Pseudomonas cepacia colonization and infection in intensive care units

John M. Conly,* MD
Leslie Klass, RN
Lynn Larson, RN
James Kennedy, RT
Donald E. Low, MD, FRCPC
Godfrey K.M. Harding, MD, FRCPC

Pseudomonas cepacia **has become a prominent epidemic nosocomial pathogen over the past 15 years. Between December 1982 and September 1983 it was isolated from 29 patients in two intensive care units (ICUs) at one hospital. Twelve infections — five bacteremias, four pneumonias and three urinary tract infections — occurred. Most of the isolates (25/29) were from the respiratory tract, and most (23/29) had the same antibiogram as the only environmental isolate, which was cultured from a contaminated ventilator thermometer, a previously unrecognized source of nosocomial infection. The ventilator thermometers were calibrated in a bath whose water had not been changed for months and contained *P. cepacia*. Despite elimination of this reservoir, *P. cepacia* was eradicated from the ICUs only after intensive infection control efforts were instituted.**

Depuis 15 ans le *Pseudomonas cepacia* joue un rôle pathogène important dans les épidémies nosocomiales. On le trouve chez 29 malades dans deux services de soins intensifs d'un même hôpital, de décembre 1982 à septembre 1983. Il s'agit 12 fois d'infections: 5 bactériémies, 4 pneumonies et 3 infections des voies urinaires. La plupart des isolats (25/29) sont d'origine respiratoire; la plupart ont le même antibiogramme que la seule souche isolée du milieu ambiant, soit à partir du thermomètre d'un respirateur. C'est là une cause jusqu'ici méconnue d'infection nosocomiale. La calibration des thermomètres se faisait dans un bain dont l'eau n'avait pas été changée depuis des mois et qui contenait des *P. cepacia*. Malgré l'élimination de ce bain, il a fallu une lutte anti-infectieuse intense pour venir à bout de ce germe dans les deux services.

From the departments of Medicine and Medical Microbiology and the Infection Control Unit, St. Boniface General Hospital, University of Manitoba, Winnipeg

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*Recipient of a fellowship from the Medical Research Council of Canada. Present address: Department of Medicine, University Hospital, University of Saskatchewan, Saskatoon

Reprint requests to: Dr. Godfrey K.M. Harding, Section of Infectious Diseases, Department of Medicine, St. Boniface General Hospital, Winnipeg, Man. R2H 2A6

Pseudomonas cepacia, formerly known as *P. multivorans*, has traditionally been regarded as an organism of low pathogenicity for humans. However, in recent years *P. cepacia* has become a prominent nosocomial pathogen. Several reports have cited serious infections, including bacteremia, pneumonia, urinary tract infections and wound infections,[1-6] and since 1971 there have been at least 15 reported outbreaks of epidemic nosocomial bacteremia. Hospitalized patients who are immunocompromised owing to serious underlying diseases are most susceptible to infections with this organism.[6] At least two reports have described outbreaks due to this organism in the intensive care unit (ICU).[1,4]

In most instances of nosocomial *P. cepacia* infections the source has been traced to an aqueous environment related to infusion therapy or disinfectants or to equipment that may have had contact with an aqueous environment.[7] This report discusses the investigation of an outbreak of *P. cepacia* respiratory tract colonization and infection in two ICUs, which was traced to a hitherto unrecognized source, the ventilator thermometer.

Materials and methods

The St. Boniface General Hospital is an acute care hospital of approximately 800 beds, including a 7-bed medical and a 9-bed surgical ICU separated by three floors. Between early December 1982 and

late March 1983 the respiratory tracts of five patients in the medical and five in the surgical ICU and one stab wound of a patient in the surgical ICU became colonized with *P. cepacia*. The clustering of isolates of *P. cepacia* prompted an epidemiologic investigation. The microbiology records were reviewed for identification of any cluster of isolates of this organism from any part of the hospital in the 12 months before the start of the ICU isolations, and the medical records of all patients in whom this organism had been isolated from any site between September 1982 and April 1983 were reviewed to determine any common factor or exposure.

Criteria of infection

A diagnosis of septicemia was made if *P. cepacia* was isolated in pure culture from at least one blood sample and there was clinical evidence (fever, rigors and neutrophilia, with or without hypotension) of a bacteremic illness. Respiratory tract infection was diagnosed if *P. cepacia* was isolated in pure culture or was the predominant organism in mixed cultures from sputum or endotracheal secretions and there was clinical evidence (fever, purulent sputum, deteriorating gas exchange) and radiologic evidence (new or progressive pulmonary infiltrates) of pneumonia. Urinary tract infection was considered present if the urine contained more than 10^8 organisms per litre.

Microbiologic methods

Blood and MacConkey's agar were used as primary nonselective media for both clinical and environmental isolates. Clinical isolates were identified as *P. cepacia* by growth on MacConkey's agar with crystal violet, the morphologic features of the colonies, the results of Gram's staining, oxidase production, motility, oxidation-fermentation with Hugh-Leifson dextrose, and use of the API 20E strip (API Laboratory Products, St. Laurent, PQ). Environmental isolates were identified by the morphologic features of the colonies, the results of Gram's staining, oxidase production, motility, oxidation-fermentation with glucose, xylose, lactose, maltose, mannitol and sucrose, triple sugar-iron reaction, deoxyribonuclease production, and the results of the lysine decarboxylase and orthonitrophenylgalactosidase tests. Isolates were stocked in 10% glycerol in skim milk. Susceptibility to antimicrobial agents was tested by the standard Kirby-Bauer disc technique.[8]

Possible environmental sources of *P. cepacia* were selected for culture on the basis of the known high frequency of isolation of this organism from aqueous sources and the respiratory tract colonization of 10 of the 11 patients; all aspects of respiratory care were considered. The possible sources in the ICU areas that were sampled for culture included tap water, tap water filters, drains, sinks, cleaning hoppers, distilled water, sterile normal saline used for suctioning the tracheobronchial tree, ice machine, ice, all disinfectants and cleansers, suction bottles and tubing, lubricants for laryngoscopes, laryngoscope blades, endotracheal tubes, topical anesthetic sprays and nebulization equipment.

The ventilator cleaning procedure was reviewed, and specimens for culture were obtained from the spirometer, heating element, expiratory water collection bottle, cascade humidifier, cascade tubing, ventilator tubing and the swivel that attaches the endotracheal tube to the ventilator tubing. Procedures involving the respiratory service room, used by the respiratory technologists as a depot for both ICUs, were also reviewed, and specimens for culture were obtained from the ventilator thermometer water bath and a "dirty" thermometer.

Finally, the ICU personnel, including respiratory therapists, were asked to wash their hands in a sterile plastic bag containing a known amount of trypticase soy broth, which was then cultured quantitatively.[9]

Proportions were compared by the chi-square test with Yates's correction.

Results

Review of the microbiology records for the 12 months before the start of the ICU isolations revealed no isolates of *P. cepacia* from either ICU and only one clinical isolate from all other areas of the hospital. The temporal clustering of isolates from the ICU between December 1982 and March 1983 suggested a common point-source of exposure.

The 10 cases with respiratory tract isolates were analysed with regard to age, sex, diagnosis, date of admission, date of *P. cepacia* isolation, use of broad-spectrum antimicrobials within 7 days before the isolation of *P. cepacia*, presence of an endotracheal tube and mechanical ventilation, and interval between intubation and isolation of *P. cepacia*. In all 10 cases there had been prior antimicrobial therapy (with an aminoglycoside and a cephalosporin in 8 cases and a cephalosporin alone in 2) and mechanical ventilation, in 1 case through a tracheostomy. The rates of respiratory colonization with *P. cepacia* for ventilated versus nonventilated patients during the ICU outbreak were as follows: medical ICU 5/57 v. 0/156 and surgical ICU 5/220 v. 0/102; in the medical ICU ventilation was significantly associated ($p = 0.002$) with respiratory tract colonization by *P. cepacia*.

The 10 respiratory tract isolates had an identical antibiogram: they were resistant to ampicillin, tetracycline, cefazolin, gentamicin and carbenicillin but sensitive to chloramphenicol and piperacillin. In addition, of the seven isolates tested for sensitivity to cefotaxime, all were sensitive. The

single nonrespiratory isolate had a different antibiogram.

Two infections occurred among the 11 patients. An 85-year-old woman with a history of chronic pulmonary disease was admitted to the surgical ICU after elective cholecystectomy because she could not be weaned from the ventilator postoperatively. Therapy with gentamicin, cefazolin and metronidazole was started 3 days postoperatively for presumed biliary tract sepsis. Five days later a temperature spike and polymorphonuclear leukocytosis prompted blood cultures, which revealed *P. cepacia*. Subsequent cultures of bile and tracheal secretions also revealed *P. cepacia*. Chloramphenicol therapy led to complete recovery. In the second case adult respiratory distress syndrome developed in a 54-year-old man who was being treated with gentamicin, cefoxitin and penicillin after small bowel resection and superior mesenteric artery embolectomy. Eleven days after surgery a heavy growth of *P. cepacia* from tracheal secretions was reported at the same time as the appearance of the chest x-ray film deteriorated. With a change in the antimicrobial therapy to chloramphenicol and gentamicin the patient gradually recovered over a few weeks.

Selected environmental sampling for culture from the various ICU areas revealed no evidence of *P. cepacia*.

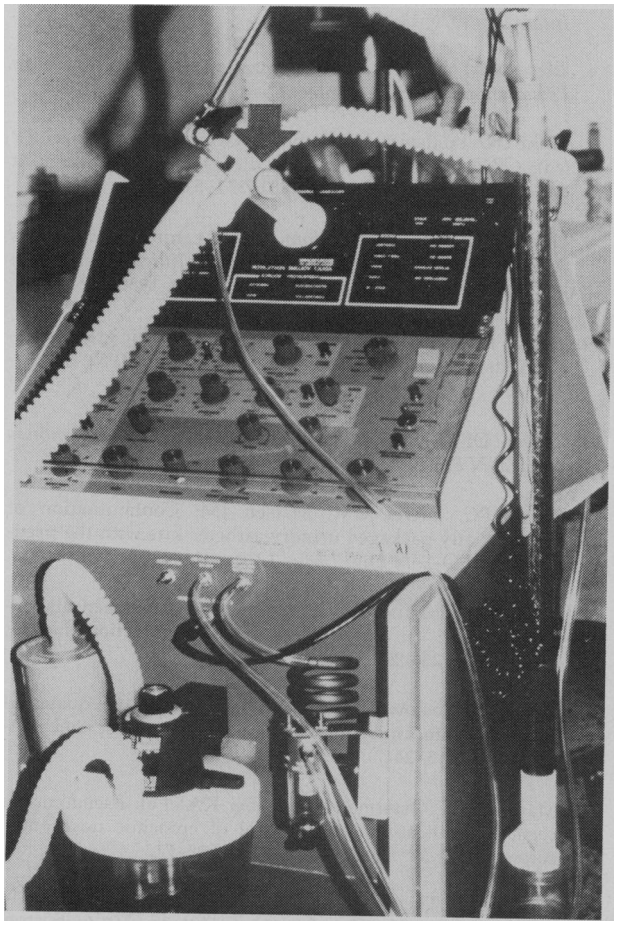

Fig. 1—Thermometer in ventilator tubing.

The ventilator cleaning procedure was as follows: The ventilators were stripped of all external parts in a "dirty" service room, wiped down with 70% alcohol and then placed in a clean assembly room. The external components, including tubing, cascades and spirometers, were placed in 2% alkalinized glutaraldehyde in a decontamination system (Cidematic RT 8100, Surgikos Canada Inc., Peterborough, Ont.) for a minimum of 20 minutes, then were rinsed in a clean sink and placed in a dryer. The ventilators were reassembled in the clean assembly room and stored for later use. Specimens for culture from the water collection bottle (attached to the expiratory tubing), the swivel (attached to the endotracheal tube and the ventilator tubing), and the "dirty" ventilator tubing of one patient with documented colonization of the respiratory tract yielded *P. cepacia*. All other specimens from the ventilators and their components gave negative culture results.

In the respiratory service room a water bath was used to calibrate the ventilator thermometers. The thermometers were then placed into the ventilator tubing (Fig. 1) to measure the temperature of the air delivered to the patients. The bath water had not been changed for several months, and no standard cleaning procedure was followed. Quantitative cultures of the water bath revealed *P. cepacia* in a count of 1×10^7 colony-forming units (CFU) per litre. A swab of the "dirty" ventilator thermometer was rinsed in 1 mL of sterile phosphate-buffered saline and cultured quantitatively; *P. cepacia* was present in a count of 1×10^5 CFU/L. This isolate of *P. cepacia* had an antibiogram identical to that of the respiratory tract isolates.

The hands of 19 of the ICU personnel were washed in culture broth on one occasion; none of the cultures yielded *P. cepacia*, but enterococci, *Staphylococcus epidermidis*, *Streptococcus viridans*, *Neisseria* sp. and *Staph. aureus* were identified, *Staph. epidermidis* being the most frequently found.

Mechanical cleansing and the addition of 2% alkalinized glutaraldehyde to the water bath eliminated the *P. cepacia*. The contents of the bath were changed every 2 weeks and cultured every 4 weeks. Subsequently only one isolate of *P. cepacia* was obtained from the bath, in April 1983, but in each of the succeeding months isolates were obtained from several patients in both ICUs.

Over the next 6 months *P. cepacia* was isolated from 18 more patients in the two ICUs, in 15 instances from the respiratory tract; 4 patients had bacteremia, 3 pneumonia and 3 urinary tract infections. Of these isolates 12 had the same antibiogram as the previous respiratory-tract and water-bath isolates.

Further chart analysis, a thorough review of all aspects of respiratory care, and repeated culturing of environmental samples failed to reveal any source for the continued presence of *P. cepacia*. In September 1983 an urgent memorandum was issued to all medical and paramedical personnel,

outlining the nature of the problem and demanding meticulous attention to handwashing. In addition, an intensive program of education on infection control procedures was conducted. No further isolates of *P. cepacia* were obtained from either ICU for the remainder of the year.

Discussion

P. cepacia has been isolated from many human sources, including urine, blood, stool, bronchial washings, eyes, skin, joints, vagina, nares, the throat and wounds.[6] It has been cultured from various solutions and aqueous sources and is considered a ubiquitous environmental organism. The unusual potential for this organism to proliferate in commonly used chemical disinfectants, such as quaternary ammonium compounds and 10% povidone-iodine solution,[10-13] and its innate resistance to many antimicrobials underscore its emerging role as a nosocomial pathogen.

The outbreak of *P. cepacia* colonization and infection in two ICUs at our institution over a 10-month period illustrates the potential for *P. cepacia* to behave as an opportunistic pathogen in the appropriate setting. As previously reported,[7] this organism can proliferate readily in aqueous sources. The water bath concentration of 10^7 CFU/L provided enough inoculum that approximately 10^5 CFU/L were transferred directly to the ventilator thermometer. Once in the ventilator tubing, an aerosol of *P. cepacia* could have been delivered directly into the tracheas of critically ill, immunocompromised patients. The concomitant administration of broad-spectrum antimicrobials to which *P. cepacia* is characteristically resistant may have promoted colonization and subsequent infection in many of the cases. A 2-year review revealed that 27 of 39 patients from whom *P. cepacia* was isolated (from 41 sites) were receiving one or more antimicrobials.[6] As well, three patients in an intensive care unit who had septicemia due to *P. cepacia* acquired from contaminated saline solution had been receiving antimicrobials when the organism was first isolated.[1] Our experience with ICU patients, 12 of whom had bacteremia, pneumonia or urinary tract infection without directly receiving a large inoculum through intravenous administration of a contaminated solution, emphasizes the enhanced pathogenicity of *P. cepacia* in the ICU.

This report adds to the growing list of reports of epidemic nosocomial colonization and infection traced to an aqueous reservoir of *P. cepacia*.[14] It illustrates the significant illness that may ensue as a result of infection by this organism, particularly in an intensive care unit, where patients, by virtue of their underlying illness, proximity and need for invasive devices, are at greater risk of nosocomial infection.[15] In addition, this is the first report of a contaminated ventilator thermometer as a reservoir for potential nosocomial *P. cepacia* colonization and infection. This reservoir, however, cannot be implicated as the cause of the continued isolation of *P. cepacia* in our ICUs. We can only speculate that some other unidentified environmental niche or poor infection control techniques, or both, were responsible. None the less, after an intensive educational program directed toward all aspects of infection control, the organism disappeared from both units. This underscores the principle that removal of the offending reservoir is not a substitute for sound infection control practices.

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