American Journal of Infection Control 43 (2015) 951-5

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Time-dependent influence on assessment of contaminated environmental surfaces in operating rooms

Yuhei Saito RN, MS *, Hiroshi Yasuhara MD, PhD, Satoshi Murakoshi MD, PhD, Takami Komatsu MD, PhD, Kazuhiko Fukatsu MD, PhD, Yushi Uetera MD, PhD

Surgical Center, University of Tokyo Hospital, Tokyo, Japan

Key Words:
Environmental contamination
Time course
Health care–associated infection
Assessment method

Background: There is no established method to assess the contamination of environmental surfaces because the results change with time. We evaluated current methods for assessment of contamination of environmental surfaces in the operating room (OR).

Methods: Contamination of environmental surfaces in the OR was assessed using an adenosine triphosphate (ATP) test and bacterial culture. We collected 480 ATP test samples from 17 surfaces in 6 ORs to determine the influence of surface features, including frequency of touching and surface orientation on contamination, after completion of daily scheduled operations. Another 54 pairs of ATP and microbial samples were taken from 3 surfaces in each of the same OR except 1 to determine the time course of the results of ATP and microbial tests when ORs were not used.

Results: Multivariate analysis demonstrated that the ATP results were strongly influenced by frequency of touching and orientation of environmental surfaces. The microbial counts declined over time, whereas the ATP results remained at a high level.

Conclusion: The ATP test result could be used as a relatively stable trace of contamination of environmental surfaces; however, it is not a surrogate indicator of the number of viable microbes which declines over time.

Recently, there has been increasing concern about contamination of environmental surfaces as an important factor associated with health care–associated infection.[1-3] Various attempts have been made to control the level of contamination of environmental surfaces.[4-9] Microbial counts, which represent the risk of transmission of microorganisms from an environmental surface to humans, were commonly used in previous studies. However, they sometimes dealt with the level of contamination only at a given time, and it was assumed that microbial counts remained stable and the measured level of contamination lasted for a long time period.[10-13] A previous study revealed that the number of microbes decreased rapidly even over a short period of time.[14] Therefore, transmissibility of infection may decline over time. In addition, not all microbial species have infectivity in humans.[1] Microbial counts alone may be insufficient or even inappropriate for assessing the level of contamination of environmental surfaces in hospitals because they do not always reflect the risk of infection.

Adenosine triphosphate (ATP) measurement is another option to evaluate contamination of environmental surfaces. It estimates the degree of contamination reflected by the amount of ATP on the surface, which is produced in or secreted from living organisms.[15] Many studies have shown only a weak correlation between microbial count and ATP result, partly because ATP remains after bacteria lose viability.[1,15] ATP measurements are reported to show little influence of time in experimental conditions.[16] The ATP test may enable us to analyze contamination of environmental surfaces in hospitals based on more stable information. The aim of this study was to identify the time-dependent changes of environmental surfaces in operating rooms (ORs) and determine the role of ATP measurement.

METHODS

The environmental surface was monitored in 6 ORs using ATP and microbial tests during the period between October 2011 and January 2014. The ORs were selected on the basis of surgical

* Address correspondence to Yuhei Saito, RN, MS, Surgical Center, The University of Tokyo Hospital, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan 113-8655.
E-mail address: saitoyu-ope@h.u-tokyo.ac.jp (Y. Saito).

Conflicts of interest: None to report.

Financial disclosure: This study was partly supported by Society for the Study of Infection Control (the Oiso Forum) sponsored by 3M Health Care Ltd).

http://dx.doi.org/10.1016/j.ajic.2015.04.196

Table 1
Features and level of contamination of environmental surfaces in operating rooms

Surface (n)	Frequency of touching	Orientation	Height above floor	ATP value (log_{10} RLU)	
				Mean	SD
EMR keyboards for nurses (30)	High	U	I	2.8	0.3
EMR keyboards for anesthesiologists (30)	High	U	I	2.8	0.3
EMR touch screens for anesthesiologists (30)	High	V	I	2.0	0.3
Floor of surgeons' workspace (30)	High	U	Low	3.1	0.5
Floor of anesthesiologists' workspace (30)	High	U	Low	3.1	0.4
Patient monitor displays (30)	I	V	I	1.9	0.3
Anesthetic machine tables (30)	I	U	I	2.0	0.4
Transfusion stand trays (30)	I	U	I	2.0	0.3
Transfusion stand poles (30)	I	V	I	3.0	0.3
Door hand switches (15)	I	V	I	2.2	0.2
Door foot switches (15)	I	V	Low	2.6	0.4
EMR monitor displays for nurses (30)	Low	V	I	2.3	0.6
Wall close to anesthetic machines (30)	Low	V	High	1.7	0.2
Wall near entrance of ORs (30)	Low	V	High	1.7	0.1
Ceiling supply units (vertical surface) (30)	Low	V	High	2.6	0.3
Ceiling supply units (horizontal surface) (30)	Low	D	High	1.8	0.2
OR lights (30)	Low	D	High	2.1	0.5

ATP, adenosine triphosphate; *D*, downward; *EMR*, electronic medical records; *I*, intermediate; *OR*, operating room; *U*, upward; *V*, vertical.

specialties: thoracic operations, abdominal operations, and operations in other specialties. In the first stage of the study, we determined the influence of surface features on the degree of contamination, and in the second stage of the study, we examined the persistence of ATP on a specific environmental surface.

Influence of surface features on the degree of contamination

The influence of surface features on contamination of environmental surfaces was evaluated using the ATP test. On the basis of the estimated frequency of touching and the distance from patients during the operation, 17 environmental surfaces were selected (Table 1). These surfaces were categorized, based on our data of frequency of touching by health care workers in the OR in our preliminary study (data not presented), as high (frequent), intermediate (occasional), and low (almost never) frequency. The samples were collected after terminal cleaning was completed in each OR.

A total of 60 operations were performed during the study period. They included 21 operations in ophthalmology, 8 in obstetrics and gynecology, 6 in gastrointestinal surgery, 5 in pulmonary surgery, 5 in urology, 4 in cardiac surgery, 3 in orthopedic surgery, 2 in otolaryngology, 1 in neurosurgery, 1 in hepatic surgery, 1 in colorectal surgery, 1 in breast surgery, 1 in endocrine surgery, and 1 in plastic surgery. They did not include any patients with tuberculosis, methicillin-resistant *Staphylococcus aureus*, HIV, prion, or *Clostridium difficile* infection.

To determine factors that influence the level of contamination, 14 variables were selected (Table 2). These represent the features of environmental surfaces (frequency of touching, orientation, height above floor), number of operations performed in a day, specialty the OR was used for, features of the operations performed in each OR, including class of American Society of Anesthesiologists physical status of patients, surgical wound classification, surgical position, operation time, time in OR, blood loss, infusion volume, blood transfusion, and others (time between sampling, end of operation).

Routine cleaning of environmental surfaces was conducted regularly during the study period. The floor was cleaned by interim cleaning with wet mops. For terminal cleaning, the electronic medical record (EMR) keyboards for anesthesiologists, patient monitor displays, tables of anesthetic machines, and trays or poles of transfusion stands were cleaned with wipes and disposable towels moistened with detergent. The hand or foot switches of automatic doors, OR lights, walls close to anesthetic machines, walls near the entrance of the OR, and surface of ceiling supply units were cleaned weekly at weekends. EMR keyboards for nurses, EMR displays for anesthesiologists and EMR displays for nurses were not subject to routine cleaning. Detergent containing hydrogen peroxide was used for moistening mops, wipes, and disposable towels. Additional disinfection was not conducted in our hospital.

Time course of contamination

The time course of contamination of environmental surfaces was assessed using the ATP test and microbial counts. Swabs were taken from the wall near the entrance, EMR keyboards for anesthesiologists, and EMR monitors for nurses at 2 hours, 48 hours, and 7 days after the last operation in each of the same OR except 1. The assessments were carried out during the holiday season when there were no scheduled operations or emergency operations. For the sake of this study, no cleaning was conducted in the ORs during the study period.

ATP assessment

An ATP bioluminescence test was used for assessment of contamination of environmental surfaces. The test area of a square with 10-cm sides on the surface was swept gently in 2 directions at right angles, 10 times each, using a swab of the ATP monitoring system (Clean-Trace Hygiene Monitoring System; Sumitomo 3M, Tokyo, Japan). Each trace line was kept at 1-cm intervals. The amount of ATP gathered on the swab was measured in relative light units (RLU) with a luminometer (Clean-Trace Luminometer UNG3; Sumitomo 3M, Tokyo, Japan). The data were adjusted according to the size of the area when the surface was <100 cm^2. Adjustment was performed for the measurement of ATP on ceiling supply units, keyboards for anesthesiologists and nurses, and transfusion stand poles. ATP values were categorized into >250 RLU and ≤ 250 RLU in the study of surface features and used as continuous variables in the study of the time course.

Microbial assessment

Microbial assessment was performed using a sample-ready culture medium system (Petrifilm Aerobic Count Plates; Sumitomo 3M, Tokyo, Japan). A square with 10-cm sides adjacent to the