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A study of three methods for assessment of hospital environmental cleaning

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Abstract. ***Background*:** The environment is increasingly appreciated as a factor in healthcare associated infections. Several methods for measuring environmental contamination are available. Our goal was to compare quantitative microbiology to adenosine triphosphate (ATP) detection on a sample of hospital surfaces both pre- and post-cleaning, and to assess fluorescent marker results in the same rooms.

***Methods*:** In a sample of 10 rooms, ATP readings by relative light units (RLU) and quantitative determination of colony forming units (CFU) were measured pre- and post-cleaning on 10 high-touch hospital environmental surfaces. Removal of fluorescent markers (FM) was evaluated post-cleaning in the same rooms. Methods were compared using correlational analyses.

***Results*:** The ATP readings were usually higher than CFU readings compared with their respective norms for cleanliness. The direction of change in cleanliness assessment (usually down after cleaning) was consistent between the RLU and CFU methods. In addition, CFU and RLU values correlated pre-cleaning, but not post-cleaning. A receiver operating characteristic (ROC) curve suggested a 'clean' cutoff of 8 RLU/cm^2 for the ATP assay, higher than 2.5 RLU/cm^2 cutoff most often used. Neither method correlated well with FM results.

***Conclusions*:** The methods for measuring environmental cleanliness have shown inconsistent correlation, but measure different parameters. Additional studies are needed to assess the correlation and predictive value of the three methods for room cleanliness assessment.

Additional keywords: ATP device, environmental cleanliness assessment.

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Introduction

Visual inspection of a hospital surface is quite inadequate as a measure of microbial cleanliness. Better methods for evaluating the cleanliness of the hospital environment such as the ATP assay, quantitative microbiology and the fluorescent marker solution method are available but all have limitations.[1–12] The purpose of this project is to provide additional data on environmental cleanliness assessment by studying these methods.

Methods

The Nebraska Medical Center is an acute care, 689-bed tertiary referral hospital in Omaha, NE. Standard rooms for study were selected from acute care wards.

Study design

A convenience sample of 10 hospital rooms was studied after patient discharge. A single trained research coordinator obtained specimens. These rooms were tested using the 3M

Implications

- The standard methods of environmental cleanliness determination do not necessarily correlate.
- Quantitative microbiology and ATP detection have shown general directional consistency.
- There should be additional study of the cleanliness cutoff for the above two methods.

Clean Trace ATP system, quantitative microbiology and the fluorescent marker (FM) technique both pre- and post-terminal cleaning (after patient discharge). The surfaces most likely to be contaminated have been defined in the literature as surfaces with high ATP counts, surfaces with high microbial contamination or surfaces observed to be most frequently touched.[5,8–11] In each room 10 high-touch surfaces were quadrisected so that the same object could be sampled pre and post by both ATP and quantitative microbiology methods (Table 1). The surface area of each high-touch surface was measured to allow standardisation of results per cm^2; larger surfaces had a manageable sample area selected (e.g. 400 cm^2 for the mattress top) using a sterile template. In the same rooms, 10 other high-touch surfaces were selected for FM placement (Table 2). We did not select FM surfaces immediately adjacent to the ATP or CFU surfaces to avoid contamination of the latter by the fluorescent solution.

Quantitative cultures were obtained by rubbing a polyester swab pre-moistened with sterile surfactant solution over the designated high-touch area for 30 s. The samples were obtained approximately 1 h after cleaning of the environment, generally with a quaternary ammonium compound, by which time the disinfectant or cleaning agent had dried. For the microbiologic samples, the swab tip was placed in phosphate-buffered saline, vortex-mixed at high speed for 30 s, serially diluted and cultured in triplicate on Malt Extract Agar (MEA) for fungal analysis and Tryptic Soy Agar (TSA) for bacterial analysis. The MEA plates were held at 25°C for 10 days and TSA plates were held at 37°C for 2 days before counting. Results were reported as colony forming units per square centimetre of surface area (CFU cm^{-2}).

The ATP readings were obtained using an ATP bioluminescence assay (3M Clean-Trace Surface ATP System; 3M Co., St. Paul, MN). A single sterile polystyrene swab was rubbed over the designated high-touch area for 30 s, placed in a plastic tube and shaken for 30 s, and then placed in the portable handheld luminometer which provides a digital readout of the light generated by the luciferase reaction in relative light units (RLU). We selected the most widely-used thresholds for clean surfaces as readings below 2.5 CFU cm^{-2} and 250 RLU/surface (generally 100 cm^2).[2,5,7–10]

The FM surfaces were marked with an invisible dye (DAZO, Ecolab) before cleaning, and examined by ultraviolet light immediately post-cleaning. Surfaces were negative for background UV fluorescence. Scores were graded as dye removed (cleaning took place), dye partially removed (partial cleaning) and dye present (not cleaned).

Analysis and statistical methods

Primary analyses were conducted for each measure of cleanliness, with measures from all surfaces combined for these analyses.

Associations between the ATP values and total CFUs were evaluated using Pearson χ^2-test (chi-square) tests and correlation coefficients as appropriate. Two types of comparisons were made based on the cleanliness measurements: 'raw score difference' and 'sign of difference'. The raw score differences for each measurement were calculated by subtracting the post-cleaning measurement from the pre-cleaning measurement. The sign of difference was the direction of pre- to post-clean change.

Values were recorded as follows: 3 = Positive sign (the item was cleaner after the room was cleaned); 2 = Value is

Table 1. Median values for pre-clean, post-clean, and differences of pre-clean and post-clean readings for ATP and CFU

$n = 10$ for all surfaces except room chair arms and bedrail inner panel, where $n = 9$. Based on cutoffs of 2.5 RLU/cm^2 and 2.5 CFU/cm^2 Since each number is a median, the sum of values for 'change' and 'post-clean' do not necessarily equal the values for 'pre-clean'

Surface	Adenosine triphosphate values (RLU cm^{-2})			CFU values (CFU cm^{-2})		
	Pre-clean	Post-clean	Difference	Pre-clean	Post-clean	Difference
Top of mattress – head	1.2	0.5	0.4	0.5	0.0	0.4
Mattress side – mid	1.5	1.7	–0.5	0.1	0.0	0.1
Bed head/foot board	7.1	1.5	6.1	2.7	0.1	2.7
Bedrail – top	13.0	2.7	6.4	5.9	0.2	5.9
Bedrail – inner panel	14.0	9.5	4.5	2.0	0.1	1.9
Overbed table	5.3	1.3	3.6	1.5	0.1	1.3
Commode seat	1.9	0.4	0.8	5.5	0.1	5.0
Room chair arms	18.1	8.5	8.1	14.4	0.7	12.1
Call light	12.4	9.3	3.3	13.5	0.1	8.9
Patient telephone	15.5	5.6	8.3	6.7	0.1	5.3

Table 2. Status of post-cleaning fluorescent markings by surface, in descending order from least clean

Present = not cleaned; partial removal = partially cleaned; complete removal = cleaned

Surface	*n*	Present (%)	Partial removal (%)	Complete removal (%)
Sharps box	10	9 (90.0)	1 (10.0)	0 (0.0)
Oxygen flow meter	10	9 (90.0)	0 (0.0)	1 (0.0)
Room flashlight	4	3 (75.0)	0 (0.0)	1 (25.0)
Soap dispenser lever	10	6 (60.0)	2 (20.0)	2 (20.0)
Room light switch	10	5 (50.0)	0 (0.0)	5 (50.0)
Toilet flush handle	10	3 (75.0)	1 (10.0)	6 (60.0)
Sink – faucet handles	10	2 (20.0)	3 (30.0)	5 (50.0)
Stethoscope diaphragm	7	2 (28.6)	0 (0.0)	5 (71.4)
Overbed table control	10	2 (20.0)	1 (10.0)	7 (70.0)
Exterior door handle	10	2 (20.0)	0 (0.0)	8 (80.0)