Human astrovirus infection associated with encephalitis in an immunocompetent child: a case report

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Abstract

Background: Until today, classic human astroviruses have not been associated with central nervous system infections in immunocompetent patients.

Case presentation: A 16-month-old Caucasian girl presented with repetitive generalized seizures with a 4-day history of watery diarrhea, which had already gradually improved. Initially, the prolonged seizures ceased after systemic midazolam treatment and were thought to be fever associated. However, her mental status remained altered, and after seizure recurrence, she was transferred to our pediatric intensive care unit. Seizure control was achieved by a combination of high-dose levetiracetam and phenobarbital, but she remained unconscious. An electroencephalogram at this time revealed generalized high voltage theta activity. All laboratory analyses, including extended blood and cerebrospinal fluid analyses, and a brain magnetic resonance imaging were normal.

On day 4, the child gradually became conscious, but was very agitated and not able to walk. Since an electroencephalogram at this time still revealed generalized high voltage theta activity, although she had not received sedative medications for 72 hours, she was diagnosed as having encephalopathy. At that time, results of diagnostic testing of the stool sample were positive for classic astrovirus infection, and we decided to analyze the initially obtained cerebrospinal fluid for astrovirus as well. Cerebrospinal fluid was also found positive for human astrovirus. Sequencing analysis revealed a classic astrovirus genotype 1 with exactly the same nucleotide sequence as in the feces. Clinically, the child gradually improved and was discharged on day 9.

Conclusions: Whereas the new human astrovirus subtypes have been recently associated with central nervous system infection, this is the first case of encephalitis in an immunocompetent child due to classic human astrovirus. Considering that classic human astroviruses are the third most common etiological agents of viral gastroenteritis in children, we believe that human astroviruses as causative agents for central nervous system infections should be considered more often, especially in children and infants with preceding gastroenteritis.

Keywords: Classic human astroviruses, CNS infections, Encephalitis, Immunocompetent, Gastroenteritis
hospitalized infant with severe combined immunodeficiency (SCID) in Switzerland [1].

**Case presentation**
A 16-month-old Caucasian girl presented with prolonged, generalized, repetitive tonic-clonic seizures to our emergency department. She had watery diarrhea with a low-grade fever up to 38.4 °C and new types of seizures 4 days before. Two months earlier, she was admitted to our neuropediatric ward due to suspected generalized seizures. At that time, her psychomotor development and all clinical and laboratory findings, such as cerebrospinal fluid (CSF) status, electroencephalography as well as a cerebral magnetic resonance imaging (MRI) were normal. After a video documentation, a diagnosis of breath-holding spells was made. On admission day, she was unconscious with a generalized tonic-clonic seizure for approximately 20 minutes. At our emergency department, she received 5 mg midazolam buccal and the seizures subsided. She was then transferred to the general pediatric ward under the impression of a febrile seizure. However, during the

| Table 1 Blood parameters | Reference range | Day of admission | Day 3 |
|--------------------------|-----------------|------------------|------|
| **Complete blood count** |                 |                  |      |
| Leukocytes               | 6.2–15 × 10^3/μl| 5.9 × 10^3/μl    | 4.6 × 10^3/μl |
| Erythrocytes             | 4.1–5.0 × 10^12/μl| 4.3 × 10^12/μl | 4.17 × 10^12/μl |
| Hemoglobin               | 10.3–12.4 g/l   | 12.0 g/l         | 11.8 g/l |
| Hematocrit               | 26–37%          | 36%              | 33% |
| MCV                      | 81–99 fl        | 82 fl            | 80 fl |
| MCH                      | 23–28 pg/cell   | 28 pg/cell       | 28 pg/cell |
| MCHC                     | 32–36 g/dl      | 33.8 g/dl        | 35.5 g/dl |
| Thrombocytes             | 130–450 × 10^3/μl| 267 × 10^3/μl   | 255 × 10^3/μl |
| Normoblasts %            | 0.1%            |                  |      |
| Neutrophils %            | 21–67%          | 50%              |      |
| Lymphocytes %            | 20–64%          | 35%              |      |
| Monocytes %              | 5–11%           | 14%              |      |
| Eosinophils %            | 0–4%            | 1%               |      |
| Basophils %              | 0–1%            | 0%               |      |
| **Chemistry panel**      |                 |                  |      |
| Urea                     | 17–43 mg/dl     | 33 mg/dl         | 11 mg/dl |
| Creatinine               | 0.6–1.1 mg/dl   | 0.44 mg/dl       | 0.37 U/l |
| CK                       | < 247 U/l       | 75 U/l           |      |
| GOT                      | < 82 U/l        | 49 U/l           |      |
| GPT                      | < 30 U/l        | 15 U/l           |      |
| LDH                      | < 300 U/l       | 241 U/l          |      |
| CRP                      | < 0.5 mg/dl     | < 0.2 mg/dl      | < 0.2 mg/dl |
| Ammonia                  | 16–53 μmol/l    | 34.9 μmol/l      | 41.6 μmol/l |
| Magnesium                | 0.77–1.03 mmol/l|                 | 0.77 mmol/l |
| Potassium                | 3.4–4.5 mmol/l  | 4.0 mmol/l       | 4.3 mmol/l |
| Sodium                   | 136–146 mmol/l  | 143 mmol/l       | 141 mmol/l |
| Calcium                  | 1.15–1.29 mmol/l| 1.27 mmol/l      | 1.22 mmol/l |
| Glucose                  | 70–105 mg/dl    | 74 mmol/l        | 87 mmol/l |
| Chloride                 | 98–106 mmol/l   | 108 mmol/l       | 104 mmol/l |
| HbA1c%                   | < 6%            | 4.8%             |      |
| Cortisol                 | 6.7–22.6 μg/dl  | 22.3 μg/dl       |      |
| ACTH                     | 4.7–48.8 pg/ml  | 15.8 pg/ml       |      |

**ACTH** adrenocorticotropic hormone, **CK** creatine kinase, **CRP** C-reactive protein, **GOT** glutamic oxaloacetic transaminase, **GPT** glutamate-pyruvate transaminase, **HbA1c** glycated hemoglobin, **LDH** lactate dehydrogenase, **MCH** mean corpuscular hemoglobin, **MCHC** mean corpuscular hemoglobin concentration, **MCV** mean corpuscular volume
following hours seizures reoccurred. She received levetiracetam intravenously up to a total dose of 50 mg/kg per day without a lasting effect. Full blood count, electrolytes, ammonia, blood gas analysis, inflammatory markers, and transaminases as well as ophthalmologic assessment were all repeatedly normal (Table 1). On day 2, she still had short generalized seizures and her consciousness deteriorated steadily so that a lumbar puncture was performed. Seizure control was only achieved after the application of phenobarbital (30 mg/kg) and she was then transferred to the pediatric intensive care unit. At that point, electroencephalography showed an encephalopathic picture with a generalized high voltage theta activity, even though she had not received any sedative medication for 72 hours. The results of the stool samples, which were obtained on the third day of her hospitalization, were negative for *Campylobacter, Salmonella, Shigella, Yersinia* species, norovirus, enterovirus, Rotavirus, and adenovirus except for HAstV (Table 3).

We then hypothesized an astrovirus-related CNS infection and tested the initially obtained CSF sample for the virus. Sanger sequencing revealed a classic genotype HAstV-1 with the same nucleotide sequence in both samples (Fig. 1). Initially, we considered a therapy with intravenous immunoglobulin (IVIG) ± methylprednisolone, but abstained from it due to her fast and good clinical improvement. Over the following days, she improved gradually, the electroencephalography normalized and on day 9 she was discharged. On follow-up over the next 6 months she showed a normal sensorimotor development without any signs of neurological impairment. Despite extensive investigations, we could not identify the source of the infection in this case. Most commonly described reservoirs and sources of infection for humans include fruits, vegetables, and water [2].

**Table 2 Cerebrospinal fluid parameters**

| Cerebrospinal fluid results          |                  |
|--------------------------------------|------------------|
| Cell count                           | 1/3 /μl          |
| Glucose                              | 60 mg/dl         |
| Protein                              | 12.6 mg/dl       |
| Lactate                              | 12.4 mg/dl       |
| Epstein–Barr virus DNA               | Negative         |
| Astrovirus PCR                       | Positive         |
| Herpes virus 1 and 2                 | Negative         |
| Enteroviruses                        | Negative         |
| Isoelectric focusing                 | No sign of oligoclonal bands (serum and CSF) |
| Reibergram                           | Acute inflammatory process with intrathecally produced IgG and IgM, normal CSF barrier function |

CSF cerebrospinal fluid, IgG immunoglobulin G, IgM immunoglobulin M, PCR polymerase chain reaction

**Table 3 Stool parameters**

| Stool results                          |                  |
|----------------------------------------|------------------|
| *Campylobacter* antigen (ELISA)        | Negative         |
| Astrovirus antigen (ELISA)             | Positive         |
| Adenovirus Antigen (ELISA)             | Negative         |
| Norovirus (PCR)                        | Negative         |
| Rotavirus (PCR)                        | Negative         |
| *Salmonella* (stool culture)           | Negative         |
| *Shigella* (stool culture)             | Negative         |
| *Yersinia* species (stool culture)      | Negative         |
| Clostridium difficile PCR (toxin A + B)| Negative         |

ELISA enzyme-linked immunosorbent assay, PCR polymerase chain reaction

Discussion and conclusions

HAstVs constitute the third most common viral agent of acute diarrhea after Rotavirus and norovirus and are responsible for up to 10% of non-bacterial gastroenteritis [3]. However, the recently discovered highly divergent HAstVs, named MLB and VA/HMO, have been identified as the cause of CNS infections in vulnerable individuals highlighting that these viruses bypass the gastrointestinal tract and infect other tissues and organs [4]. HAstV-VA1/HMO-C has also been detected in the brain tissue of immunocompromised patients with acute encephalitis. Overall, CNS infection with the newly described HAstVs almost exclusively occurs in immunocompromised patients [5].

Here, we report the first case of a CNS infection with a classic HAstV in a non-immunocompromised infant. However, common CSF findings of CNS infections such as pleocytosis were in our case completely normal,
which is in line with previous reports [1]. Diagnosis of an astrovirus CNS infection is further complicated by the unreliable detectability of acute IgM antibodies in CSF and the fact that even serum antibodies in the acute phase of infection were detectable only in a few patients [6]. Therefore, the diagnosis of an acute astrovirus CNS infection currently relies exclusively on the clinical picture, specific detection of astrovirus in the CSF mostly by next-generation sequencing (NGS)-based diagnosis, and exclusion of other known causes for encephalitis, as in this case.

Similar to previous reports on immunocompromised patients and infection of HAstV-MLB or VA strains, the most probable route of infection was enteric inoculation followed by viral translocation and infection of the CNS via the bloodstream. In previous case reports, HAstV-VA1 was found in neurons and astrocytes [7]. A recent publication showed for the first time that the novel described HAstV-VA1 could be propagated in cell culture without trypsin, which was mandatory for the cell culture of classic HAstV strains. The authors supposed that classic and novel HAstV genotypes react differently toward trypsin for the proteolytic cleavage of the viral capsid. This may influence the contribution of the tissue tropism of HAstVs and novel HAstV strains might spread toward tissues with low trypsin levels; however, so far the mechanism of neuroinvasion of HAstV remains unclear [8]. Interestingly, CNS infections in
mammals such as swine, sheep, and cattle seem to be quite common [9].

We therefore believe that in the future the possibility of HAstV CNS infection needs to be considered on a routine basis in non-immunocompromised infants and young children with sensitive detection systems covering all HAstV species (classic HAstV genotypes 1 to 8 as well as HAstV-MLB and VA strains). Even though there are currently no specific therapeutic options available, the identification of the causative agent in an encephalopathic child is of utmost importance – for the community to implement prophylactic actions and even more for the parents who always seek to obtain an explanation – in particular, in possibly very debilitating diseases such as encephalopathy/encephalitis.

Abbreviations
CNS: Central nervous system; CSF: Cerebrospinal fluid; HAstV: Human astrovirus; HSV-1: Herpes simplex virus type 1; HSV-2: Herpes simplex virus type 2; IgG: Immunoglobulin G; IgM: Immunoglobulin M; IVIG: Intravenous immunoglobulin; MLB: Melbourne; MRI: Magnetic resonance imaging; NGS: Next-generation sequencing; SCID: Severe combined immunodeficiency; VA/HMO: Virginia/Human-Mink-Ovine-like

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Authors’ contributions
GK and JU were responsible for the patient during the hospital course. JU and AJ interpreted the findings and were responsible for clinical decision making. GK and AJ wrote the manuscript. JU, SN, SJ, and BH critically reviewed the manuscript. SN and SJ performed genotyping and sequencing analysis of the virus. All authors read and approved the final manuscript.

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Consent for publication
Written informed consent from the legal parents on behalf of their child for the publication of this manuscript and any accompanying medical data was obtained. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare that they have no competing interests.

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