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ORIGINAL RESEARCH

Factors related to the monitoring and elimination of an outbreak of carbapenemase-producing Klebsiella pneumoniae in the neonatology unit of the Metropolitan Hospital of Quito.

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Abstract

Introduction: Nosocomial infections are a burden for the healthcare system. This study reports the observational data from an outbreak of Klebsiella pneumoniae in a neonatology unit and measures taken following identification.

Methods: We used a descriptive, observational, ambispective design to study nosocomial infections. Strict barrier measures were implemented with checklists and surveillance cameras in the Neonatology Unit. The observations were reported and analyzed using descriptive statistics.

Results: Six cases were diagnosed with Klebsiella pneumoniae; all were premature newborn patients, three of them extreme. Four patients had early sepsis. The culture samples included three blood cultures, two urine cultures, and one culture of pharyngeal secretion. Along with the Klebsiella pneumoniae culture, other pathogens were identified. The coinfection of Klebsiella with S. aureus lasted longer in isolation compared with Klebsiella alone. Among the cultures, two were positive for extended-spectrum beta-lactamases (ESBL) producing Klebsiella pneumoniae, and four were positive for multi-sensitive Klebsiella pneumoniae. After intervention, there were no new cases during the 12 months following the outbreak.

Conclusions: After the outbreak of six cases of Klebsiella pneumoniae in the neonatology unit, strict biosafety measures were established, in which compliance was registered on checklists and monitored by security cameras. The elimination of nosocomial infections was achieved in a control period after 12 months following the interventions.

Keywords: Klebsiella Pneumoniae, Infections Klebsiella, Neonatology, Critical Care, Neonatal Intensive Care Units.

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Introduction

Neonatal intensive care units represent an environment that must remain relatively free of resistant and multi-resistant pathogens since this is where newborns, who come directly from the delivery room after being in the uterine environment, are admitted. At this point in life, the neonate acquires the microorganisms directly from the mother's microbiome during ectopic delivery and early attachment to the mother's womb, assuming that in most cases, the mothers are healthy and free of resistant bacteria. All of the above indicates that the neonatology area is an environment where infection control through active interventions should be taken with greater emphasis and enthusiasm than in other intensive care areas.

Globally, gram-negative bacteria cause around 20 to 40% of all late sepsis in neonatal units and are often associated with adverse clinical outcomes [1-3]. However, not all newborns develop an obvious clinical disease, which is one of the most significant challenges since many are only colonized carriers of the bacteria. The colonization of multi-resistant gram-negative bacteria (MDR) in neonates hospitalized in neonatal intensive care units is a worrying issue due to the possibility of infection and a chain of transmission that often goes unnoticed; thus, creating a source of MDR bacteria and multi-resistant genes.

Recently, there has been increasing interest in Klebsiella pneumoniae, a type of gram-negative bacteria, based on its impact on public health due to the development of resistance to carbapenems. Klebsiella pneumoniae producing carbapenemases (KPCS) confer resistance to this family of broad-spectrum antibiotics. KPCS is a nosocomial pathogen that can have negative consequences in neonatology, in which patients may have critical conditions with risk factors such as prematurity, presence of venous and arterial catheters, history of antibiotic treatment, and the use of parenteral nutrition, which could allow this germ to unleash a catastrophic outbreak. In addition, if there is poor control and surveillance by the medical and nursing staff along with inadequate care and biosecurity measures, there would be an increase in the neonatal mortality rate and an impact on prognosis, hospital stay, and hospital costs.

This objective of this study was to describe the clinical, epidemiological, and microbiological characteristics and intervention measures that allowed for the successful control of an outbreak of Klebsiella pneumoniae.

Population and methods

Study Design

An observational, ambispective study was conducted.

Stage

We collected relevant clinical, epidemiological, and microbiological data from neonatology unit patients at the Metropolitan Hospital. The first part of the study is a retrospective analysis of data obtained from January 1, 2019, until July 30, 2020, presenting a report of a positive case of ESBL-producing Klebsiella pneumoniae. The second part of the study is a prospective analysis of a one-time biosafety control system installed on August 1, 2019 and monitored until June 30, 2020. The intervention time corresponds to the prospective period. Sample collection (culture results) were finished when the study concluded on June 30, 2020.

Participants

A registry was made of all cases admitted to the neonatology unit in the Metropolitan Hospital. The positive reports were focused on Klebsiella pneumoniae-positive cultures.

Variables

The number of cases of positive microbiological samples.

Data sources

The source was direct, we proceeded to collect data included in subsequent statistical tables. We used a form to transcribe patient data.

Procedures for the collection of information and instruments.

Data sources/measurement: the two sources were patient observations and the active surveillance cultures. The cultures were obtained according to the established standards of asepsis and antisepsis of the neonatology unit. Blood cultures, urine cultures, and pharyngeal secretion cultures were taken according to the patient's symptoms and underlying pathology.

Microbiological study of the samples

The patient cultures were sent to the microbiology laboratory of the Metropolitan Hospital of Quito. Samples were processed in specific cultures, and antimicrobial testing with targeted antibiotic discs were performed for each of the strains of microorganisms found.

Additionally, environmental samples were taken from the entire neonatology unit: sinks, cribs, the hands of the medical and nursing staff who were rotating at that time in the neonatology unit, and the boiling water reservoir.

Procedures to reinforce the reduction of infections after the outbreak.

During the study's prospective period, each resident physician and nurse who rotated in the nursing area were provided with education and training along with the staff working permanently in the area and parents of hospitalized neonatal patients.

The first training was based on hand washing, involving twelve steps and five moments of the same, for a set time indicated on a digital chronometer in the unit. They were also educated on complying with the rules when entering the neonatology area.

For the daily assessment of these implemented measures, a checklist was established and scored for each of the neonatology area workers (see Table 1).

Table 1 Handwashing Checklist

Gown (apron) removal, jackets, or coats
Removal of rings, watch, or bracelets
Sleeves folding
Cap placement
Activating the stopwatch
Carrying out 12-zone hand washing.
Comply with the five moments of hand washing.

Environmental medical equipment cleanup, isolation, and contact precautions:

During the study period, a procedure was carried out to clean the entire area. The following measures were taken:

Disinfection of cribs, incubators, equipment, tables, and counters; use of disinfectant towels with 17% alcohol (CaviWipes®; Metrex) and a 3-minute exposure time of this solution.

Entertainers for infants were removed and sterilized after their use.

Diaper changes were made with gloves. Diapers were weighted and discarded immediately, including the handling gloves. Handwashing was performed and recorded at the bottom of the checklist.

Drugs were prepared and administered immediately, to avoid leaving drugs on auxiliary tables.

To avoid the accumulation of containers or bottles, food or liquids were not to be ingested in the unit.

Fan and blender hose sets were changed every fourth day.

Reforms in the operation and infrastructure of the unit.

The entrance from the direct access door between the neonatology and gynecology units was used only for newborns in critical condition requiring intensive or intermediate care.

Under prior legal authorization from the hospital, a surveillance camera was installed at the lavatory site to monitor and reinforce hand washing for all health personnel and parents of newborns.

Measures established with patients.

Several measures were established for the patients in the different areas of possible colonization, while also accounting for their diet, invasive steps, and venous or arterial accesses. The measures were as follows:

The preparation of bottles was made with a water bottle, by labeling the date and time of opening, without using sterile or boiled water.

Liquid milk bottles with leftovers were discarded.

Heparin-Free Intravenous Devices (HFID) and Intravenous Devices with Heparin (IDWH) had caps containing antiseptic. These caps were changed every time a drug was administered and the caps were removed and discarded.

For central, umbilical and percutaneous line placement, prior disinfection was performed with 2% chlorhexidine together with a 0.9% saline solution.

The disinfection of the central, umbilical and percutaneous entry routes, was carried out with three sachets of chlorhexidine.

Control of the sources of bias.

Medical records were not excluded and all possible cases of biological samples that were sent for cultures

were analyzed. The protocol of this study was pre-approved by the Institutional Teaching Committee and the Bioethics Committee of the University of Cuenca. This study is not considered experimental since the normal procedure of the anesthesia department and the intubation preferences of the specialist doctors were observed.

Study Scope

The sample was non-probabilistic; all positive cases were included in this report.

Management of quantitative variables

The discrete variables are presented as frequency and percentages (%). A 95% confidence interval is used for proportions.

Statistical Methods

The data collected from the forms were entered into the statistical program SPSS, IBM 22.0 freeware version.

Results

Sociodemographic characterization of the study population.

During the retrospective observation period, 6 cases were identified, which occurred in a single quarter corresponding to May 2019: 2 cases, June 2019: 2 cases, July 2019: 2 cases. No cases were reported in the months of January to April or from August to December. The general characteristics of the group of patients with a positive culture are reported in Table 2.

Clinical outcomes

Of the six patients identified, all were premature newborns, three extreme. We accounted for other pathologies manifesting at that time, which could exacerbate the risk of colonization, along with clinical manifestations of infection; thus, we obtained four patients with early sepsis (shown in Fig. 1). The culture samples included three blood cultures, two urine cultures, and one culture of pharyngeal secretion.

Along with the Klebsiella pneumoniae culture, other pathogens were identified and isolated. These were kept in isolation until the cultures were negative (Figures 2 and 3).

The coinfection of Klebsiella with S. aureus lasted more days in isolation compared to the isolation of Klebsiella alone. Of all the cultures, two were positive for ESBL-producing Klebsiella pneumoniae, and four for multi-sensitive Klebsiella pneumoniae (Fig. 2).

The gestational age of the patients was related to the days of isolation and hospital stay.

There was no direct relationship between the time of prematurity and the days of hospitalization and days of isolation, indicating that the patients' comorbidities influenced recovery and therefore the days of hospitalization.

After receiving the results of the antimicrobial testing, antibiotic therapy was administered to the patients. 28% received meropenem, followed by vancomycin and gentamicin with 18%.

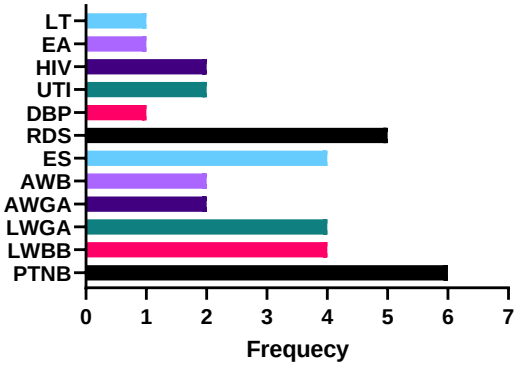

Fig. 1 Clinical diagnoses in the study group. PTNB Preterm Newborn. PAAN: AWB: Appropriate Weight at Birth. LBW: Low Birth Weight. LWGA: Low Weight of Gestational Age. RNPT: Pre-Term Newborn. RDS: Respiratory Distress Syndrome. UTI: urinary tract infection. ES: early sepsis. EA: Esophageal Atresia. LT: Laryngotracheitis.

Table 2 Clinical and epidemiological data and patient outcome in confirmed Klebsiella-positive cases.

Case	LG	Sex	Diagnostics	Days of stay	Type of culture	Germ	Days of isolation	Initial antibiotherapy	Targeted antibiotherapy	Outcome
1	25.5	M	PTNB + LBW+ LWGA + Early Sepsis + RDS + HIV	36	Blood Culture	Klebsiella Pneumoniae BLEE	13	Ampicillin+Gentamicin	Ampiouna, Gentamicin, Cephtaddma, Meropenem	Alive
2	29.6	F	PTNB+ LBW + LWGA + Early Sepsis + RDS	76	Blood Culture	Staph Aurels, Klebsiella Pneumoniae MS	24	Vancomycin, Cefotaxime	Vancomicyn Linezolid	Alive
3	54	F	PTNB + PAEG + AWB+ RDS + UTI	54	Urine Culture	Klebsiella Pneumoniae + Citrobacter Farmeri	17	Vancomycin, Cefotaxime	Meropenem	Alive
4	54	F	PTNB + PAEG + AWB + RDS + UTI	53	Urine Culture	Klebsiella Pneumoniae	10	Gentamicin	Gentamicin	Alive
5	36	M	PTNB + Esophageal Atresia + Laryngotracheitis + Early Sepsis	13	Tracheal Secretion	Serratia Marcenses + 5. Viridans Klebsiella Pineumoniae	6	Vancomycin, Cefotaxime	Cefepime, Vancomicyn	Alive
6	24.3	M	PTNB + LBW + LWGA + Early Sepsis +RDS+HIV	15	Blood Culture	Klebsiella Pneumoniae BLEE	5	Ampicillin+Gentamicin	Meropenem	Deceased

M: Male. F: Female. PTNB Preterm Newborn. PAAN: AWB: Appropriate Weight at Birth. LBW: Low Birth Weight. LWGA: Low Weight of Gestational Age. RNPT: Pre-Term Newborn. RDS: Respiratory Distress Syndrome. UTI: urinary tract infection

Results implementation of intervention strategies to control the outbreak

When implementing the checklist for hand washing and general measures for admission to the neonatology unit, we observed excellent 99% adherence to the five moments of handwashing and its twelve steps. The main fault occurred in when activating the timer, with 90% (shown Fig. 4). As for the environmental cultures, they were only positive for the samples taken in the sinks. In the rest of the sites, they were negative.

Overall, in the long term and after the implementation of the indicated measures, the outbreak was contained as no further cases were recorded from July 2019 to June 2020, the date that this study was closed (Fig. 5).

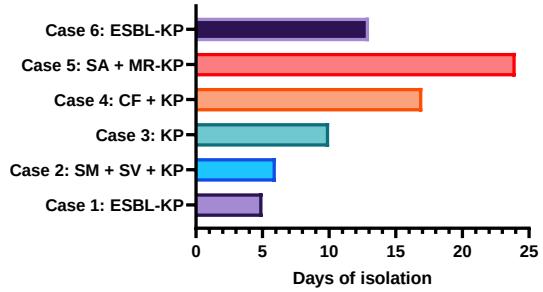

Fig. 2 Days of isolation in the study cases. KP: klepsiella pneumonia. ESBL: extended-spectrum beta-lactamases. MR Multi-resistant, SA: Staphylococcus Aureus, SM: Serratia marcescens, SV: Streptococcus viridans, CF: Citrobacter farmeri.

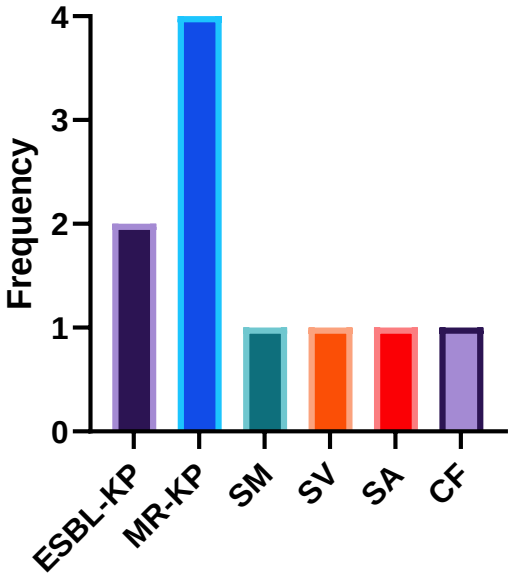

Fig. 3 Bacteria isolation prevalence. ESBL-KP: Extended-spectrum beta-lactamases Klepsiella pneumonia. MR Multi-resistant, SA: Staphylococcus Aureus, SM: Serratia marcescens, SV: Streptococcus viridans, CF: Citrobacter farmeri

Discussion

The results of the present investigation describe six cases of nosocomial infections and the absence of nosocomial infections after the implementation of outbreak control intervention strategies.

Within the implementation strategies, we monitored compliance with the biosafety regulations with feedback from the medical team and retraining hand hygiene observers.

It was evident that the primary control measure was educating the health personnel who work in the neonatology area. By establishing the checklists, this made both the health personnel and the patients' parents more committed to the control measures.

Also, infection control in the neonatology area was significantly impacted by the implementation of personal hygiene measures and cleaning measures in the area along with the supervision of adherence to the contact isolation measures.

Another way the spread of Klebsiella pneumoniae was avoided in the neonatology unit was by reinforcing the use of liquid milk, preferably 100%, minimizing powdered milk, and directly reducing their preparation. If this case, it was prepared with bottled water, not boiled.

Several studies from Colombia, Italy, and Spain were carried out in neonatology areas. They implemented a similar package of measures, including daily bathing of patients with chlorhexidine gluconate and performing cultures upon admission and monthly follow-up cultures to evaluate Klebsiella colonization [4-9].

In our neonatology area, we monitored for strict compliance with performing cultures for patients admitted extramurally during the first 48 hours of admission.

In 2012, the Centers for Disease Control and Prevention in Atlanta, USA (CDC) published a guide for the control of carbapenem-resistant Enterobacteriaceae that includes among the core of recommendations: hand hygiene, individual contact isolation or in cohorts with monitoring and feedback, minimization of the use of invasive devices, promotion of the prudent use of antibiotics, baths with 2% chlorhexidine and screening (initial and periodic) to identify colonized and infected patients [9, 10].

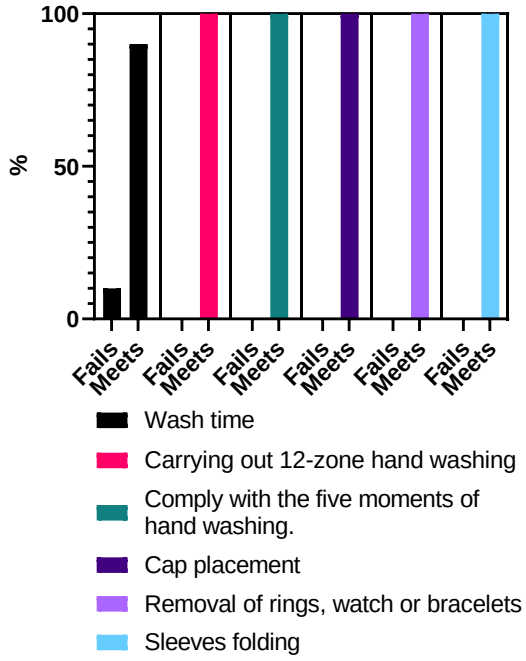

Fig. 4 Compliance with barrier measures.

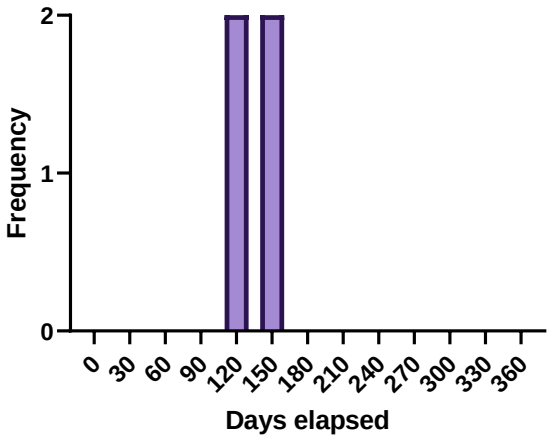

Fig. 5 Report of cases during the outbreak and subsequent control period.

The measures suggested by the CDC are used in our neonatology area with adequate adherence, compliance, and, above all, predisposition of the staff.

Effective communication and teamwork between neonatology, infectology, nursing, and microbiology allowed for the identification of the outbreak and the adequate implementation of intervention strategies that led to the successful control of the outbreak.

Conclusions

Following the report of 6 cases of Klebsiella pneumoniae in the neonatology unit, strict biosecurity measures were established. These included registration checklists and monitoring by security cameras. These interventions were effective in removing nosocomial infections over a control period after 12 months after implementation. This system could be useful for other biological risks, including COVID-19.

Abbreviations

AWB: Appropriate Weight at Birth, LBW: Low Birth Weight, LWGA: Low Weight of Gestational Age, PTNB: Pre-Term Newborn, RDS: Respiratory Distress Syndrome

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Authors' contributions

SG: Research idea, data collection, article writing, editorial corrections.
JU: Research idea data collection, statistical analysis.
FA: Research Idea, critical analysis of the article, bibliographic review.
KF: Data collection, article writing.
All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due participant confidentiality but are available from the corresponding author on reasonable request.

Ethical statements

Protection of persons

The authors declare that the procedures followed were in accordance with the ethical standards of the responsible human experimentation committee and in accordance with the World Medical Association and the Declaration of Helsinki.

Confidentiality of the data

The authors declare that they have followed the protocols of their work center on the publication of patient data.

Consent for publication

The authors have obtained the informed consent from the guardians of the patient referred to in the article. This document is in the possession of the corresponding author. The parents have signed the authorization for publication of this case.

Competing interests

The authors have no competing interests to declare

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