

was not the case in our study. Genetic differences in circulating CHIKV lineages could also explain poor testing performance. Furthermore, the OnSite Chikungunya IgM Combo CE POC test uses a recombinant antigen covering the 226 residues of the E1 gene from CHIKV variant A226; recent studies on CHIKV protein characterization showed that more sensitive serologic assays can be obtained using specific early-phase E2 glycoprotein as antigens (3).

The successful use of rapid immunochromatography-based assays with monoclonal antibodies to detect viral diseases (e.g., dengue) has encouraged the development of rapid immunoassays for CHIKV antigens, and preliminary results for these assays seem promising (6). External quality assessment programs for POC tests and quality controls consisting of standardized positive serum could also be helpful for improving the performance of diagnostic tests.

In conclusion, returning travelers are sentinels of the rapidly changing epidemiology of CHIKV; thus, they require a prompt diagnosis and careful surveillance for their possible role in subsequent autochthonous disease transmission. Implementation of user-friendly, rapid, and easily deliverable POC tests for a prompt and accurate laboratory diagnosis is therefore needed to improve patient management and disease control measures.

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References

1. Kosasih H, Widjaja S, Surya E, Hadiwijaya SH, Butarbutar DP, Jaya UA, et al. Evaluation of two IgM rapid immunochromatographic tests during circulation of Asian lineage chikungunya virus. *Southeast Asian J Trop Med Public Health*. 2012;43:55–61.
2. Rianthavorn P, Wuttirattanakowit N, Prianantathavorn K, Limpaphayom N, Theamboonlers A, Poovorawan Y. Evaluation of a rapid assay for detection of IgM antibodies to chikungunya. *Southeast Asian J Trop Med Public Health*. 2010;41:92–6.
3. Yap G, Pok KY, Lai YL, Hapuarachchi HC, Chow A, Leo YS, et al. Evaluation of chikungunya diagnostic assays: differences in sensitivity of serology assays in two independent outbreaks. *PLoS Negl Trop Dis*. 2010;4:e753. <http://dx.doi.org/10.1371/journal.pntd.0000753>
4. Blacksell SD, Tanganuchitcharnchai A, Jarman RG, Gibbons RV, Paris DH, Bailey MS, et al. Poor diagnostic accuracy of commercial antibody-based assays for the diagnosis of acute chikungunya infection. *Clin Vaccine Immunol*. 2011;18:1773–5. <http://dx.doi.org/10.1128/CVI.05288-11>
5. Prat CM, Flusin O, Panella A, Tenebray B, Lanciotti R, Leparç-Goffart I. Evaluation of commercially available serologic diagnostic tests for chikungunya virus. *Emerg Infect Dis*. 2014;20:2129–32. <http://dx.doi.org/10.3201/eid2012.141269>
6. Okabayashi T, Sasaki T, Masrinoul P, Chantawat N, Yoksan S, Nitatattana N, et al. Detection of chikungunya virus antigen by a novel rapid immunochromatographic test. *J Clin Microbiol*. 2015;53:382–8. <http://dx.doi.org/10.1128/JCM.02033-14>

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Novel Single-Stranded DNA Circular Viruses in Pericardial Fluid of Patient with Recurrent Pericarditis

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To the Editor: Circular replication initiation protein (Rep)-encoding single-stranded DNA (ssDNA) (CRESS-DNA) genomes are found in diverse group II virus families, which all possess a conserved Rep-encoding gene and a nonenveloped icosahedral capsid, except geminiviruses, which have twinned particles (1). Gemycircularvirus (GcV) were initially discovered in fungi, but a growing number of new species has been characterized by metagenomics in air, sewage, insects, and feces from a broad range of vertebrates (1–5). GcVs have also been found in the brain and serum of humans with multiple sclerosis; in the cerebrospinal fluid of a patient with encephalitis; and in several blood samples, including those from an HIV-positive blood donor (6–8). We report the presence of 2 divergent GcVs and a novel CRESS-DNA virus (CV) in 2 pericardial fluid samples from a patient with idiopathic recurrent pericarditis.

The patient, a 14-year-old girl who had thoracic scoliosis surgery in 2007, was admitted to the hospital in 2009 for pleuropneumonia and pericarditis, which required pericardial drainage twice within 3 weeks (samples PF₁ and PF₂, respectively). She had thrombocytopenia, a leukocyte count within the normal range, and a high C-reactive protein level. Biochemical and cytologic testing, bacterial cultures, and PCR of pericardial fluid samples for cytomegalovirus, varicella zoster and herpes simplex viruses, parvovirus B19, fungal 18S rRNA, bacterial 16S rRNA, and *Mycobacterium tuberculosis* were negative. Upon approval from the Institut Fédératif de Recherche IFR48 Ethics Committee (Marseille, France) and written informed consent from the patient's parents, we submitted the drainage samples for further investigation.

Virus particles in 0.45- μ m filtrates were purified and analyzed by metagenomics as described (9); resulting contigs were aligned against the National Center for Biotechnology Information nonredundant protein database using blastx (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>). Three contigs were of viral origin (viral first hit, E-value $\leq 1E-03$), all belonging to the ssDNA circular viruses. We obtained complete genomic sequences by PCR with ad hoc primer pairs and Sanger sequencing technology (online Technical Appendix Table, <http://wwwnc.cdc.gov/EID/article/22/10/16-0052-Techapp1.pdf>).

We annotated genomes using GeneMark (heuristic parameters; <http://exon.gatech.edu/GeneMark/>) and EMBOSS palindrome (<http://emboss.bioinformatics.nl/cgi-bin/emboss/palindrome>). Analysis of PF₁ enabled characterization of HV-GcV1 (GenBank accession no. KU343136) (Figure). This genome displayed a typical GcV architecture, with a 2,264-nt circular DNA molecule carrying a capsid gene on 1 strand and 2 genes on the opposite strand, which coded for Rep1 (involved in replication initiation) and Rep2 (involved in replication termination), respectively. A putative hairpin structure showed a nanonucleotide motif, which was thought to be the Rep target, TAATGTTAT. A fourth gene with no homologs in databases was predicted upstream of the capsid gene. Phylogenetic inference from concatenated Rep placed this virus close to another GcV (found in sewage) in a clade comprising 2 other human-associated GcVs (online Technical Appendix Figure 1).

PF₂ contained 2 other viruses: HV-GcV2 (GenBank accession no. KU343137), another GcV, and HV-CV1 (GenBank accession no. KU343138), a novel CRESS-DNA virus. HV-GcV2 (2,262 nt) shares the same stem-loop motif and genomic structure with HV-GcV1, with the exception of the *rep* gene, which is coded by a single open reading frame. HV-GcV2 proteins share low sequence similarity with HV-GcV1 proteins (33% for capsid and 46% for Rep, as determined by blastp [<https://blast.ncbi.nlm.nih.gov/>

Blast.cgi]). HV-GcV2 belongs to another clade of the phylogenetic tree that also contains sewage- and bird feces-associated viruses (online Technical Appendix Figure 1). HV-CV1 (2,951 nt) possesses characteristics of CRESS-DNA genomes. Phylogenetic analysis of REP sequences showed

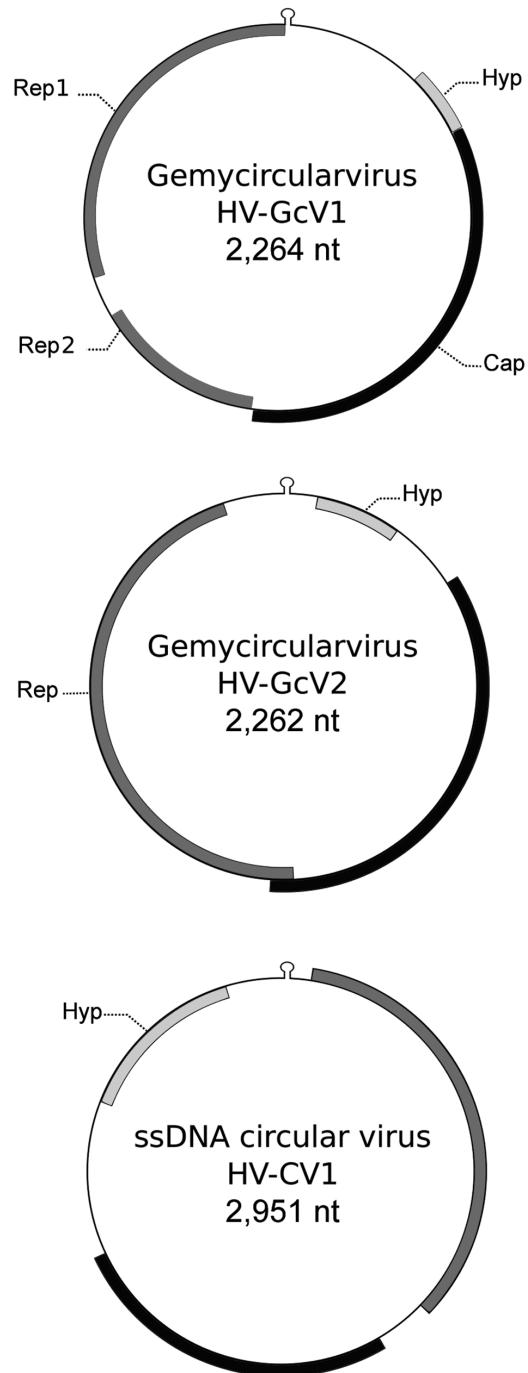


Figure. Genomic features of gemycircularviruses HV-GcV1 and HV-GcV2 and of a novel circular single-stranded DNA (ssDNA) virus, HV-CV1, including hairpin structure and predicted open reading frames. Cap, capsid; Hyp, hypothetical protein with unknown function; Rep, replication initiation protein.

that HV-CV1 and its closest homologue, an ssDNA circular virus of unknown taxon discovered in an Antarctic shelf pond, are distantly related to other CRESS-DNA viruses (online Technical Appendix Figure 2). HV-GcV2 and HV-CV1 displayed no capsid protein similarity between them or with any other virus, as determined by blastp. Annotation of the HV-CV1 capsid gene required use of HHblits (<https://toolkit.tuebingen.mpg.de/hhblits>), a more sensitive algorithm (E-value $1.2E-06$, probability of 97.2%).

PCR confirmed the absence of HV-GcV1 in PF₂ and HV-GcV2 and HV-CV1 in PF₁, suggesting multiple infections before each pericarditis event or a rapid fluctuation in the load of all 3 persisting viruses. An additional blastx search on 53 other virus metagenomes sequenced from pericardial fluids after pericarditis events failed to retrieve these sequences. To exclude the possibility of sample contamination during procedures, we simultaneously treated a sample with the same reagents and kits used for PF₁ and PF₂ and surveyed it by PCR; results were negative. All metagenomes are publically available in the METAVIR (<http://metavir-meb.univ-bpclermont.fr>) directory under the pericardial fluids heading.

No relationship between these viruses and pericarditis was established. However, the fact that some CRESS-DNA viruses are animal pathogens (10) and the growing number of GcVs found in human samples in pathologic contexts (6,7) indicate that the viral genomes described here might replicate in human cells, possibly as opportunistic pathogens (8). On the other hand, although diagnostic tests ruled out fungal or bacterial infections, we should still consider the possibility that these viruses infect other uncharacterized organisms. The genomes described here will assist further studies of the prevalence of these viruses in human populations.

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References

- Rosario K, Dayaram A, Marinov M, Ware J, Kraberger S, Stainton D, et al. Diverse circular ssDNA viruses discovered in dragonflies (Odonata: Epiprocta). *J Gen Virol*. 2012;93:2668–81. <http://dx.doi.org/10.1099/vir.0.045948-0>
- Yu X, Li B, Fu Y, Jiang D, Ghabrial SA, Li G, et al. A geminivirus-related DNA mycovirus that confers hypovirulence to a plant pathogenic fungus. *Proc Natl Acad Sci U S A*. 2010;107:8387–92. <http://dx.doi.org/10.1073/pnas.0913535107>
- Whon TW, Kim MS, Roh SW, Shin NR, Lee HW, Bae JW. Metagenomic characterization of airborne viral DNA diversity in the near-surface atmosphere. *J Virol*. 2012;86:8221–31. <http://dx.doi.org/10.1128/JVI.00293-12>
- Kraberger S, Argüello-Astorga GR, Greenfield LG, Galilee C, Law D, Martin DP, et al. Characterisation of a diverse range of circular replication-associated protein encoding DNA viruses recovered from a sewage treatment oxidation pond. *Infect Genet Evol*. 2015;31:73–86. <http://dx.doi.org/10.1016/j.meegid.2015.01.001>
- Sikorski A, Massaro M, Kraberger S, Young LM, Smalley D, Martin DP, et al. Novel myco-like DNA viruses discovered in the faecal matter of various animals. *Virus Res*. 2013;177:209–16. <http://dx.doi.org/10.1016/j.virusres.2013.08.008>
- Lamberto I, Gunst K, Müller H, Zur Hausen H, de Villiers EM. Mycovirus-like DNA virus sequences from cattle serum and human brain and serum samples from multiple sclerosis patients. *Genome Announc*. 2014;2:pii: e00848-14. <http://dx.doi.org/10.1128/genomeA.00848-14>
- Phan TG, Mori D, Deng X, Rajindrajith S, Ranawaka U, Fan Ng TF, et al. Small circular single stranded DNA viral genomes in unexplained cases of human encephalitis, diarrhea, and in untreated sewage. *Virology*. 2015;482:98–104. <http://dx.doi.org/10.1016/j.virol.2015.03.011>
- Uch R, Fournier PE, Robert C, Blanc-Tailleux C, Galicher V, Barre R, et al. Divergent gemycircularvirus in HIV-positive blood, France. *Emerg Infect Dis*. 2015;21:2096–8. <http://dx.doi.org/10.3201/eid2111.150486>
- Fancello L, Monteil S, Popgeorgiev N, Rivet R, Gouriet F, Fournier PE, et al. Viral communities associated with human pericardial fluids in idiopathic pericarditis. *PLoS ONE*. 2014;9:e93367. <http://dx.doi.org/10.1371/journal.pone.0093367>
- Segalés J, Allan GM, Domingo M. Porcine circovirus diseases. *Anim Health Res Rev*. 2005;6:119–42. <http://dx.doi.org/10.1079/AHR2005106>

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Reemergence of Japanese Encephalitis in South Korea, 2010–2015

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To the Editor: Japanese encephalitis (JE) is caused by a virus transmitted by *Culex tritaeniorhynchus* mosquitoes. JE was the major public health concern in South Korea until the late 1960s, with several thousand cases reported annually. The national vaccination program with the inactivated mouse brain-derived Nakayama strain was initiated in 1983 and targeted children <15 years of age. During 1983–2000, annual booster vaccinations were given to children <15 years of age, but in 2000, the booster schedule was changed to 2 doses (1 dose each) for children 6 and 12 years of age. The live attenuated JE vaccine SA

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