ANESTHESIOLOGY

Hepatitis C Contamination of Medication Vials Accessed with Sterile Needles and Syringes

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Health care–acquired hepatitis C virus infection continues to occur
- Current guidelines caution against using multidose vials for more than one patient unless the vials are kept in a location away from the patient treatment area
- It is possible that in some circumstances these guidelines are not always followed

What This Article Tells Us That Is New

- When a medication vial diaphragm is contaminated with hepatitis C virus, the contents of the vial can become contaminated with subsequent access with a clean syringe, and the viral content is sufficient to infect cells in culture
- Hepatitis C virus remains infectious in contaminated medications for several days
- Cleaning the vial surface with 70% isopropyl alcohol does not eliminate the risk of vial contamination with hepatitis C virus

ABSTRACT

Background: Health care–associated hepatitis C virus outbreaks from contaminated medication vials continue to be reported even though most practitioners deny reusing needles or syringes. The hypothesis was that when caring for hepatitis C virus–infected patients, healthcare providers may *inadvertently* contaminate the medication vial diaphragm and that subsequent access with sterile needles and syringes can transfer hepatitis C virus into the medication, where it remains stable in sufficient quantities to infect subsequent patients.

Methods: A parallel-arm lab study (n = 9) was performed in which contamination of medication vials in healthcare settings was simulated using cell culture–derived hepatitis C virus. First, surface-contaminated vials were accessed with sterile needles and syringes, and then hepatitis C virus contamination was assessed in cell culture. Second, after contaminating several medications with hepatitis C virus, viral infectivity over time was assessed. Last, surface-contaminated vial diaphragms were disinfected with 70% isopropyl alcohol to determine whether disinfection of the vial surface was sufficient to eliminate hepatitis C virus infectivity.

Results: Contamination of medication vials with hepatitis C virus and subsequent access with sterile needles and syringes resulted in contamination of the vial contents in sufficient quantities to initiate an infection in cell culture. Hepatitis C virus remained viable for several days in several commonly used medications. Finally, a single or 2- to 3-s wipe of the vial diaphragm with 70% isopropyl alcohol was not sufficient to eliminate hepatitis C virus infectivity.

Conclusions: Hepatitis C virus can be transferred into commonly used medications when using sterile single-use needles and syringes where it remains viable for several days. Furthermore, cleaning the vial diaphragm with 70% isopropyl alcohol is not sufficient to eliminate the risk of hepatitis C virus infectivity. This highlights the potential risks associated with sharing medications between patients.

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In North America, nearly 4 million people are infected with hepatitis C virus, causing greater disease burden than any other infectious disease in the country.[1–3] Regrettably, health care–acquired hepatitis C virus infections continue to be reported as a result of unsafe injection practices, poor sanitation procedures, or contaminated medical equipment.[4–10] To address this, infection-control guidelines for safe medication administration are published by reputable organizations and widely disseminated. The American Society of Anesthesiologists (ASA), U.S. Centers for Disease Control and Prevention, and the Provincial Infectious Diseases Advisory Committee of Ontario all strongly caution against the reuse of needles or syringes.[11–18] These organizations advise that medication vials should only be used for a single patient, and if a vial is to be shared, strict aseptic techniques must be used to minimize transmission of blood-borne pathogens.[11,12] They also suggest that if multidose vials are used for more than one patient, the medication vials must be restricted to a centralized medication area and not brought into the immediate patient treatment area (*e.g.,* operating room, patient room/cubicle). Nevertheless, it has remained common practice in North America to share medication

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vials between patients in the operating room, provided single-use sterile needles and syringes are used.[15,19–22]

Over the past 5 yr, public health agencies in the province of Ontario, Canada, have reported four independent outbreaks of patient-to-patient hepatitis C virus transmission at endoscopy clinics, resulting in 16 new hepatitis C virus infections.[23–26] Investigations concluded that contaminated medications, administered by the anesthesiologist, were the likely source of transmission, but most of the anesthesiologists involved denied reusing needles or syringes when accessing a vial for multiple patients. Similar investigations in the United States have also traced hepatitis C virus transmission to the administration of contaminated medications by practitioners who claimed to have used sterile needles and syringes for each patient.[4,7,9] Despite persistent denials, investigators assume reuse of syringes, and alternative theories of contamination have not been explored.

Inadvertent contamination of anesthesiology workspaces, including medication preparation areas, has been clearly demonstrated.[26–31] In this environment, it is possible that a healthcare provider could unknowingly contaminate the rubber diaphragm of a medication vial with bodily fluids containing viral particles when caring for a hepatitis C virus–infected patient (many of whom are unaware of their hepatitis C virus status). If the contaminated vial is then used for additional patients, it is plausible that hepatitis C virus could be transmitted from the outer vial diaphragm into the medication itself, despite the use of a new sterile syringe and needle for each vial entry. With this in mind, we hypothesized that when caring for hepatitis C virus–infected patients, practitioners may *inadvertently* contaminate the medication vial diaphragm and that subsequent access with sterile needles and syringes can transfer hepatitis C virus into the medication, where it remains stable in sufficient quantities to infect subsequent patients. The primary objectives of this study are to determine: 1) whether hepatitis C virus can be transferred *via* a sterile needle and syringe into a medication vial if the rubber access diaphragm is contaminated; 2) whether hepatitis C virus remains viable in common medications; and 3) whether cleaning with 70% isopropyl alcohol is sufficient to eliminate the transmission risk.

Material and Methods

Determination of Hepatitis C Virus Infectivity

Infectious cell culture–derived hepatitis C virus was produced as described previously,[32] and viral titers were determined by focus-forming unit assay. Briefly, cell supernatants from hepatitis C virus–infected cells were serially diluted 10-fold in Dulbecco's modified Eagle's medium and used to infect 4×10^4 Huh-7.5 cells/well (8-well chamber slides) for 5 h, and then cells were supplemented with fresh complete medium. Viral titers were determined at 3 days postinfection by immunofluorescence staining for hepatitis C virus core (Supplemental Digital Content, Supplemental Materials and Methods, http://links.lww.com/ALN/B951). Viral titers are expressed as focus-forming units/ml, determined by the number of hepatitis C virus core–positive foci detected at the highest dilutions. Hepatitis C virus foci were defined as a minimum cluster of three hepatitis C virus core–positive cells.

Quantification of Viral Titers in International Units

To quantify viral titers, additional hepatitis C virus RNA quantification was performed on the viral stock using a quantitative real-time reverse transcription–polymerase chain reaction assay (Center de Recherche du Center Hospitalier de l'Université de Montréal) as previously described.[33]

Hepatitis C Virus Contamination Assay

The rubber access diaphragms (13 mm) of 5-ml glass medication vials containing 4 ml of cell culture medium were contaminated with 33 μl (mean volume of an inadvertent contamination)[34] of hepatitis C virus stock (2.56×10^7, 2.56×10^6, or 8×10^5 U/ml, representing high, intermediate, or low titers, respectively). Droplets were allowed to dry on the diaphragm surface (within the biological safety cabinet), and then the vials were accessed five times, each time using a sterile, blunt-fill needle and syringe (18 gauge × 1½ inch). Subsequently, the contents of the vial were used to infect 8×10^4 Huh-7.5 cells. As positive and negative controls, the cell culture medium was directly contaminated with 33 μl of hepatitis C virus or replication-defective viral stock, respectively. Hepatitis C virus contamination was assessed by focus-forming unit assay or quantitative real-time reverse transcription–polymerase chain reaction analysis at 5 days postinfection. Assessment of contamination was performed for each sample on a nominal scale where each replicate was split into 8 wells of a chamber slide, and a positive-well was indicated by a minimum of three hepatitis C virus foci. The data were summarized using the mean frequency of hepatitis C virus–positive wells per condition with standard error.

Medications

The commonly used medications examined individually for hepatitis C virus stability and viability include: dexamethasone (4 mg/ml, Omega, Canada), lidocaine HCl injection with methylparabin 1 mg/ml as preservative (10 mg/ml, Aveda Pharma, Canada), neostigmine methylsulfate (1 mg/ml, Omega), phenylephrine HCl (10 mg/ml, Sandoz, Canada), propofol (10 mg/ml, Fresenius Kabi, Canada), rocuronium bromide (10 mg/ml, Sandoz), and vehicle (normal saline, 0.9%).

Hepatitis C Virus Stability Assay

Infectious hepatitis C virus stock (3.27×10^5 focus-forming units/ml) was diluted 1:10 in dexamethasone, lidocaine, neostigmine, phenylephrine, propofol, rocuronium,

or vehicle (saline) and incubated at room temperature. At 0 to 72 h, 100 μl of contaminated medications were further diluted to a final concentration of 10% (6% for lidocaine) in cell culture medium. Medication dilutions were then used to infect 8×10^4 Huh-7.5 cells, and focus-forming unit assay or quantitative real-time reverse transcription–polymerase chain reaction analyses were performed at 5 days postinfection.

Evaluation of Disinfection Methods

Rubber diaphragms (13 mm) were contaminated with 3.27×10^5 focus-forming units/ml hepatitis C virus stock (as described above) and subsequently cleaned with a 70% isopropyl alcohol swab using a single, 2- to 3-s, or 10-s wipe with friction with or without drying. Rubber diaphragms were rehydrated in 2 ml of cell culture medium for 1 h, and this medium was then used to infect 9×10^4 Huh-7.5 cells seeded in 6-well plates. After 5 h, input medium was replaced with fresh medium, and hepatitis C virus contamination was assessed by focus-forming unit assay or quantitative real-time reverse transcription–polymerase chain reaction analyses at 5 days postinfection. Untreated rubber diaphragms contaminated with hepatitis C virus or replication-defective virus stock were used as positive and negative controls, respectively.

Data Analysis

All statistical analyses were performed using GraphPad Prism v7 (GraphPad, USA). No *a priori* statistical power calculation was conducted. The sample size was based on similar studies, as well as our previous experience with studies of similar design. All data are representative of three independent experiments with three independent replicates per experiment (n = 9). All data points are representative of eight (focus-forming unit assays) or two (quantitative real-time reverse transcription–polymerase chain reaction assays) independent measurements per replicate, and error bars represent the SD. Statistical significance was determined using a one-way ANOVA with Tukey's multiple comparison test to provide statistically significant differences from the medium-only control.

Results

Hepatitis C Virus Can Be Transferred into Medication Vials with Single-use Needles and Syringes

To simulate clinical contamination scenarios, rubber diaphragms of medication vials containing cell culture medium were contaminated with high-, intermediate-, or low-titer concentrations of hepatitis C virus (where the low titer, 8×10^5 U/ml, represents the boundary between a low and high viral load clinically).[35] After drying and reaccessing vials with a sterile needle and syringe to simulate medication reaccess for multiple patients, the contents were assessed for hepatitis C virus infectivity using a focus-forming unit assay. At all titers tested, hepatitis C virus foci were present in surface contaminated vials after access with sterile needles and syringes (fig. 1A; fig. S1, Supplemental Digital Content, http://links.lww.com/ALN/B951, showing hepatitis C virus foci at high and intermediate titers). When contaminated with the highest titer, 100% (72 of 72 wells) were hepatitis C virus–positive (fig. 1B). For the intermediate and low titers, 85% (61 of 72 wells) and 43% (31 of 72 wells) were hepatitis C virus–positive, respectively, suggesting a dose-dependent decrease in hepatitis C virus contamination (fig. 1B). Quantification of the level of contamination using quantitative real-time reverse transcription–polymerase chain reaction analysis resulting from the high titer contamination yielded, on average, 3.4×10^6 hepatitis C virus genome copies/ml after 5 days in culture (fig. 1C). However, quantitative real-time reverse transcription–polymerase chain reaction was not sensitive enough to detect viral RNA contamination resulting from the intermediate or low titer. Taken together, these results suggest that hepatitis C virus can be efficiently transferred from the surface of medication vials *via* access with sterile needles and syringes, resulting in contamination of the vial contents in sufficient quantities to initiate an infection in cell culture.

Hepatitis C Virus Remains Infectious after Incubation for Several Days in Common Medications

In line with previous studies,[34,36–39] we found that hepatitis C virus remained relatively stable at room temperature and resulted in less than a 0.5-log reduction in infectivity after 72 h in cell culture medium (fig. 2). In addition, hepatitis C virus remained stable and infectious in all medications tested for more than 72 h as assessed by both focus-forming unit assay (fig. 2) and quantitative real-time reverse transcription–polymerase chain reaction analysis (fig. 3, A through F). Importantly, with the exception of lidocaine, none of the medications were toxic to the cells at a 10% dilution in cell culture medium (Supplemental Digital Content, http://links.lww.com/ALN/B951, table S1, medication concentrations that maintain 90% cell viability, and fig. S2, cell viability dose-response curves of medications). Because of the greater cytotoxicity observed with lidocaine, we diluted lidocaine to a 6% final concentration in stability and infectivity assays (figs. 2 and 3). Taken together, these results suggest that once contaminated with hepatitis C virus, the virus remains stable and infectious for at least 72 h in all medications tested in sufficient quantities to initiate an infection in cell culture.

Common Vial Diaphragm Cleaning Methods Are Not Sufficient to Eliminate Hepatitis C Virus Infectivity

To assess whether cleaning with 70% isopropyl alcohol was sufficient to eliminate hepatitis C virus infectivity, we

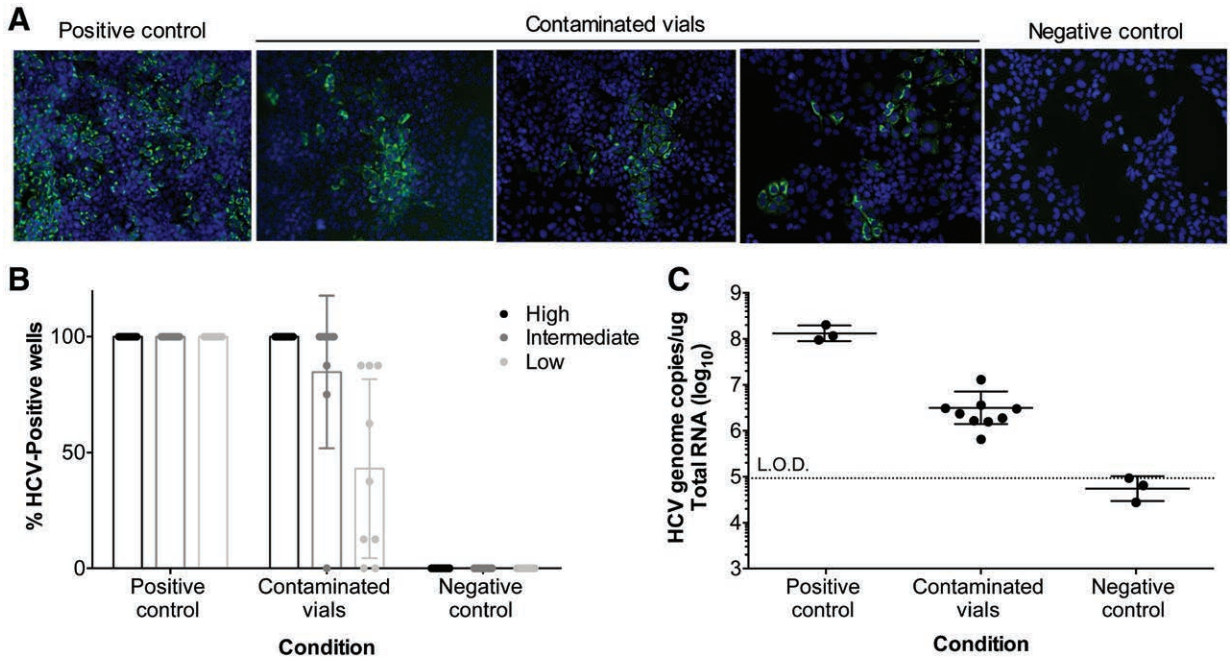

Fig. 1. Hepatitis C virus (HCV) can be transferred *via* sterile needle and syringe into medication vials if the rubber diaphragm is contaminated at all HCV titers tested. (*A*) Representative fluorescence microscopy images from Huh-7.5 cells in 8-well chamber slides grown in cell culture medium from medication vials contaminated with a high titer (2.56×10^7 U/ml) of HCV. The cells were fixed and stained with 4[prime],6[prime]-diamino-2-phenylindole (*blue*, cell nuclei) and anti-HCV core antibody (*green*, HCV core protein). (*B*) The percentage of HCV-positive wells in focus-forming unit assays using high- (2.56×10^7 U/ml), intermediate- (2.56×10^6 U/ml), and low-titer (8×10^5 U/ml) HCV. A positive well is defined as a minimum of three HCV foci/well, where HCV foci are defined by a minimum cluster of three HCV core–positive cells. All data are representative of at least three independent experiments, and *error bars* represent SD. (*C*) Quantitative real-time reverse transcription–polymerase chain reaction analyses of vials contaminated with high titer HCV. All data are representative of at least three independent experiments, and *error bars* represent the SD.

contaminated rubber access diaphragms, cleaned the diaphragms with alcohol swabs, and then assayed for residual hepatitis C virus infectivity. We found that a single or 2- to 3-s wipe with 70% isopropyl alcohol was not sufficient to eliminate infectivity, and hepatitis C virus foci were readily observed under these conditions (fig. 4, A and B). A 2- to 3-s wipe resulted in a ~1-log reduction in hepatitis C virus genome copies compared to the untreated positive control (fig. 4C). When we performed a 10-s wipe with friction (the recommended cleaning protocol in the Centers for Disease Control, ASA, and Ontario guidelines[12,14,18]), in most cases, we were unable to observe hepatitis C virus foci, except for one instance in which a single foci was observed (data not shown). Furthermore, even though a 10-s wipe was below the limit of detection in most replicates (and similar to the negative control sample by quantitative real-time reverse transcription–polymerase chain reaction analysis), viral RNA was detected in two replicates after 5 days in culture (fig. 4C). We did not observe significant differences in efficacy whether or not the alcohol was allowed to dry in any of the conditions tested. Taken together, this suggests that a single or 2- to 3-s wipe with 70% isopropyl alcohol does not ensure reliable elimination in hepatitis C virus infectivity. Moreover, although a 10-s wipe dramatically reduced the risk of contamination, it was not sufficient to eliminate hepatitis C virus infectivity in all replicates.

Discussion

This study demonstrates that if poor hand hygiene and infection control practices inadvertently cause tiny amounts of hepatitis C virus to be placed on the outside of a medication vial, the contents of the vial can be unknowingly contaminated. The virus can be easily transferred from the surface of the vial into the vial contents in sufficient quantities to cause an infection, even when the vial is accessed with a sterile needle and syringe. This may result in health care–associated hepatitis C infection when sharing medication vials and strongly supports the possibility of a previously unreported mechanism of nosocomial hepatitis C virus transmission.

At all titers tested, we observed hepatitis C virus contamination, and the dose-dependent nature of the resultant hepatitis C virus infectivity is consistent with our hypothesis

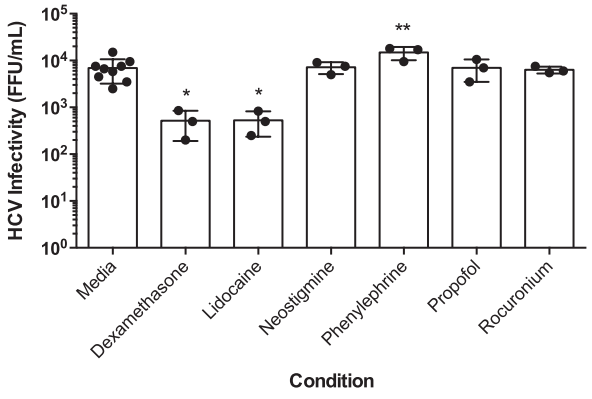

Fig. 2. Hepatitis C virus (HCV) remains infectious after incubation in all medications tested for at least 72 h. High-titer (3.27×10^5 focus-forming unit [FFU]/ml) HCV stock was diluted in cell culture medium or the indicated medications. After 72 h, medications were further diluted in cell culture medium and plated on Huh-7.5 cells. Viral titers were assessed by FFU assay at 5 days postinfection. All data are representative of at least three independent replicates, and *error bars* represent SD. The *P* values were calculated using one-way ANOVA. $*P \leq 0.05$; $**P \leq 0.01$.

and supports its face validity. It is noteworthy that even at the lowest titer tested (designed to specifically reflect the hepatitis C virus titer of a patient at the boundary between a low and high viral load, 8×10^5 U/ml),[35] contamination was clearly demonstrated. We also found that hepatitis C virus remained stable and infectious for at least 72 h in sufficient quantities to initiate an infection in cell culture in several commonly used medications. The most unsettling observation may be that a single or 2- to 3-s wipe with an alcohol swab was not sufficient to eliminate hepatitis C virus infectivity, although a reduction in hepatitis C virus genome copies was observed. Even after scrubbing the vial diaphragm for 10 s with 70% isopropyl alcohol, we were still able to detect hepatitis C virus in two replicates, which suggests that this results in a substantial reduction, but not complete elimination, of the risk of hepatitis C virus transmission. However, because this study was neither designed nor powered to determine the optimal cleaning protocol to eliminate the risk of transmission, we are unable to categorically recommend a "safe" cleaning procedure. Nonetheless, we demonstrated that a potential infection risk still remains even when implementing the recommended strict cleaning protocol. Considering typical clinical practice, scrubbing the top of the vial with a 70% isopropyl alcohol swab for 10 s and allowing the vial to dry is rarely done.[22] In fact, a recent survey demonstrated that only 5% of anesthesiologists claimed to routinely disinfect medication vials by scrubbing the vial diaphragm with alcohol for 10 s before accessing it for more than one patient.[22]

Although it is reassuring that using a new sterile needle and syringe for each patient appears to be the standard of care, survey evidence demonstrates that 3 to 7% of respondents still admit to reusing syringes.[20–22] Using medication vials for more than one patient is a much more prevalent practice that raises several complex issues. Our recent survey suggests that more than half of the anesthesia providers share medications between patients.[22] The reasons for this include cost reduction, medication shortages, as well as packaging design (vials much larger than single-patient doses). Sharing medications between patients may be even more common in developing countries where there are frequent drug shortages. Even though this practice is not consistent with the Centers for Disease Control and ASA guidelines,[14,18] almost all practitioners surveyed considered the risk of transmitting blood-borne pathogens to be negligible provided sterile needles and syringes are used.[22]

The Centers for Disease Control guidelines state to "dedicate multidose vials to a single patient whenever possible. If multidose vials are used for more than one patient, restrict them to a centralized medication area and do not bring them into the immediate patient treatment area (*e.g.*, operating room)."[11] The Association of Anaesthetists of Great Britain and Ireland and the Australian and New Zealand College of Anaesthetists both caution against sharing of multidose vials and recommend using aseptic techniques when preparing medications.[40,41] The concept of a medication preparation area that is geographically remote from the patient care area, although standard throughout most hospitals, may not always exist in the operating room. Anesthesiologists are constantly moving between the patient, the anesthetic machine (patient care area), and the medication cart (medication preparation area), areas that are not geographically separated. The nature of this practice demands emergent management decisions, often requiring multiple medications drawn up within seconds to maintain patient safety; it is simply not feasible to go to a geographically remote area to draw up medications.

This reality is confounded by the contamination risks that exist in a typical operating room. As an illustration, a unique simulation study used fluorescent marker on a mannequin's lips and inside the mouth to demonstrate that 13 locations in an operating room were contaminated 100% of the time within a 6-min simulated scenario.[30] Most notable of these were the anesthesia machine surface, anesthesia cart, and the intravenous injection port. Medication syringes were contaminated 90% of the time; however, because this was a simulation, medication vials were not actually accessed within the scenario. Remarkably, hepatitis C virus has been shown to remain infectious for up to 6 weeks at room temperature on inanimate surfaces.[34,37] Because a single drop of blood could contain hundreds of thousands of hepatitis C virus particles[42–45] and an infection may be transmitted by as few as 10 viral particles,[46] the consequences of breaches in infection control are alarming. An exposed medication vial diaphragm could thus inadvertently and unknowingly become contaminated with bodily

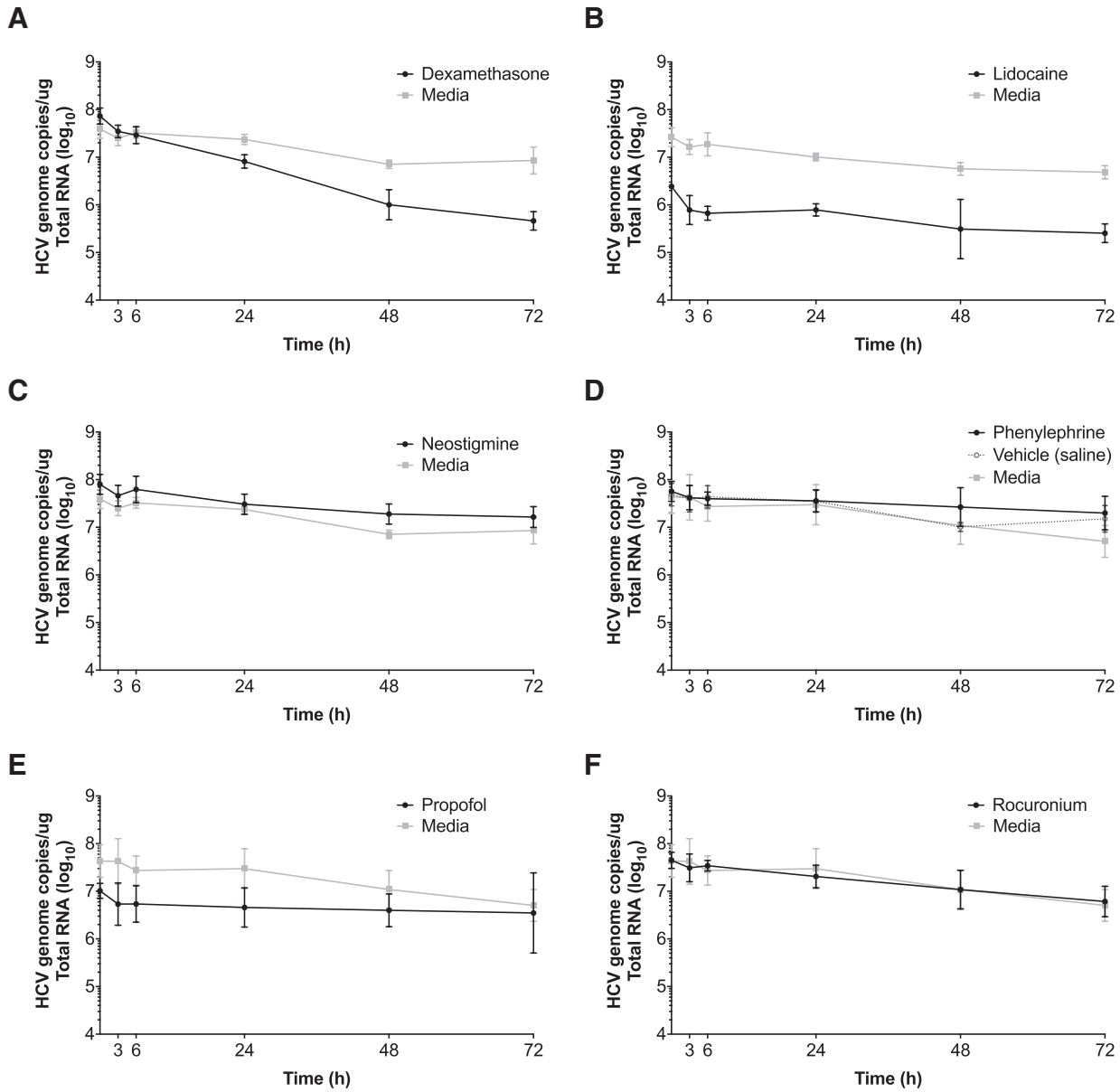

Fig. 3. Hepatitis C virus (HCV) remains stable in all medications tested for at least 72 h. High-titer (3.27×10^5 focus-forming unit/ml) HCV stock was diluted in dexamethasone (*A*), lidocaine (*B*), neostigmine (*C*), phenylephrine and vehicle (saline; *D*), propofol (*E*), rocuronium (*F*), or cell culture medium. At the indicated time points, contaminated medications were further diluted in cell culture medium and plated on Huh-7.5 cells. HCV genome copies were assessed by quantitative real-time reverse transcription–polymerase chain reaction analysis at 5 days postinfection. All data are representative of three independent experiments, and *error bars* represent SD.

fluids containing hepatitis C virus. Similar to our observations, several other studies have demonstrated that hepatitis C virus remains stable and infectious in a number of medications commonly used in anesthesia practice.[36,39]

The risk of patient-to-patient transmission of hepatitis C virus could be eliminated by strict adoption of the recommendation never to use a medication vial for more than one patient. However, this will inevitably lead to increased waste, increased cost, and further exacerbations of medication shortages. Short-term solutions could involve pharmacy-prepared single-patient dose syringes using true aseptic technique, whereas a long-term solution would require the pharmaceutical industry to package medications in single-patient doses to avoid excessive waste. Pediatric single-patient doses are particularly challenging and thus may be more difficult to address. The increasing incidence of

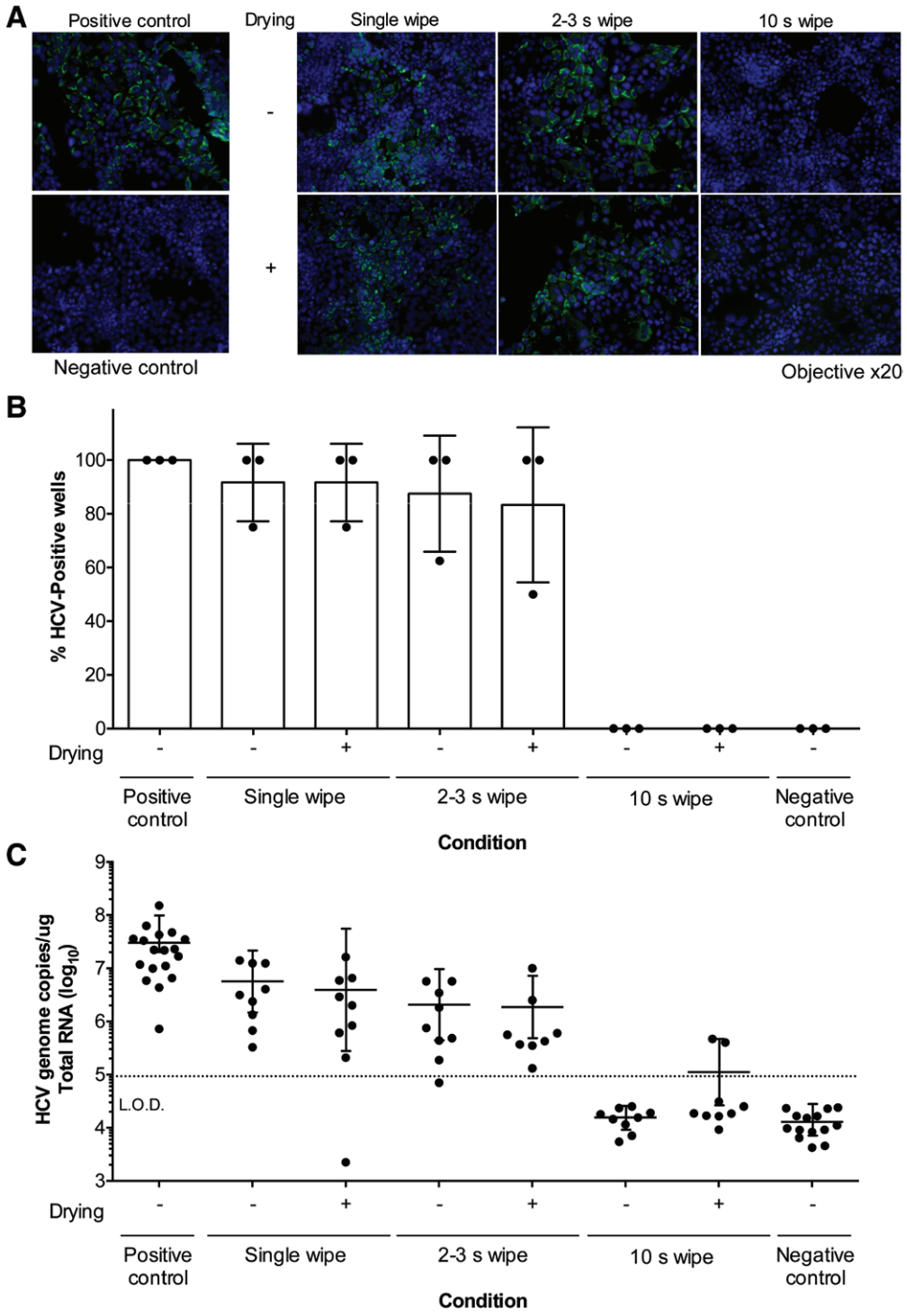

Fig. 4. Cleaning vial diaphragms with 70% isopropyl alcohol is not sufficient to eliminate hepatitis C virus (HCV) infectivity. (*A*) Representative fluorescence microscopy images from Huh-7.5 cells in 8-well chamber slides grown from cell culture medium from high titer (2.56×10^7 U/ml) HCV-contaminated and rehydrated rubber vial diaphragms after cleaning with 70% isopropyl alcohol with or without drying. The cells were fixed and stained with 4[prime],6[prime]-diamino-2-phenylindole (*blue*, cell nuclei) and anti-HCV core antibody (*green*, HCV core protein). (*B*) Percentage of HCV-positive wells in focus-forming unit assays from high-titer HCV-contaminated and rehydrated rubber vial diaphragms after cleaning with 70% isopropyl alcohol with and without drying. A positive well is defined as a minimum of three HCV foci/well, where HCV foci are defined by a minimum cluster of three HCV core–positive cells. (*C*) Quantitative real-time reverse transcription–polymerase chain reaction analyses from high-titer HCV-contaminated and rehydrated rubber vial diaphragms after cleaning with 70% isopropyl alcohol with and without drying. All data are representative of three independent experiments, and *error bars* represent SD ($n = 9$ for all samples); data points below the axis limits are not shown.

nosocomial hepatitis C virus infections is simply not acceptable; thus, we recommend investment in education and knowledge translation across medical specialties, elimination of multidose vials, and use of single-dose vials for only one patient to minimize the risk of nosocomial hepatitis C virus infections. Our recommendations are supported by recent guidelines from the Society for Healthcare Epidemiology of America.[47] The Society for Healthcare Epidemiology of America guidelines emphasize the growing evidence for contamination of the anesthesia workspace leading to health care–associated infections and increased risk of mortality. The authors acknowledge the challenging environment for anesthesiologists but also include several achievable recommendations including more frequent hand hygiene, better environmental cleaning between cases, disinfection of intravenous ports and medication vials with alcohol, use of multidose vials for only one patient, and removal of all syringes from the operating room at the end of a case.

Limitations

Importantly, our study has several limitations, the most significant being that it was performed *in vitro.* Every attempt was made to appropriately and accurately simulate the clinical practice environment as outlined in the Materials and Methods, but for obvious reasons, an *in vivo* study was not possible. Second, this is a descriptive study, with the aim to simply demonstrate the "possibility" of disease transmission by this mechanism. This study was not statistically powered to determine the incidence, probability, or frequency of contamination. Last, we used medications packaged in both single-dose and multidose formats. We did not make distinctions based upon single or multidose labels, formulations, or preservatives used to prolong shelf-life. However, previous studies have noted that lipid-based formulations, such as propofol, that contain an emulsion of soybean oil, glycerol, and egg lecithin may prolong hepatitis C virus stability because the virus is strongly associated with lipoproteins, and the lipid envelope of the viral particle may help the virus to resist drying or dehydration.[34,39] Furthermore, the label "multidose" may be misinterpreted as "safe for use in multiple patients." For example, rocuronium (10 mg/ml, Sandoz) is labeled multidose" but is preservative-free, whereas phenylephrine (10 mg/ml, Sandoz) is labeled single-dose and preservative-free but contains metabisulfites. Regardless, the use of preservatives or antimicrobial agents in multidose vials does not protect against the risk of viral contamination.

Conclusions

This study has demonstrated that hepatitis C virus can be transferred *via* sterile needle and syringe into medication vials if the diaphragm is contaminated with hepatitis C virus–containing fluid. Additionally, in keeping with previous studies, hepatitis C virus remains stable and infectious in several commonly used medications. Of even greater concern, a single or 2- to 3-s wipe of the vial diaphragm with 70% isopropyl alcohol was not sufficient to eliminate hepatitis C virus infectivity. Therefore, we conclude that even with clean needles/syringes and aseptic technique, the potential for hepatitis C virus transmission still exists when medication vials are used for more than one patient.

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Competing Interests

The authors declare no competing interests.

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