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Polymicrobial Deep Joint Replacement Infection Temporally Associated With Building Construction: A Case Series

To the Editor:

We report four polymicrobial infections occurring in total joint arthroplasty performed at our general district hospital that were associated temporally with the construction of a new emergency department adjacent

to the operating theater suite (Figure). Construction of the new building began at the end of 2001 and finished in December 2002. Three hundred fifty arthroplasties were performed in the 20 months before the outbreak with only one deep joint infection. Twenty-one were performed in August and September and the infection rate increased from less than 1.0% to approximately 20% (relative risk, 62; $P < .00005$). Four infections occurred in a cluster around the end of August and were unusual in the variety and number of organisms involved.

Four patients had total joint arthroplasty with standard antibiotic prophylaxis (1 g of cephalothin 30 minutes prior to incision), povidone-iodine preparation, and gentamicin-loaded cement (dePuy CMW1 and CMW3, DePuy Orthopaedics, Warsaw, IN). They all presented between 11 and 13 days postoperatively with deep joint infections and were surgically washed out. The organisms isolated from these cases are listed in the table. The organisms were disparate, with only *Staphylococcus aureus* (three oxacillin sensitive and one methicillin resistant) being common to all cases. Unfortunately, typing of the organisms and sampling of the staff and the environment were not conducted, so the true source of the organisms remains unidentified.

Potential risk factors were considered. There was no significant association with any particular surgical, anesthetic, central sterile supply, or ward staff member and there had been no change in technique for either surgeon. Additionally, no patient factors contributed to the increased infection rate. There was no association with the prosthesis implanted or the type of cement. The only positive association was that all of the procedures had occurred in the same operating room (operating room 4), which is mainly used for orthopedics. During this period, other surgical services did not report an increased infection rate and the only other orthopedic infection was in a healthy 21-year-old man who developed a *Klebsiella pneumoniae* infection in his fifth metacarpal plate in July.

Air quality was monitored in the operating room during and after procedures and increased colony counts of coagulase-negative staphylococci, *Bacillus*, and *Pseudomonas* species were found in the circulated air in all rooms.

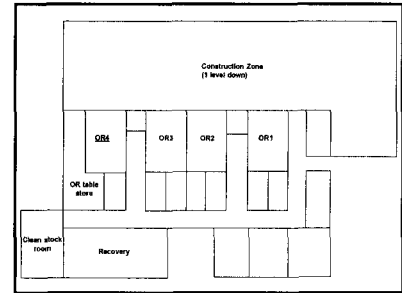


FIGURE. The operating theater suite and the construction zone. Operating room (OR) 4 is used for orthopedics. Water was found leaking into the storage room for operating room table equipment.

Fractures were noted around the air filter mounts and the high-efficiency particulate air filters thus could have been bypassed. There was no barrier between the construction site and the hospital corridors on the level below the operating room until late September. After the air conditioning system was upgraded to higher flow volume high-efficiency particulate air filters and the construction was completed, air quality was markedly improved and the number of colony-forming units during working hours was reduced by half.

Plumbing equipment in the ward immediately above operating room 4 was noted to be leaking into the ceiling space during this time and required replacement. No water was leaking into the operating room, but when maintenance was conducted, a leak into an adjacent room where the operating room table equipment was stored was found. A considerable amount of vibratory and air-hammer work was being done in August. The theater floors could be felt shaking and staff often had to shout to each other during surgery.

When the increased infection rate was noticed in the second week of September, arthroplasty was stopped for 3 months until construction and air and plumbing maintenance were completed. Arthroplasty has since resumed in the unit with only 2 infections among 195 deep joint procedures (1 of these patients fell in the shower, opened his wound, and developed a methicillin-resistant *S. aureus* infection; the other had hemarthrosis during anticoagulation for pulmonary embolus).

Building construction work has been associated with an increased incidence of invasive aspergillosis,¹⁻³

TABLE
SUMMARY OF THE CASES

Case No.	Age (y)	Gender	Procedure	Date	Organism	Result
1	56	Male	Right TKA (PFC knee/ CMW1 cement*)	August 19	<i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	Knee salvaged with good function
2	79	Female	Left patellar stabilization after TKA (PFC knee*)	August 30	<i>S. aureus</i>	Knee arthrodesis
3	79	Female	Right TKA (Genesis II knee/ CMW1 cement†)	September 2	<i>S. aureus</i> (MRSA), <i>Morganella morganii</i> , <i>Serratia marcescens</i> , <i>Enterococcus</i> species	Above knee amputation
4	70	Male	Left THA (Exeter hip/ CMW3 cement‡)	September 6	<i>Proteus mirabilis</i> , <i>S. aureus</i> , <i>Enterococcus</i> species	Hip salvaged with good function

TKA = total knee arthroplasty; MRSA = methicillin-resistant *S. aureus*; THA = total hip arthroplasty.

*DePuy Orthopaedics, Warsaw, IN.

†Smith & Nephew Orthopaedics, Memphis, TN.

‡Stryker Orthopaedics, Mahwah, NJ.

legionella,^{1,4} and polymicrobial⁵ infections, mainly in immunosuppressed patients. Construction work was associated with increased aspergillus spore counts in two prospective studies,^{6,7} but did not alter the aspergillus infection rates or spore counts in another study.⁸ There have also been reports of pseudo-outbreaks of fungal infections in association with construction due to contamination of the microbiology laboratory area.^{9,10}

Deep joint infection following total joint replacement arthroplasty is multifactorial in origin and no one factor can be said to be solely responsible for an increase in the infection rate. This case series was significantly limited by not having an experienced infection control practitioner to perform a coordinated investigation of the outbreak and to perform staff and environmental sampling and subtyping to isolate the source of the infections.

Building construction work may result in a breach of infection control measures in the operating suite. Air quality is a concern because the load of contaminants in the air may be too large for air conditioning systems to deal with⁷ or air supply systems may be disrupted due to vibratory fatigue. Disruption to plumbing, whether due to vibratory stresses or increased back-flow pressures, may compromise the quality of the water supply or contaminate the operating theater. Because some of the leaking plumbing was in the effluent system, this

may have contributed to our case series and may explain the mix of organisms that we encountered. A central sterile supply is also mandatory for providing sterile instruments to work with, and contamination can occur in the same way as in operating theaters. The breach in infection control may also enter at the ward level if there are more contaminants in the air or water, especially when a patient's wounds are washed or dressed. Our experience highlights the importance of having rigorous maintenance standards and schedules to ensure that critical elements such as air and water supply are robust enough to cope when demands are greater than expected. This cluster of infections occurred late in the construction process; there were no problems during the first 8 months. Thus, breaches in infection control can occur at any time, even though the environment may be safe most of the time. Regular monitoring of the environment seems prudent so that potential problems can be addressed before patients are affected.

This case series highlights the importance of monitoring the ability of a hospital to provide a safe operating environment at all times. Involvement of the infection control team is mandatory when planning and conducting construction on or near a hospital. We believe that factors such as air and water quality should be actively monitored more frequently and rigorously

during construction. Carter and Barr¹ published an excellent review of the problem with practical common sense suggestions for addressing infection control issues when construction is conducted. The experience of Fitzpatrick et al.,³ with guidelines for infection control being loosely adhered to, confirms that active monitoring of work practice and the environment needs to occur. Our series should also serve as a reminder that if an outbreak of infections occurs, extensive measures need to be taken to identify the source of the organisms, including environmental and staff sampling and microbiological typing of the infecting organisms.

We believe that construction in or near a hospital may increase the risk of hospital-acquired infection, especially for surgical patients with metallic implants. If an increase (whether real or suspected) in the level of contaminants or clinical infections is found while construction is occurring, elective joint replacement arthroplasty and other such infection-prone procedures should be suspended until the problem is fully investigated and rectified.

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