For IC Practitioners, OR, Endoscopy and Reprocessing Staff, Risk Managers, et al.

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What's News

A hospital in Pittsburgh, PA, is investigating the cause of a number of infections following bronchoscopy. Twelve patients appear to have been colonized or infected with antibiotic-resistant *Pseudomonas aeruginosa.* The conclusions of this newsletter's main article may be applicable to this outbreak investigation. The hospital suspects that its bronchoscopes or an automated endoscope reprocessor may be responsible for this outbreak.

Editor-in-Chief

The articles published in this newsletter are written by: **Lawrence F Muscarella, PhD**, *Chief, Infection Control* at Custom Ultrasonics, Inc. Ivyland, PA 18974 (215-364-8577).

What is 'Q-Net'?

Q-Net is a technology-assessment network of questions and answers. Its newsletter is *The* **Q-Net™** *Monthly*.

Q-Net's main goal is to encourage the infection control and endoscopy communities to not only ask good questions but to also demand succinct and well referenced responses.

Q-Net addresses the needs of both the health care provider whose goal is to provide the best care possible, and the patient who deserves affordable quality healthcare.

Antibiotic-resistant *P aeruginosa*

This article discusses the contribution of the environment to nosocomial infections caused by antibiotic-resistant *P aeruginosa*

Background

In the June 2001 issue of *Infection Control and Hospital Epidemiology* (ICHE), Sorin et al. reported that during a three month period in 1998 as many as eighteen patients at a Flushing, New York, hospital were potentially infected or colonized with imipenem-resistant *Pseudomonas aeruginosa* (IRPA) following bronchoscopy.[1] Three of these patients displayed clinical and radiographic evidence of infection requiring specific anti-*Pseudomonas* therapy. One patient reportedly died as a result of this IRPA outbreak.[1] An accompanying editorial that discussed lessons being learned from outbreaks associated with bronchoscopy was published in this same ICHE issue.[2]

Several crucial infection control issues were addressed in Sorin et al.'s report. Maybe most important, these authors reported that the instructions provided by the manufacturer of an automated endoscope reprocessor (AER) were not always consistent with the bronchoscope manufacturers' reprocessing instructions. Moreover, different brands of bronchoscopes were found to connect differently to the AER.

Due to the discrepancies in these reprocessing instructions, hospital staff were reported to have improperly connected bronchoscopes to the AER, resulting in inadequate disinfection and disease transmission. Unless specific precautions are taken, such as thorough review of the reprocessing instructions provided by both the AER and bronchoscope manufacturers to detect and resolve any inconsistencies, most endoscope and AER models would appear to be susceptible to this same type of confusion and user error.

As a result of their findings, Sorin et al. provide several important recommendations to be considered when using an AER to reprocess a bronchoscope (or other type of endoscope).[1] These recommendations, which are intended to reduce the likelihood of user error, include: (a) color-coding the appropriate connectors for each endoscope manufacturer; (b) providing additional in-service training that highlights differences in the reprocessing instructions provided by different endoscope and AER manufacturers; and, (c) if feasible, purchasing and using endoscopes from one manufacturer.

A published reply: Responding to the report of this IRPA outbreak,[1] Muscarella wrote a reply,[3a] published one year later in the July 2002 issue of ICHE, that discussed several

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implications of Sorin et al.'s investigation. For instance, if as these authors conclude this IRPA outbreak was associated with improper connection of bronchoscopes to an AER, then their report has significant infection control implications applicable not only to reprocessing (both automated and manual) bronchoscopes but also gastrointestinal (GI) endoscopes.

Featuring two valves and as many as four or five internal channels, each of which typically requires proper connection to an AER for adequate irrigation and complete disinfection, GI endoscopes are considerably more complex in design than bronchoscopes, which feature only a single channel and one (suction) valve. Reports such as Sorin et al.'s that link patient infection to improper connection by staff of an AER to a bronchoscope would seem to raise concern that, due to their many channels, connectors, and more complex internal design, GI endoscopes are particularly at risk for this type of user error and reprocessing mishap.

In addition, Sorin et al. reported that neither the source of the IRPA nor a patient-to-patient route of transmission was identified during their outbreak investigation.[1] Indeed, determination of both are crucial to the resolution of any outbreak and to the prevention of its reoccurrence as well as of future outbreaks. Because Sorin et al. identified neither, the possibility remains that the environment was a source of this outbreak's IRPA, prompting Muscarella reasonably to ask in a reply whether the IRPA could have originated on a wet surface within the hospital's environment and have been transmitted to patients via the bronchoscope.[3a,4]

To be sure, several other outbreak investigations have associated *P aeruginosa* infection with contaminated environmental surfaces within the healthcare setting, including the internal components of an AER, bronchoscopes, GI endoscopes, tap water, faucets and water taps, and wash basins.[5-18] If the route of disease transmission reported by Sorin et al. were indeed patient-to-patient, then their conclusion that improper connection of the bronchoscope to an AER resulted in inadequate disinfection and patient infection certainly seems plausible and valid. However, if instead the environment were the source of the IRPA, then Sorin et al.'s conclusion would be incomplete and potentially misleading, and this IRPA outbreak might have occurred even if hospital staff had properly connected the bronchoscope to the AER.[3a,4]

Endoscopes that are properly connected to an AER but terminally rinsed with contaminated water, inadequately dried before storage, or improperly handled before reuse can become re-contaminated with environmental organisms and transmit disease to the patient during endoscopy. Therefore, it is important that outbreak investigations such as Sorin et al.'s[1] that appear to lack the necessary data to conclude that an infected or colonized patient was the source of bacterial infections following endoscopy consider the possibility that bacteria from an environmental site within the hospital setting were transmitted to the patient via the endoscope.

Rebuttal to a reply: In response to Muscarella's reply,[3a] Segal-Maurer (one of the co-authors of the Sorin et al. report[1]) wrote a rebuttal that challenged Muscarella's suggestion that the rinse water or some other environmental factor(s) unrelated to improper connection of the AER to the bronchoscope may have contributed to Sorin et al.'s reported IRPA outbreak.[3b] As a result of this organism's displayed resistance to the antibiotic imipenem,[1] Segal-Maurer concluded that the source of the IRPA outbreak could not have been the environment, but rather had to be an infected or colonized patient:

Segal-Maurer wrote: "Foremost, Dr. Muscarella fails to recognize an important infection control principle regarding antibiotic-resistant *P aeruginosa*. It is widely recognized that such antibiotic-resistant organisms are not found in the general water supply (and thus distinguished from the usual *P aeruginosa* found in tap water). IRPA is an organism exclusively associated with the presence of nosocomial infection or colonization."[3b] She added: "There are numerous reports in the literature of *P aeruginosa* in the water supply leading to contamination or infection. These are all antibiotic-susceptible strains. The author (referring to Muscarella, the editor of this newsletter) needs to substantiate scientifically his implication that IRPA may be found in the general water supply."[3b]

Medical literature review: The suggestion to substantiate scientifically the claim that IRPA can be found in the environment seemed worthy of investigation. Therefore, the medical literature was reviewed to respond to and place in better perspective the significance of Sorin et al.'s report,[1,2] Muscarella's reply,[3a] and Segal-Maurer's rebuttal.[3b] Several reports that discuss outbreaks of *P aeruginosa* in critical care areas of the hospital unrelated to endoscopy were reviewed, although emphasis was placed on identifying reports that discuss *P aeruginosa* outbreaks in the endoscopic setting. This review investigated not only the antibiotic profile and source of the *P aeruginosa* but also measures that effectively ended the reported outbreak. Emphasis was also placed on reviewing investigations of outbreaks caused by strains of *P aeruginosa* resistant to antibiotics, specifically imipenem.

In particular, this review investigated whether antibiotic-resistant *P aeruginosa* in general and IRPA in particular are exclusively associated with nosocomial infection or patient colonization, as suggested by Segal-Maurer,[3b] or whether these strains could also be found on an environmental surface acting as a source, as suggested by Muscarella.[3a] The results of this review would likely provide critical clinical information important to bacterial outbreak investigations in hospitals and endoscopic settings.

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Antibiotic-resistant *P aeruginosa*—Critical care areas: This review of the medical literature provided an interesting finding: In addition to colonized and infected patients, the environment in critical care areas of a hospital, such as its intensive care unit (ICU), was reported to be an important source of antibiotic-resistant *P aeruginosa*.[5-8,13-16] Several reports in particular discussed strains of *P aeruginosa* resistant to several antibiotics although not specifically imipenem.[13-15] In these reports, environmental surfaces, including plumbing systems, sinks, sink and shower drains, and sink outlets in critical care areas of the hospital were determined to be the likely sources of antibiotic-resistant *P aeruginosa*.

This review also identified several outbreak investigations that determined that the environment in critical care areas of the hospital was the source of strains of *P aeruginosa* specifically resistant to imipenem (IRPA), the antibiotic described in Sorin et al.'s report.[1] For instance, a prospective study reported recovering an epidemic strain of IRPA in the sinks of the rooms of several mechanically ventilated patients in an ICU.[7] These colonized sinks were determined to be sources responsible for nosocomial colonization and patient infection. The report hypothesized that the sinks became contaminated with IRPA during the emptying of humidifier traps filled with condensed water, and, once the sinks were colonized, the patients were likely infected with IRPA via contact with healthcare staff's hands or by equipment that had become contaminated during washing in these sinks. This report stresses the importance of regularly cleaning and disinfecting sinks, to prevent the transmission of *P aeruginosa* from colonized sinks to the patient via healthcare staff's hands or equipment.

Similarly, a second report discussed an outbreak of IRPA in a neurosurgery ICU.[5] This organism was isolated from sinks and the tap water, which, according to this report, likely was its source. The outbreak ceased only after, among other measures, all of the ICU's sinks were replaced. This finding suggests that, in addition to the possibility of a patient-to-patient route of disease transmission, IRPA can be transmitted from the environment to patients via the hands of healthcare staff or nutritional solutions mixed with contaminated tap water. This report concluded that the tap water can play a crucial role in the spread of *P aeruginosa*.

And a third report, investigating an outbreak of IRPA in an ICU, isolated this organism from wash basins, water taps, and the tap water of the rooms of infected patients.[8] This report suggests that the tap water was likely the source of the outbreak and that the patients were probably contaminated with IRPA in part when crushed drugs suspended in tap water were administered to patients through gastric tubes. The outbreak was terminated after weekly pasteurization of the ICU's water taps (as well as use of sterile water for patients' drugs and food).

Antibiotic-resistant *P aeruginosa*—The endoscopic setting: This review of the literature also yielded reports that discuss the antibiotic profile and source of *P aeruginosa* associated with patient infection or colonization in the endoscopic setting, specifically following bronchoscopy and GI endoscopy. The findings of these reports were similar to those in critical care areas of the hospital. In particular, several outbreak reports cite tap water or another environmental site in the endoscopic setting as the source of antibiotic-resistant (and -susceptible) *P aeruginosa*.

For instance, one report investigated an outbreak following bronchoscopy that was caused by a resistant strain of *P aeruginosa*.[10] After reprocessing, two bronchoscopes were found to be contaminated with *P aeruginosa* (although with an antibiotic-susceptible strain). This finding suggested a failure in the reprocessing of the facility's bronchoscopes. An AER, which had not been maintained since its installation, was used to reprocess the bronchoscopes. Although extensive environmental sampling failed to identify the outbreak's exact source, the authors conclude that the source of the *P aeruginosa* was the colonized AER, which during reprocessing re-contaminated bronchoscopes. The return of two bronchoscopes to their supplier for servicing and the replacement of several of the AER's internal components were required to stop this outbreak. The authors stress the importance of training, better supervision of reprocessing staff, and more frequent servicing and maintenance of AERs to prevent an outbreak.

A second investigation discussed an outbreak that reportedly started in a hospital's endoscopy unit.[16] A colonoscope, a gastroscope, faucets of wash basins, and water taps were each contaminated with *P aeruginosa* resistant to several antibiotics including imipenem. The possible transmission of this organism via the hands of healthcare staff is discussed. The authors suggest that the faucets and water taps became contaminated and colonized with this organism when residues from drinking glasses were poured into the wash basins and splashed upwards. The endoscopes were likely contaminated when removed wet from an AER, possibly during handling by staff. The implementation of patient isolation, strict glove usage, improved hand hygiene, drying the reprocessed endoscope before storage, and periodically replacing, cleaning and disinfecting the water taps successfully broke the chain of infection.

A third report investigated an outbreak of *P aeruginosa* bacteremia following endoscopic retrograde cholangiopancreatography (ERCP).[17] Five epidemic strains of *P aeruginosa* were identified. Microbiologic sampling showed that endoscopes used during ERCP remained contaminated with an epidemic strain of *P aeruginosa* after reprocessing in an AER. One of the five outbreak strains (genotype B), of which there were four clonally related variants that displayed variable antibiotic resistance (more

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specific antibiotic-resistant data were not provided), was isolated from both the water used by the AER to rinse the endoscopes and the tap water in the endoscopy suite. This report concluded that *P aeruginosa* from the environment was transmitted via contaminated endoscopes to at least some of the bacteremic patients. This outbreak ended only after the ERCP channel and each of the endoscope's other channels were thoroughly cleaned, disinfected, and terminally dried using 70% alcohol rinse followed by compressed air before storage.

Additionally, two reports that are frequently referenced in the medical literature whenever *P aeruginosa* infections following endoscopy are discussed were also reviewed.[9,11] Both investigated the source of *P aeruginosa* infections following ERCP and traced their respective outbreaks to contaminated endoscopes, which were inadequately disinfected and dried by the hospitals' AERs. One of these reports cultured heavy colonization of *P aeruginosa* from endoscopes as well as the AER's detergent reservoir, among other sites.[9] *P aeruginosa* was presumably transmitted from the AER to patients via the endoscope, which was contaminated during the AER's terminal water rinse cycle. In the other report, residual water contaminated with *P aeruginosa* remained in the endoscope's channels after the AER's terminal water rinse cycle and was transmitted to patients during ERCP.[11] Both outbreaks ended once all of the endoscope's channels were rinsed with 70% alcohol followed by forced air drying before storage. In both reports, antibiotic susceptibility testing was performed on the outbreak strain of *P aeruginosa,* but neither report published the data revealing the organism's antibiotic profile.

Discussion: Revealing an important conclusion with significant clinical implications to outbreak investigations, this literature review found that antibiotic-resistant *P aeruginosa* is not exclusive to patient infection or colonization, as some have suggested.[3b] Several investigations researching the cause of *P aeruginosa* outbreaks, in both critical care areas within a hospital and the endoscopic setting, cite the facility's tap water[5,8,16] and other environmental sites, including water faucets,[16] sinks,[5,7,14,15] an AER,[10] and water taps,[8,16] as the source of antibiotic-resistant *P aeruginosa*.[5-17] ***To be continued next month***.

'Q-Net 2001'

'Q-Net 2001', a bound collection of all of last year's monthly newsletters is now available. Request a copy on-line by visiting: http://www.myendosite.info Topics discussed in this book include routine monitoring of rinse water, CJD, and anthrax.

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Thank you for your interest in this newsletter. *I have addressed each issue to the best of my ability. Respectfully* *Lawrence F. Muscarella, Ph.D.*

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