Effectiveness of a program for the reduction of central venous catheter-related bacteremias in a Pediatric Cardiovascular Unit

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ABSTRACT

Introduction. Central venous catheter (CVC)-related bacteremias are common in pediatric patients following surgery for complex congenital heart disease admitted to a pediatric cardiac intensive care unit (PCICU) and have a high morbidity and mortality.

Objective. To analyze the effectiveness of an interdisciplinary program for the prevention of CVC-related bacteremias in the PCICU.

Material and methods. Quasi-experimental, before and after implementation study without a control group. Study period: 01-01-2008 to 12-31-2018. Population: PCICU staff who care for patients following surgery for complex heart disease at a hospital. Pre-intervention period: 01-01-2008 to 12-31-2008; intervention period: 01-01-2009 to 01-01-2018. Intervention: implementation of an ongoing improvement program. The rate of CVC-related bacteremias/1000 days and CVC use/100 days, RACHS score, standardized infection ratio (SIR), relative risk (RR), and 95% confidence interval (CI) were analyzed and a p value < 0.05 was considered statistically significant. The reference rate was estimated as the average for the 2008-2009 period and the annual and reference rates were compared.

Results. The bacteremia reference rate for 2008-2009 was 10.6/1000 days of CVC to analyze the SIR. A RACHS score over 3 was similar across all studied periods. The annual comparison showed a statistically significant reduction ($p < 0.05$) in the SIR. The comparison between the baseline bacteremia rate/1000 days of CVC (11.9) and the final rate (3.8) showed a significant reduction (RR: 0.16; 95 % CI: 0.07–0.35; $p < 0.001$).

Conclusions. The program was effective; the rate of CVC-related bacteremias in the PCICU showed a progressive, significant reduction.

Key words: *infections, central venous catheters, bacteremia, infection control, intensive care units.*

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INTRODUCTION

Congenital heart disease refers to a group of malformations of varying complexity, with more than 200 possible diagnosis and palliative or definitive repair surgical procedures (about 150), which have an impact on morbidity, mortality, and quality of life of patients. For outcome comparison, it is necessary to adjust for the complexity of the procedures. Tools that group procedures into strata of similar mortality risk were developed to this end. The RACHS-1 score groups procedures into 6 categories of increasing risk.[1]

During the care of these patients, the use of central venous catheters (CVCs) is essential for monitoring, drug infusion, hemodialysis, and parenteral feeding. In PCICUs, CVC-related bacteremias are the most frequent, high-impact healthcare-associated infections (HAIs), prolonging hospital stay and related morbidity and mortality.[2] Currently; HAIs are considered to be a problem that affects patient safety and quality of care. Most of these infections are preventable and avoidable.[3]

The development, implementation, and adherence to active and ongoing interdisciplinary programs are considered critical to the reduction of HAIs and to the success of surgical programs in hospital critical care units caring for patients with complex heart disease.[4,5]

The objective of the study was to analyze the effectiveness of an interdisciplinary program with systematic, progressive, and permanent implementation of

measures to prevent CVC-related bacteremias in the PCICU.

MATERIAL AND METHODS

This was a quasi-experimental, before and after implementation study without a control group designed to analyze the impact of the program to reduce CVC-related bacteremias in the PCICU of Hospital de Pediatría Dr. Juan P. Garrahan.

This is a national referral PCICU with a total of 21 beds that caters for approximately 600 children with complex heart disease; of them, 42% have a RACHS-1 score of 3 or higher. The cardiovascular surgery program of Hospital de Pediatría Dr. Juan P. Garrahan performs 800 surgical procedures annually in 600 patients, including a heart transplant and extracorporeal membrane oxygenation (ECMO) program. In 90% of the patients, the post-operative period takes place in the cardiac surgery recovery unit, whose results in terms of morbidity and mortality have been reported in several publications.[6-8]

The program implemented for the prevention of related bacteremias was directed to all staff caring for children in the PCICU (physicians, nurses, anesthesiologists, intensivists, surgeons, cardiologists, and support staff).

All children with CVC use during their stay at the PCICU between January 1st, 2008 and December 31st, 2018 were included. The pre-intervention period was from January 1st, 2008 to December 31st, 2008. The post-intervention period was from January 1st, 2009 to December 31st, 2018.

This sequential, systematic, and sustained intervention included the organization of an interdisciplinary team to achieve intervention implementation and program adherence among team members, the 5 moments for hand hygiene program, CVC insertion and care protocol (see *Supplementary material 1*), solution preparation protocol, unit/patient surface hygiene and cleaning protocol, introduction of a liaison nurse (PCICU nurse, local opinion leader who worked together with the nurse for the management of infections at the unit), discussion during handoffs about the need to continue or not with CVC in each patient in the unit. Checklists were used for the direct observation of protocol adherence during the initial period of the program. Throughout the program, monthly protocol training workshops were held for the entire health care team that entered, rotated or was part of the PCICU on a permanent basis.

Monthly meetings were held with the participation of the PCICU and other departments, during which monthly HAI reports and patient analysis were presented, and the establishment of future and annual goals at each meeting. An annual closure report of morbidity and mortality and active surveillance outcomes of CVC-related bacteremias in the PCICU was made and future annual goals for the program were defined. Incidental, monthly, and annual meetings of the whole team were organized in order to obtain program outcome feedback and discuss and address emerging problems and potential solutions with the health care team. A CVC insertion checklist published in a previous study was used in the beginning of the program (see *Supplementary material 2*).[9-11] The characteristics of the PCICU where the program was implemented are described: annual indicators of number of patients, surgical procedures, rate of bed occupancy, overall mortality rate, and patients day according to pre- and post-intervention period.

The following primary measures were estimated to establish the impact of the program: rate of CVC-related bacteremias/1000 days of CVC use, rate of CVC use/100 patient days, standardized infection ratio (SIR) according to the surveillance definition by the Centers for Disease Control and Prevention (CDC) and the National Hospital Infection Control and Epidemiology Program (VIHDA)[12,13] (see *Supplementary material 3*), and the RACHS-1 score (percentage of patients with a score equal to or greater than 3).

All information in both the pre- and post-intervention periods was recorded prospectively.

Statistical analysis

Mean, median, and interquartile range were estimated; categorical variables were described using frequency tables; and RR and 95% CI were calculated. A T test, Wilcoxon test or χ^2 test were used for the bivariate analysis of program results, as applicable. A value of $p < 0.05$ was considered statistically significant. The STATA 14.0® software was used for the statistical analysis.

The program was submitted to and approved by the Ethics and Research Committee. This was an educational intervention study so it was not necessary to request participants to sign an informed consent.

RESULTS

Table 1 shows that complex surgical procedures were performed across all study periods, both before and after the program implementation, with a high percentage of patients who had a RACHS-1 score over 3 and a high bed occupancy rate. Hospitalized patients with complex heart disease showed a similar rate of overall mortality by analyzed period, except in 2016, when the overall mortality rate was higher.

Table 2 summarizes the total number of bacteremia episodes per 1000 days of CVC use, the rate of CVC use, the SIR, 95% CI, and *p* value observed in the annual comparison and over the program implementation. Based on the rate of CVC-related bacteremias, the pre-intervention period was estimated as the rate of reference: 10.60 to calculate the SIR and analyze the impact of the measures implemented via the program. We observed a similar number of patients day, a reduction in the rate of CVC use, and a progressive, statistically significant reduction in the SIR as of 2 years after the program began (2011).

The comparison between the baseline bacteremia rate/1000 days of CVC use (11.9) and the final rate (3.8) showed a significant reduction (RR: 0.16; 95% CI: 0.07–0.35; $p < 0.001$).

In relation to the distribution of microorganisms by period, Gram-negative bacilli prevailed over Gram-positive cocci across all years (*Figure 1*).

Table 1. *Characteristics of the cardiac intensive care unit by studied period*

Year	No. of surgery patients	On-pump surgery	Patients day	Bed occupancy (%)	RACHS score > 3 (%)	Mortality (%)
2008	541	444	6241	92.25	43.6	**5.5**
2009	546	484	6212	89.25	49	**5.1**
2010	426	378	6328	88.48	41.2	**5.6**
2011	462	412	6017	89.66	43.5	**4.8**
2012	465	416	6908	90.55	46.3	**7**
2013	472	394	6514	91.41	49	**5**
2014	539	460	6968	91.66	45	**5.8**
2015	580	487	7093	92.57	47	**4.3**
2016	514	431	7185	93.98	46	**9.3**
2017	537	451	7208	94.82	48	**6**
2018	498	444	7036	94	47.5	**7.2**

Table 2. *Impact of the program on central venous catheter-related bacteremias by study year*

Year	Patient	Bacteremia episodes	Days of CVC use	Rate of CVC use	Rate of bacteremia per 1000 days of CVC use	Expected bacteremia episodes	SIR	95% CI	*p* value
2008	6241	46	3849	61.7	11.9	-	-	-	-
2009	6212	36	3871	62	9.3	41	0.88	0.61–1.15	NS (**)
2010	6328	29	3284	52	8.83	35	0.83	0.54–1.12	NS
2011	6017	21	2904	48	7.23	31	0.68	0.41–0.95	< 0.05
2012	6908	16	2646	38	6.05	28	0.57	0.3–0.84	< 0.05
2013	6514	15	2800	43	5.36	30	0.51	0.26–0.76	< 0.05
2014	6968	10	2682	38	3.49	29	0.32	0.13–0.53	< 0.05
2015	7093	17	3114	44	5.46	33	0.52	0.27–0.77	< 0.05
2016	7185	22	3705	52	5.94	40	0.56	0.32–0.8	< 0.05
2017	7208	14	3380	47	4.14	36	0.39	0.2–0.58	< 0.05
2018	7036	12	3123	44	3.8	33	0.36	0.17–0.55	< 0.05

SIR: standardized infection ratio; NS: not significant; CVC: central venous catheter.

DISCUSSION

The prevention of infections in the post-operative period of cardiac surgery is one of the measures used to help reduce mortality. There are international initiatives in place to develop local, quality improvement programs, similar to the one implemented in our hospital, which achieve significant results when the implementation has a multidisciplinary approach and a high level of adherence to the recommendations is achieved.[14,15]

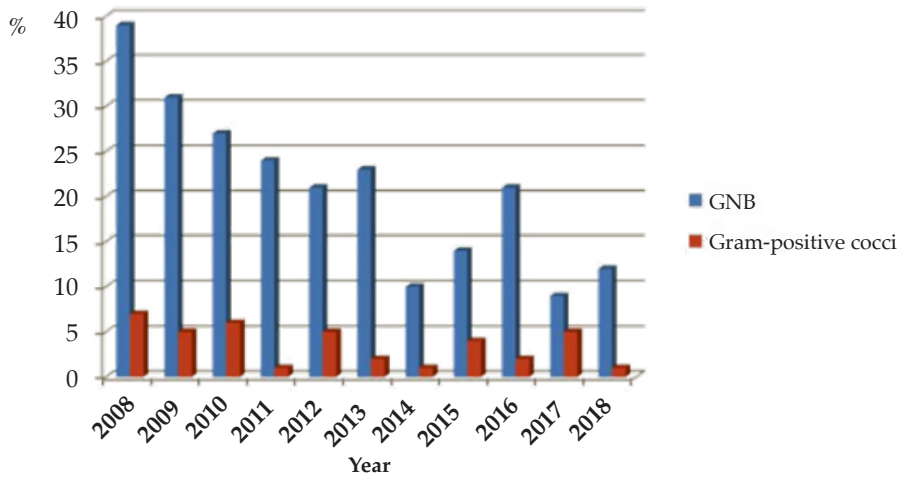
The rates observed during the pre-intervention period and the first year of the intervention (2008-2009) exceeded the expected international standards for the rate of CVC-related bacteremia in the PICU.[16] Once the existing factors were identified and analyzed (pre-intervention), a global intervention program was developed that included the operating room staff working on cardiac surgery and the PICU. A set of strategies was established and measures that comprised a group of basic practices were carried out; when implemented together, they result in improvements in the quality of care related to invasive procedures.[17] The application of these basic practices by the multidisciplinary team allowed to provide training on the recommendations to the entire health care team. Likewise, a reduction in bacteremia rates was initially achieved, with a greater impact 2 years after the program had been initiated.[10,13]

Numerous published studies indicate that the effectiveness of the program is not usually observed immediately, but rather after a period of time following its implementation. For this reason, we consider it essential to provide feedback on results, positive reinforcement to the entire health care team for improvements in processes,[18] and the annual renewal of future objectives and goals by the program. For the development of the program, the participation of all parties was essential to establish a progressive but highly significant reduction impact to the extent that the program and the adherence to the recommendations were sustained over time, similar to what has been published in other series.[13-18,19]

The prevention of HAIs requires broad changes in medical practice and the implementation of multidisciplinary programs to improve infection control. It also requires cultural changes in the behavior of health care providers through education, performance assessments, feedback, provision of progress reports, teamwork, and improvements in the overall safety culture.[13-18]

The results obtained from active surveillance allow to identify and analyze episodes of infections and assess potential causes, with the main objective of establishing or reinforcing infection control strategies. Data are collected

FIGURE 1. *Annual distribution of microorganisms*



GNB: Gram-negative bacilli.

systematically through the daily tour of the PCICU by the nurse specialized in infectious diseases and infection control. The report submitted by UCI staff is a useful source of information for the analysis of the program's development and impact. The internal comparison with the rate based on PCICU historical data (2008-2009 period) from the pre-intervention period showed a reduction of the SIR annually, which was progressive and sustained and statistically significant according to the standards established by the active epidemiological surveillance programs.[13] The rate of CVC-related bacteremias decreased significantly when comparing the pre- and post-intervention periods; Gram-negative bacilli predominated in all periods. The latter was similar to what has been published in other PICUs.[20,21]

In relation to the weaknesses of the study, it should be noted that the design did not include a control group and, since the measures implemented were progressive and many were simultaneous, it is difficult to establish which were the most successful.

We believe that the different activities developed in the program should continue and may be useful for institutions whose characteristics are similar to those of Hospital Garrahan.

CONCLUSION

The program was effective; the rate of CVC-related bacteremias in the PCICU showed a progressive, significant reduction.

The implemented program should be continued in order to achieve ongoing improvement in the care of patients with complex heart disease seen at the PCICU. ■

Supplementary material available at: https://www.sap.org.ar/docs/publicaciones/archivosarg/2022/2462_AO_Ruvinsky_Annex.pdf

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