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Original

Usefulness of business intelligence to guide antimicrobial treatment decision in infections by infrequent microorganism such as *Bordetella bronchiseptica*

Utilidad de los sistemas de análisis de datos para guiar la decisión de tratamiento antimicrobiano en infecciones por microorganismos poco frecuentes como *Bordetella bronchiseptica*

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Abstract

Human infections by *Bordetella bronchiseptica* are increasing in recent years. However, due to the lack of clinical susceptibility/resistance breakpoints, antimicrobial treatment is complex. Business Intelligence (BI) is a tool that allows to record and analyze large amounts of data in a very short time. The aim of this study was to analyze a cohort of patients with *B. bronchiseptica* infections focusing on how BI can help guide empirical antimicrobial therapy Demographic, clinical, and microbiological data about *B. bronchiseptica* infections were recovered. Then, $MIC_{50/90}$ of several antibiotics was automatically calculated through the BI. Thirteen *B. bronchiseptica* infections were identified. The lowest $MICs_{90}$ were for carbapenem, aminoglycoside, fluoroquinolones, and tetracyclines. The EUCAST PK-PD (non-species related) breakpoints showed that only piperacillin/tazobactam, imipenem and meropenem would be appropriate treatments to use empirically. In conclusion, BI systems have great potential to optimize the empirical antibiotic treatment in these types of infections.

Keywords: Business intelligence. *Bordetella bronchiseptica*. Respiratory tract infection. Antimicrobial treatment.

Resumen

Las infecciones humanas por *Bordetella bronchiseptica* están aumentando en los últimos años. Sin embargo, debido a la falta de puntos de corte clínicos de sensibilidad/resistencia, el tratamiento antimicrobiano es complejo. Los sistemas de análisis de datos (*business intelligence*; BI) es una herramienta que permite registrar y analizar grandes cantidades de datos en muy poco tiempo. El objetivo de este estudio fue analizar una cohorte de pacientes con infecciones por B. bronchiseptica, centrándose en cómo la BI puede ayudar a guiar la terapia antimicrobiana empírica. Se recopilaron datos demográficos, clínicos y microbiológicos sobre infecciones

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por *B. bronchiseptica*. Posteriormente, las $CMI_{50/90}$ de varios antibióticos se calcularon automáticamente mediante BI. Se identificaron trece infecciones por *B. bronchiseptica*. Las CMI_{90} más bajas fueron para carbapenémicos, aminoglucósidos, fluoroquinolonas y tetraciclinas. Los puntos de corte PK-PD (no relacionados con especie) de EUCAST mostraron que solo piperacilina/tazobactam, imipenem y meropenem serían tratamientos adecuados para uso empírico. En conclusión, los sistemas de BI tienen un gran potencial para optimizar el tratamiento antibiótico empírico en este tipo de infecciones.

Palabras clave: Sistemas de análisis de datos. *Bordetella bronchiseptica*. Infección del tracto respiratorio. Tratamiento antimicrobiano.

Introduction

Bordetella bronchiseptica is an aerobic, gram-negative coccobacillus that displays tropism for the respiratory tract of animals such as dogs, cats, pigs, rabbits, and horses. It causes tracheobronchitis or "kennel cough" in dogs, atrophic rhinitis in pigs, and snuffles in rabbits [1]. Typically, *B. bronchiseptica* infections in humans are uncommon and are considered zoonotic [1]. However, in recent years reports of *B. bronchiseptica* infections in humans have increased, especially respiratory tract infections (RTI) [2–10], but also in severe infections such as bacteremia [11,12] and meningitis [13,14].

The antimicrobial treatment of *B. bronchiseptica* infections is empirical most of the time. Neither the Clinical and Laboratory Standards Institute (CLSI) nor the European Committee on Antimicrobial Susceptibility Testing (EUCAST) has established specific breakpoints for the antibiotics commonly used to treat these types of infections in humans. Thus, despite the increasing numbers of reports of *B. bronchiseptica* infections, there is a lack of guidance on the most effective treatment options.

Business intelligence (BI) is an emerging tool that allows one to collect, store, and analyze data in a very short time. This type of data-driven system has already been used in Emergency Medical Services during the COVID-19 pandemic, with good results [15]. Focusing on infectious diseases, BI is a promising tool, as it could facilitate the creation of cumulative antibiograms for infections caused by infrequently isolated microorganisms, where no standardized treatment is available. Thus, the aim of this study was to describe 13 clinical cases of *B. bronchiseptica* RTI and how a BI system could optimize the antimicrobial treatment in these patients.

Material and methods

Study design, patients and ethics

We conducted a retrospective study between 2018 and 2023 at University Hospital Virgen del Rocío (Seville, Spain). All consecutive adult patients (≥18 years) with positive respiratory cultures by *B. bronchiseptica* were included in the study. The study was approved by the Ethics Committee of University Hospital Virgen del Rocío, Seville (approval number 1180-N-21).

Business intelligence and microbiological data

Demographics and microbiological data were collected using MicroBI (Beckman Coulter, Spain), a Business Intelligence-based system which automatically obtains and analyzes data from the laboratory information system (LIS). MicroBI uses associative database engine, converting raw data into user-friendly dashboards where selection and filtering capabilities transform information into actionable knowledge. In addition, it allows to obtain statistical and epidemiological information, providing a positive impact on the quality and insight that the microbiology laboratory provides to improve the patient care. The tool provides multiple key resources, including bacterial incidence, sensitivity reports, temporal trends, distribution data, cumulative graphs, real-time epidemiological information, drug combination behavior, MIC_{50} and MIC_{90} reports, patient outcomes, and a conceptual mapping system.

A search was performed for microbiological isolates of *B. bronchiseptica* from 2018 to 2023. Positive results were analyzed, and MIC_{50} and MIC_{90} values were automatically calculated using MicroBI for the following previously tested antibiotic: ampicillin, piperacillin, ampicillin/sulbactam, amoxicillin/clavulanic acid, piperacillin/tazobactam, cefuroxime, cefotaxime, ceftazidime, cefepime, aztreonam, imipenem, meropenem, gentamycin, tobramycin, amikacin, ciprofloxacin, levofloxacin, tetracycline, doxycycline, and tigecycline. In all cases, MICs were determined using MicroScan Walkaway panels (Beckman Coulter, USA).

Clinical data

The following variables were collected from patients' medical records: age, sex, comorbidities, toxic habits, presence of bacterial coinfection, antimicrobial treatment received for the *B. bronchiseptica* infection episode, and patient outcome.

Results

Thirteen positive cultures for *B. bronchiseptica* were initially identified by the MicroBI system, belonging to 13 patients admitted to University Hospital Virgen del Rocío (Seville, Spain). All isolates were from respiratory samples, specifically sputum [n=8], bronchial aspirate (n=3), pharyngeal exudate (n=1)] and bronchoalveolar lavage (n=1). In all cases, the identification of *B. bronchiseptica* was performed using MALDI-TOF mass spectrometry. A score higher than 1.8 was considered adequate.

Demographic and clinical data of these patients are summarized in **Table 1.** The median age was 56 years (range 51-61) and 9 (69%) were men. Regarding comorbidities, all patients had risk factors for *B. bronchiseptica* infection, such as lung diseases (9/13, 69.2%) or HIV (3/13, 23%). It would be interesting to have information on whether the patient had intimate contact with pets, but it is not specified in any of their medical records. Regarding treatment, 11 of the 13 patients received antibiotics to treat *B. bronchiseptica* infection. The antibiotics used varied significantly (**Table 1**). Remarkably, 4 patients (30.8%) died.

Using BI, we calculated MIC_{50} and MIC_{90} values (**Table 2**). The lowest MIC_{90} in our isolates was for imipenem (1 mg/L), meropenem (1 mg/L), gentamicin (4 mg/L), tobramycin (4 mg/L), ciprofloxacin (1 mg/L), levofloxacin (1 mg/L), tetracycline (4 mg/L) and minocycline (4 mg/L). In contrast, the highest MIC_{90} was for cefotaxime (64-128 mg/L). The rest of the antibiotics such as penicillins, amoxicillin/clavulanic acid, cefuroxime, ceftazidime, cefepime and aztreonam had variable $MICs_{50/90}$ value (**Table 2**). Since there are no specific clinical breakpoints for *B. bronchiseptica*, we decided to use the PK-PD (non-species related) breakpoints according to the EUCAST [16]. According to these cut-off points, piperacillin/tazobactam, imipenem and meropenem would be the only appropriate antimicrobials for the treatment of *B. bronchiseptica* infections in our cases.

Discussion

This study analyzes the clinical and microbiological characteristics of a cohort of patients with *B. bronchiseptica* infections, focusing on how the BI-based systems could help guide antimicrobial therapy appropriately. The patients included were mainly men, and the majority had some type of immunosuppression (AIDS, neoplasia, solid organ transplantation, diabetes mellitus) associated with *B. bronchiseptica* infections.

Treatment of infections by these infrequently isolated microorganisms is sometimes problematic due to the absence of specific guidelines to guide antibiotic therapy. Several studies have reported the antibiotic treatment decision based on isolate MICs [7,8,13], some of them reporting susceptibility/resistance categorization. However, none of them specify any guidance document.

Based on the MIC_{50} and MIC_{90} values obtained, piperacillin/tazobactam, imipenem and meropenem could be the best option to be used as empirical treatment in patients with *B. bronchiseptica* infections in our hospital, according to the microbiological criteria of susceptibility/resistance based on PK/PD (EUCAST) [16]. However, it is crucial to emphasize that, particularly for low-prevalence microorganisms, the small sample size imposes limitations that require careful interpretation of the results. Although representativeness may be limited and MIC values potentially affected by outliers, even a small dataset can offer valuable insights to inform therapeutic decisions in the context of rare microorganisms. Furthermore, in line with our results, a recent study carried out in northern Spain, García-de la fuente *et al.* [17] reported low MIC_{90} to imipenem (2 mg/L) and meropenem (0.5 mg/L), although piperacillin/tazobactam was not tested. However, it is important to consider that our results could not be extrapolated to other centers and more studies are necessary to define global clinical breakpoints to *B. bronchiseptica*.

In the case of *B. bronchiseptica*, a microorganism with low prevalence in human infections but significant in certain clinical contexts (e.g., immunocompromised patients or individuals exposed to animals), the use of BI systems connected to the Laboratory Information System (LIS) is particularly advantageous. These systems can maximize the utility of limited data and uncover patterns that might be difficult to identify manually. Because low-prevalence microorganisms often involve a small number of isolates within a laboratory, traditional methods may fall short in assessing antibiotic susceptibility, resistance trends, or epidemiological correlations. BI systems overcome these challenges by enabling multivariate and contextualized analyses, even with minimal datasets.

From a technical standpoint, BI systems integrate diverse data sources, including phenotypic and clinical information, to construct a comprehensive microbiological profile. For *B. bronchiseptica,* these systems can detect variations in resistance patterns linked to factors such as sample type (e.g., respiratory, blood), patient antibiotic history, or associations with zoonotic infections. Furthermore, BI systems employ advanced methods, such as frequency distribution analysis, to accurately calculate metrics like MIC_{50} and MIC_{90}, even with limited isolate numbers, while also identifying outliers that may signal

Table 1. Demographical and clinical characteristics of the patients infected with *Bordetella bronchiseptica*.

Patient	Sex/Age (years)	Toxic habits	Comorbidities	Sample origin	Bacterial coinfection	Treatment	Death
1	M/57	Former smoker	Heart transplant, type 2 diabetes	BAL	-	Piperacillin/tazobactam, meropenem	No
2	M/47	Smoker; heroin and cocaine	Lung cancer. COPD	Sputum		Levofloxacin	No
3	M/61	Cocaine	HIV, HCV. Pulmonary TB (2000)	Sputum	*Sarcoptes scabiei*	Ivermectin, permethrin	Yes
4	M/53	Smoker; heroin and cocaine	COPD. HBV. HCV	Bronchial aspirate	*Staphylococcus aureus*	Ciprofloxacin	No
5	M/46	Smoker; alcohol and cocaine	HIV, Pulmonary TB (1996)	Sputum	*Streptococcus pneumoniae*	Ceftriaxone	Yes
6	F/34	No TH	Cystic fibrosis, lung transplant	Pharyngeal exudate	-	Levofloxacin	No
7	F/56	No TH	Asthma	Sputum	-	Not reported	No
8	F/57	No TH	Asthma	Sputum	-	Not reported	No
9	M/51	Former smoker	LBCL	Bronchial aspirate	-	Amoxicillin/clavulanic acid, ceftazidime, vancomycin and meropenem	Yes
10	M/53	No TH	HIV	Sputum	-	Levofloxacin	No
11	F/72	No TH	Type 2 diabetes, obesity, asthma. COPD, Lupus	Sputum	RSV	Amoxicillin/clavulanic acid	No
12	M/68	Former smoker	AML	Sputum	Influenza B RSV	Azithromycin, levofloxacin, oseltamivir	No
13	M/73	Former smoker	COPD. Pulmonary TB	Bronchial aspirate	SARS-COV2 *Aspergillus fumigatus*	Ceftriaxone	Yes

F: female, M: male, TH: toxic habits, COPD: chronic obstructive pulmonary disease, HCV: hepatitis C virus, HBV: hepatitis B virus, AML: acute monocytic leukemia, LBCL: large B cell lymphoma, RSV: respiratory syncytial virus; BAL: bronchoalveolar lavage.

Table 2. MIC_{50} and MIC_{90} distribution of *Bordetella bronchiseptica* clinical isolates.

Antibiotic	MIC_{50} (mg/L)	$MIC_{50/90}$ (mg/L)	MIC_{90} (mg/L)
Ampicillin	16	-	>256
Piperacillin	8	-	128
Ampicillin/sulbactam	16	-	32
Amoxicillin/clavulanic acid	8	-	>256
Piperacillin/tazobactam	-	8	-
Cefuroxime	32	-	>256
Cefotaxime	64	-	128
Ceftazidime	16	-	32
Cefepime	16	-	32
Aztreonam	-	32	-
Imipenem	-	1	-
Meropenem	-	1	-
Gentamicin	-	4	-
Tobramycin	-	4	-
Amikacin	8	-	16
Ciprofloxacin	-	1	-
Levofloxacin	-	1	-
Tetracycline	-	4	-
Minocycline	-	4	-

MIC: Minimum inhibitory concentration.

emerging resistance mechanisms or laboratory inconsistencies.

Automated comparisons with national and international databases, such as those provided by EUCAST or CLSI, contextualize local susceptibility data for *B. bronchiseptica* against global trends. This helps to identify discrepancies that may reflect unique geographical or epidemiological factors. Such functionality is particularly valuable for low-prevalence microorganisms, where global data are often insufficient for guiding local decisions. BI systems also enable longitudinal monitoring of resistance patterns, making it possible to detect increases in *B. bronchiseptica* infections or the emergence of novel resistance profiles that require adjustments to empirical treatment protocols.

In conclusion, MicroBI is a promising tool in Clinical Microbiology services that will help combat infections caused by infrequent microorganisms such as *B. bronchiseptica*, reducing the probabilities of therapeutic failures.

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Conflict of interest

Authors declare no have conflict of interest.

Authors contributions

Conceptualization, A.R.V.; methodology, R.D.J.; formal analysis, M.V.H.A. and A.R.V.; writing—original draft preparation, M.V.H.A. and A.R.V.; writing—review and editing, J.A.L. All authors have read and agreed to the published version of the manuscript.

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