

## **Klebsiella**

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Klebsiella are Gram-negative, non-motile, encapsulated, lactose fermenting, facultative anaerobic, rod shaped bacteria. It is clinically the most important member of the Klebsiella genus of Enterobacteriaceae; it is closely related to *K. oxytoca* from which it is distinguished by being indole-negative and by its ability to grow on both melezitose and 3-hydroxybutyrate.

Members of the Klebsiella genus typically express 2 types of antigens on their cell surface. The first, O antigen, is a component of the lipopolysaccharide (LPS), of which 9 varieties exist. The second is K antigen, a capsular polysaccharide with more than 80 varieties. Both contribute to pathogenicity and form the basis for serogrouping. The capsule is readily seen in colonies. The capsule protects the cells from desiccation, and may also protect them from phagocytosis when they are in an animal host.

Klebsiella was named after the German bacteriologist Edwin Klebs (1834-1913). The Danish scientist Hans Christian Gram (1853-1938), developed the technique now known as Gram staining in 1884 to discriminate between *K. pneumoniae* and *Streptococcus pneumoniae*.

### **Epidemiology**

Bacteria of the genus Klebsiella are widely distributed in nature, in the soil and in water.

*K. pneumoniae* is found in the normal flora of the intestines but usually in low numbers compared with *E. coli*. They may also colonize the mouth and skin. Klebsiellas are naturally occurring in the soil and water. About 30% of strains can fix nitrogen in anaerobic condition. As a free-living diazotroph, its nitrogen fixation system has been much studied.

### **Clinical Description**

*K. pneumoniae* is clinically the most important member of the Klebsiella genus of Enterobacteriaceae. There is a geographic preponderance of *K. pneumoniae* severe manifestations in Asia (liver abscesses, meningitis).

Klebsiella infections tend to occur in people with a weakened immune system from improper diet (alcoholics and diabetics).

*Klebsiella pneumoniae* is a well-known cause of community-acquired pneumonia in certain patients, such as alcoholics. The classic clinical presentation is dramatic: toxic presentation with sudden onset, high fever, and hemoptysis (currant jelly sputum). Chest radiographic abnormalities such as bulging interlobar fissure and cavitary abscesses are prominent. However, the incidence of community-acquired Klebsiella pneumonia has apparently declined in the United States. In studies from the 1920s to the 1960s, *K.*

*pneumoniae* was considered an important cause of community-acquired pneumonia; however, in the last decade *K. pneumoniae* accounted for less than 1% of cases of pneumonia requiring hospitalization in North America.

*K. pneumoniae* can also cause community-acquired urinary tract infections with bacteremia.

The most common infections due to *K.pneumoniae* are nosocomial infections. At risk are patients receiving long courses of broad spectrum antibiotics, patients with prolonged ICU stays, particularly in NICU, patients with numerous medical comorbidities associated with advanced age, such as diabetes mellitus, cardiac disease, and chronic airway disease. Common hospital acquired infections are pneumonia, bacteremias, surgical wound and urinary tract infections.

### Klebsiella pneumoniae Carbapenemase (KPC)

Carbapenemase is an enzyme first found in *Klebsiella pneumoniae* isolates (hence, the name). However, it can be produced by other organisms including, *Serratia* spp., *Enterobacter* spp., *E. coli*, and *Salmonella enterica*. The global spread of KPC-producing organisms appears to have been rapid. There are diverse KPC genes, named in sequential numeric order from KPC-2 to KPC-6.

KPC infection and colonization may be difficult to detect. Resistance to carbapenemases may be reduced but not complete. ESBL producers may be mistaken for KPC producers in some phenotypic tests. Some automated susceptibility testing systems have low sensitivity and specificity for detection of KPC carbapenemases when using imipenem or meropenem as testing agents. This may result in an under-estimation of the true incidence of KPC-producing organisms and the duration of KPC epidemics.

The most common mechanism of carbapenem resistance among Enterobacteriaceae in the United States is the production of the *Klebsiella pneumoniae* carbapenemase (KPC). KPC-producing Enterobacteriaceae are widespread in the United States and other countries.

The production of these enzymes results in resistance to all penicillins, cephalosporins (i.e., cefepime, ceftriaxone), carbapenems (i.e., meropenem, ertapenem), and aztreonam. Treating infections caused by KPC-producing organisms is very difficult and very few antibiotics are effective. Often, these organisms are only susceptible to tigecycline and colistin. These antibiotics have significant side effects, are potentially inferior to more conventional therapies and can be costly.

### Carbapenem-resistant Enterobacteriaceae (CRE)

In July 2010, a patient with a carbapenem-resistant *Klebsiella pneumoniae* was diagnosed in India with a strain that produced a Verona integron-encoded metallo-beta-lactamase (VIM) carbapenemase . This isolate is not susceptible to any antimicrobials usually used to treat *Klebsiella*. Cases of CRE are a significant, emerging public health problem regardless of the mechanism of carbapenem resistance, and procedures to rapidly recognize and report CRE cases to infection prevention personnel should be in place in all acute and long-term--care facilities. Facilities that have not identified cases of CRE should undertake periodic laboratory reviews to identify cases. Patients with CRE should be managed using contact precautions, and patients exposed to CRE patients (e.g., roommates) should be screened with surveillance cultures

## **Laboratory Testing**

*Klebsiellas* are diagnosed by microbiology techniques in cultures.

### KPC organisms:

An increase in the number of ESBL isolates with elevated minimum inhibitory concentration (MIC) to imipenem should lead to suspect KPC. A case of probable is a KPC-producing organism is any Gram-negative organism with an ESBL phenotype and an MIC to imipenem of 1 µg/mL or greater on broth microdilution. The Microbiology Lab should have an algorithm in place for suspected KPC-producing organisms. If an organism is suspected to be a KPC producer, susceptibility testing for tigecycline and colistin should be conducted.

Plating of rectal swab samples directly onto McConkey agar with imipenem and ertapenem discs provided accurate results within 24 hours of test initiation, and 96.5% concordance with the polymerase chain reaction (PCR) assay for KPC detection. Unless KPC results are urgently required, direct plating onto agar with imipenem and ertapenem discs is the most accurate and cost-effective laboratory method to screen for KPCs.

### **Treatment**

*K.pneumoniae* is typically resistant to extended-spectrum penicillins, such as ampicillin, ticarcillin, and piperacillin, due to production of beta-lactamase(s). In addition, *K pneumoniae* isolates have become increasingly resistant to extended-spectrum penicillins, and to many cephalosporins due to the production of extended-spectrum beta-lactamases. Klebsiella beta-lactamases are usually susceptible to carbapenems, such as imipenem, and to beta-lactamase inhibitors, such as clavulanic acid, sulbactam and tazobactam.

KPC: Polymyxin B and colistin have been associated with high rates of nephrotoxicity and thus must be considered drugs of last resort. Emerging data have shown that the polymyxins may not be as nephrotoxic as previously believed.

### **Surveillance**

If an organism is a confirmed KPC producer or VIM, the patient's physician should be notified as well as Infection Control. Infection Preventionists should educate the staff about the significance of this finding.

Patients identified as having infections caused by KPC-producing organisms are placed on Contact Precautions.

### **Outbreak control**

Detection of carriers is made on rectal swabs.  
Cohort colonized and infected patients.