An Outbreak of *Enterobacter hormaechei* Infection and Colonization in an Intensive Care Nursery

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*Enterobacter hormaechei* was first identified as a unique species in 1989. Between 29 November 1992 and 17 March 1993, an outbreak of *E. hormaechei* occurred among premature infants in the intensive care nursery (ICN) at The Hospital of the University of Pennsylvania. The 10 infants whose cultures were positive for *E. hormaechei* (six were infected and four were colonized) had a lower median estimated gestational age and birth weight than did other ICN infants; other risk factors for infection or colonization with *E. hormaechei* were not identified. Cultures from three isolettes and a doorknob in the ICN were positive for *E. hormaechei*. Pulsed-field gel electrophoresis of isolates from six patients and two isolettes were identical. Observations of health care workers revealed breaks in infection control techniques that may have allowed transmission of this organism. We found that *E. hormaechei* is a nosocomial pathogen that can infect vulnerable hospitalized patients and that can be transmitted from patient to patient when infection control techniques are inadequate.

Methods

A case-patient was defined as any patient in The Hospital of the University of Pennsylvania ICN between 29 November 1992 and 17 March 1993 (the epidemic period) whose culture was positive for *E. hormaechei* (specimen from any site). Risk factors were evaluated in a cohort study of all ICN patients during the epidemic period. Medians were compared with Wilcoxon’s rank sum test, and proportions were compared with Fisher’s exact test.

On 16–17 March 1993, we cultured ICN tap water, isolette tops and ports, doorknobs, and health care workers’ hands. Hand cultures were obtained by wiping hands with a sterile cloth, adding Tween 80 solution, shaking for 20 minutes, filtering through a 0.45-μ filter, and placing the filter on MacConkey agar.

Available *E. hormaechei* isolates were sent to the Centers for Disease Control and Prevention (CDC; Atlanta) for confirmation and identification by standard biochemical tests and the API 20E system (bioMérieux Vitek, Hazelwood, MO), antimicrobial susceptibility testing, and pulsed-field gel electrophoresis.

Results

The ten case-patients had a median estimated gestational age of 26 weeks (range, 24–28 weeks) and a median birth weight of 762 g (range, 662–1,1130 g); the median age at the first positive culture for *E. hormaechei* was 16 days (range, 3–67 days). Six case-patients were female, and nine were black. *E. hormaechei* was isolated from the blood of five infants, from tracheal aspirates from five infants, from the nasopharynx of six infants, and from the rectum of ten infants. Six case-patients were considered to be infected (five with bloodstream infection, and one with tracheitis), and four were considered to be colonized. Of the six infected case-patients, four were treated with vancomycin, netilmicin, and cefotaxime; one was treated with netilmicin and cefotaxime; and one was treated with netilmicin alone.

The cohort study included 10 case-patients and 197 control infants. Case-patients had a lower median estimated gestational age (26 vs. 36 weeks, *P* < .001) and a lower median birth weight (762 vs. 2,550 g, *P* < .001) than did control infants. Case-patients and control infants did not differ significantly in rates of cesarean section delivery (7 of 10 vs. 83 of 197, *P* = .1) or mortality (1 of 10 vs. 17 of 197, *P* = 1.0). The one case-patient who died was colonized but was not infected with...
E. hormaechei, and E. hormaechei was not considered to have contributed to the patient’s death.

Since all case-patients had a birth weight of ≤1,500 g and an ICN stay of ≥3 days at the time of the first positive culture, a subgroup of ICN patients with a birth weight of ≤1,500 g and an ICN stay of ≥3 days was analyzed. In this subgroup, the median birth weight was lower among the 10 cases than among the 16 control infants, but the difference was not statistically significant (762 vs. 940 g, \( P = .2 \)).

All 26 infants were placed on assisted ventilation, given iv fluids through umbilical arterial and/or venous catheters, and treated empirically with ampicillin and gentamicin; therefore, these therapies were not found to be significant risk factors for E. hormaechei infection or colonization. In addition, infants who had an endotracheal tube or umbilical arterial or venous catheter placed in the delivery room were not at higher risk for E. hormaechei infection or colonization than were those who underwent placement in the ICN.

**Microbiology.** All E. hormaechei isolates were resistant to ampicillin and gentamicin. Isolates from the six infected infants were susceptible to aztreonam, ceftazidime, ceftriaxone, ciprofloxacin, imipenem, and trimethoprim-sulfamethoxazole; all isolates were resistant to cephalexin, pipercillin, and tobramycin; one of six isolates was resistant to netilmicin, and none of three tested were resistant to amikacin.

Cultures from the hands of 4 (18%) of 22 ICN personnel were positive for Enterobacter species, but none of these isolates were identified as E. hormaechei. Of the 25 water or environmental surface cultures, E. hormaechei was isolated (from broth only) from the tops of three isolettes and one door-knob. All environmental (\( n = 2 \)) and case-patient (\( n = 6 \)) E. hormaechei isolates that were typed had identical pulsed-field gel electrophoresis DNA banding patterns.

**Infection control practices.** Most medications were prepared in the pharmacy; medications prepared in the ICN were contaminated commercial powdered infant formula [7].

**Interventions and follow-up.** Infants whose cultures were positive for E. hormaechei were placed in contact isolation [2] in a common cohort room. Beginning on 26 December 1992, certain nurses and respiratory therapists were assigned to care for case-patients during a given shift. Additional in-service education was provided for health care workers. Increased attention was directed to cleaning environmental surfaces (e.g., isolette tops). Beginning in March 1993, weekly surveillance cultures were obtained from infants who weighed <1,200 g, and empirical antimicrobial therapy for suspected sepsis was changed from ampicillin and gentamicin to ampicillin and ceftaxime or ampicillin and ceftazidime. E. hormaechei colonization was diagnosed in the last case-patient on 17 March 1993. In July 1993, empirical therapy was changed back to ampicillin and gentamicin. As of October 1996, no additional infants whose cultures were positive for E. hormaechei had been identified.

**Discussion**

Risk factors for infection with Enterobacter species include being immunosuppressed, having a significant underlying illness, having an indwelling catheter or having undergone a recent invasive procedure, receiving care in an intensive care unit, and receiving antimicrobials [3, 4]. Enterobacter species have been implicated in both point-source outbreaks and outbreaks caused by patient-to-patient transmission via the hands of hospital personnel [3, 5]. Enterobacter cloacae and Enterobacter aerogenes are the Enterobacter species most commonly associated with human disease [6]. Enterobacter sakazakii was implicated in a neonatal intensive care unit outbreak traced to contaminated commercial powdered infant formula [7].

The outbreak of E. hormaechei infection and colonization described herein occurred among vulnerable, low-birth-weight premature infants. Environmental contamination and lapses in infection control may have facilitated transmission from patient to patient by health care workers. Resistance to ampicillin and gentamicin, the antimicrobials used to empirically treat infants with suspected sepsis in this ICN, may have enabled E. hormaechei to become epidemic. The outbreak ended after case-patients were isolated from other infants, adherence to infection control practices was increased, cleaning of environmental surfaces was enhanced, and empirical antimicrobial coverage was changed.

**References**