demic period) who had hemolysis diagnosed >48 hours after undergoing hemodialysis. To identify case-patients and to determine background rates, the medical records of patients from facilities A, B, and C who were undergoing hemodialysis during the epidemic and pre-epidemic (that is, May 5-19, 1998) periods were reviewed. Experiments simulating hemodialysis with the same lot numbers of hemodialysis blood-tubing cartridge sets used on case- and control-patients were conducted.

The rates of hemolysis among patients at facilities A, B, and C were significantly higher during the epidemic than the pre-epidemic period (13/118 vs 0/118, $P<.001$; 12/298 vs 0/298, $P=.001$; and 5/62 vs 0/65, $P=.03$, respectively). All case-patients had hemolysis. Twenty (66%) had hypertension, 18 (60%) had abdominal pain, and 10 (36%) were admitted to an ICU. There were two deaths. The only commonality among the three outbreaks was the use of the same lot of disposable hemodialysis blood-tubing from one manufacturer. Examination of the implicated hemodialysis blood-tubing cartridge sets revealed narrowing of an aperture through which blood was pumped before entering the dialyzers. In vitro experiments with the hemodialysis blood tubing revealed that hemolysis was caused by increased pressure on erythrocytes as they passed through the partially occluded hemodialysis blood tubing.

The investigation traced the multiple hemolysis outbreaks to partially occluded hemodialysis blood tubing produced by a single manufacturer. On May 25, 1998, the manufacturer issued a voluntary nationwide recall of the implicated lots of hemodialysis blood-tubing cartridge sets.

FROM: Duffy R, Tomashek K, Spangenberg M, Spry L, Dwyer D, Safranek TJ, et al. Multistate outbreak of hemolysis in hemodialysis patients traced to faulty blood tubing sets. *Kidney Int* 2000;57:1668-1674.

Modeling Biofilm Antimicrobial Resistance

In the past 20 years, there has been a great deal of research on biofilms, the slime layers that are deposited on surfaces by microorganisms growing in liquids ranging from water to blood. The organisms are protected by the matrix of the biofilm, and they are, in essence, resistant to germicides or antibiotics.

In a recent paper, Dodds and coinvestigators, from the Center for Biofilm Engineering, Department of Chemical Engineering, Montana State University, in Bozeman, described a computer model capable of integrating mechanisms of biofilm resistance to disinfection by antimicrobial agents. Resistance mechanisms considered included retarded penetration due to a stoichiometric reaction between the antimicrobial agent and biomass, incomplete penetration due to a catalytic reaction between the antimicrobial agent and the biomass, and the existence of a fraction of the cells in a resistant phenotypic state. Mathematical models of these processes were derived and solved in a computer simulation package. Four sets of fitted experimental data on the disinfection of *Pseudomonas aeruginosa* biofilms were fit to each of the three models. No one model fit all of the data sets adequately. Killing of a 2-day old biofilm by tobramycin was best described by the physiological limitation model. Killing by hypochlorite was best described by the stoichiometric transport model. Killing by hydrogen peroxide was best simulated by the catalytic transport model.

These results suggest that multiple mechanisms of biofilm reduced susceptibility are manifested even in biofilms of the same species and that the particular resistance mechanism depends on the biofilm age, antimicrobial agent, and biofilm thickness. The models presented in this article may be useful for diagnosing mechanisms of biofilm resistance from experimental data.

FROM: Dodds MG, Grobe, KJ, Steward PS. Modeling biofilm antimicrobial resistance. *Biotechnol Bioeng* 2000;68:456-465.

Aged Dialyzers Cause Outbreak of Severe Reactions

An event in which seven patients at one hospital developed decreased vision and hearing, conjunctivitis, headache, and other severe neurological symptoms 7 to 24 hours after hemodialysis drew attention to the issue of the long-term integrity of dialysis machines and materials. Hutter and colleagues, from the FDA's Center for Devices and Radiological Health, and the CDC's Hospital Infections Program conducted an investigation to determine the cause of the adverse reactions that occurred during this event. A retrospective cohort study was conducted of all nine patients who received hemodialysis at hospital A on September 18, 1996, the day of the outbreak. A case-patient was defined as any hospital A patient with acute onset of decreased vision and hearing and conjunctivitis after dialysis on that day. Non–case-patients were all others who underwent dialysis at hospital A on that day but did not develop adverse reactions. In an attempt to reproduce the conditions of the event, cellulose acetate dialysis membranes of various ages were retrieved from other sources and tested for physical and chemical degradation, and degradation products were identified, characterized, and injected intravenously into rabbits. The primary outcome measures were clinical signs and symptoms, time to resolution of symptoms, mortality, and dialyzer type and age, for case- versus non–case-patients.

Seven of the nine patients met the case definition. In addition to diminished vision and hearing, conjunctivitis, and headache, some case-patients had blood-leak alarm activation (n=6), confusion/lethargy (n=5), corneal opacification (n=4), cardiac arrest (n=2), or other neurological signs and symptoms. One case-patient died during hospitalization after the event; five of seven case-patients died within 13 months. Resolution of signs and symptoms varied but persisted more than 3 years or until death in three

of the six patients who survived hospitalization. All case-patients, but no non–case-patients, were exposed to 11.5-year-old cellulose acetate dialyzers (all of these dialyzers were discarded by the hospital before the investigation). Laboratory investigation of field-retrieved 0- to 13.6-year-old dialyzers of similar type indicated significant chemical degradation in the older membranes. In vivo injection of extracts of membrane degradation products produced iritis and hemorrhages in rabbits' eyes.

It was concluded that severe patient injury was associated with exposure to aged cellulose acetate membranes of dialyzers, allowing cellulose acetate degradation products to enter the blood. Clinicians should be aware that aged cellulose acetate membranes might cause severe adverse reactions.

FROM: Hutter JC, Kuehnert MJ, Wallis RR, Lucas AD, Sen S, Jarvis WR. Acute onset of decreased vision and hearing traced to hemodialysis treatment with aged dialyzers. *JAMA* 2000;283:2128-2134.

Molecular Epidemiology of *S epidermidis* in an NICU

Coagulase-negative staphylococci, especially *Staphylococcus epidermidis,* are increasingly important nosocomial pathogens, particularly in critically ill neonates. Villari and coinvestigators, from the Department of Health and Preventive Sciences, University Federico, Naples, Italy, conducted a 3-year prospective surveillance of nosocomial infections in a neonatal intensive care unit (NICU) using traditional epidemiological methods, as well as molecular typing of microorganisms. The objectives of the study were (1) to quantify the impact of *S epidermidis* on NICU-acquired infections; (2) to establish if these infections are caused by endemic clones or by incidentally occurring bacterial strains of this ubiquitous species; (3) to evaluate the use of different methods for the epidemiological typing of the isolates; and (4) to characterize the occurrence and the spread of staphylococci with decreased glycopeptide susceptibility.

The results showed that *S epidermidis* is one of the leading causes of NICU-acquired infections and that the reduced glycopeptide susceptibility, if investigated by appropriate detection methods such as population analysis, is more common than is currently realized. Typing of isolates, which can be performed effectively through molecular techniques such as pulsed-field gel electrophoresis but not through antibiograms, showed that many of these infections are due to clonal dissemination and thus are potentially preventable by strict adherence to recommended infection control practices and the implementation of programs aimed toward the reduction of the unnecessary use of antibiotics. These strategies are also likely to have a significant impact on the frequency of the reduced susceptibility of staphylococci to glycopeptides, since this phenomenon appears to be determined either by more resistant clones transmitted from patient to patient or, to a lesser extent, by strains that become more resistant as a result of antibiotic pressure.

FROM: Villari P, Sarnataro C, Iacuzio L. Molecular epidemiology of *Staphylococcus epidermidis* in a neonatal intensive care unit over a three-year period. *J Clin Microbiol* 2000;38:1740-1746.

Growth of *S epidermidis* and *P aeruginosa* on Biomedical Polymers

The infection risk of biomaterials implants varies between different materials and is determined by an interplay of adhesion and surface growth of the infecting organisms. Gottenbos and colleagues from the University of Groningen, The Netherlands, conducted a study that compared initial adhesion and surface growth of *Staphylococcus epidermidis* HBH(2) 102 and *Pseudomonas aeruginosa* AK1 on poly(dimethylsiloxane), Teflon, polyethylene, poly-propylene, polyurethane, poly(ethylene terephthalate), poly(methyl methacrylate), and glass. Initial adhesion was measured in situ in a parallel plate flow chamber with microorganisms suspended in phosphate-buffered saline, while subsequent surface growth was followed in full and in 20 times diluted growth medium. Initial adhesion of both bacterial strains was similar to all biomaterials. In full growth medium, generation times of surface growing *S epidermidis* ranged from 17 to 38 minutes with no relation to wettability, whereas in diluted growth medium, generation times increased from 44 to 98 minutes with increasing surface wettability. For *P aeruginosa,* no influence of surface wettability on generation times was observed, but generation times increased with decreasing desorption rates, maximal generation times being 47 minutes and minimal values down to 30 minutes. Generally, generation times of adhering bacteria were shorter than of planktonic bacteria.

The authors concluded that surface growth of initially adhering bacteria is influenced by biomaterials surface properties to a greater extent than initial adhesion.

FROM: Gottenbos B, van der Mei HC, Busscher HJ. Initial adhesion and surface growth of *Staphylococcus epidermidis* and *Pseudomonas aeruginosa* on biomedical polymers. *J Biomed Mater Res* 2000;50:208-214.

Catheter-Associated UTIs Are Rarely Symptomatic

Catheter-associated urinary tract infection (CA UTI) is the most common nosocomial infection, accounting for more than 1 million cases each year in US hospitals and nursing homes. Up to one half of the patients requiring an indwelling urethral catheter for 5 days or longer will develop bacteriuria or candiduria. Silent catheter-associated bacteriuria comprises a huge reservoir of antibiotic-resistant organisms in the hospital, particularly on the critical-care unit. Although there have been recommen-