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ORIGINAL ARTICLE

Bloodstream infection caused by *S. aureus* in patients with cancer: a 10-year longitudinal single-center study

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Abstract

Background *Staphylococcus aureus* bloodstream infections (SABIs) represent a significant cause of morbidity and mortality in cancer patients. In this study, we compared infection characteristics and evaluated epidemiology and risk factors associated to SABIs and 30-day attributable mortality in cancer patients.

Methods Clinical and microbiological data from patients with cancer and positive blood cultures for *S. aureus* were retrieved during a 10-year period at an oncology reference center. Analyses were performed according to type of malignancy and infection with methicillin-resistant *S. aureus* (MRSA). Data was evaluated using competing risk analyses to identify risk factors associated to 30-day mortality and used to create a point system for mortality risk stratification.

Results We included 450 patients and MRSA was documented in 21.1%. Hospital-acquired infection, healthcare-associated pneumonia, and type-2 diabetes were associated to MRSA. In patients with hematologic malignancies, MRSA was more frequent if hospital-acquired, but less likely in primary bacteremia. Variables associated to mortality included abdominal source of infection, hematologic malignancy, MRSA, glucose levels > 140 mg/dL, and infectious endocarditis; catheter removal and initiation of adequate treatment within 48 h of positive blood culture were protective factors. From our designed mortality prediction scale, patients with a score > 3 had a 70.23% (95%CI 47.2–85.3%) probability of infection-related death at 30 days.

Conclusion SABIs are a significant health burden for cancer patients. Risk factors for SABI-related mortality in this population are varied and impose a challenge for management to improve patient's outcomes. Risk stratification might be useful to evaluate 30-day mortality risk.

Keywords *Staphylococcus aureus* bloodstream infection · Cancer complications · Hematologic malignancies · Infection-related mortality in cancer · MRSA

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Introduction

Staphylococcus aureus (*S. aureus*) is the second leading cause of bloodstream infections (BSIs) [1, 2] with a significant proportion of cases developing severe complications [3]. Mortality attributable to *S. aureus* bloodstream infection (SABI) within 30 days of infection has been estimated up to 30% in the general population [4]. Methicillin-resistant *S. aureus* (MRSA) infection and an increased number of comorbidities in cancer patients have been consistently associated to worse outcomes [4, 5].

The use of chemotherapy, either alone or in combination with radiotherapy, and/or surgery are common procedures used for the treatment of cancer, with increasing disease-free and overall survival in most neoplasias during the last two decades [6]. However, these therapeutic modalities may lead to healthcare-associated infections, increasing morbidity, mortality, and health-related costs [4–6].

SABIs in cancer patients are a significant cause of morbidity and mortality in both neutropenic and non-neutropenic patients [7, 8]. Known risk factors for mortality attributable to SABI in this population include hematologic malignancies, MRSA infection, inadequate empiric therapy, hospital-acquired infections, and septic shock, amongst others. Data and clinical course of SABI in hematologic patients have been well documented [9]; however, data on solid malignancies has not been extensively evaluated and studies that compare clinical characteristics and outcomes between these groups of patients are scarce. Here, using data collected from our BSI surveillance program, we studied BSIs caused by methicillin-sensitive *S. aureus (*MSSA) and MRSA in cancer patients to evaluate incidence, risk factors, clinical course, and 30-day mortality related to SABIs in this population.

Methods

Study population and setting

The Instituto Nacional de Cancerologia (INCan) is a 146-bed teaching hospital for adult patients with cancer. We screened all positive, non-duplicate, blood cultures for *S. aureus* from 2006 to 2015 amongst all positive blood cultures collected at INCan during the study period. Electronic medical records were reviewed for clinical, microbiological, and outcome-related information. Subjects who had either insufficient data or who were determined to have a positive blood culture due to contamination were excluded. Follow-up was comprised from the moment at which the BSI was diagnosed via blood culture up to 1 year to record SABI relapses, infectious and oncologic-related complications, and mortality.

Microbiological identification and susceptibility testing

Blood samples were cultured in BD BACTEC™ blood culture media and plated in blood, chocolate, and MacConkey agar for microbiological identification. Identification of isolates was performed with Microscan (Siemens Laboratory Diagnostics) from 2008 to 2010. In 2011, the automated equipment was changed to BD Phoenix (Becton, Dickinson and Co.). Since 2014, isolates have been processed utilizing matrix-assisted laser desorption/ionization-time-of-flight mass spectrometry (MALDI-TOF MS). Susceptibility to antimicrobial agents was determined according to current Clinical Laboratory Standards Institute (CLSI) criteria. Susceptibility tests were identified by means of an automated microbiology system (BD, Phoenix 100, USA).

Definition of studied variables and outcomes

BSI was defined as laboratory-confirmed isolation of *S. aureus* from blood samples classified as (A) Central Line-associated BSI (CLABSI) if time to positivity between blood cultures taken from central catheter was ≥ 2 h from that of the peripheral line, along with signs of systemic infection with no other apparent source, and/or catheter-tip culture positivity for the same organisms after catheter removal, and/or signs and symptoms of catheter entry-site infection with cultures showing the same strain isolated from the blood. (B) Secondary BSI was diagnosed when there was another source of infection with bloodstream seeding related to urinary tract, skin, soft tissue, or abdominal infection, pneumonia, or any other source. (C) Primary BSI occurred when no underlying infection was diagnosed despite intense clinical and radiological workout. (D) Persistent bacteremia was defined by the continuous presence of bacteria in the bloodstream > 48 h after administration of appropriate treatment. All bacteremias were further classified as hospital-acquired, if diagnosis occurred ≥ 48 h after patients' admission, or healthcare-associated, if patients were under chemotherapy, were using a central venous catheter (CVC), or had undergone an invasive procedure in the last 30 days.

We also evaluated 30-day SABI-related mortality and 6-month all-cause mortality, from the moment of microbiological confirmation to death. Additional outcome measures included *S. aureus*-related intensive care unit (ICU) admission; relapse of *S. aureus* bacteremia, defined as a second case of bacteremia during 1-year follow-up in a patient with proven microbiological recovery; and infectious endocarditis (IE), defined by Duke's modified criteria as either confirmed or possible IE [10]. Adequate treatment for *S. aureus* infection was defined as initiation of treatment with specific/targeted antimicrobial agents (e.g., vancomycin, dicloxacillin) within the first 48 h of the first positive blood culture [11].

Healthcare-associated pneumonia was defined as an episode of radiographically confirmed pneumonia acquired ≥ 48 h of hospital stay; pneumonia acquired before that time frame was defined as community-acquired. Abdominal source was considered as any infectious foci originated in the abdominal cavity, as abscess, cholangitis, peritonitis, or organ and space surgical infection; in hematologic patients, abdominal source also included neutropenic colitis. Severe neutropenia was defined as < 500 neutrophils/mm^3 in a blood specimen at the date of positive blood culture.

Statistical analysis

Demographic and laboratory data were described using mean and standard deviation (SD) or with median and interquartile range as appropriate; categorical variables were described using frequencies. Chi-squared, Student's *t*, and *U* of Mann-Whitney tests were used where appropriate. First, we fitted logistic regression analyses to develop an explanatory model for MRSA infections; variables were removed from the model until maximizing the adjusted r^2 value for the dependent variable in both the overall population and in patients with hematologic malignancies.

We evaluated mortality differences between MRSA and MSSA infections using survival analysis, calculating time until death at 30 days or censorship as outcome variables and using log-rank tests for comparisons in Kaplan-Meier curves. Cox proportional risk regression models were fitted to evaluate risk factors associated to 30-day SABI-attributable mortality, adjusted using the Charlson Comorbidity Index [12] to account for the effect of age and comorbidity. To adjust for competing risk of death related to non-infectious causes, a second model was fitted using semi-parametric proportional hazards regression as proposed by Fine and Gray et al. [13]. We used beta coefficients from competing risk models to construct a point system and aggregated the score to evaluate subjects at baseline for 30-day mortality according to stratified scores. Comparisons were evaluated using 95% confidence intervals (95%CI) and a p value < 0.05 was considered statistically significant. Statistical analyses were performed in SPSS software for Windows® (SPSS Inc., Chicago, IL, version 21.0), GraphPad Prism version 6.0, and R version 3.4.1 using *cmprsk* and *survival* packages [13].

Results

Study subjects

A total of 5155 positive blood cultures were recorded during the study period, of which 521 (10.1%) were positive for *S. aureus*. Fifty-nine subjects were removed because of incomplete data and 12 because of blood culture contamination. After conducting initial file reviews, 450 patients completed inclusion criteria and were included in the analysis (Fig. 1). BSIs were classified as CLABSI in 258 patients (57.3%), secondary bacteremia in 118 (26.2%), and primary bacteremia in 74 patients (16.4%). Persistent bacteremia was observed in 51 (11.3%). Most of these infections were detected on ambulatory patients and classified as healthcare-associated (N = 335). We classified 115 cases (25.6%) as hospital-acquired, with higher rates of MRSA (48.7%). Amongst the evaluated subjects, 135 (30.0%) had an hematological malignancy, 167 (37.1%) had breast cancer, 36 (8.0%) had gastrointestinal malignancies, 21 (4.7%) had testicular cancer, and 91 (20.2%) had tumors in other body locations.

Evaluation according to MSSA vs. MRSA status

We identified MSSA in 355 (78.8%) subjects; 95 (21.1%) had confirmed MRSA. MSSA BSIs decreased over time, without a significant reduction in *S. aureus*-related mortality; however, we found a significant decrease in 30-day mortality rate for MRSA over the 10-year period (Fig. 2). We observed no significant differences in age and sex between patients with MSSA and MRSA; hematologic malignancies were significantly more frequent in subjects with MRSA in comparison to MSSA (42.1 vs. 26.8%, p = 0.004), while subjects with MRSA had lower rate of solid malignancies (57.9 vs. 73.2%, p < 0.001, Table 1).

Patients with MRSA had a significantly higher frequency of diabetes mellitus (18.9 vs. 10.4%, p = 0.024); as expected, most cases of MRSA (58.9%) were acquired during hospitalization, while MSSA was mostly healthcare-associated (83.4%) and related to CVC. When considering the source of infection, most cases of MRSA were associated to healthcare-associated pneumonia (20.0%), while catheter-related infections mostly yielded positive MSSA culture (60.0%). Patients with MRSA were also more likely to have neutropenia < 500 cells/mm^3 and coinfection with gram-positive cocci different than *S. aureus* or gram-negative bacteria. All of these neutropenic patients except three had hematological malignancy, and ten had received chemotherapy within the last 30 days (35.7%). All MRSA patients were treated as inpatients and had a higher length of hospital stay when compared to MSSA (p < 0.001), except for two patients who were terminally ill and opted for no further treatment.

In multivariate logistic regression analyses, we identified associations between hospital-acquired infection, healthcare-associated pneumonia, and diabetes with MRSA infection after adjustment by Charlson Comorbidity Index and glycemia > 140 mg/dL. In a second model, which only included patients with hematologic malignancies, we identified hospital-acquired infection as a risk factor for MRSA; primary bacteremia was less likely to be found in MRSA patients. The variability of the composite outcome measure explained by models 1 and 2 was 23.9 and 19%, respectively (Supplementary Material).

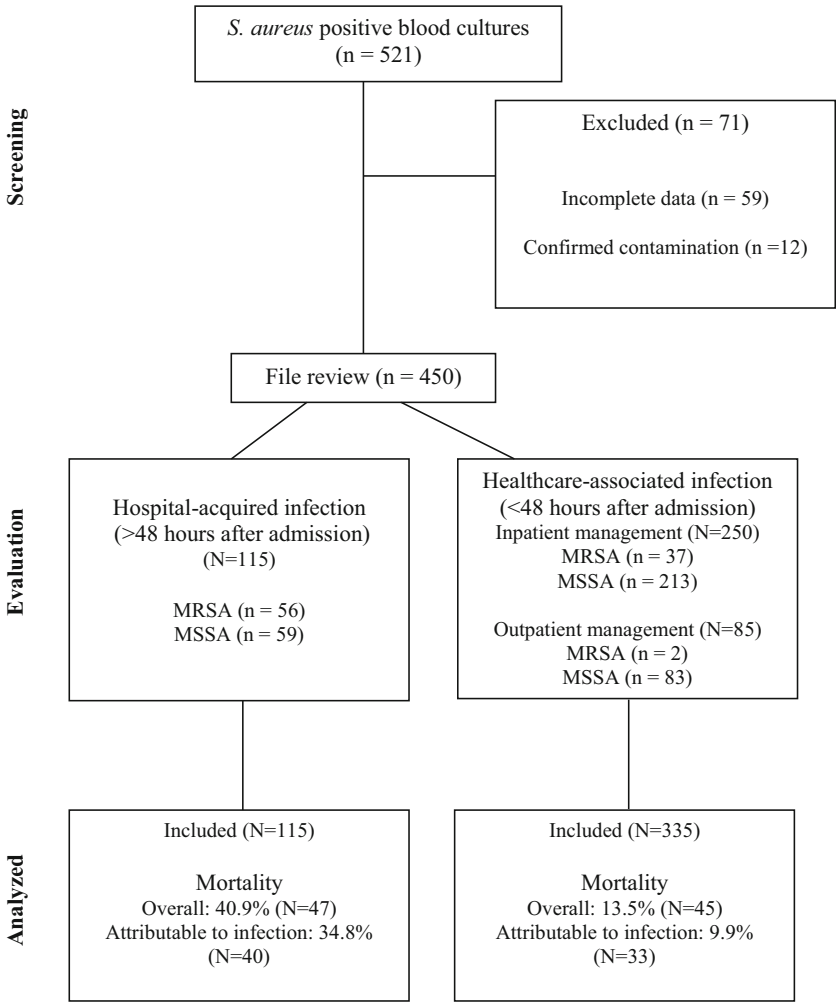

Fig. 1 Classification of *S. aureus* bloodstream infections according to type of bacteremia, management (inpatient or outpatient), and antibiotic susceptibility

Infection-related outcomes

We observed 124 all-cause deaths over 117,997 days of patient follow-up of which 92 occurred at 30 days, for an estimated 30-day mortality of 20.4%; 75 were SABI-related at 30 days (16.7%). Mortality was significantly higher in MRSA infection in both, solid and hematologic malignancies ($p < 0.001$); however, the difference in mortality was steeper for patients with hematologic malignancies (Fig. 3). MRSA patients had a higher rate of *S. aureus*-related admission to the ICU and higher rate

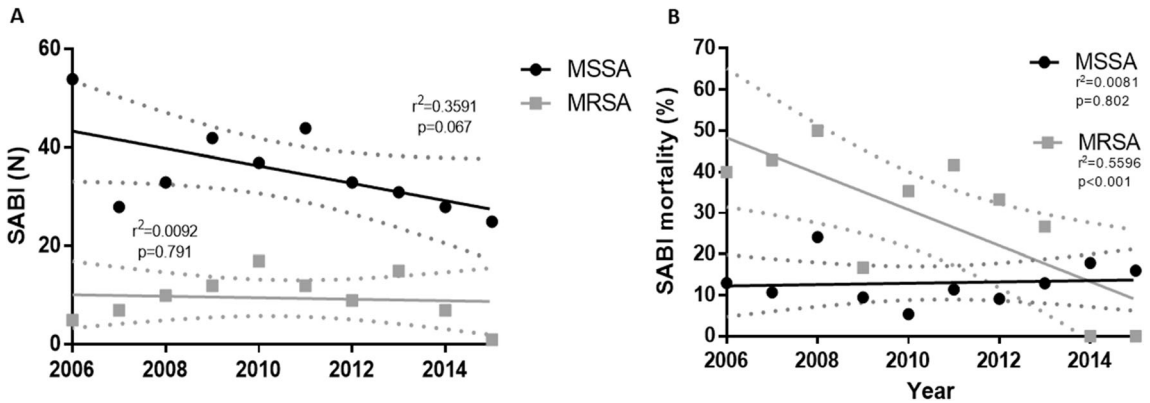

Fig. 2 **a** Yearly record of *S. aureus* bloodstream infections in the evaluated population according to antibiotic susceptibility. **b** Yearly mortality rate attributable to *S. aureus* bloodstream infections according to antibiotic susceptibility

Table 1 Clinical characteristics of studied subjects, considering microbiological characteristics of the SABI

Parameter	Total $N = 450$	MSSA $N = 355$	MRSA $N = 95$	P value
Age (years)	47 (17–87)	47 (17–87)	47.5 (17–75)	0.717
Male sex (%)	273 (60.7)	221 (62.3)	52 (54.7)	0.183
Charlson Comorbidity Index	4.0 (2.0–6.0)	4.0 (2.0–6.0)	3.0 (2.0–6.0)	0.184
Type of neoplasia (%)				
- Hematologic	135 (30.0)	95 (26.8)	40 (42.1)	0.004
- Solid	315 (70.0)	260 (73.2)	55 (57.9)	< 0.001
BSI site (%)				
- Healthcare-associated	335 (74.4)	296 (83.4)	39 (41.1)	< 0.001
- Hospital-acquired	115 (25.6)	59 (16.6)	56 (58.9)	< 0.001
Infectious foci (%)				
Community-acquired pneumonia	34 (7.6)	26 (7.3)	8 (8.4)	0.719
Healthcare-associated pneumonia	33 (7.3)	14 (3.9)	19 (20.0)	< 0.001
Soft tissue infection	28 (6.2)	21 (5.9)	7 (7.4)	0.603
Osteomyelitis	6 (1.3)	6 (1.7)	0	0.202
CVC	254 (56.4)	213 (60.0)	41 (43.2)	0.003
Abdominal	27 (6.0)	22 (6.2)	5 (5.3)	0.733
Unknown	68 (15.1)	57 (16.1)	11 (11.6)	0.279
Neutropenia (< 500 cells/mm^3, %)	86 (20.7)	58 (18.0)	28 (30.1)	0.011
Coinfections (%)				
- Gram-negative bacteria	87 (19.3)	56 (15.8)	31 (32.6)	< 0.001
- Gram-positive bacteria	31 (6.9)	20 (5.6)	11 (11.6)	0.042
Inpatient management (%)	365 (81.1)	272 (76.6)	93 (97.9)	< 0.001
Specific anti-*SA* treatment < 48 h (%)	354 (78.7)	289 (81.6)	65 (68.4)	0.006
CVC removal (%)	270 (71.8)	222 (74.2)	48 (62.3)	0.038
Days from infection to CVC removal	2.0 ± 3.0	2.0 ± 3.0	3.0 ± 5.0	0.023
Intensive care admission (%)	46 (10.2)	19 (5.4)	27 (28.4)	< 0.001
-Septic shock	22 (4.9%)	9 (2.5)	13 (13.7)	0.001
Relapse of *SA* bacteremia (%)	34 (7.6)	32 (9.0)	2 (2.1)	0.024
Secondary any-cause bacteremia at 6 months (%)	35 (7.8)	27 (7.6)	8 (8.4)	0.846
Infectious endocarditis (%)	7 (1.6)	6 (1.7)	1 (1.1)	0.905
30-day *SA*-related mortality (%)	75 (16.7)	45 (12.7)	30 (31.6)	< 0.001
6-month overall mortality (%)	124 (27.6)	83 (23.4)	41 (43.2)	< 0.001

CVC central venous catheter, *SA S. aureus*, *MRSA* methicillin-resistant *SA*, *MSSA* methicillin-sensitive *SA*, *BSI* bloodstream infection

of 30-day infection-related and all-cause mortality (31.6 and 43.2%, respectively). During the study period, fourteen cases of possible IE (3.1%) were recorded, seven were confirmed by using Duke's modified criteria, and all but one occurred in the MSSA group. Overall, 105 patients underwent echocardiographic evaluation to rule out IE.

Using Cox proportional risk regression analyses (Supplementary Material), we identified community-acquired pneumonia, abdominal source of infection, hematologic malignancy, MRSA, glucose levels > 140 mg/dL, and possible or confirmed endocarditis as risk factors for 30-day mortality; protective factors for mortality included catheter removal and initiation of adequate treatment for *S. aureus* < 48 h after positive blood cultures. After adjustment for competing risk of death using semi-parametric proportional hazard regression models considering non-infectious causes of 30-day mortality, community-acquired pneumonia and possible endocarditis were no longer associated to mortality (Table 2).

Prediction of 30-day mortality in SABIs

Finally, we evaluated the utility of the identified risk factors to stratify subjects in our cohort according to 30-day mortality risk. We used β-coefficients from the fitted regression model from competing risk data to approximate a point system using the magnitude of the coefficient. We observed that scores

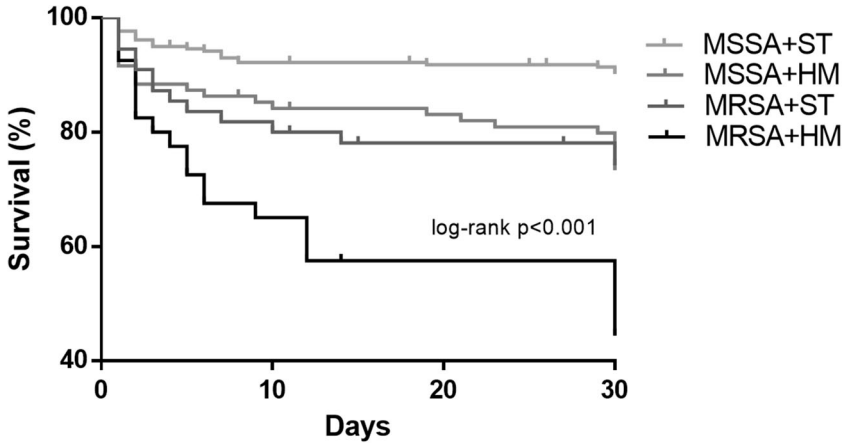

Fig. 3 Kaplan-Meier curve comparing survival in MRSA and MSSA bacteremias in patients with solid and hematologic malignancies. Abbreviations: Methicillin resistant *S. aureus* (MRSA), methicillin-sensitive *S. aureus* (MSSA), solid tumor (ST), and hematologic malignancy (HM)

< − 2.0 had 3.34% (95%CI 1.11–7.86%) probability of infection-related mortality at 30 days, scores ≤ 0 but > − 2.0 had 12.71% (95%CI 8.77–17.4%), scores > 0 but ≤ 3.0 had 29.11% (95%CI 19.5–39.5%), and scores > 3.0 had 70.23% (95%CI 47.2–85.3%) probability of infection-related death at 30 days. The comparison between probability of death at each cutoff level was statistically significant in both the Kaplan-Meier (Fig. 4) and cumulative incidence analyses ($p < 0.001$ both).

Discussion

Our results demonstrate that SABIs imply significant disease burden for patients with cancer, increasing 30-day mortality in patients with hematologic malignancies and MRSA infections. MRSA was also associated to hospital-acquired infections and particularly to healthcare-associated pneumonia and in patients with diabetes. SABI-associated 30-day mortality at our institution was lower than those reported in other series (1–5), with significantly increased rates for the group of subjects with hematologic malignancies, MRSA infection, endocarditis, and hyperglycemia. The reduction in mortality associated to early catheter removal and initiation of specific antibiotic treatment for *S. aureus* has been observed in other series and demonstrates the significant role of hospital-level interventions in reducing the health burden associated to SABI. Finally, we demonstrated the utility of identified risk factors to stratify patients for infection-related 30-day mortality risk using a simplified score derived from our regression models.

Oncology patients are at high risk for SABIs [14, 15]. Previous reports have demonstrated that BSI and, particularly, SABIs are a significant cause for 30-day mortality in cancer patients [16]. Strategies to reduce SABIs are targeted at prediction of onset, including effective treatment and proper catheter management [17, 18]. We observed a decline over time in the rate of SABIs, which reflects the implementation and reinforcement of catheter care to reduce CLABSIs, and the reinforcement of hand hygiene programs. Over the study period, we also had significant improvements in our facilities for the isolation of neutropenic patients and an increase in the patients: infectious diseases physicians' ratio, all of which have led to improvement in the management and care of bloodstream infections, with positive changes in both, SABI incidence and SABI-related outcomes. In addition, improvement in diagnostic and therapeutic techniques, implementation of ambulatory chemotherapy regimens, and long-distance patient follow-up have

Table 2 Semi-proportional hazard regression adjusted for competing risk of death for 30-day mortality attributable to *S. aureus* bloodstream infections in cancer, adjusted by CCI

Variables	β	Wald	HR (95%CI)	*P* value
Abdominal source	1.292	2.41	3.64 (1.27–10.40)	0.016
Hematologic malignancy	1.118	3.93	3.28 (1.81–5.93)	< 0.001
MRSA	0.990	3.40	2.69 (1.52–4.76)	< 0.001
Glucose > 140 mg/dL	0.949	3.14	2.58 (1.43–4.67)	0.002
Catheter removal	− 0.868	− 2.95	0.42 (0.24–0.75)	0.003
Anti-staph treatment < 48 h	− 0.964	− 3.18	0.38 (0.21–0.69)	0.001
Infectious endocarditis	1.699	2.73	5.47 (1.62–18.49)	0.006

CCI Charlson Comorbidity Index, *MRSA* methicillin-resistant *S. aureus*, *HR* hazard ratio, *95%CI* 95% confidence interval

a

Variables	Point system
Abdominal source of infection	2.5
Hematologic malignancy	2
MRSA	2
Glucose >140mg/dL	2
Catheter removal	-2
Anti-staph treatment <48 hours	-2
Confirmed endocarditis	3

b

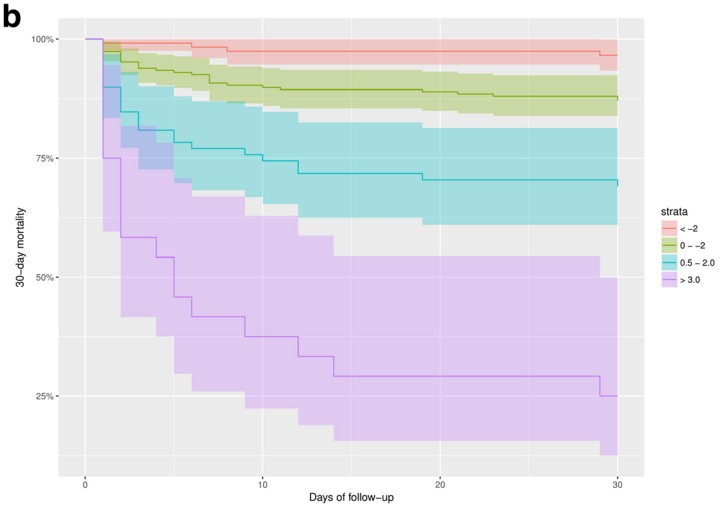

Fig. 4 **a** Score to evaluate prediction differences according to identified cutoff points using risk factors for 30-day mortality from competing risk data. **b** Cumulative incidence functions comparing strata of the predictive score to evaluate 30-day mortality risk

had significant effect on reducing infection-related mortality and disease burden.

MRSA-BSI is a cause of concern in oncology patients due to a higher mortality rate associated with methicillin resistance [19]. In our study, there was no reduction in MRSA incidence over time compared to MSSA; this could be explained by the higher frequency of MRSA in subjects with neutropenia, hematologic malignancies, and chemotherapy. Additionally, we observed an association of MRSA with diabetes, which has a higher prevalence in our population compared to worldwide estimates [20]. This association with diabetes is particularly interesting, given the known role of hyperglycemia with increased mortality in SABI for subjects with increased age and comorbidity independent of corticosteroid use, as confirmed in our study [21, 22]. Considering our observation that oncologic patients with diabetes have an increased rate of MRSA and that MRSA increases mortality in cancer, patients with diabetes and cancer should be closely monitored if SABI is suspected.

Subjects with hematologic malignancies are at an increased risk of acquiring BSI, infectious-related complications, and death, compared to patients with solid tumors [23, 24]. Venditti et al. found that non-neutropenic subjects with SABI and hematologic malignancies had a higher rate of early and late SABI-related complications compared to neutropenic patients [23]. This supports our observation that hematologic malignancy, but not severe neutropenia, was independently associated to higher 30-day infection-related mortality. We also observed that subjects with hematologic malignancies and MRSA have significantly higher 30-day mortality compared to subjects with solid tumors and MRSA infection [9, 24].

To quantify the role of mortality-associated risk and protective factors, we developed a scale which could be useful to predict 30-day mortality. An abdominal source of infection is considered a high-risk source as it increases the rate of treatment failure in patients with SABI [25]; in our study, subjects with an abdominal source of infection had significantly higher predicted mortality, even when adequate treatment for SABI was initiated and independently of the underlying malignancy. IE is a relevant comorbidity in SABI, causing increased early morbidity and mortality, particularly when effective treatment is not promptly initiated [26, 27]. In our scale, IE was considered the most significant predictor of mortality but in most subjects, catheter removal and early initiation of adequate treatment outweighed the associated risk. Risk estimation in SABI is relevant, since most risk factors for mortality are non-modifiable and patients at higher risk might require specialized and urgent care [27]. To evaluate the role our predictive score for infection-related mortality in SABI, external validation studies must be conducted, with special attention to patients with hematological malignancies.

Our study has some strengths and limitations. First, we evaluated a large and diverse cohort of oncologic patients that allowed comparison between solid and hematologic malignancies according to methicillin resistance. Second, due to our systematic epidemiologic surveillance system, we could collect sufficient and reliable clinical information over a 1-year period after the infection and were able to confirm the presence of comorbidity, cancer status, treatment, infectious source, and infection-related death from the patient's files. Third, we fitted all mortality models based on cumulative incidence from competing risk data,

which is a reasonable approach in oncologic patients and improves the performance of predictive models [13]. Amongst the limitations is the data collection process from clinical files, which is common in evaluation of BSIs in cancer but limits our ability to establish causal relationships for all variables, particularly in treatment-related data. Additionally, even though we performed adjustment using the Charlson Comorbidity Index, there exists the possibility of residual confounding for age and comorbidity in mortality models. Patients with hematological malignancies are a population that clearly differs from patients with solid neoplasia, in both burden of disease and life-threating complications, which calls for a targeted study in patients with hematologic malignancies to confirm our observations and improve mortality prediction.

In conclusion, our data demonstrates that SABIs are a significant burden in patients with cancer. MRSA infection was associated with hospital-acquired setting, pneumonia, and diabetes mellitus. For patients with hematologic malignancies, MRSA was more frequent if hospital-acquired and less likely in patients with primary bacteremias. Mortality rate in our institution decreased for MRSA infection and is lower to those reported in similar series. Risk factors for infection-related 30-day mortality include MRSA, hematologic malignancy, hyperglycemia, abdominal source of infection, and endocarditis. The reduction in mortality associated to early catheter removal and initiation of specific antibiotic treatment for SABI demonstrates the significant role of hospital-level interventions and the increasing supportive clinical care in cancer patients. Using these risk factors to stratify patients might be a useful approach to predict the probability of 30-day infection-related mortality.

Author contributions *Omar Yaxmehen Bello-Chavolla*: Research idea and study design, data acquisition, data analysis/interpretation, statistical analysis, manuscript drafting. *Jessica Paola Bahena-López*: Research idea and study design, data acquisition, data analysis/interpretation, statistical analysis, manuscript drafting. *Pamela Garciadiego-Fosass*: Research idea and study design, data acquisition, data analysis/interpretation. *Patricia Volkow*: Manuscript drafting and mentorship. *Alejandro Garcia-Horton*: Data acquisition, data analysis/interpretation. *Consuelo Velazquez-Acosta*: Data acquisition, microbiology analysis and review. *Diana Vilar-Compte*: Research idea and study design, data acquisition, data analysis/interpretation, manuscript drafting, supervision or mentorship.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval and informed consent For this type of study, formal consent is not required. All data was protected and confidentiality was guaranteed. This article does not contain any studies with human participants or animals performed by any of the authors.

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