We report a clinical case of meningoencephalitis with subdural empyema in an immunocompromised farmer caused by toxigenic \textit{Clostridium perfringens} type A, which was identified by 16S RNA gene analysis of cerebrospinal fluid and subdural empyema. In immunocompromised patients, \textit{C. perfringens} should be considered a potential pathogen of sepsis.

**CASE REPORT**

In June 2011, a 74-year-old farmer developed headache, fever, nausea with emesis, and fatigue within 24 h prior to admission to a community hospital. Due to a systemic inflammatory response syndrome (SIRS), he was referred to the intensive care unit (ICU). Empirical intravenous antibiotic treatment with piperacillin-tazobactam and clarithromycin was started based on the clinical presentation of pneumonia with a suspicious infiltrate in the basal lobe. The patient was immunosuppressed secondary to unclassified myelodysplastic syndrome (MDS) and was on continuous steroid treatment for bronchiolitis obliterans organizing pneumonia. Three weeks prior to hospital admission, the farmer had been struck by a cow, but did not seek medical attention. Two hours after admission, the patient developed a generalized seizure (Fig. 1a). Therefore, the patient was referred to a tertiary care hospital for neurosurgical intervention. There, in addition to fever, and tachycardia, reduced consciousness, left-sided hemiparesis, and postictal reduced consciousness and left-sided Todd’s paresis. A cerebral computed tomography (CT) showed a thin hypodense subdural parieto-occipital lesion on the right side with adjacent brain edema, suggestive of a chronic subdural hematoma (Fig. 1a). Therefore, the patient was referred to a tertiary care hospital for neurosurgical intervention. There, in addition to fever and tachycardia, reduced consciousness, left-sided hemiparesis, and slight neck stiffness were present. The laboratory findings revealed the following: white blood cell count, 1.02 $\times$ 10^{6}/ml (34% neutrophils, 63% lymphocytes, 1% eosinophils, and 2% monocytes); thrombocyte count, 23 $\times$ 10^{6}/ml; prothrombin ratio, 58%; international normalized ratio (INR), 1.3; serum C-reactive protein, 13.3 mg/dl; and HIV and hepatitis B negative. Based on clinical presentation with headache, fever, epileptic seizure, and slight neck stiffness, a central nervous system (CNS) infection was postulated. Antibiotic treatment was changed to intravenous ceftriaxone, amoxicillin, metronidazole, vancomycin, and acyclovir in order to cover microorganisms potentially causing central nervous system (CNS) infection (including \textit{Listeria} spp., anaerobic bacteria, penicillin-resistant \textit{Streptococcus pneumoniae}, and herpes simplex virus). Due to impaired coagulation with increased risk of spinal bleeding, a lumbar puncture was initially declined. A cerebral CT scan showed a progression of the subdural lesion to the right frontal lobe, suggestive of an active subdural process, such as empyema (Fig. 1a and 1c). Two days after reconstitution of coagulation, the right frontal part of the lesion was evacuated through a burr hole for microbiological workup. An intraventricular drain (IVD) was inserted on the contralateral side. The intraoperative macroscopic findings supported the radiological diagnosis of subdural empyema. Samples from cerebrospinal fluid (CSF) and empyema were processed for CSF cell count, cytospin and Gram staining, bacterial broad-range 16S RNA gene PCR, fungal broad-range PCR targeting the internal transcribed spacer (ITS) region, and microbiological cultures. Unfortunately, initial analysis of the CSF cell count failed, and CSF drainage was suspended immediately after surgery due to clotting of the catheter. The direct staining of both specimens showed plump, Gram-positive rods with blunt ends suggestive of \textit{Clostridium} spp. \textit{C. perfringens} was finally identified in both samples by bacterial broad-range 16S RNA gene PCR followed by sequence analysis of the amplicon (4). A nested PCR as the second amplification step was not required, for which the time to result was substantially reduced. PCR amplicons were sequenced (500 bp), and homology analysis was performed using IDNS software (SmartGene, Zug, Switzerland). A homology of 99%, with a minimal of 0.5% difference from the second homologous species, allows for identification at the species level. The sequences of the PCR products (465 and 468 bp, respectively) showed 100% identity to the 16S rRNA gene of \textit{Clostridium perfringens}. The second homologous species was \textit{Clostridium saccharobutylicum}, with an identity of 94.7%, enabling an accurate assignment of \textit{C. perfringens} present in both specimens. The sequence electropherograms gave no indication for a possible polymicrobial infection. A broad-range fungal PCR targeting the internal transcribed spacer (ITS) region (15) was performed using the DNA extracts of the cerebrospinal fluid and the subdural empyema, which was negative for both samples. Subsequently, \textit{C. perfringens} toxin typing was performed by multiplex PCR (34) followed by sequence analysis for confirmation, which showed the presence of the \textit{cpb} gene (encoding alpha-toxin) in both CSF and subdural empyema samples. PCR for \textit{cph} (B-toxin), \textit{cpb} (B2-toxin), \textit{etz} (ε-toxin), \textit{iap} (β-toxin) and \textit{cpe} (enterotoxin) genes were negative. Anaerobic cultures on brucella agar remained negative even after 10 days of...
were not possible. According to MIC data for incubation. Therefore, biochemical tests and susceptibility testing
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incubation. Therefore, biochemical tests and susceptibility testing were not possible. According to MIC data for C. perfringens and clinical breakouts of European Committee for Antimicrobial Susceptibility Testing (EUCAST) for Gram-positive anaerobes (20, 32), antibiotic treatment was adapted to intravenous penicillin (4 million IU 4 times per day [q.i.d.] and metronidazole (500 mg 3 times per day [t.i.d.]). The disease course was complicated by severe septic shock with multiorgan failure consisting of disseminated intravascular coagulation (DIC) with IVD-associated intracerebral hemorrhage in the left frontal lobe (Fig. 1d), acute respiratory and renal failure, hepatic dysfunction, and aggravated pancytopenia. Intensive care management with mechanical ventilation, hemofiltration, extensive substitution of blood products, and high-dose catecholamine treatment was needed. After stabilization of septic shock, tracheal aspergillosis was microbiologically and histologically diagnosed by biopsy of the tracheal wall and was treated with voriconazole. The patient could be discharged from the ICU after 1 month of intensive care treatment. He remained in a stable condition, and neurologically, continuous improvement of alertness and communication was observed. Spontaneous directed movement of the left hemibody with only slight impairment of force further proved the functional recovery of the right hemisphere. Unfortunately, right-sided hemiplegia

The most frequent clinical manifestation of C. perfringens infection is myonecrosis, or gas gangrene. If only minor amounts of toxins are produced, infections may present as a mild, self-limiting disease. If local infections spread via hematogenous dissemination, every organ might be involved, including the brain. Central nervous system manifestation of C. perfringens infection in humans is rare (9). Most commonly, the meninges are affected (1, 3, 6, 7, 10–14, 16–19, 21, 22, 23–25, 29, 30) after clinical manifestations of sepsis (31). Rarely, focal or diffuse encephalitis with or without pneumocephalus has been presented (2, 13, 22, 27, 29), and only a single case of subdural empyema has been reported in the current literature (23). In our patient due to the clinical findings of generalized epileptic seizure, radiological evidence of progressive brain edema, and detection of C. perfringens type A by molecular analysis of CSF and subdural empyema, we diagnosed a meningoencephalitis and subdural empyema with C. perfringens. We were unable to cultivate C. perfringens, probably due to the antibiotic treatment started 3 days before sampling. However, the diagnosis was unambiguous according to (i) direct microscopic detection of plump Gram-positive, rod-shaped bacteria in large quantities in two independent samples of the subdural lesion and (ii) 100% identification of the 16S rRNA gene PCR amplicon with C. perfringens in both clinical samples (cerebrospinal fluid and subdural empyema). In addition, the cpa gene, which codes for the virulence factor alpha-toxin of C. perfringens type A, was amplified and confirmed by sequence analysis.

Usually, infections with C. perfringens start from a recent surgical wound, trauma, or intra-abdominal disease, such as infections of the biliary tract or other gastrointestinal infections (26). However, in most of the cases of C. perfringens meningoitis, the site of infectious origin remains unidentified (6, 11, 13, 14, 18, 21, 23, 24, 28), as in our patient. C. perfringens is a common part of the intestinal flora of domestic animals, such as cattle, and the bacteria are spread into the environment by feces (33). In our case, gastrointestinal disease caused by a food-borne infection was ruled out. There was a history of minor trauma caused by a strike of a cow’s hoof 3 weeks before onset of symptoms. Possibly, C. perfringens type A was carried on the cow’s hoof and transmitted into the wound. Due to the preexisting coagulopathy and the history of trauma, we assume a chronic subdural hematoma as the site of onset for the CNS manifestation. Although repeated normal aerobic and anaerobic blood cultures remained negative, a transient bacteremia with C. perfringens type A is likely to have happened in a chronically exposed and immunocompromised farmer.

Subdural empyema and diffuse encephalitis with C. perfringens are reported to be fulminant and have a fatal outcome in 30 to

![FIG 1](a) Native CT scan of the patient’s head at admission to our institution. Arrows mark hypodense parieto-occipital lesion. Extensive brain swelling of the right hemisphere with elapsed sulci is shown. (b) Native CT scan of the patient’s head before transfer to the communal hospital. Arrows mark a residual hypodense parieto-occipital lesion. A relaxed right hemisphere with pronounced sulci is shown. Arrowheads mark residual blood of the left frontal hemorrhage. (c) Coronary native CT scan of patient’s head before surgical intervention. Arrows mark a hypodense right frontal lesion. Extensive brain swelling of the right hemisphere with elapsed sulci is shown. (d) Coronary native CT scan of the patient’s head after surgical intervention. Virtually complete evacuation of the right frontal subdural lesion is shown. An arrowhead marks the intraventricular catheter. Arrows mark the small IVD-associated hemorrhage.
100% of untreated patients (9). The functional recovery in our patient might be explained by the early targeted therapy with penicillin and metronidazole. There are expert recommendations but no in vivo data regarding the treatment of *C. perfringens* CNS manifestations (21). In vitro, antibiotic drugs with activity against Gram-positive anaerobic bacteria (penicillin, clindamycin, and metronidazole) reportedly show low MICs (32). To date, no *C. perfringens* isolates resistant to penicillin, clindamycin, or metronidazole according to EUCAST clinical breakpoints for anaerobic Gram-positive rods (20) have been described. In the treatment of a brain abscess with *C. perfringens*, a favorable outcome after immediate surgical debridement or drainage was reported (5, 8).

In conclusion, we report the first case of cerebral infection due to *C. perfringens* type A manifested with subdural empyema and diffuse meningoencephalitis, which was diagnosed by 16S rRNA sequencing and a multiplex PCR approach. The patient was successfully treated with targeted antibiotic therapy and surgical removal of subdural empyema. Even though rarely reported, *C. perfringens* type A should be considered a differential pathogen in a patient with immunosuppression. If no pathogen can be cultivated due to ongoing antibiotic treatment, molecular analysis such as broad-range 16S RNA PCR is a valuable and rapid tool leading to an accurate diagnosis.

**Nucleotide sequence accession number.** The 16S sequence of the patient’s isolate has been submitted to GenBank under accession no. JQ782390.

**REFERENCES**