient on waiting list (d), median (IQR)	148.5 (31–570.5)	154 (36–524)	152.5 (35–529)	0.97
Donor age (y), mean (SD)	53.1 (17)	53.2 (17.8)	53.2 (17.7)	0.96
Donor gender–male, *n* (%)	77 (56.6)	474 (57.0)	551 (56.9)	0.94
Donor cause of death, *n* (%)				0.48
Cerebral haemorrhage	78 (57.4)	492 (59.1)	570 (58.9)	
Ischaemic stroke	16 (11.8)	77 (9.3)	93 (9.6)	
Postanoxic encephalopathy	16 (11.8)	85 (10.2)	101 (10.4)	
Trauma	20 (14.7)	145 (17.4)	165 (17.1)	
Coma	3 (2.2)	9 (2.2)	12 (1.2)	
Other causes	24 (2.1)	3 (1.8)	27 (2.8)	
Recipient ICU LOS after Tx (d), median (IQR)	1.9 (0–5)	2 (0–5)	2 (0–5)	0.41
Recipient time of mechanical ventilation after Tx (h), median (IQR)	0.0 (0.0–11.1)	0.0 (0.0–12.3)	0.0 (0.0–12.12.3)	0.58
Recipient CRE rectal colonization, *n* (%)	60 (44.1)	332 (39.9)	392 (40.5)	0.35
CRE carrier before TX	8 (5.9)	64 (7.7)	72 (7.4)	0.45
CRE carrier after Tx	52 (38.2)	268 (32.2)	320 (33.1)	0.17
Recipient non–donor-derived infection during hospital stay, *n* (%)	39 (28.7)	220 (26.4)	259 (26.8)	0.59
Non–donor-derived CRE infection	11 (8.1)	75 (9.0)	86 (8.9)	0.31
Recipient LOS (d), median (IQR)	18 (11–37)	17 (10–33)	17 (10–33)	0.24
Rejection, *n* (%)	33 (24.3)	193 (23.2)	226 (23.3)	0.78
Retransplantation, *n* (%)	6 (4.4)	25 (3.0)	31 (3.2)	0.39
Recipient in-hospital mortality, *n* (%)	13 (9.6)	47 (5.6)	60 (6.2)	0.08
Recipient 30-d mortality, *n* (%)	4 (2.9)	16 (1.9)	20 (2.0)	0.44
Recipient 90-d mortality, *n* (%)	11 (8.1)	40 (4.8)	51 (5.3)	0.11
Recipient 1-y mortality, *n* (%)	17 (12.5)	69 (8.3)	86 (98.9)	0.11
Recipient overall mortality, *n* (%)	27 (19.9)	120 (14.4)	147 (15.2)	0.102

BC, blood culture; COPD: Chronic obstructive pulmonary disease; CRE, carbapenem-resistant Enterobacterales; HCC, Hepatocellular carcinoma; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; Tx, transplant.

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Results

Study population

During the study period, 968 SOT recipients were included (Fig. 1).

Overall, 136 of 968 (14%) recipients received organs from 97 donors with unrecognized BSI. Among 150 microorganisms isolated in donors BC (19 recipients had a donor with polymicrobial BSI), 54% (81 of 150) were Gram-negative, 39% (59 of 150) Gram-positive, and 7% (10 of 150) fungi. Multidrug resistance was observed in 47% (38 of 81) of GNB, 19% (11 of 59) of Gram-positive isolates, and 10% (1 of 10) of fungi (Table S1; Fig. 1). Ninety coagulase-negative Staphylococci and other skin flora bacteria isolated in donor BC were considered contaminants and excluded, with no transmissions observed.

Among MDR organisms, the most common pathogens were CRE (40%, 20 of 50), CRAB (30%, 15 of 50), and methicillin-resistant *S. aureus* (18%, 9 of 50) (sequence type [ST] 1).

Clinical outcomes

Clinical and demographic characteristics were comparable between recipients from donors with and without unrecognized BSI. No differences were observed in hospital, 30-day, or 90-day mortality, and graft survival (Tables 1 and 2).

Table 2
Comparison of patients who survived vs did not survive at 1-year assessment

Characteristics	Survived	Did not survive	Overall	p value
Patients, *n* (%)	882 (91.1)	86 (8.9)	968	
Recipient age (y), median (IQR)	55 (45–62)	58.5 (46–62)	55 (45–62)	0.24
Recipient gender–male, *n* (%)	598 (67.8)	31 (36.0)	629 (65.0)	<0.05
Recipient cause of Tx, *n* (%)				<0.05
HCC and other hepatic malignancies	203 (23.0)	24 (27.9)	227 (23.5)	
Metabolic/alcoholic liver disease	82 (9.3)	7 (8.1)	89 (9.2)	
Viral hepatitis	46 (5.2)	8 (9.3)	54 (5.6)	
Biliary tract diseases	37 (4.2)	1 (1.2)	38 (3.9)	
Fulminant hepatitis	7 (0.8)	1 (1.2)	8 (0.8)	
Other liver diseases	34 (3.6)	4 (4.7)	38 (3.9)	
Glomerular or tubulointerstitial kidney diseases	72 (8.2)	1 (1.2)	73 (7.4)	
Polycystic kidney diseases	55 (6.2)	0 (0.0)	55 (5.7)	
Vascular kidney disease	30 (3.4)	0 (0.0)	30 (3.1)	
Unknown-aetiology chronic kidney disease	141 (16.0)	6 (7.0)	147 (15.2)	
Cystic fibrosis	17 (1.9)	6 (7.0)	23 (2.4)	
Interstitial lung disease	25 (2.8)	7 (8.1)	32 (3.3)	
COPD	24 (2.7)	1 (1.2)	25 (2.6)	
Ischaemic heart disease	16 (1.8)	2 (2.3)	19 (2.0)	
Nonischaemic cardiopathy	56 (6.3)	11 (12.8)	67 (6.9)	
Graft failure	37 (4.2)	6 (7.0)	43 (4.4)	
Recipient infections before Tx, *n* (%)	73 (8.3)	23 (26.7)	96 (9.9)	<0.05
Recipient ICU stay before Tx, *n* (%)	45 (5.1)	19 (22.1)	64 (6.6)	<0.05
Type of Tx, *n* (%)				<0.05
Liver	421 (47.7)	51 (59.3)	472 (48.8)	
Kidney	323 (36.6)	7 (8.1)	330 (34.1)	
Lung	66 (7.5)	14 (16.3)	80 (8.3)	
Heart	72 (8.2)	14 (16.3)	86 (8.9)	
Year of Tx, *n* (%)				0.44
2016	100 (11.3)	15 (17.4)	115 (11.9)	
2017	156 (17.7)	11 (12.8)	167 (17.3)	
2018	121 (13.7)	15 (17.4)	136 (14.1)	
2019	120 (13.6)	10 (11.6)	130 (13.4)	
2020	119 (13.5)	14 (16.3)	133 (13.7)	
2021	154 (17.5)	12 (14.0)	166 (17.1)	
2022	112 (12.7)	9 (10.5)	121 (12.5)	
Recipient on waiting list (d), median (IQR)	158 (38–541)	90 (18–392)	153 (35–529)	<0.05
Donor age (y), median (IQR)	54 (42–66)	57.5 (44–68)	55 (42–67)	0.26
Donor gender–male, *n* (%)	498 (56.5)	53 (61.6)	551 (56.9)	0.34
Donor cause of death, *n* (%)				0.08
Cerebral haemorrhage	526 (59.6)	44 (51.2)	570 (58.9)	
Ischaemic stroke	84 (9.6)	9 (10.5)	93 (9.6)	
Postanoxic encephalopathy	84 (9.6)	17 (19.8)	101 (10.4)	
Trauma	151 (17.1)	14 (16.2)	165 (17.1)	
Coma	11 (1.2)	1 (1.6)	12 (1.2)	
Other causes	26 (2.9)	1 (1.6)	27 (2.8)	
Recipient ICU LOS after Tx (d), median (IQR)	1.9 (0–4.6)	5.4 (1.8–20.3)	2.1 (0–12.4)	<0.05
Recipient time of mechanical ventilation after Tx (h), median (IQR)	0.0 (0.0–7.5)	33.3 (0.0–486)	0.0 (0.0–12.3)	<0.05
Recipient CRE rectal colonization, *n* (%)	351 (39.8)	41 (47.7)	392 (40.5)	0.16
CRE carrier before Tx	58 (6.6)	14 (16.3)	72 (7.4)	<0.05
CRE carrier after Tx	293 (33.2)	27 (31.4)	320 (33.1)	0.73
Recipient non–donor-derived infection during hospital stay, *n* (%)	208 (23.6)	51 (59.3)	259 (26.8)	<0.05
Non–donor-derived CRE infection	62 (7.0)	29 (33.7)	91 (9.4)	<0.05
Recipient LOS (d), median (IQR)	16 (10–29)	45 (13–85)	17 (10–32)	<0.05
Rejection, *n* (%)	207 (23.8)	19 (22.6)	226 (23.7)	0.81
Retransplantation, *n* (%)	25 (2.8)	6 (7.0)	31 (3.2)	<0.05

COPD: Chronic obstructive pulmonary disease; CRE, carbapenem-resistant Enterobacterales; HCC, Hepatocellular carcinoma; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; Tx, transplant.

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One-year survival probability, adjusted for confounders, was comparable between the two groups (adjusted hazard ratio [aHR], 1.32; 95% CI, 0.86–2.03; p 0.12; Table 3; Fig. 2). After stratification by microorganism type in donor BC, recipients of grafts from donors with unrecognized MDR BSI had a lower 1-year survival probability compared with recipients from BC-negative donors (aHR, 2.29; 95% CI, 1.08–4.87; p 0.04) (Table 3; Fig. 3). No difference was observed among recipients from donors with BC positive for multisensitive organisms and those from donors with negative BC (aHR, 1.34; 95% CI, 0.65–2.72; p 0.62) (Table 3; Fig. 3).

Transmission rate

A total of five DDIs occurred, confirmed by WGS analysis (high sequence similarity: 99.6%, 99.6%, 99.4%, 99.4%, and 94.6%) (tables S2 and S3), corresponding to an overall transmission rate of 3.7% (5 of 136). All DDIs occurred in liver recipients, with a transmission rate of 6.9% (5 of 73). No transmissions were observed among kidney, heart, or lung recipients. Three additional cases of suspected DDI due to KPC-producing *Klebsiella pneumoniae* were identified in two kidney and one liver Tx but ST was different and WGS did not confirm the donor origin of the strains (low sequence similarity: 23.5%, 60%, and 90.2%).

Analysing transmission rate by microorganism, MDR GPC and fungi in donor BC did not result in DDIs, whereas MDR GNB had a transmission rate of 13.2% (5 of 38).

Despite extended-spectrum prophylaxis, five CRE DDIs, confirmed by WGS (Tables S2 and S3; Fig. 4), occurred in liver Tx recipients: four caused by KPC-producing *Klebsiella pneumoniae*, and one by metallo-β-lactamase–producing *Enterobacter aerogenes* (Table S2). All were detected within 2 days after Tx through surveillance cultures; most patients were asymptomatic, promptly treated, and none died from infection. One patient died 2 months after Tx from Tx-related complications.

Additionally, nine recipients at risk for MDR GPC DDIs received targeted prophylaxis, resulting in no transmissions. Treatment continued until negative BCs on days 2 and 5, preventing any DDIs.

Discussion

This study prospectively included all patients that underwent SOT from 2016 to 2022 and compared survival probability among recipients from donors with unrecognized BSI and those from donors without BSI, managed under our LASS. Among 968 recipients, 14% received organs from bacteraemic donors, with 33% involving MDR organisms. Survival was comparable between recipients from donors with and without unrecognized BSI, supporting the effectiveness of LASS. However, transplantation from donors with MDR bacteraemia was associated with slightly lower 1-year survival probability, suggesting that careful risk–benefit assessment may be warranted when considering organs from such donors. Only five DDIs occurred, all CRE in liver recipients, with a 25% CRE transmission rate and no attributable mortality.

Our study found a slightly higher rate of donor bacteraemia than previous reports. This may be partly attributed to the LASS implemented at our centre as active surveillance systems are more sensitive than passive systems because of more systematic collection of samples, enhanced communication, and centralized microbiological testing. Other factors may include donor characteristics, local epidemiology, or study design differences. In our cohort, 5% (50 of 968) of our recipients received an organ from a donor with MDR bacteraemia, reflecting the prevalence of MDR GNB in our geographical area [12–16]. In our study, despite a 25% CRE transmission rate, early recognition and prompt initiation of targeted prophylaxis prevented unfavourable outcomes. Svoronos et al. [17] recently showed the benefit of preventive antibiotic therapy in a retrospective study of 56 kidney recipients from donors with positive BC. Among 23 treated recipients, no transmissions occurred.

In our population, all DDIs were caused by MDR GNB, whereas other microorganisms were not associated with transmission, and occurred only in liver recipients, suggesting a potentially increased vulnerability of this population. Our study demonstrated comparable survival between recipients of organs from donors with and without BSI. This finding is concordant with available literature [18–20]. In particular, Siddiqi et al. [18], retrieving data from the United Network for Organ Sharing database, reported that positive donor BCs were not associated with reduced survival in heart recipients. These results have important clinical implications, particularly in the context of organ shortages, as they support the judicious use of organs from bacteraemic donors under well-defined protocols. MDR organism DDIs are reported less but can have severe outcomes. Lewis and Sifri [21] reported a 52% transmission rate for MDR GNB DDIs, with 59% resulting in death or graft loss.

As outlined by Pouch and Ison [22], risk mitigation strategies, including effective donor and recipient management, are essential to reduce the clinical consequences of MDR DDI.

The large cohort of 968 recipients enhances the reliability and generalizability of our findings. Another significant strength is the LASS implemented at ISMETT based on effective communication, systematic data sharing, and standardized recipient management. Centralization of donor samples processing at ISMETT enables the Tx infectious diseases team to access microbiological results more efficiently and in a timely manner, supporting prompt decision-

Table 3
Multivariate regression analysis of factors associated with survival probability

Factors	aHR[a]	95% CI	p value
Donor BC with MDR (compared with donor BC negative)	2.29	1.08–4.87	0.04
Donor BC with MultiS (compared with donor BC negative)	1.34	0.65–2.72	0.62
Recipient age, per 1 y older	1.03	1.01–1.05	0.003
Recipient gender, male	0.32	0.20–0.51	<0.001
Type of Tx			
Heart Tx (compared with kidney Tx)	4.23	1.64–10.93	0.003
Liver Tx (compared with kidney Tx)	4.57	2.06–10.14	<0.001
Lung Tx (compared with kidney Tx)	6.58	2.47–17.56	<0.001
Recipient pre-Tx ICU stay	2.71	1.46–5.04	0.002
Recipient days in ICU after Tx	1.02	1.01–1.03	0.01
Recipient non–donor-derived CRE infection	4.35	2.49–7.59	<0.001

aHR, adjusted hazard ratio; BC, blood culture; CRE, carbapenem-resistant Enterobacterales; ICU, intensive care unit; MDR, multidrug-resistant microorganisms; MultiS, multisensitive microorganisms; Tx, transplant.
[a] Adjusted for all the factors showed in table.

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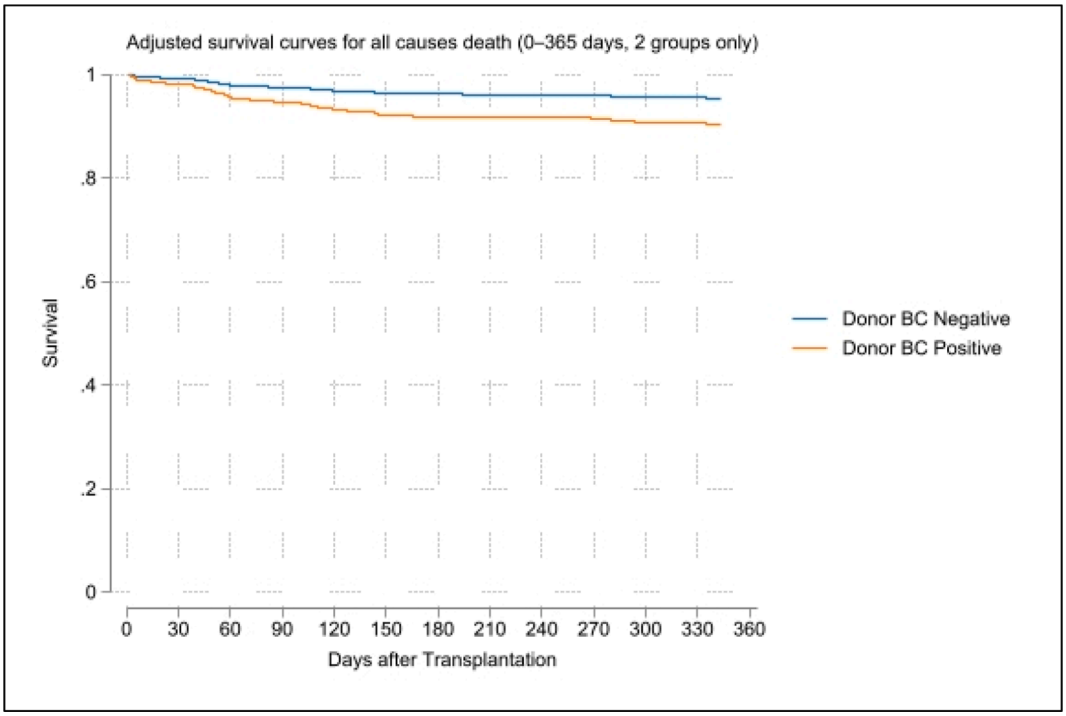

Fig. 2. Adjusted 1-year survival probability of recipients stratified by donor blood culture (BC) results. Adjusted survival curves derived from a Cox proportional hazards model. The p values correspond to Wald tests from the multivariable Cox model.

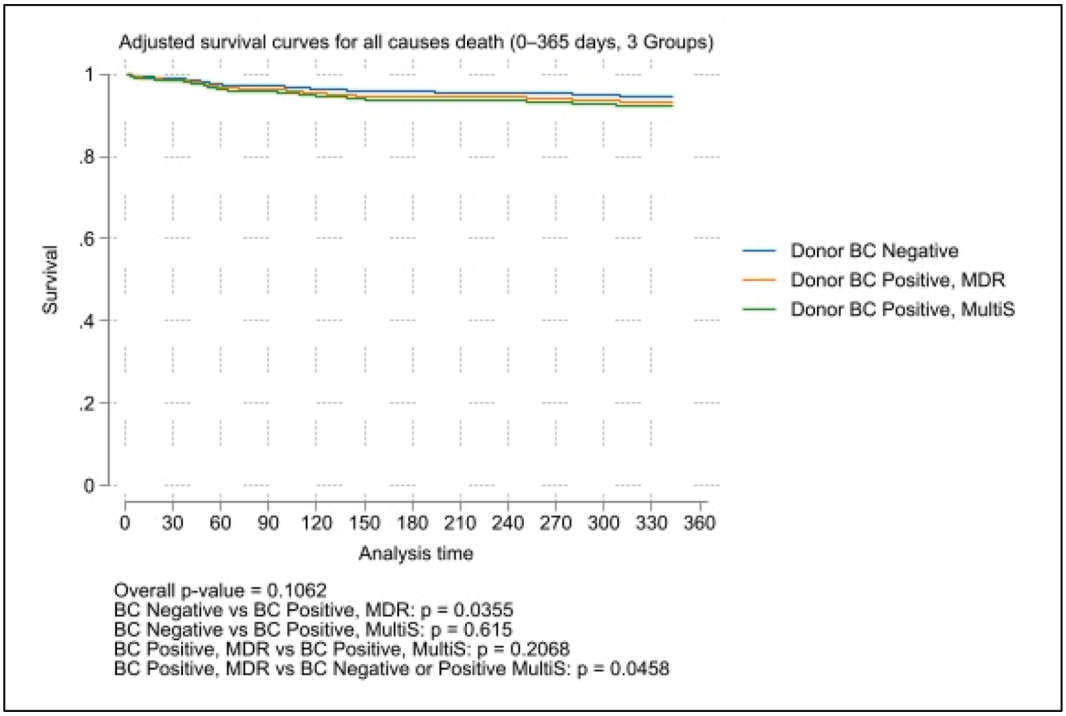

Fig. 3. Adjusted 1-year survival probability of recipients stratified by type of microorganism in donor blood culture (BC). Adjusted survival curves derived from a Cox proportional hazards model. The p values correspond to Wald tests from the multivariable Cox model. MDR, multidrug-resistant microorganisms; MultiS, multisensitive microorganisms.

making for DDI management. The use of WGS to confirm DDIs further strengthens the scientific rigour of our study. Advanced diagnostic tools, including molecular pathogen identification and WGS, are increasingly valuable in managing infections [23].

Another strength of our study is the inclusion of donors with unrecognized BSI due to MDR organisms, making it relevant in the context of the worldwide rise of MDR infections. In our cohort, recipients of organs from donors with MDR bacteraemia had a lower

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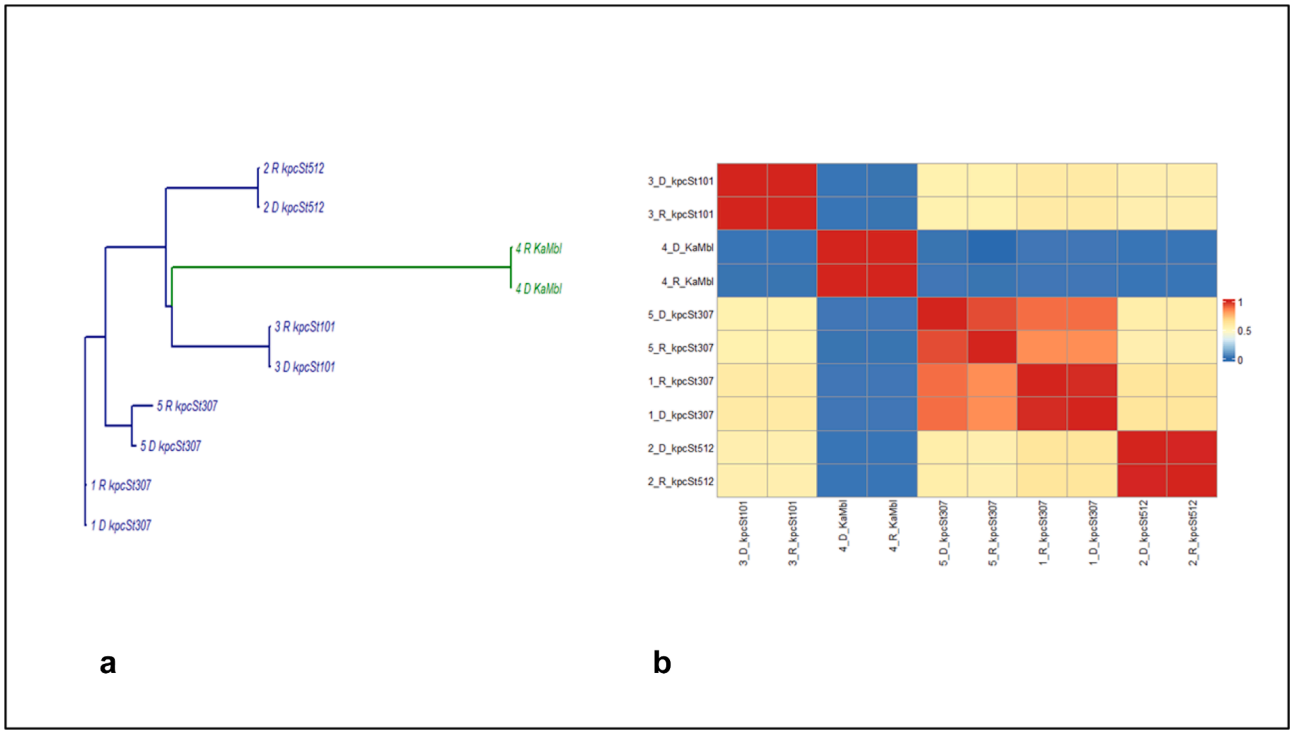

Fig. 4. Results of whole genome sequencing analysis. (a) Dendrogram showing hierarchical clustering of *Klebsiella pneumoniae* isolates based on genomic similarity. Each label indicates the isolate number, role (R indicates recipient, D indicates donor), and sequence type. The vertical proximity of samples reflects their similarity, whereas the length of the horizontal branches indicates dissimilarity; longer branches denote greater distance between samples. Branches of the same colour group similar samples. Samples with Single Nucleotide Polymorphisms (SNPs) ≤20 are considered identical. (b) Heatmap representing pairwise percentage identity between isolates. Each square corresponds to the identity relationship between two samples, with coordinates indicating the compared isolates. Colours range from blue (0 = 0% identity) to red (1 = 100% identity), according to the scale bar. Donor-recipient pair relationships with depth of coverage (DoC) and SNP: 1_D_kpcSt307 (DoC 30) and 1_R_kpcSt307 (DoC 33) SNP 9; 2_D_kpcSt5122 (DoC 35) and R_kpcSt512 (DoC 34) SNP 4; 3_D_kpcSt101 (DoC 36) and 3_R_kpcSt101 (DoC 30) SNP 1, 4_D_KaMbl (DoC 48) and 4_R_KaMbl (DoC 36) SNP 2, 5_D_kpcSt307 (DoC 31) and 5_R_kpcSt307 (DoC 30) SNP 17.

1-year survival probability but, during the initial phase of the study, newer β-lactam/β-lactamase inhibitor combinations active against CRE were not available. Recent data indicate that mortality among patients with CRE BSI treated with newer agents is comparable with that of infections caused by susceptible strains. Future studies should specifically assess the impact of these newer antibiotics in the Tx setting.

Moreover, the reduced survival probability observed in this group may be considered a surrogate marker of the donor's clinical condition prior to organ procurement and of subsequent graft functionality. Unfortunately, detailed data on donor clinical status and graft function were not available in our study, preventing adjustment for these potentially important confounders. Future studies incorporating these variables are needed to clarify their contribution to post-Tx outcomes. Additionally, the relatively small number in the group of recipients from donors with MDR bacteraemia may have limited statistical power.

Our study has other limitations. As a single-centre study, our findings may not be generalized to all SOT centres and require confirmation in multicentre studies. The high proportion of CRAB-positive donors may reflect local epidemiology or donor-related factors, although this was not formally assessed in our study. Another limit is that our study was conducted in a region with a high prevalence of MDR GNB, which may limit the generalizability of our findings to areas with different rates of MDR infections. Furthermore, ISMETT's unique characteristics, such as its active surveillance system, institutional antibiotic prescribing practices, availability of rapid molecular diagnostic and WGS, may further limit generalizability. As the study period coincided with LASS implementation and events were limited, temporal effects could not be assessed. However, a previously reported cluster of carbapenem-resistant GNB DDIs at our centre occurred prior to LASS introduction, linked to unrecognized donor infection and miscommunication of results, has already been described [7]. Lastly, some variables that have been shown to play a potential role in previous studies, such as Charlson Comorbidity Index score and cold ischaemic time, were not retrievable in our dataset.

In conclusion, our study offers important findings regarding the safety and feasibility of transplanting organs from donors with unrecognized BSI under well-established clinical protocols. Even in setting with high prevalence of MDR infections, early targeted therapy and active surveillance can mitigate transmission risk, although further studies are needed to confirm long-term safety.

CRediT authorship contribution statement

Andrea Cona: Conception, Data curation, Investigation, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review and editing. Caterina Curatolo: Data curation, Writing – original draft, Writing – review and editing, Validation. Paola Giordani: Data curation, Writing – review and editing, Validation. Flavia D'Andrea: Data curation, Writing – review and editing, Validation. Diego Bellavia: Formal analysis, Methodology, Software Supervision, Writing – original draft, Writing – review and editing, Validation. Maria Campanella: Data curation, Validation. Elena Conoscenti: Data curation, Validation. Sabina Caruso: Data curation, Validation. Giovanni Mulè: Data curation, Validation. Francesco Monaco: Data curation, Validation. Francesca Cardinale: Data curation, Validation. Giuseppina Di Martino: Data curation, Validation. Nicola Cuscino: Validation.

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Floriana Barbera: Data curation, Validation. Daniele Di Carlo: Data curation, Validation. Nicola Coppola: Validation. Raffaele Bruno: Validation. Giuseppe Nunnari: Validation. Salvatore Gruttadauria: Validation. Antonio Arcadipane: Validation. Angelo Luca: Validation. Malgorzata Mikulska: Methodology, Supervision, Validation. Paolo Antonio Grossi: Methodology, Supervision, Validation. Alessandra Mularoni: Conception, Data curation, Investigation, Formal analysis, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review and editing.

Transparency declaration

Potential conflict of interest

The authors declare that they have no conflicts of interest.

Financial report

This study was supported by the Italian Ministry of Health, Rome, Italy (Ricerca Corrente: RC 2025, Linea 2).

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgements

The results of this study were presented as Oral Presentation at the European Congress of Clinical Microbiology and Infectious Diseases (ESCMID GLOBAL 2025) in Vienna, Austria. The authors wish to thank all the patients and staff that participated in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cmi.2026.03.026.

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