ETIOLOGY OF BACTERIAL COMMUNITY-ACQUIRED PNEUMONIA AMONG HOSPITALIZED CHILDREN IN HAI PHONG CHILDREN'S HOSPITAL

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The objectives of this study were to determine the etiology of bacterial community-acquired pneumonia (CAP) in children hospitalized at Hai Phong Children's Hospital (HCH) in 2019 and these bacteria's antibiotic resistance properties. The subjects were the qualified medical records of all inpatients at the Respiratory Department of Hai Phong Children's Hospital aging from 1 month to 15 years old diagnosed with CAP according to the diagnostic criteria of the World Health Organization with positive nasopharyngeal swab culture results from January 1st, 2019, to December 31st, 2019. The sample size included all medical records of patients who met the inclusion criteria of this research during the study period. The success rate of nasopharyngeal swab culture test of CAP patients was 638/1605 (39.7%). The most common pathogens of CAP in children at HCH were S. aureus, S. pneumoniae, H. influenzae and M. catarrhalis. Antibiogram revealed that each of them showed high resistance to a various type of antibiotics. Our study also provided valuable data on the antibiotic sensitivity and raised alarm over presence of multidrug-resistant bacteria inducing CAP in children.

Keywords: community-acquired pneumonia, children, bacteria, antibiotic resistance.

I. INTRODUCTION

Community-acquired pneumonia (CAP) is defined as pneumonia acquired outside the hospital and is still the leading cause of hospitalization and death among children in developing countries, including Vietnam.[1,2] Various pathogens might cause pneumonia in children, including bacteria, virus, fungi or parasite. In Vietnam, bacteria is still one of the main cause.[3] Nasopharyngeal culture remains a popular test to identify the type of bacteria in CAP, especially the typical one and it can be combined with the antibiogram in order to investigate their antibiotic resistance properties.[4]

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Bacteriological profile in community acquired pneumonia (CAP) is different in different countries and changes with time even within the same country.[5] We performed this research in order to clarify the bacterial etiology in community-acquired pneumonia (CAP) among hospitalized children in Hai Phong Children's Hospital – a tertiary center in Northern Vietnam in 2019 and the *in vitro* antibiotic resistance properties of these causative bacteria.

II. METHODS

1. Research subjects

We performed a descriptive study using retrospective data of case series to investigate the medical records of all the inpatients in the Respiratory Department of Hai Phong Children's Hospital aging from 1 month to 15 years diagnosed with CAP with a positive nasopharyngeal swab culture from January 1st,

2019, to December 31st, 2019.

Inclusion criteria: Patients were diagnosed with pneumonia according to the WHO criteria: cough, tachypnea or dyspnea, crackles and bronchial breathing on auscultation. Microbiological evaluation was based on a nasopharyngeal swab test performed at the Microbiological Laboratory - Hai Phong Children's Hospital at the time of hospital admission for Gram stain, culture and antibiogram complying with the Decision 1539/ QD-BYT – *Guidelines for clinical practice of microbiology techniques* of the Ministry of Health.

Children with acute asthma, underlying chronic diseases or immunosuppression were excluded.

2. Sample size and sampling method

Convenient sampling method by including all medical records of patients which met criteria for selecting research subject during the study period. In total, 638 cases with microbiological diagnosis found pathogenic bacteria among 1605 CAP patients with this test.

We collected research data from all the qualified medical records selected according to a pre-designed sample of medical records. The following parameters were recorded: date of presentation; age; bacteria found by nasopharyngeal swab test and results of antibiogram.

III. RESULTS

The main causative pathogens of CAP in children in Hai Phong Children's hospital were *S. aureus*, *H. influenzae*, *S. pneumoniae* and *M. catarrhalis* (Fig. 1A). There were clear differences in the ratio of main bacterial pathogens responsible for CAP among the 3 age groups of patients (Fig. 1B, C and D). *S. aureus* was the most common bacteria detected in the children at the 2 age groups (1m - < 1y old and > 5y old), while *S. pneumoniae* was the most common bacteria detected in the children at the 1y - < 5y old group and *S. aureus* was only accounted for 8.2% in this group.

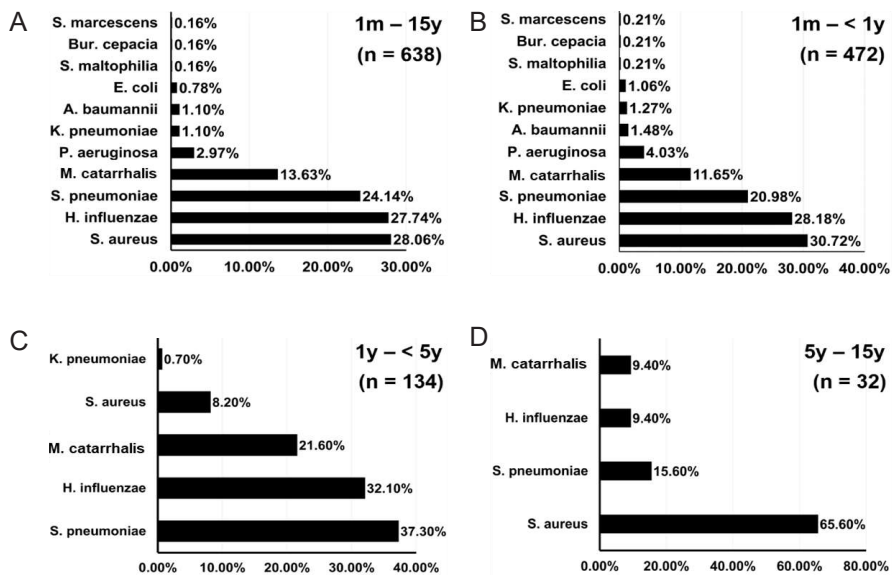

Figure 1. The bacterial pathogens responsible for CAP in children

The distribution of pathogenic bacteria of CAP in children globally (A) and in each age group (B, C and D)

We further found 2 peaks of the distribution of the 4 most common pathogens in children with CAP following to the time of diagnosis. *S. aureus*, *H. influenzae*, *S. pneumoniae* were *most detected* from March to April and from November to December while *M. catarrhalis* was more popular from November to December.

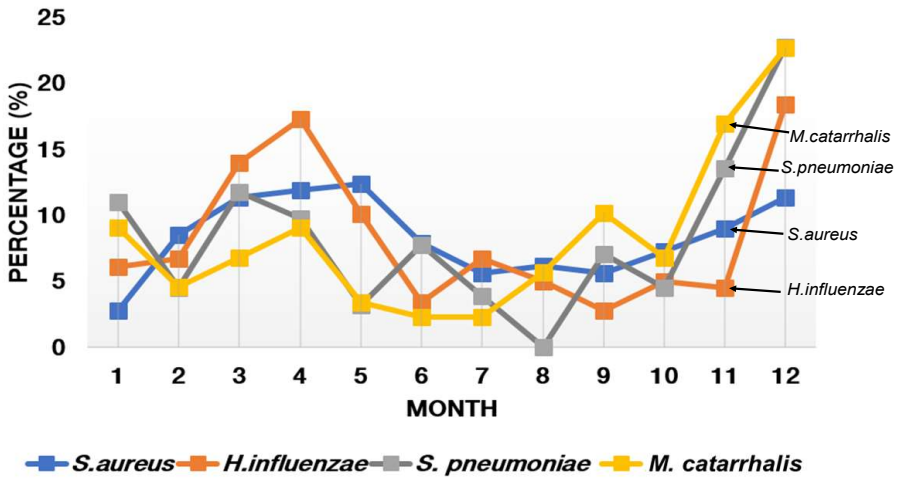

Figure 2. The distribution of the pathogens according to the time of diagnosis

1. *In vitro* antibiotic susceptibility of bacteria inducing CAP in children

We assessed the *in vitro* antibiotic susceptibility of the 5 main causative bacteria found in children with CAP using antibiogram of nasopharyngeal swab samples.

Table 1. Antibiotic susceptibility of several common bacteria inducing CAP in children

Antibiotics \ Bacteria	*H. influenzae*	*S. pneumoniae*	MRSA	non-MRSA	*M. catarrhalis*
Amoxicillin/Clavulanic acid	40.1	94	- (*)	87.8	98.8
Ampicillin/Sulbactam	59.8	-	0	-	-
Cefotaxime	59	93.4	0	93.2	91.5
Ceftriaxone	59.8	94.7	0	93.2	68.1
Cefuroxime	7.9	63.3	0	95.1	5.8
Meropenem	94.3	98.7	0	93.2	-
Piperacillin/Tazobactam	86.8	-	0	88.4	-
Trimethoprim/Sulfamethoxazole	9	3.5	-	-	29.4
Azithromycin	11.3	3.4	12	34.2	20
Ciprofloxacin	87.2	-	67.1	-	100
Chloramphenicol	-	80	-	-	-
Clindamycin	-	5.9	-	-	-

Antibiotics \ Bacteria	*H. influenzae*	*S. pneumoniae*	MRSA	non-MRSA	*M. catarrhalis*
Vancomycin	-	100	100	100	-
Amikacin	-	-	99.2	97.7	-

(*): (-) means not applicable; MRSA: Methicillin-resistant S. aureus

The antibiotic susceptibility was largely varied among different type of pathogens. All of these 4 most common pathogens inducing CAP in children showed low susceptibility to various type of antibiotics.

IV. DISCUSSION

Microbiological patterns

The successful rate of nasopharyngeal swab test culture of patients with CAP was at 39.7% (638/1605).

We firstly found that *S. aureus* was the most common bacteria inducing CAP in children from 1 month to under 1 year of age (30.72%) more than *H. influenzae*, *S. pneumoniae* and *M. catarrhalis* (Fig. 1B). In the patient group of 1–5-year-old, the most common causative bacteria of CAP were *S. pneumoniae* (37.3%), followed by *H. influenzae*, *M. catarrhalis* and *S. aureus* (Fig. 1C). Notably, these 4 types of bacteria were also the causative pathogens of CAP in children older than 5-year-old but in this group, *S. aureus* were the most common bacteria in charge of CAP (65.6%), followed by *S. pneumoniae, H. influenzae* and *M. catarrhalis* (Fig. 1D). Our results were similar to the results of a multicenter study by author Bénet et al. showing that the most common pathogen inducing CAP in children under 5-year-old was *S. pneumoniae* (42.2%).[7] Joseph L. Mathew et al. studied the etiology of CAP among children in India and found that in nasopharyngeal aspirate culture, *S. pneumoniae* (79.1%) predominated, followed by *H. influenzae* (9.6%) and *S. aureus* (6.8%).[8] According to the results of Pham Van Dem, the positive rate of bacteria culture was 46.1%. Among 90 positive bacterial cultures, the three most common etiologies were *H. influenzae*, *S. pneumoniae* and *M. catarrhalis* (48.7%, 27.8%, 18.3%, respectively).[9] A study by Le Thi Hong Hanh et al. at the National Children's Hospital on 668 children under 15-year-old with CAP by culturing nasopharyngeal specimens showed that the rate of bacteria isolated was 179/668 (26.8%). Among them, the three most common bacterial etiologies were *S. pneumoniae*, *H. influenzae* and *M. pneumoniae* (27.3%, 25.7% and 25.1%, respectively).[4,8] As said, bacteriological profile in CAP in children is varied in different countries and changes with time even within the same country.[5] Beside this, it should be noted that one of the disadvantage of NPS culture is that it couldn't detect the atypical bacteria inducing CAP in children, which are increasingly recognized as important causes of community acquired pneumonia (CAP) worldwide.[10] The lack of detection of atypical bacterial etiology of CAP is a limit of this study and could lead to the overall high ratio of *S. aureus* in our study.

Our seasonal distribution of CAP agents study showed monthly prevalence of *S. aureus*, *H. influenzae* and *S. pneumoniae* from March to April and from November to December in 2019, while *M. catarrhalis* was predominantly found from September to December 2019 (Fig.2). Our result was different from a study of Borges et al. in Brazil showing that infections caused by *M. catarrhalis* demonstrated seasonal distribution and the median monthly count was higher

during fall-winter, compared to spring-summer while the frequency of *S. pneumoniae* or *H. influenzae* infection did not show a seasonal pattern.[11]

Antibiotic susceptibility of bacteria inducing CAP in children

Antibiogram results revealed that *H. influenzae* showed high susceptibility to a few types of antibiotics (meropenem, piperacillin/tazobactam and ciprofloxacin) and moderate susceptibility to some antibiotics (cefotaxime, ceftriaxone, ampicillin/sulbactam) but very low susceptibility to cefuroxime and trimethoprim/sulfamethoxazole (Table 1). Our data can be compared with the study of Nguyen Thi Ngoc Diep on pneumonia in 155 children under 5 years old at Vietnam - Sweden Hospital (Quang Ninh) in 2016 showing that *H. influenzae* was resistant to a high rate with the antibiotics: amoxicillin and trimethoprim/sulfamethoxazole.[6]

S. pneumoniae isolated from patient's nasopharyngeal specimen showed high susceptibility to various types of antibiotics, such as amoxicillin/clavulanic acid, the 3rd generation cephalosporins, carbapenems and vancomycin (Table 1). A high percentage of *S. pneumoniae* isolates showed resistance to azithromycin (93.97%), trimethoprim/sulfamethoxazole (93.71%) and clindamycin (91.91%) (data not showed). Our data were consistent with the results of Tran Do Hung's study on patients under 5-year-old with pneumonia at Can Tho Children's Hospital in 2008 for *S. pneumoniae* with a high rate of resistance to antibiotics widely used in Viet Nam such as penicillin, amoxicillin and erythromycin while still highly sensitive with the quinolone and amoxicillin/clavulanic acid.[12]

133 MRSA isolates showed very high susceptibility to vancomycin and amikacin but moderate susceptibility to ciprofloxacin (Table 1). 86.11% of MRSA isolates showed resistance to Azithromycin (data not showed). Our data is comparable to research of Garoy EY. (2019) in Eritrea, Africa on MRSA antimicrobial sensitivity showing that 15.9% of the isolates were resistant to vancomycin, 11.0% to erythromycin, and only 1.2% to gentamicin.[13]

M. catarrhalis isolates showed high susceptibility to a few antibiotics: ciprofloxacin, amoxicillin/clavulanic acid and cefotaxime (Table 1). Our results was similar to a study of Bandet et al. showing that all *M. catarrhalis* isolates were sensitive to amoxicillin/clavulanic acid, doxycycline, clarithromycin, levofloxacin and trimethoprim/sulfamethoxazole.[14]

V. CONCLUSION

The most common bacteria inducing CAP in children at Haiphong Children's hospital were *S. aureus, S. pneumoniae, H. influenzae* and *M. catarrhalis*. We suggest that treatment of CAP in children should focus on these bacteria. Our study has also provided valuable data on the antibiotic sensitivity of these bacteria and raised alarm over presence of multidrug-resistant bacteria inducing CAP in children. The high proportion of pneumococcal infections in this study emphasizes the possible importance of pneumococcal immunization.

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