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Assessment of percent positive agreement between fluorescent marker and ATPase for environmental cleaning monitoring during sequential application in an intensive care unit

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Abstract

Terminal room cleaning is of critical importance to prevent pathogen transmission, but the optimal cleaning effectiveness assessment modality is still being investigated. We sequentially compared cleanliness assessment agreement between a fluorescent marker and an adenosine triphosphate bioluminescence method, finding no significant differences between modalities.

Keywords

terminal cleaning; adenosine triphosphate bioluminescence; fluorescent marker

Hospitalized patients are at increased risk of multidrug resistant organism (MDRO) acquisition if a previous occupant of their hospital room was infected or colonized with an MDRO [1–3]. Therefore, terminal room cleaning after patient discharge or transfer is of critical importance to prevent MDRO transmission. The optimal method to assess terminal room cleaning effectiveness is still being investigated. Studies comparing the effectiveness of disinfecting methods and/or cleanliness monitoring strategies are uncommon.[4] One method to monitor cleanliness is by measuring adenosine triphosphate (ATP) bioluminescence, which correlates with bacterial burden [5]. Previous studies have measured concurrent cleanliness assessment agreement of fluorescent biomarkers and ATP bioluminescence methods [6, 7], but not sequentially. Our goal was to determine agreement

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of sequential cleanliness assessment between a fluorescent marker (Glo Germ, Ecolab, St. Paul, MN) and an ATP bioluminescence method (SystemSURE Plus ATP Cleaning Verification System, Hygiena, Camarillo, CA). Assessing results with the second modality after achieving a “clean” score by the first modality will better define agreement on appropriate endpoints between modalities.

Methods

The study was conducted between November 2018 and February 2019 in the surgical intensive care unit at Barnes-Jewish Hospital, a 1250-bed academic tertiary referral center in St. Louis, MO.

This non-randomized study had three phases: 1) determination by ATP bioluminescence of the relative light unit (RLU) score of fluorescent marker on high-touch objects (Table), to assess for potential confounding effect of prior treatment with fluorescent marker on ATP bioluminescence results, 2) ATP bioluminescence testing of surfaces after cleaning, with re-cleaning until a passing score achieved, followed by assessment of fluorescent marker removal by the cleaning, and 3) testing of fluorescent marker removal by cleaning of surfaces, with re-cleaning until a passing score achieved, followed by testing of the same surfaces by ATP bioluminescence (see Supplementary Material). High-touch objects were chosen based on CDC recommendations, with the addition of analogous items in rooms with private bathrooms,[8] and included overbed tray table, call box/button, bedside telephone, room sink, room light switch, chair, room door knob (inner), bathroom inner door knob/plate, bathroom light switch, bathroom sink, toilet seat, toilet flush handle. Cleaning failure for ATP bioluminescence was a score >25 relative light units (RLUs) consistent with manufacturer’s recommendations and for fluorescent marker was any visible fluorescent marker. For phases two and three, the initial monitoring method (ATP bioluminescence or fluorescent marker, respectively) had to achieve a passing result on each object before cleanliness was assessed using the second modality. Testing was performed immediately upon completion of room cleaning by staff. Cleaning staff were instructed on which objects failed the initial modality and needed to be re-cleaned. Objects were re-cleaned until they received a passing score by the first test modality (ATP bioluminescence in phase two, fluorescent marker in phase three). A quaternary ammonium was used for all cleaning.

Statistical analysis

With α=0.05 and β=0.80, we calculated that we would be able to detect a 30% difference in percent agreement between Glo Germ and Hygiena SystemSURE Plus ATP Cleaning Verification System with 13 rooms with 13 potential high-touch objects in both phases two and three [9].

To compare the sequential use of cleaning assessment methods, we performed weighted least squares regression on the log odds of passing the cleanliness assessment for each method in each phase, stratified by room. The parameters of interest were assessed for statistical significance in comparison to an F distribution with (1,22) degrees of freedom, due to the small sample size of rooms (26). We considered three potential effects on cleaning

pass rate: method (ATP bioluminescence versus fluorescent marker), period (initial versus second method in a phase), and phase.

Results

In phase one, fluorescent marker had no significant RLU signal on high-touch objects by ATP bioluminescence testing (12 surfaces tested, three times per surface; median RLU = 0 range 0 – 12). In phases two and three, 26 rooms were measured, 13 in each phase. A total of 293 high-touch objects were measured, 145 in phase two and 148 in phase three (not every room had every possible object). In phase two, 26.2% (38/145) failed the initial cleaning as monitored by ATP bioluminescence. In phase three, 14.2% (21/148) failed the initial cleaning as monitored by fluorescent marker.

In phase two (ATP bioluminescence followed by fluorescent marker), percent positive agreement of sufficient terminal cleaning was 73.8% (95% confidence interval (CI) [65.9–80.7]). In phase three (fluorescent marker followed by ATP bioluminescence), percent positive agreement was 85.8% (95% CI [79.1–91.0]).

Adjusted for method, period, and room, the odds of passing the second modality in phase two (fluorescent marker) were 0.47 (95% CI [0.14, 1.51]) times the odds of passing in phase three (ATP bioluminescence). The odds of passing the first modality in phase two (ATP bioluminescence) were 0.54 [0.27, 1.08] times the odds of passing the first modality in phase three (fluorescent marker). Considering initial and second modality pass rates between phases, there was no overall difference between the two cleanliness assessment modalities.

Discussion

Our results suggest that there is no significant difference in terminal room cleaning effectiveness assessment between ATP bioluminescence and a fluorescent marker. Notably, this assessment was performed in the context of real-time feedback to cleaning personnel.

The number of rooms tested in our pilot study was small and we cannot determine whether the cleanliness of individual high-touch objects are better assessed by one methodology (fluorescent marker versus ATP bioluminescence), nor whether individual objects/surface types are more prone to cleaning failure. However, switching between testing modalities should not significantly affect overall assessment results. Knowing that the two modalities perform similarly will be useful in scenarios where both are used at a single institution or when a switch from one modality to the other is required.

Our study is limited by lack of a gold standard to confirm cleanliness. In the future, this work could be expanded by including environmental sampling/culturing and collecting data on hospital-acquired infections in a randomized trial of ATP bioluminescence compared to fluorescent marker testing. In addition, quaternary ammonium was used for cleaning in this study, which may either enhance, quench, or have no effect on ATP readings. [10–12] Given the mixed data, it is unclear what role, if any, quaternary ammonium may have had on ATP readings.

In conclusion, our pilot study suggests that ATP bioluminescence and fluorescent markers are not significantly different for determining cleanliness of high-touch objects.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights:

- Sequential application of fluorescent marker and ATP bioluminescence were assessed
- Fluorescent marker and ATP bioluminescence perform similarly in cleaning assessment
- Alongside real-time cleaning feedback, cleaning assessment methods were equivalent