IDCases 9 (2017) 56–58

Contents lists available at ScienceDirect

IDCases

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Case report

New Delhi metallo-β-lactamase-1 (NDM-1) *Escherichia coli* isolated from household vacuum cleaner—Oregon, 2013

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ARTICLE INFO

Keywords:
Escherichia coli
NDM-1-beta-lactamase
Environmental microbiology
Plasmids
Vacuum cleaner

ABSTRACT

The first Oregon case of New Delhi metallo-β-lactamase-1 (NDM-1)-producing *Escherichia coli* was reported during November 2013. Epidemiologic investigation revealed only local outpatient medical care and no travel outside Oregon for both the patient and his household contact. Environmental sampling discovered a matching isolate from the patient's household vacuum cleaner, suggesting environmental persistence.

Introduction

Carbapenemase-producing carbapenem-resistant *Enterobacteriaceae* (CP-CRE) facilitate the spread of broad-spectrum antibiotic resistance around the globe via transferable plasmids. New Delhi metallo-β-lactamase-1 (NDM-1)-producers are increasingly reported; however, they remain rare in the northwest US [1]. The NDM-1-carrying plasmid is commonly associated with *Escherichia coli,* but is found in *Klebsiella, Pseudomonas*, *Acinetobacter*, and *Salmonella* [2]. The vast majority of NDM-1 reports are associated with returning travelers or healthcare from endemic areas; however, uncommonly these exposures are not identified [3,4]. Little is known about where the isolate might persist in non-endemic areas. During November 2013, Oregon identified its first reported NDM-1-producing *E. coli* via mandated laboratory CRE surveillance.

Methods

Oregon began statewide CRE surveillance during December 2011, after establishing the Drug Resistant Organism Prevention and Coordinated Regional Epidemiology (DROP-CRE) network [5]. At the time this case was identified, CRE were defined as *Enterobacteriaceae* isolates non-susceptible to ≥1 carbapenem and non-susceptible to any tested third-generation cephalosporins. Isolates meeting the case definition were submitted by laboratories to the Oregon State Public Health Laboratory (OSPHL) for phenotypic screening (e.g., modified Hodge test, Carba NP test), followed by genotypic testing [6–8]. By November 2013, DROP-CRE had identified 137 CRE cases; of these, 2 were KPC-producing *Klebsiella pneumoniae*. Per CP-CRE protocol, we investigated to determine potential risk factors, identify the source, and prevent transmission.

Because initial review of the NDM case did not reveal traditional risk exposures, we launched a more in depth investigation. The investigation included laboratory and chart reviews, case and healthcare provider interviews, healthcare and household contact screenings, site visits, and, when indicated, environmental testing. Additionally, molecular typing, whole genome sequencing, and environmental testing were performed [9]. All samples were collected from the original containers or the vacuum bag, placed into a sterile Whirl-Pak®, and submitted directly for extraction and testing.

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http://dx.doi.org/10.1016/j.idcr.2017.06.004
Received 22 May 2017; Accepted 11 June 2017

Table 1
Minimum inhibitory concentrations (MIC) for an isolate of NDM-producing *Escherichia coli*— Oregon, 2013.

Minimum inhibitory concentrations (MIC) for NDM-producing *Escherichia coli*— Oregon, 2013										
Antibiotic[a]	A/S	PT	CTX	CEP	IMI	MER	GEN	CIP	COL	PB
MIC (μg/mL)	> 16/8	> 64	> 32	> 16	> 8	> 8	2	> 2	0.5	0.5
Interpretation	R	R	R	R	R	R	S	R	NA	NA

[a] A/S = ampicillin/sulbactam, PT = Piperacillin/tazobactam, CTX = ceftriaxone, CEP = cefepime, IMI = imipenem, MER = meropenem, GEN = gentamicin, CIP = ciprofloxacin, COL = colistin, PB = polymixin B.

Results

Case investigation

A shin wound culture taken in the outpatient setting from a rural Oregon Caucasian resident yielded an NDM-1 positive, extended-spectrum β-lactamase (ESBL) CTX-M-27-producing *E. coli* O25b-ST131 isolate with a IncF plasmid of type F29:A2:B10 [9]. Antimicrobial susceptibility Microscan® results for the *E. coli* isolate are summarized below (Table 1).

The patient had injured his lower leg at home; cellulitis ensued despite self-treatment with an expired triple-antibiotic cream. The wound culture grew 1+ Gram-negative bacilli, identified as NDM-1-producing *E. coli*, and 4+ methicillin-sensitive *Staphylococcus aureus,* presumed to be the causative organism, as the case improved with oral clindamycin. The patient and spouse denied international or interstate travel, international visitors or international travel among close contacts, foreign healthcare providers, and direct contact with domestic or wild animals. They denied hospitalizations or medical procedures in the previous 12 months; we confirmed only local, outpatient clinic visits during the previous year. They reported purchasing nutritional supplements on the internet, and ate seafood at a local Thai restaurant. Wild deer, elk, and turkey roamed their forested property. Cattle grazed one-half mile away. Review of regional laboratory reports did not identify other NDM-positive CRE during the preceding year, even for laboratory certification purposes. CRE surveillance rectal swabs collected from the case (n = 3) at 3, 5, and 7.5 weeks after the index isolate, and from the spouse (n = 1) at 15 weeks, were negative. Given the lack of an obvious NDM source, we considered outpatient clinic specimen contamination or laboratory error, unusual exposures such as food or spice contamination, wild animal feces, and household water system contamination.

Environmental testing

Spice (n = 14), nutritional supplement (n = 15), indoor environmental (n = 13), outdoor environmental (n = 18), and vacuum dust (n = 4) samples were collected two months after index culture. An NDM-1-producing *E. coli* isolate indistinguishable by PFGE from the patient's isolate was extracted and cultured from a household vacuum bag dust sample. The case reported vacuuming indoors weekly. The clinical and household vacuum isolates were found to be homogeneous by DNA-DNA hybridization (value 99.3% ± homogeneity) [9] (Fig. 1).

Discussion

NDM-1-producing CRE are rare in the U.S.; since 2009, only 157 cases had been reported at the time of our investigation. Previously reported NDM-1-producing CRE have been associated with healthcare, travel to endemic areas, and spontaneous acquisition [1]. While we were unable to identify a single source of NDM-1 producing *E. coli*, recovery of a matching strain from a vacuum cleaner likely excludes a false identification, and raises the concern about the persistence of pathogenic strains in the environment.

After excluding typical risk factors for CRE colonization or a pseudo-source (e.g., laboratory contamination), we pursued alternatives based upon exposure history, including foodstuffs. Spices, including red and black pepper, can support the growth of some bacteria, and have been the source of previous outbreaks [10,11]. Similarly, nutritional supplement manufacturing is not regulated, and investigation of the brands used by the case revealed that components were sourced from China, Malaysia, and India (PMC, communications with manufacturer). Although spices and nutritional supplements were suspected, carbapenem-resistant *E. coli*were not isolated from these sources [9]. Seafood has been associated with multidrug-resistant Gram-negative isolates, and is commonly processed in Asia, even after harvest in US waters [12]. This risk may derive from contaminated environmental water sources [13,14].

Whatever the initial source of acquisition, the patient likely contaminated his environment with a CRE, which persisted even two months after the initial wound isolation. Pathogens (e.g., *E. coli* O157:H7 [15], *Salmonella* spp. [16]) can survive for extended periods in common household vacuum cleaners [17,18]. As suggested by this investigation, CRE can persist in the environment in protected niches for extended periods of time.

The Oregon clone has unique epidemiologic and molecular characteristics. NDM-1 is usually associated with global *E. coli* clones (e.g., sequence types 405 and 101). However, this *E. coli* belongs to ST131, a globally emergent pathogenic clone that accounts for approximately two-thirds of ESBL-producing *E. coli* in the US. The ESBL phenotype of these strains is typically a result of plasmid-mediated $bla_{\text{CTX-M-15}}$ carriage by a distinctive ST131 clade known as C2/H30Rx [19]. However, ST131 carriage of $bla_{\text{CTX-M-27}}$ is now increasingly being described, with cases now reported from Japan, Korea, China, Australia, Nepal, Cambodia, Israel, Czech Republic, Switzerland, Spain, France, Portugal, Netherlands, Canada, and the United States [20]. A recent analysis by Matsumura et al. of 21 $bla_{\text{CTX-M-27}}$-bearing ST131 isolates from Japan (n = 13), Australia (n = 3), US (n = 2, including our patient), Canada (n = 1), Thailand (n = 1), and Vietnam (n = 1) suggested that this unique clade (known as C1-M27) emerged from the larger C1/H30R clade of ST131 in Japan during the late 2000 s [20]. In addition, our *E. coli* carried an IncF plasmid of type F29:A2:B10, which was common among the international isolates of C1-M27 strains [21–24]. Given these observations, we suspect that a ST131 strain of the C1-M27 clade,

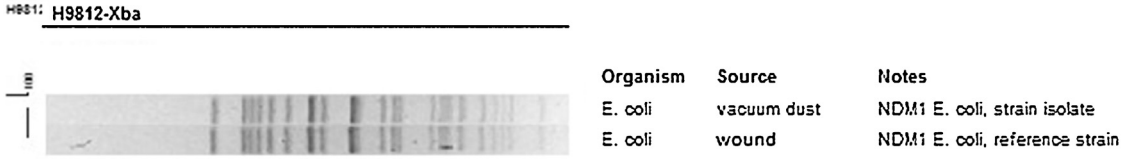

Fig. 1. Pulsed-field gel electrophoresis profiles of case NDM-1-producing *E. coli* isolate and household vacuum bag dust sample obtained two months after the index clinical culture.

carrying $bla_{CTX\text{-}M\text{-}27}$ on an F29:A2:B10 plasmid, acquired NDM on a separate plasmid backbone, such as IncN2.

Conclusions

We report a patient with domestically acquired NDM-1-carrying *E. coli* strain carrying a suspected East Asian or Australian plasmid presumably acquired through non-healthcare exposures. As our knowledge and experience of CP-CRE expand, we recommend during investigation to inquire about travel exposures and imported food that can transport multidrug-resistant organisms from endemic to non-endemic regions worldwide [25]. Broadened hypothesis generation as part of the case investigation might include relevant foodstuffs processed in countries with endemic CP-CRE. Libraries of molecular strain characterizations supplemented with detailed epidemiologic data could permit trace-back to sources, as is done in foodborne outbreak investigations.

Funding

G.L.B., P.M.C, R.V., C.D.P., Z.G.B.: This work was funded by the Epidemiology and Laboratory Capacity cooperative agreement numberNU50CK000484-01-01 with the Centers for Disease Control and Prevention. The authors report no conflicts of interest between themselves and this manuscript.

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