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Original article

Prevalence and clinical distribution of multidrug-resistant bacteria (3537 isolates) in a tertiary Chinese hospital (January 2012–December 2013)

Prévalence et distribution clinique des bactéries multi-résistantes (3537 isolats) dans un hôpital chinois tertiaire (janvier 2012–décembre 2013)

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ABSTRACT

Objective. – Multidrug-resistant organisms (MDROs) have become a widespread serious problem in recent years. Our objective was to determine the prevalence and clinical distribution of MDROs in a tertiary care hospital in China from January 1, 2012 to December 31, 2013.
Methods. – The strains were cultured according to standard methods; bacterial identification and susceptibility testing were detected by Vitek 2 system. The prevalence and clinical distribution of extended-spectrum β-lactamases (ESBLs)-producing *enterobacteriaceae*, carbapenem-resistant *enterobacteriaceae* (CRE), multiple-drug/pan-drug resistant *P. aeruginosa* (MDR/PDR-PA), carbapenem-resistant *A. baumannii* (CR-AB), methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) were analyzed by WHONET 5.6.
Results. – A total of 3537 (33.4%) MDROs were found among 10,594 microbial isolates. ESBLs producing *E. coli* (ESBLs-ECO) (1153 cases) were the most frequent MDROs, followed by CR-AB (827 cases). The proportion of acquired resistance of *A. baumannii* (48.9%) accounted for the highest in all the MDROs. These MDROs were mainly isolated from respiratory (70.3%) and secretions (12.7%). Various types of intensive care unit (ICU) and surgery were the main source departments. The proportion of CRE and VRE were relatively few. CRE was most isolated from respiratory tract and closed body cavity fluid, while the distribution of VRE was relatively dispersed.
Conclusion. – High prevalence of MDROs has emerged in our hospital, particular in various ICU and surgical department. The effective way to prevent the further spread of MDROs is to strengthen the protection of respiratory tract and surgical wounds.

Mots clés :
Organismes multi-résistants
Prévalence
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RÉSUMÉ

Les bactéries multi-résistantes (BMR) sont devenues un problème majeur de santé publique. Notre objectif a été de déterminer leur prévalence et leur distribution par service dans un hôpital chinois de soins tertiaires entre le 1er janvier 2012 et le 31 décembre 2013. Un total de 3537 BMR a été analysé parmi 10 594 souches isolées (33,4 %). Les souches de *Escherichia coli* productrices de BLSE ont été les plus fréquentes suivies de celles de *Acinetobacter baumannii* résistantes aux carbapénèmes. Ces BMR ont été principalement d'origine respiratoire (70,3 %) et de sécrétions (12,7 %), les principales sources étant les soins intensifs et la chirurgie. La résistance des entérobactéries aux carbapénèmes ainsi que celle

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d'entérocoques aux glycopeptides est faible et d'origine variable. La non-propagation de BMR devra s'appuyer sur un renforcement de la protection des voies respiratoires et celle des plaies chirurgicales.

1. Introduction

Multidrug-resistant organisms (MDROs) are serious challenges on clinical treatment, infection control and public health [1,2]. Commonly encountered MDROs with clinical significance include extended-spectrum β-lactamases (ESBLs)-producing *enterobacteriaceae*, carbapenem-resistant *enterobacteriaceae* (CRE), multiple-drug/pan-drug resistant *P. aeruginosa* (MDR/PDR-PA), carbapenem-resistant *A. baumannii* (CR-AB), methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant *enterococcus* (VRE) [3]. These MDROs can cause various types of infections such as pneumonia, urinary tract infection, abdominal infection and wound infection. The complexity and recurrent features of MDROs pose a threat to affected patients worldwide and frequently lead to poorer outcomes such as longer hospital stays, increased mortality, and higher hospitalization cost [3]. It is important for us to explore the characteristics of prevalence and clinical distribution of MDROs. Then we can take effective prevention and control measures to avoid the outbreak of MDROs in centralized departments.

This study analyzed the prevalence and clinical distribution of MDROs retrospectively during a two-year period in a tertiary health care hospital in China. Through this research, we can better grasp the situation of MDROs and take more effective measures to control the occurrence of MDROs in future.

2. Materials and methods

2.1. Setting

The study was carried out at a comprehensive tertiary health care hospital in China. The hospital is located in the center of Liaocheng city, west of Shandong Province, China. It has 3000 inpatient beds and 82 clinical departments, one comprehensive intensive care unit (ICU) and five various specialized ICUs, including neonatal intensive care unit (NICU), pediatric intensive care unit (PICU), respiratory intensive care unit (RICU), neurology ICU and neurosurgery ICU.

Table 1
Frequency of multi-drug resistant organisms in microbial isolates in a tertiary care hospital from 2012 to 2013.

Organism	*n*	MDROs	MDROs *n* (%)
Escherichia coli	2860	ESBLs-ECO	1153 (40.3)
		CR-ECO	2 (0.1)
Klebsiella pneumoniae	1614	ESBLs-KPN	424 (26.3)
		CR-KPN	35 (2.2)
Klebsiella oxytoca	85	ESBLs-KOX	31 (36.5)
		CR-KOX	4 (4.7)
Enterobacter cloacae	384	CR-ECL	7 (1.8)
Pseudomonas aeruginosa	2148	MDR/PDR-PA	628 (29.2)
Acinetobacter baumannii	1691	CR-AB	827 (48.9)
Staphylococcus aureus	1539	MRSA	449 (29.2)
Enterococcus faecium	150	VR-EFM	4 (2.7)
Enterococcus faecalis	123	VR-EFA	8 (6.5)

MDROs: multidrug-resistant organisms; ESBLs-ECO: extended-spectrum β-lactamases producing *E. coli*; CR-ECO: carbapenem-resistant *E. coli*; ESBLs-KPN: extended-spectrum β-lactamases producing *K. pneumoniae*; CR-KPN: carbapenem-resistant *K. pneumoniae*; ESBLs-KOX: extended-spectrum β-lactamases producing *K. oxytoca*; CR-KOX: carbapenem-resistant *K. oxytoca*; CR-ECL: carbapenem-resistant *E. cloacae*; MDR/PDR-PA: multiple-drug/pan-drug resistant *P. aeruginosa*; CR-AB: carbapenem-resistant *A. baumannii*; MRSA: methicillin-resistant *S. aureus*; VR-EFM: vancomycin-resistant *E. faecium*; VR-EFA: vancomycin-resistant *E. faecalis*.

2.2. Microbiological Methods

All strains were isolated from a variety of non-duplicate clinical specimens in our hospital from January 1, 2012 to December 31, 2013. The strains were cultured according to standard methods; bacterial identification and susceptibility testing were detected by Vitek 2 automated microbial system (bioMérieux; Marcy l'Étoile, France). ESBLs producing *E. coli* (ESBLs-ECO), *K. pneumoniae* (ESBLs-KPN) and *K. oxytoca* (ESBLs-KOX) were detected by the expert system of Vitek 2 in relation with the CLSI double disk diffusion method [4]. The resistance mechanisms of carbapenem-resistant *E. coli* (CR-ECO), *K. pneumoniae* (CR-KPN), *K. oxytoca* (CR-KOX) and *E. cloacae* (CR-ECL) were confirmed by modified Hodge test and PCR. *P. aeruginosa* was classified as MDR-PA by non-susceptibility to at least one agent in three or more antibiotic classes. The interpretation of PDR-PA was the strain resistant to all conventional antibiotics [5]. MRSA was detected by the expert system of Vitek 2 in relation with disk diffusion method with cefoxitin [4]. Vancomycin-resistant *E. faecium* (VR-EFM) and *E. faecalis* (VR-EFA) were confirmed by the Epsiolon test (Etest; bioMérieux) and agar dilution method [4].

2.3. Statistical Analysis

Data of antimicrobial susceptibility testing was extracted from the laboratory information system and converted centrally into a standard format using WHONET 5.6. The distribution of department sources and specimen types of MDROs were analyzed: secretions including cuts and wounds exudates, pus, etc., but excluding secretions from the oral cavity, nasopharynx, and anal swabs; respiratory specimens including sputum, bronchoalveolar lavage fluid, but upper respiratory tract specimens were not included and closed body cavity fluid including pleural fluid, ascites, cerebrospinal fluid, synovial fluid, bile and closed drainage fluid, etc. The rare specimen types were classified into the "Other" categories, such as cornea, the catheter tip, organizations, etc.

Table 2
Pattern of microbial isolates in culture multi-drug resistant organisms specimens in a tertiary care hospital from 2012 to 2013.

MDROs	Specimen					
	Respiratory (*n* = 2485)	Secretion (*n* = 448)	Urine (*n* = 243)	Closed body cavity fluid (*n* = 179)	Blood (*n* = 169)	Others (*n* = 13)
ESBLs-ECO (*n* = 1153)	584	125	227	106	103	8
CR-ECO (*n* = 2)	2	0	0	0	0	0
ESBLs-KPN (*n* = 424)	357	23	5	10	29	0
CR-KPN (*n* = 35)	27	0	0	5	3	0
ESBLs-KOX (*n* = 31)	6	20	0	2	3	0
CR-KOX (*n* = 4)	0	1	0	3	0	0
CR-ECL (*n* = 7)	0	2	0	5	0	0
MDR/PDR-PA (*n* = 628)	490	106	5	13	12	2
CR-AB (*n* = 827)	739	45	2	31	7	3
MRSA (*n* = 449)	305	122	2	8	12	0
VR-EFM (*n* = 4)	0	2	2	0	0	0
VR-EFA (*n* = 8)	0	3	0	2	3	0

MDROs: multidrug-resistant organisms; ESBLs-ECO: extended-spectrum β-lactamases producing *E. coli*; CR-ECO: carbapenem-resistant *E. coli*; ESBLs-KPN: extended-spectrum β-lactamases producing *K. pneumoniae*; CR-KPN: carbapenem-resistant *K. pneumoniae*; ESBLs-KOX: extended-spectrum β-lactamases producing *K. oxytoca*; CR-KOX: carbapenem-resistant *K. oxytoca*; CR-ECL: carbapenem-resistant *E. cloacae*; MDR/PDR-PA: multiple-drug/pan-drug resistant *P. aeruginosa*; CR-AB: carbapenem-resistant *A. baumannii*; MRSA: methicillin-resistant *S. aureus*; VR-EFM: vancomycin-resistant *E. faecium*; VR-EFA: vancomycin-resistant *E. faecalis*.

Table 3
Distribution and constituent ratios of multi-drug resistant organisms in mainly departments (%).

MDROs	Department *n* (%)				
ESBLs-ECO (*n* = 1153)	Gastrointestinal surgery 133 (11.5)	Neurosurgery ICU 124 (10.8)	NICU 113 (9.8)	Neonatology 110 (9.5)	Comprehensive ICU 98 (8.5)
CR-ECO (*n* = 2)	Neurosurgery ICU 2 (100.0)	–	–	–	–
ESBLs-KPN (*n* = 424)	Neurosurgery ICU 76 (17.9)	NICU 59 (13.9)	Neonatology 41 (9.7)	Comprehensive ICU 36 (8.5)	Respiratory 27 (6.4)
CR-KPN (*n* = 35)	NICU 16 (45.7)	Comprehensive ICU 7 (20.0)	Neurosurgery ICU 6 (17.1)	Neonatology 5 (14.3)	PICU 1 (2.9)
ESBLs-KOX (*n* = 31)	Orthopedics 9 (29.0)	Neurosurgery ICU 8 (25.8)	Gastrointestinal surgery 7 (22.6)	Neonatology 4 (12.9)	Comprehensive ICU 3 (9.7)
CR-KOX (*n* = 4)	PICU 3 (75.0)	Orthopedics 1 (25.0)	–	–	–
CR-ECL (*n* = 7)	Orthopedics 3 (42.9)	Burns branch 3 (42.9)	Comprehensive ICU 1 (14.3)	–	–
MDR/PDR-PA (*n* = 628)	Comprehensive ICU 101 (16.1)	Neurosurgery ICU 88 (14.0)	Burns branch 69 (11.0)	Neurology ICU 45 (7.2)	Orthopedics 44 (7.0)
CR-AB (*n* = 827)	Comprehensive ICU 316 (38.2)	Neurosurgery ICU 105 (12.7)	RICU 101 (12.2)	Neurology ICU 92 (11.1)	Respiratory 56 (6.8)
MRSA (*n* = 449)	Orthopedics 91 (20.3)	Comprehensive ICU 73 (16.3)	Neurosurgery ICU 68 (15.1)	RICU 33 (7.3)	Burns branch 19 (4.2)
VR-EFM (*n* = 4)	Infectious department 2 (50.0)	Hepatobiliary surgery 1 (25.0)	Nephrology 1 (25.0)	–	–
VR-EFA (*n* = 8)	Orthopedics 4 (50.0)	PICU 3 (37.5)	Infectious department 1 (12.5)	–	–

MDROs: multidrug-resistant organisms; ESBLs-ECO: extended-spectrum β-lactamases producing *E. coli*; CR-ECO: carbapenem-resistant *E. coli*; ESBLs-KPN: extended-spectrum β-lactamases producing *K. pneumoniae*; CR-KPN: carbapenem-resistant *K. pneumoniae*; ESBLs-KOX: extended-spectrum β-lactamases producing *K. oxytoca*; CR-KOX: carbapenem-resistant *K. oxytoca*; CR-ECL: carbapenem-resistant *E. cloacae*; MDR/PDR-PA: multiple-drug/pan-drug resistant *P. aeruginosa*; CR-AB: carbapenem-resistant *A. baumannii*; MRSA: methicillin-resistant *S. aureus*; VR-EFM: vancomycin-resistant *E. faecium*; VR-EFA: vancomycin-resistant *E. faecalis*.

3. Results

A total of 3537 (33.4%) MDROs were found among 10,594 microbial isolates. ESBLs-ECO were the most frequent MDROs, followed by CR-AB, MDR/PDR-PA, MRSA and ESBLs-KPN. The proportion of acquired resistance of *A. baumannii* accounted for the highest in all the MDROs, followed by ESBLs-ECO. The strains of *P. aeruginosa* and *S. aureus* showed moderate resistance, MDR/PDR-PA and MRSA exhibited similar rates in the corresponding species. The proportion of CRE and VRE were relatively low. CR-KPN was the dominant strain in CRE. CR-ECL, CR-KOX and CR-ECO were also isolated from our hospital simultaneously. The strains of VRE were composed of VR-EFM and VR-EFA (Table 1).

Pattern of microbial isolates in culture MDROs specimens are shown in Table 2. MDROs were mainly isolated from respiratory and secretions, followed by urine, closed body cavity fluid and blood. Respiratory specimens were the main source of ESBLs-producing *enterobacteriaceae*, followed by urine. CR-AB, MDR/PDR-PA and MRSA were most isolated from the respiratory tract, and specimens of MDR/PDR-PA and MRSA occupied a certain distribution in secretion. CRE was most separated from the respiratory tract and closed body cavity fluid, while the distribution of VRE was relatively dispersed.

These MDROs specimens mainly derived from various types of ICU, including neurosurgery ICU, comprehensive ICU, RICU, PICU and NICU. Gastrointestinal surgery was the main source department of ESBLs-ECO. MRSA, MDR/PDR-PA and CR-ECL occupied a certain distribution in orthopedic and burn department. The CR-KPN specimens mainly derived from NICU, while VRE mainly derived from orthopedics, PICU and infectious department. Details are given in Table 3.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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