Letters to the Editor

Aspergillosis Due to Carpet Contamination

To the Editor:

Invasive aspergillosis remains a serious opportunistic infection in immunocompromised patients with prolonged granulocytopenia.[1] Clusters of invasive aspergillosis have been reported by various bone marrow transplant and leukemia treatment centers, in association with hospital construction,[2] lack of high-efficiency particulate air (HEPA) filtration, lack of laminar flow ventilation[2,3] or contaminated hospital materials including filters and fireproofing." In most instances, it is difficult to identify the environmental source of an outbreak." Thus, amphotericin-B is often used empirically and a discriminant scorecard has been proposed that identifies patients who are likely to be infected." At our institution, a low incidence of *Aspergillus* infections prevailed between 1987 and 1991 in patients undergoing autologous or allogeneic bone marrow transplantation, or induction chemotherapy for acute leukemia. We report efforts to contain and identify the source of a clustered outbreak of invasive *Aspergillus* species in this population between July 1991 and March 1992.

The bone marrow transplant/leukemia service has been located on a 22-bed inpatient unit since 1987. The unit has a HEPA filtered air system (12 to 15 air exchanges per hour) and a hallway carpet that is impregnated with the fungistatic/bacteriostatic agent Intersept (Interface Research Corp, Kennesaw, GA), a durable quaternary amine complex shown to be effective in reducing the buildup of microorganisms in building materials.[5] A multidisciplinary team of physicians, nurses, administrators, construction supervisors, and a pharmacist coordinates a prospective monitoring program to identify and reduce the risk of opportunistic infections among patients. A neutropenic precautions policy, implemented in 1984, mandates handwashing prior to any patient contact, high-filtration masks for any person entering the patient's room, cleaning of all medical examination equipment prior to each use, use of high-filtration masks by patients when they leave their room for any reason, and a low-pathogen diet. Strict protocols govern evaluation of fever and the use of antibiotics. Infection records are reviewed monthly and infection rates and trends are monitored prospectively.

In June 1990, construction was initiated on a lo-story research tower within 200 yards of the hospital. In October 1990, demolition and excavation of four buildings began within 100 yards of the hospital, followed in February 1991 by construction of a new 12-story hospital tower. These construction projects continued through 1993. During this time, engineering records of cross HEPA-filter pressure indicated that the filters were constantly operating within specifications. Monthly volumetric air sampling began in March 1990 using a Centrifugal Air Sampler RCS [Biostat]; it identified up to 75 fungal spores/100 cu ft in the outside air, including 0 to 8 *Aspergillus* species. Lower spore counts (0 to 12/100 cu ft) were found inside the hospital in areas of construction whereas few spore isolates were found (0 to 2 spores/100 cu ft) on the transplant/leukemia unit.

Between 1987 and 1990, three to four cases of invasive aspergillosis occurred per year (some categorized as community-acquired by our prior definitions),[1,4] without evidence of seasonal clustering. On June 23, 1991, a tire broke out in a 110-year-old building across the street from the hospital and in direct view of the transplant/leukemia unit. The interior, attic, and roof of the building were gutted completely, and internal demolition and reconstruction began in July 1991.

During the week of the fire, a patient had repeatedly opened the window in his room to smoke cigarettes, in violation of the hospital no-smoking policy; when this was discovered the window was sealed shut. Three weeks later, the patient developed invasive aspergillosis. Twelve additional cases of *Aspergillus* occurred over the subsequent 9 months. The rate of *Aspergillus* infections was significantly higher between July 1991 and March 1992 than between January 1989 and June 1991, when only seven cases were observed over 30 months ($P<0.001$). All cases of invasive *Aspergillus* infections were confirmed by histology and microbiology using previously described criteria.' Five patients had *Aspergillus flavus* and six had *Aspergillus fumigatus* infection; two were identified by biopsy alone as presumed *Aspergillus* species.

Of the 13 cases that occurred during the cluster, 10 had pulmonary infection, and one each had infection of the skin, bone, and sinus. Ages of the 13 patients (7 males) ranged from 38 to 73; all received chemotherapy. Eight of the 13 patients survived; all who died had a relapsed or treatment-resistant malignancy.

In our investigation into possible sources of the epidemic, carpet tile

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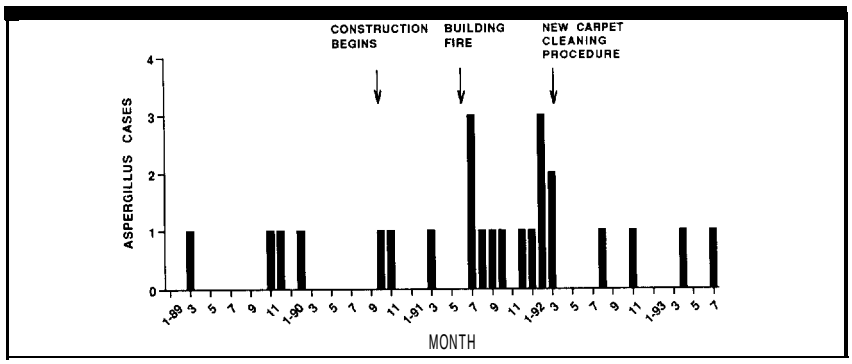

FIGURE. Outbreak of invasive aspergillosis and its relationship to environmental events. Cases of invasive aspergillosis are shown during the month in which the diagnosis was established. "Construction begins'' indicates the onset of construction of new buildings and demolition of old structures adjacent to the hospital. "Building fire" indicates the fire in a 110-year-old building located across the street from the transplant/leukemia unit. "New carpet cleaning procedure" indicates the date that water extraction of the hall carpet was begun.

samples were removed for culture in January 1992. Particulate matter from triplicate four centimeter square samples taken from two different 12-inch square tiles on each occasion were placed on potato dextrose agar and colony isolates were speciated. An average of eight *Aspergillus* colonies (one *A flavus,* one *A fumigatus,* and six *Aspergillus niger)* per sample were identified. No Intersept-mediated antimicrobial activity was detected in the carpet (determined by absence of a zone of inhibition), which also was noted to contain a large amount of dirt, debris, and wax and soap buildup. Until this time, the carpet was cleaned weekly using a commercial carpet shampoo applied with a bonnet on a buffer machine. We speculated that residual soap served to block the inorganic bacteriostatic compound in the base of the carpet from wicking up into the top fibers.

At the suggestion of the manufacturer, weekly water extraction of the carpet was begun in February 1992. Cultures of the carpet were obtained in late February and again in September 1992. On each occasion, two 12-inch square tiles were removed from different areas of the floor and processed as above. Less dirt and debris was noted, and bacteriostatic/fungistatic activity of the Intersept was detected within the carpet. The February 1992 culture grew an average of three *A niger* colonies per carpet sample without evidence of other *Aspergillus* species, whereas the carpet culture obtained in September 1992 grew no *Aspergillus* species colonies. After institution of the water extraction method of carpet cleaning, the rate of *Aspergillus* species infections on the transplant/leukemia service again fell to the level seen prior to the epidemic; only four cases of nosocomial *Aspergillus* species infection were noted over the 15-month period between April 1992 and June 1993 ($P<0.01$) compared with the period July 1991 through March 1992.

Environmental sources of invasive aspergillosis outbreaks have been reported in bone marrow transplant and leukemia treatment centers.[2,3,6] Efforts to reduce these environmental exposures include the use of HEPA or laminar air filtration,[3] application of fungistatic agents to the fireproofing of new construction,[6] and protection of patients from areas of hospital construction. The invasive aspergillosis case cluster reported here occurred during a period of new building construction. However, the onset of the case cluster occurred 1 year after the construction began, making it less likely that new construction itself was the major culprit, especially because *Aspergillus* species were not found on the unit using the air sampling technique. Instead, the temporal proximity between the onset of the case cluster and a fire in an old building close to the hospital, with repeated window opening by a patient soon after the fire, suggests that these two events may have been the proximate cause of the case cluster. Thereafter, we believe that the contaminated hall carpet provided an ongoing source of infection, although it is plausible that the carpet was simply a marker of an airborne contamination. Unwittingly, the use of standard carpet cleaning agents blocked the action of the incorporated active antimicrobial compound and failed to remove particulate matter from the carpet adequately, allowing fungal sporulation. Once modifications to the carpet cleaning procedures were instituted, the *Aspergillus* spore load was reduced and the case cluster subsided. Only sporadic cases of *Aspergillus* infection have been seen in the subsequent 15 months, despite ongoing construction.

This report is the first describing tire-induced fungal contamination of carpet as a source of invasive *Aspergillus* in immunocompromised patients. We suggest that building fires, demolition, andcontaminated carpet be added to the list of potential reservoirs of *Aspergillus* spores. Aggressive monitoring of hospital epidemics can uncover sources of nosocomial infection in immunocompromised patients and reduce their morbid impact.

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Stanton L. Gerson, MD
Pamela Parker BSN, CIC
Michael R. Jacobs, MD, PhD
Richard Creger, PharmD
Hillard M. Lazarus, MD, FACP
University Hospitals of Cleveland
and Case Western Reserve University
School of Medicine
Cleveland, Ohio

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Statistical Process Control Charts

To the Editor:

Statistical process control (SPC) is possibly the most enticing gadget in the industrial quality control toolbox. It promises much. While reading John Sellick's article,' an old aphorism came to mind: "There is no such thing as a free lunch."

The potentials of SPC are dual: A) that control charting of clinical variables will reveal "opportunities for improvement" by directing scrutiny to events that involve special causes of variation; and B) that a clinical process, once tuned to eliminate special cause variation, is as well-suited as it can be for alterations aimed at reducing common cause variation or producing more desirable mean values of a process variable. The *A-B* sequence is crucial to quality improvement (CQI). *A* feeds to CQI signals sorted from noise. *B* seems a safe approach to the hornet's nest inherent in improving clinical care because it limits opportunities for drawing erroneous cause-effect inferences after details of care are altered to improve outcome.

Shewhart[2] derived SPC from theoretical considerations that involve normal (ie, Gaussian) distributions, but it is a common misconception that SPC is hampered for processes whose inherent variation is other than normal. "Being in control" is not tantamount to "being in a normal (or Poisson or binomial) distribution" and vice versa. Dr. Sellick's discourse on SPC's origin hints that he may think otherwise. Wheeler and Chambers" have compared charting of normally distributed data and data from a variety of non-normal distributions (Burr, chi-square with two degrees of freedom, right triangle, uniform, and exponential) for hypothetical in-control processes. Shewhart 3-sigma charts give false alarms for a meager 1% to 2% of process data in this test. In these instances, SPC would have correctly advised managers with 98% to 99% accuracy to leave in-control processes unchanged.

I am confused by the statement that "the number of sigma that defines the control limits will determine the number of times that an out-of-control signal will be erroneous." This is nonsensical and should have been nailed by reviewers. What is meant by the word *erroneous?* A few pages later, the statement is made that "these charts should not be used for very infrequent events or small denominator samples." Is Sellick arguing that more data be gathered if infrequent defects are pursued? In what sense is "events" used here? Are "events" the denominator or the phenomena counted in numerators? The penalty of using small data sets in SPC is that genuine special variation may "hide" within putative common variation. However, this flaw cannot trigger ill-crafted CQI sorties. It is confusing to suggest that small data set control charts are "less accurate." They are just less useful, a different criticism.

SPC may hide useful CQI information. A case in point has emerged from our wound infection surveillance program." Using 1992 wound infection data in SPC (p-chart, 3-sigma limits), 86% of the complications appear as outcomes within common cause variation limits. SPC would suggest that the other 14% of flawed cases be searched for special causes of variation. Total case review in our system consistently reveals that about half of wound infections are associated with an identifiable departure from excellent practice. SPC would have led us to overlook a huge majority of cases, half of which on average contain valuable grist for the mill in feedback to surgical teams. This anecdote shows the conflicted linkage between putative variation causes and statistically defined special variation on a control chart. I think the conflict will haunt SPC applications to other prob lems in clinical care monitoring.

Many surgical outcome flaws lie in or below the same frequency range as wound infection and share its features of multifactorial etiology and few fully determinant preventative maneuvers. These thiigs make me worry that uncritical SPC use will hinder process improvement in my specialty (using Donabedian's definitions of "process" to denote technical aspects of care). Healthcare quality managers may shoot themselves in the foot by relying on SPC as a source for CQI projects, unwittingly confirming another old aphorism, "Out of sight, out of mind."

James T. Lee, MD, PhD, FACS
VA Medical Center
Minneapolis, Minnesota

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The author replies.

Dr. Lee has reaffirmed the utility and potential shortcomings of statistical process control (SPC) charts. The risk of overreliance and overinterpretation were discussed in the "Caveats" section of the paper. Specific points raised by Dr. Lee bear comment:

1) Clearly, my intent in discussing attributes of SPC charts was to show that SPC theory can be used in the evaluation of nonparametric variables. However, the mechanics of generating the charts is based on normal approximations. Being "in (statistical) control" is defined by the fall of points within the control limits, which are based on the statistical distribution of data.'