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Brief Report

Middle East respiratory syndrome coronavirus on inanimate surfaces: A risk for health care transmission

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The Middle East Respiratory syndrome coronavirus (MERS-CoV) has been responsible for multiple health care–associated outbreaks. We investigated whether high-touch surfaces in 3 rooms of laboratory-confirmed MERS-CoV patients were contaminated with MERS-CoV RNA. We found 2 out of 51 surfaces were contaminated with MERS-CoV viral genetic material. Hence, environmental contamination may be a potential source of health care transmission and outbreaks. Meticulous environmental cleaning may be important in preventing transmission within the health care setting.

In September 2012, the Middle East respiratory syndrome coronavirus (MERS-CoV) was identified from a patient in Saudi Arabia. As of March 29, 2016, the World Health Organization reported 1,698 laboratory-confirmed MERS cases in 26 countries, with 609 deaths (36%).[1] In its most recent report, the Centers for Disease Control and Prevention has stressed the great importance of personal protective equipment (PPE), source control, and environmental infection control measures to help eliminate the threat of health care–associated outbreaks.[2]

Most health care–associated MERS-CoV outbreaks has occurred in Saudi Arabia. Although the precise mechanism of human-to-human transmission has not been elucidated, MERS-CoV can be recovered from plastic surfaces after 48 hours at 20°C and 40% relative humidity (RH), and the virus is viable for 8 hours at 30°C and 80% RH and for 24 hours at 30°C and 30% RH.[3] Further, data from the South Korean outbreak (May 2015) demonstrated that several environmental surfaces frequently touched by laboratory-confirmed MERS patients and health care workers were contaminated by MERS-CoV.[4] Additionally, viral sheading was detected by viral cultures from respiratory secretions up to 25 days postdisease onset.[4]

Although MERS-CoV was isolated from numerous high-touch surfaces in 2 Korean hospitals affected by MERS outbreak,[4] such data are lacking in the Middle East. Therefore, the objective of this study was to examine the extent of environmental contamination with MERS-CoV during an outbreak in a Saudi hospital.

MATERIALS AND METHODS

The study was performed in the intensive care unit (ICU) at King Abdul-Aziz Medical City, Riyadh, during a MERS-CoV outbreak from

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September 1-October 5, 2015. The ICU had strict environmental cleaning policies, which included cleaning the rooms at least twice daily using ammonium-based disinfectant and chlorine solution 1:10 or 5,000 ppm, having a checklist, and frequent inspection using fluorescent light or culturing of high-touch areas.

Table 1
Characteristic, physiologic, and laboratory variables for the patients in the rooms during environmental sampling

Variables	Patients		
	A	B	C
Age, y	35	85	30
Sex	Female	Male	Male
Body mass index, kg/m^2	28.7	24.9	37.3
APACHE II score	18	31	15
Time in room before environmental sampling, d	8	16	4
Time from last positive MERS-CoV to environmental sampling, h	24	24	72
MERS-CoV, C_p/C_T	E = 17 O = 18	E = 20 O = 20	E = 34 O = 35
FiO_2, %	55	30	40
Tidal volume, mL	250	380	450
PEEP, cm H_2O	16	5	8
PaO_2/FiO_2 ratio	152.6	269.3	166.8
Leukocyte count, $\times 10^9$ cells/L	14.6	16.7	11.6
Platelet count, $\times 10^9$ cells/L	345	89	286
Lactate level, mmol/L	1.03	2.42	0.58
Creatinine concentration, μmol/L	65	117	399
Bilirubin level, μmol/L	13.3	31.9	12.7
AST level, U/L	41	879	39
ALT level, U/L	36	808	20

NOTE. C_p or C_T value is the cycle at which fluorescence achieves a defined threshold. The number of cycles needed for the amplification-associated fluorescence to reach a specific threshold level of detection (C_T or C_p value) is inversely correlated to the amount of nucleic acid that was in the original sample. C_T <29 is a strong positive reaction indicative of abundant target nucleic acid in the sample; C_T of 30-37 is a positive reaction indicative of moderate amounts of target nucleic acid, and C_T of 38-40 is a weak reaction indicative of minimal amounts of target nucleic acid.
ALT, alanine aminotransferase; *APACHE II*, Acute Physiology and Chronic Health Evaluation II; *AST*, aspartate aminotransferase; *C_p*, crossing point; *C_T*, threshold cycle; *E*, E-protein gene (upstream of the envelope gene); *FiO_2*, fraction of inspired oxygen; *MERS-CoV*, Middle East respiratory syndrome coronavirus; *O*, open reading frame 1b (*ORF 1b*); *PaO_2/FiO_2*, arterial oxygen partial pressure to fractional inspired oxygen; *PEEP*, positive end expiratory pressure.

Three negative-pressure rooms of laboratory-confirmed MERS patients (A, B, and C) were selected for this study (Table 1). The room temperature was 20.0°C-25.0°C, and RH was 30%-40%. The air exchange rate was 12 per hour, and the pressure gradient between the room and its anteroom ranged from 2.5-12.5 Pa. Sixteen high-touch surfaces were evaluated (Table 2): 14 in the patients' room (bedrails, mechanical ventilator, ventilator tubing, sink, garbage bin, monitor, intravenous poles, intravenous pumps, telephone, door knobs, floor, drapes-blinds, air conditioning vent, and shelf of the surgical boom) and 2 outside (computer and medical chart). Environmental samples were collected as described by Julian et al.[5] Briefly, a sterile swab premoistened with viral transport media was used to swab each surface (at least 10 cm^2) horizontally, vertically, and diagonally for 30 seconds. This procedure was repeated using eluents: 1/4 lactated ringer solution and phosphate buffer solution (PBS). Virus detection was performed using specific real-time reverse-transcription polymerase chain reaction (PCR) assays for the upstream of the envelope gene and the open reading frame 1A. Positive tests were reported as the cycle threshold value for both upstream of the envelope gene (E) and open reading (O) frame 1A.

RESULTS

The demographic for the patients are summarized in Table 1. All 3 laboratory-confirmed MERS patients were on mechanical ventilators, with an average PaO_2/FiO_2 ratio of 196. The mean ICU length of stay and time from last positive tracheal aspirate for MERS-CoV RNA to environmental sampling were 9.3 days and 40 hours, respectively.

Sixteen surfaces were evaluated in each of the 3 ICU rooms, with 153 environmental samples processed (Table 2). MERS-CoV viral nucleic acid was detected in 2 specimens (PBS as eluent) taken from room C. The positive surfaces were the shelf of the surgical boom and the inside door knob, with cycle threshold values E = 33/O = 31 (positive) and E = 36/O = 0 (intermediate), respectively.

Table 2
Fomites and different isolation reagents

		Room A (n = 51)			Room B (n = 51)			Room C (n = 51)		
Fomites		UTM Swab	1/4LR	PBS	UTM Swab	1/4LR	PBS	UTM Swab	1/4LR	PBS
Inside ICU room										
1	Bedrails 1 (head)	–	–	–	–	–	–	–	–	–
2	Bedrails 2 (side)	–	–	–	–	–	–	–	–	–
3	Vent	–	–	–	–	–	–	–	–	–
4	Vent tubing	–	–	–	–	–	–	–	–	–
5	Sink	–	–	–	–	–	–	–	–	–
6	Garbage bins	–	–	–	–	–	–	–	–	–
7	Monitors	–	–	–	–	–	–	–	–	–
8	Intravenous poles	–	–	–	–	–	–	–	–	–
9	Intravenous pumps	–	–	–	–	–	–	–	–	–
10	Telephone	–	–	–	–	–	–	–	–	–
11	Door knob	–	–	–	–	–	–	–	–	+
12	Floor	–	–	–	–	–	–	–	–	–
13	Drapes-blinds	–	–	–	–	–	–	–	–	–
14	Air vent	–	–	–	–	–	–	–	–	–
15	Surgical boom shelf	–	–	–	–	–	–	–	–	+
Outside ICU room										
16	Keyboards (computer)	–			–	–	–	–	–	–
17	Chart	–			–	–	–	–	–	–

NOTE. The results of real-time polymerase chain reaction for Middle East respiratory syndrome coronavirus viral RNA from various ICU environmental surfaces and eluents (solvents) used.
ICU, intensive care unit; *PBS*, phosphate buffer solution; *UTM*, universal transport medium; *1/4LR*, one-quarter lactate ringers; –, negative test result in the room; +, positive test result in the room.

DISCUSSION

Our study revealed that MERS-CoV viral RNA was isolated from the environmental surfaces of MERS patients.

Currently, much remains uncertain about the transmission mechanism responsible for MERS nosocomial outbreaks. It was postulated from the outbreak in Al-Hasa, Saudi Arabia, in May-June 2012 that respiratory droplet and airborne transmission during aerosol-generating procedures were the most likely transmission modes.[6] However, genetic data from a cluster in Hafr Al-Batin, Saudi Arabia, showed that direct person-to-person contact could not account for all of their cases,[7] therefore raising the likelihood of an alternate transmission mechanism. Studies on kinetics and patterns of viral excretion indicate that MERS-CoV RNA was isolated from urine and feces 13 and 16 days, respectively, after initial symptoms.[8] Viral shedding from respiratory aspirates may persist up to 33 days after illness onset.[9] Prolonged viral shedding[8,9] and survival on surfaces for 48 hours[3] make it difficult to ignore contaminated environmental surfaces as a potential etiology of hospital outbreaks.

The rate of detecting MERS-CoV in our environmental samples was low (1.3%) compared with recently published data (PCR positive = 20.3%; culture positive = 4.0%),[4] but the current methods for isolating viruses from the environmental surfaces are not optimal.[5] Based on reported methodologies, we used a polyester swab, 1/4 lactated ringer solution,[5] PBS[5] and viral transport media[4] because they seem to give the best yield for isolating viruses from fomites. However, we did screening at the tail-end of our outbreak when the patients' viral load might have been low and our infection control practices might have been optimal. Additionally, MERS patients were managed in our ICU since 2013 and were usually cohorted in 1 unit where the staff became very meticulous about PPE use and environmental cleaning. Moreover, fairly weak disinfectants, such as povidone iodine, have a rapid virucidal activity (reduction in virus titer by $\geq 4 \log_{10}$) against MERS-CoV, with an exposure time of just 15 seconds.[10] Further, Leclercq et al demonstrated that at relatively low temperatures of 56°C, only 25 minutes was needed to reduce the initial titer by 4 $\log_{10}$, while at 65°C virucidy dropped significantly to 1 minute.[11] This sensitivity to weak disinfectants could explain why our stringent environmental cleaning policies may have attenuated the recovery of viral genetic material on fomites within the patients' rooms.

CONCLUSIONS

Our finding of MERS-CoV RNA on environmental samples within our ICU shows that the viral material may contaminate fomites and can be a theoretical cause of nosocomial infections**.** However, we did not use viral cultures; therefore, we do not know if the positive PCRs correlate with live viruses or infectivity. Despite this, we believe that in addition to proper hand hygiene and correct PPE donning and doffing, meticulous environmental cleaning is of paramount importance to eliminate health care outbreaks.

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