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Long-lasting outbreak due to CTX-M-15-producing *Klebsiella pneumoniae* ST336 in a rehabilitation ward: report and literature review

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SUMMARY

Background: Whereas *Klebsiella* species are the most frequently occurring agents in nosocomial outbreaks due to multidrug-resistant Gram-negative organisms, very few outbreaks have been reported from rehabilitation wards.
Aim: To describe a long-lasting outbreak due to extended-spectrum β-lactamase-producing (ESBL) *Klebsiella pneumoniae* in a rehabilitation ward.
Methods: ESBL *K. pneumoniae* from all in- and outpatients whose specimens were tested at a tertiary care university hospital between 2007 and 2012 were typed by pulsed-field gel electrophoresis and selected isolates were submitted to multi-locus sequence typing and ESBL genotyping. Outbreak characteristics and infection control interventions were summarized. The literature was searched for *K. pneumoniae*-related outbreaks in rehabilitation wards.
Findings: ESBL *K. pneumoniae* was detected in 69 out of 2478 *K. pneumoniae*-positive patients (2.8%) during the study period. Eight related outbreak clones from 35 patients, 25 of whom were in the rehabilitation ward, produced CTX-M-15 and belonged to ST336. The outbreak lasted for more than three years and was controlled by sequentially increasing measures culminating in review of all patient-related care, compulsory educational meetings for personnel, profession-specific guidelines and educational flyers for patients.
Conclusion: Half of ESBL *K. pneumoniae*-positive patients identified over six years at a tertiary care university hospital harboured related clones, and more than a third were hospitalized in a rehabilitation ward. Rehabilitation wards pose particular challenges for infection control because of patient dependency and an environment that encourages socializing. They are, however, rarely involved in *K. pneumoniae*-related outbreaks.

Introduction

Klebsiella species are the most frequently found agents in nosocomial outbreaks due to multidrug-resistant Gram-negative bacteria [1]. *Klebsiella* species may reside in the bowel, nose, and trachea and on the skin, and are readily transmitted

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between patients [2–5]. Contamination of gloves and gowns occurs in 14% of healthcare worker–patient interactions [6] and the organisms survive for more than 2 h on hands [7]. In the environment, *Klebsiella* species have been detected from sources such as sinks, room surfaces, door handles, thermometers and liquid soap [1]. Whereas the majority of nosocomial outbreaks due to extended-spectrum β-lactamase-producing (ESBL) *Klebsiella pneumoniae* occur in intensive care units [1], very few have been reported from rehabilitation wards, despite prevalent risk factors for transmission such as length of stay, urinary catheter use and high degree of dependency [1,8].

The primary purpose of this project was to describe a long-lasting outbreak of an ESBL *K. pneumoniae* that was first noticed in the rehabilitation ward of our institution in late 2007. The secondary purpose was to examine ESBL genotypes in *K. pneumoniae* that were isolated from inpatients and outpatients during the study period.

Methods

Setting

Landspítali University Hospital and its Department of Microbiology serve more than 200,000 individuals in the Reykjavík capital area in Iceland. It is a 650-bed tertiary care institution whose wards are located in seven buildings in various parts of the city. The hospital's rehabilitation department, located off the main hospital campuses, includes an inpatient ward and physical and occupational therapy wards for inpatients and outpatients. No other hospital wards are in the building. During the study period the 24 inpatient beds were divided between 10 double-occupancy and four single-patient rooms. Patients wear their own clothes that are washed by family members, take meals in a common dining room, are treated both in the inpatient ward and in the separate physical and occupational therapy wards and visitors are allowed 6–8 h per day. The majority of inpatients have suffered spinal cord injuries or stroke or have neurological diseases. During the study period the mean yearly number of inpatient admissions and physical/occupational therapy patient visits was 326 and 28,672, respectively, and the mean length of hospitalization was 31 days. The majority of discharged inpatients continue to receive physical therapy as outpatients. The study was approved by the Bioethics Committee of Landspítali University Hospital (no. 37/2010) and the Icelandic Data Protection Authority (nos. 2009110977 and 2013091115).

Infection control

Daily reports about resistant organisms, including ESBL-producing bacteria, from the microbiology laboratory to the department of infection control were already in place before the study period. The reports were used as surveillance and to direct daily infection control measures. Routine infection control procedures that had been established prior to the outbreak included education about transmission routes and contact precautions every time an ESBL-producing organism was first isolated from a patient, isolation for infected patients who received all care and physical therapy in their rooms, single patient rooms for colonized patients who were otherwise allowed to use all shared facilities, and appropriate contact precautions. Upon patients' discharge the rooms received intensified cleaning. Reinforced infection control procedures consisted of enhanced education and a review of contact precautions employed by patients and personnel and of cleaning methods for rooms, assistive devices and other multiple-patient-use objects. When education and review of compliance failed to eradicate the outbreak, a three-point action plan was implemented. It included compulsory educational meetings, profession-specific written guidelines and screening of patients and personnel for ESBL *K. pneumoniae* by the use of rectal swabs. Educational flyers were given to those patients who harboured ESBL-producing organisms.

Study population and definitions

The study population included all patients whose specimens yielded *K. pneumoniae* during the period of January 1st, 2007 to December 31st, 2012. Demographic and medical data were collected for patients who had ESBL *K. pneumoniae* and they were followed for three months after the last isolation of the organism. Case patients were defined as those whose *K. pneumoniae* showed ≥80% relatedness by pulsed-field gel electrophoresis (PFGE). Outbreak patients were those who met the case patient definition and who were hospitalized in the rehabilitation ward during the period of 2007–2012. The outbreak group thus included patients who had their first ESBL *K. pneumoniae* isolated before, during or after their stay in the rehabilitation ward and served as potential sources of transmission inside and outside the ward. The periods before (2004–2006) and after (2013–2015) the study period were examined for the number and ward location of hospitalized patients with healthcare-associated ESBL *K. pneumoniae* isolates. Healthcare-associated infections were defined according to Centers for Disease Control and Prevention/National Healthcare Safety Network criteria [9]. Patients who had ESBL-producing *Escherichia coli* while in the rehabilitation ward during the study period were identified in order to gain a broader picture of the prevalence of ESBL-producing organisms in the ward.

Microbiological methods

Extended-spectrum β-lactamase-producing *K. pneumoniae* isolates were tested for antimicrobial susceptibility by Kirby–Bauer disc-diffusion method and for ESBL production by the use of screen and confirmatory tests according to Clinical and Laboratory Standards Institute guidelines [10]. Screening of patients and personnel for ESBL-producing organisms was done by the use of a rectal swab that was streaked onto two plates containing MacConkey agar no. 3 (Oxoid, Basingstoke, UK) with 1 mg/L ceftazidime (GlaxoSmithKline, Brentford, UK) in one plate and 1 mg/L cefotaxime (Sandoz, Holzkirchen, Germany) in the other plate [11]. Plates were incubated for 48 h; Enterobacteriaceae-like colonies were identified to species level and ESBL confirmatory tests performed as described above. Isolates of ESBL *K. pneumoniae* and ESBL *E. coli* were preserved by freezing at −80°C in tryptose–glycerol solution and subcultured on blood agar for molecular tests. One to four ESBL *K. pneumoniae* and ESBL *E. coli* were selected from each patient for strain typing by PFGE that was done in CHEF DR-II system (Bio-Rad Laboratories, Hercules, CA, USA) according to the PulseNet protocol for *Escherichia coli*, *Salmonella*, and *Shigella* [12]. The conditions included an initial