ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, June 2008, p. 2285–2286 Vol. 52, No. 6
0066-4804/08/$08.00+0 doi:10.1128/AAC.00076-08

Chronic Respiratory Infections by Mucoid Carbapenemase-Producing *Pseudomonas aeruginosa* Strains, a New Potential Public Health Problem▽

Pseudomonas aeruginosa is a major cause of chronic respiratory infections (CRI) in patients with underlying diseases such as cystic fibrosis, bronchiectasis, or chronic obstructive pulmonary disease (COPD) (1, 6, 7). The establishment of *P. aeruginosa* CRI is driven by the acquisition of an important number of adaptive mutations required for long-term persistence (10, 12). Among them, the hallmark of *P. aeruginosa* CRI is the conversion to the mucoid phenotype that drastically increases the organism's resistance to clearance by the immune system and antimicrobial treatments (2). Antimicrobial resistance development in this setting is frequent, although so far it is generally driven by mutations in chromosomal genes and not by the horizontal acquisition of resistance determinants (4, 8, 9).

In June 2007, a mucoid multidrug-resistant (MDR) *P. aeruginosa* strain was isolated from the respiratory secretions of a 66-year-old male patient (patient 1) admitted to H. Son Dureta Intensive Care Unit due to a severe acute exacerbation of COPD. This isolate (P1jun07) was found to be resistant to ceftazidime, cefepime, piperacillin, piperacillin-tazobactam, imipenem, meropenem, ciprofloxacin, gentamicin, and tobramycin; intermediate to amikacin; and susceptible only to aztreonam and colistin by the Etest method. The screening test performed (Etest-MBL) was positive for class B carbapenemases (metallo-β-lactamase [MBL]). The genetic element harboring the MBL-encoding gene was characterized by PCR and sequencing, following previously established protocols (3), revealing the presence of a class I integron in which the integrase-encoding *int1* gene was followed by *aacA4* [encoding an AAC(6′)-Ib aminoglycoside-modifying enzyme that confers resistance to gentamicin and tobramycin] and bla_{VIM-2}.

Patient 1 suffered a very severe obstruction to airflow (forced expiratory volume in 1 s [FEV_1] of 15%) and had been admitted in the last few years to a chronic care hospital (H. Joan March) for long time periods. Pulsed-field gel electrophoresis (PFGE) analysis (Fig. 1), MDR pattern, and PCR revealed that the mucoid MBL-producing clone had been present in this patient since at least April 2007 (isolate P1apr07). Isolate P1apr07 was obtained during one of the previous admissions to the chronic care hospital, which may suggest that it was acquired in that institution. The follow-up performed at the chronic care hospital revealed that a true CRI (defined as at least three sequential positive samples over a 6-month period) had been established: sequential cultures prospectively obtained up to December 2007 were always positive for the mucoid MBL-producing strain (Fig. 1), despite several courses of antimicrobial treatments that included various combinations of amikacin, azithromycin, and inhaled colistin.

In August 2007, a second case of respiratory infection by mucoid MBL-producing *P. aeruginosa* was prospectively detected in the chronic care hospital. This 80-year-old female patient (patient 2) suffered from chronic bronchiectasis and, like the first patient, had been admitted to the chronic care facility on several occasions over the last few years. The retrospective analysis of the *P. aeruginosa* isolates from this patient revealed the presence of the mucoid MBL-producing strain since at least May 2007 (isolate P2may07), and the prospective follow-up demonstrated the persistence of the strain in the respiratory tract at least up to December 2007, despite azithromycin and inhaled colistin treatment, again showing that a CRI had been established. PFGE analysis (Fig. 1) revealed that all of the sequential isolates belonged to the same clonal type of the MBL-producing strain of patient 1; the resistance pattern was also identical, and the presence of bla_{VIM-2} was confirmed by PCR. These two patients were admitted to the chronic care facility in the same time frame before the detection of the first case in June 2007, and therefore before strict contact precautions could be adopted. Although they never shared rooms, cross transmission between them due to sporadic contact in common areas of the chronic care facility cannot be ruled out.

Finally, a third case of MBL-producing *P. aeruginosa* was detected in the same institution in October 2007. It was isolated from the respiratory tract of an 83-year-old female patient (patient 3) diagnosed with moderate COPD (FEV_1 of 69%) and bronchiectasis. PFGE analysis showed that this isolate also belonged to the clone described above (Fig. 1), although, interestingly, this isolate did not show the mucoid phenotype. Furthermore, follow-up cultures obtained in November and December 2007 after treatment with inhaled colistin yielded negative results; the fact that a CRI was apparently

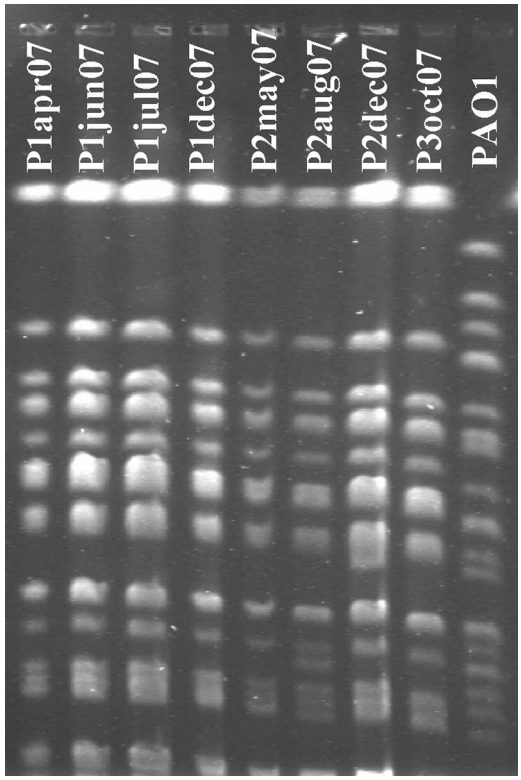

FIG. 1. SpeI DNA restriction patterns obtained through PFGE of the sequential MDR *P. aeruginosa* isolates from patients 1, 2, and 3.

not established in this patient could be related to the absence of the mucoid phenotype in this isolate.

In summary, we describe the first cases of CRI by mucoid *P. aeruginosa* strains harboring horizontally acquired MBL-producing integrons in patients with COPD and bronchiectasis. Furthermore, a single *P. aeruginosa* clone infected the three documented patients, highlighting the spreading capacity of this strain. Horizontally acquired MDR, driven by MBL-producing integrons, in *P. aeruginosa* is emerging as a major clinical problem in the hospital setting worldwide (5, 11, 13). On the other hand, CRI by mucoid *P. aeruginosa* in patients with chronic underlying respiratory diseases are extremely difficult to manage with antimicrobial agents; once they are fully established, eradication is generally no longer possible (10). Certainly, the confluence of these two major threatening features of *P. aeruginosa* infections, chronicity and horizontally acquired MDR, represents a potential major public health problem, since despite our therapeutic efforts, these patients will likely become chronic reservoirs of these highly concerning MDR determinants. Since patients with CRI are periodically admitted to both chronic and acute care hospitals, they may represent a high risk for the spread of MDR *P. aeruginosa*. Therefore, active surveillance of MBL-producing *P. aeruginosa* strains in patients with chronic underlying respiratory diseases should be a priority in the epidemiological control of MDR *P. aeruginosa*.

This work was supported by the Ministerio de Sanidad y Consumo, Instituto de Salud Carlos III through the Spanish Network for the Research in Infectious Diseases (REIPI C03/14 and RD06/0008) and by the Govern de les Illes Balears (PROGECIC-4C). The contribution of the RESC Program of the chronic care public hospital Hospital Joan March to this work is acknowledged.

REFERENCES

1. **Evans, S. A., S. M. Turner, B. J. Bosch, C. C. Hardy, and M. A. Woodhead.** 1996. Lung function in bronchiectasis: the influence of *Pseudomonas aeruginosa*. Eur. Respir. J. **9:**1601–1604.
2. **Govan, J. R. W., and V. Deretic.** 1996. Microbial pathogenesis in cystic fibrosis: mucoid *Pseudomonas aeruginosa* and *Burkholderia cepacia*. Microbiol. Rev. **60:**539–574.
3. **Gutiérrez, O., C. Juan, E. Cercenado, F. Navarro, E. Bouza, P. Coll, J. L. Pérez, and A. Oliver.** 2007. Molecular epidemiology and mechanisms of carbapenem resistance in *Pseudomonas aeruginosa* isolates from Spanish hospitals. Antimicrob. Agents Chemother. **51:**4329–4335.
4. **Henrichfreise, B., I. Wiegand, W. Pfister, and B. Wiedemann.** 2007. Resistance mechanisms of multiresistant *Pseudomonas aeruginosa* strains from Germany and correlation with hypermutation. Antimicrob. Agents Chemother. **51:**4062–4070.
5. **Lauretti, L., M. L. Riccio, A. Mazzariol, G. Cornaglia, G. Amicosante, R. Fontana, and G. M. Rossolini.** 1999. Cloning and characterization of bla_{VIM}, a new integron-borne metallo-β-lactamase gene from a *Pseudomonas aeruginosa* clinical isolate. Antimicrob. Agents Chemother. **43:**1584–1590.
6. **Lieberman, D., and D. Lieberman.** 2003. Pseudomonal infections in patients with COPD: epidemiology and management. Am. J. Respir. Med. **2:**459–468.
7. **Lyczak, J. B., C. L. Cannon, and G. B. Pier.** 2002. Lung infections associated with cystic fibrosis. Clin. Microbiol. Rev. **15:**194–222.
8. **Maciá, M. D., D. Blanquer, B. Togores, J. Sauleda, J. L. Pérez, and A. Oliver.** 2005. Hypermutation is a key factor in development of multiple-antimicrobial resistance in *Pseudomonas aeruginosa* strains causing chronic lung infections. Antimicrob. Agents Chemother. **49:**3382–3386.
9. **Oliver, A., R. Cantón, P. Campo, F. Baquero, and J. Blázquez.** 2000. High frequency of hypermutable *Pseudomonas aeruginosa* in cystic fibrosis lung infection. Science **288:**1251–1253.
10. **Oliver, A., A. Mena, and M. D. Maciá.** 2008. Evolution of *Pseudomonas aeruginosa* pathogenicity: from acute to chronic infections, p. 433–444. *In* F. Baquero, C. Nombela, G. H. Cassell, and J. A. Gutiérrez-Fuentes (ed.), Evolutionary biology of bacterial and fungal pathogens. ASM Press, Washington, DC.
11. **Peña, C., C. Suárez, F. Tubau, O. Gutiérrez, A. Domínguez, A. Oliver, M. Pujol, F. Gudiol, and J. Ariza.** 2007. Nosocomial spread of *Pseudomonas aeruginosa* producing the metallo-β-lactamase VIM-2 in Spanish hospital: clinical and epidemiological implications. Clin. Microbiol. Infect. **13:**1026–1029.
12. **Smith, E. E., D. G. Buckley, Z. Wu, C. Saenphimmachak, L. R. Hoffman, D. A. D'Argenio, S. I. Miller, B. W. Ramsey, D. P. Speert, S. M. Moskowitz, J. L. Burns, R. Kaul, and M. V. Olson.** 2006. Genetic adaptation by *Pseudomonas aeruginosa* to the airways of cystic fibrosis patients. Proc. Natl. Acad. Sci. USA **103:**8487–8492.
13. **Walsh, T. R., M. A. Toleman, L. Poirel, and P. Nordmann.** 2005. Metallo-β-lactamases: the quiet before the storm? Clin. Microbiol. Rev. **18:**306–325.

Carlos Juan*
Servicio de Microbiología and Unidad de Investigación
Hospital Son Dureta
Instituto Universitario de Investigación en Ciencias de la Salud (IUNICS)
C. Andrea Doria no. 55
07014 Palma de Mallorca, Spain

Olivia Gutiérrez
Área de Microbiología
Hospital Son Llàtzer
Palma de Mallorca, Spain

Feliu Renom
Hospital Joan March
Palma de Mallorca, Spain

Margarita Garau
Carmen Gallegos
Área de Microbiología
Hospital Son Llàtzer
Palma de Mallorca, Spain

Sebastián Albertí
Área de Microbiología
Universitat de les Illes Balears
Instituto Universitario de Investigación en Ciencias de la Salud (IUNICS)
Palma de Mallorca, Spain

José Luis Pérez
Antonio Oliver
Servicio de Microbiología and Unidad de Investigación
Hospital Son Dureta
Instituto Universitario de Investigación en Ciencias de la Salud (IUNICS)
07014 Palma de Mallorca, Spain

*Phone: 34 971 175 334
Fax: 34 971 175 185
E-mail: cjuan@hsd.es

▽ Published ahead of print on 7 April 2008.