Case Report

Peritonitis due to *Neosartorya pseudofischeri* in an elderly patient undergoing peritoneal dialysis successfully treated with voriconazole

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Aspergillus peritonitis is a rare life-threatening complication of peritoneal dialysis (PD). We report a case of symptomatic *Neosartorya pseudofischeri* peritonitis in a 60-year-old woman treated by continuous ambulatory peritoneal dialysis (CAPD) for 13 months, who performed peritoneal exchanges independently. This is believed to be the first published case of *N. pseudofischeri* in an elderly patient. Comprehensive treatment included early removal of the PD catheter and the use of voriconazole (200 mg Vfend twice daily) for a period of 5 weeks. This case supports the need for more effective prophylaxis and treatment of non-*Candida* fungal infections in CAPD patients. Our conclusions from this case and a review of the literature are that infection with this fungus can cause substantial morbidity and is best treated with prompt catheter removal, aggressive antifungal therapy with voriconazole or amphotericin B, and vigilant observation for complications. Our report describes for what is believed to be the first time the administration of voriconazole to treat a *Neosartorya* peritonitis case.

Introduction

Peritonitis due to both intermittent and continuous ambulatory peritoneal dialysis (CAPD) remains the most common and serious complication of peritoneal dialysis (PD) (Piraino, 1998; Bibashi *et al.*, 2003). Gram-positive bacteria are isolated in 55–80 % of cases (Gloor *et al.*, 2003; Iqbal *et al.*, 2008), and fungal isolates in up to 10 % of cases (Pimentel *et al.*, 2005; Ram *et al.*, 2008). In fungal peritonitis (FP), *Aspergillus* is rare and associated with a high mortality rate (De Hoog *et al.*, 2000; Donnelly, 2002; Ram *et al.*, 2008). FP is a potentially life-threatening complication of both intermittent and CAPD. Significant numbers of PD-associated cases of FP due to yeasts have been reported by several investigators (Chan *et al.*, 1994; Garcia-Martos *et al.*, 1991; Melez *et al.*, 1995). *Candida* species account for more than 85 % of the cases, whereas filamentous FP is less frequent (Bibashi *et al.*, 2003). Although filamentous fungi causing peritonitis are reported less frequently, they encompass a wide range of agents, from the classic, systemic fungi (Bibashi *et al.*, 1993) to the zygomycetous species (Polo *et al.*, 1989).

The genus *Neosartorya* (family *Trichocomaceae*) was established by Malloch & Cain (1972) to accommodate

teleomorphs of species belonging to the section *Fumigati*. This section now includes the anamorphs of 11 sexual *Neosartorya* species and 5 asexual *Aspergilli* (Varga *et al.*, 2000; Hong *et al.*, 2008). The species are thermophilic and closely related to *Aspergillus fumigatus*. *Neosartorya pseudofischeri* has whitish, fast-growing colonies at 37 °C and 45 °C, but not at 50 °C, whereas *A. fumigatus* grows at all these temperatures. It is very likely that infections by *Neosartorya* species are underdiagnosed in clinical practice because white aspergilli are often regarded as contaminants in the laboratory (Guarro *et al.*, 2002). The morphology of such isolates should be carefully examined by using conventional cultures on malt extract or Czapek Dox agar (Difco), and sequence-based analysis should be used for species level identification.

Case report

A 60-year-old woman was on CAPD for end-stage renal insufficiency/failure due to renovascular disease and interstitial nephritis. Her past medical history included hypertension, hyperparathyroidism, and chronic obstructive pulmonary disease. She had commenced CAPD 13 months prior to this reported episode and performed peritoneal exchanges independently. During that period, there had been multiple episodes of suspected peritonitis, each treated empirically with 1 g cefazolin and 40 mg

Abbreviations: CAPD, continuous ambulatory peritoneal dialysis; CT, computed tomography; FP, fungal peritonitis; PD, peritoneal dialysis; WCC, white cell count.

gentamicin, and with a single intraperitoneal dose of 500 mg ciprofloxacin. In September 2005, she had a 3 day history of abdominal pain, accompanied by fever and nausea, and cloudy PD bags. On examination, she was found to be febrile (37.8 °C) with a tense abdomen, rebound tenderness and decreased bowel sounds.

Initially the Tenckhoff catheter site was clean with no sign of inflammation. Full blood examination showed an elevated white cell count (WCC) of 13.8×10^6 cells l^{-1} and a red cell count of 4.1×10^6 red blood cells l^{-1} . The C-reactive protein level was raised to 165 mg l^{-1} and the albumin level was 33 g l^{-1} . The urea level was 12.2×10^6 mmol l^{-1} and the creatinine level was 448×10^6 μ mol l^{-1} . The fluid in the PD bag was pale yellow, cloudy with fibrous material and slow to drain. The PD fluid was sent for microscopy and culture, and was found to have a WCC of 3800×10^6 cells l^{-1} with a red cell count of 676×10^6 cells l^{-1} . WCC decreased on the three following days to 400×10^6 cells l^{-1} , and rose again to 4400×10^6 cells l^{-1} on the eighth day after first examination, whereas the red cell count remained between 40×10^6 and 20×10^6 cells l^{-1} . No organisms were observed with the use of the Gram stain. *Neosartorya* was isolated from repeated peritoneal fluid and Tenckhoff catheter culture. Even after removal of the catheter a week later, before voriconazole therapy was administered, we were able to detect *N. pseudofischeri* on culture plates from peritoneal fluid, which supports the theory that the fungus cannot be a laboratory contaminant since several cultures were independently positive. Therefore, the *N. pseudofischeri* was considered to be the causative factor of peritonitis.

Prior to removal of the catheter on the eighth day after first examination an abdominal computed tomography (CT) scan was performed (Fig. 1), which indicated an underlying oedematous inflammation due to the fungal infection. Subsequently, after the removal of the Tenckhoff catheter, the patient was transferred to haemodialysis treatment. The

therapy with 200 mg voriconazole was administered on the fifteenth day after first examination, after the catheter had been removed, for 5 weeks twice daily after the *N. pseudofischeri* was identified.

Methods

Identification of *N. pseudofischeri* (teleomorph of *Aspergillus thermomutatus*). Colony characteristics of strains were initially observed by culture on blood agar, and then by subculture on Sabouraud dextrose agar (Oxoid), and malt extract and Czapek Dox agar (Difco Laboratories) plates at 25 °C, 30 °C and 45 °C for 2 to 3 days; culture at 50 °C revealed no growth. The culture on malt extract yielded abundant growth of ascospores at 25 °C. Morphological features of strains were observed by lactophenol cotton blue staining. Conidiophores with mature conidia of *N. pseudofischeri* morphologically resemble *A. fumigatus*; however, their conidia are whitish to greyish yellow instead of a deep bluish green. Electron microscopy scanning was not available; therefore, there was no characterization of the ascospores. However, the species could not be identified by its conidia formation. To identify the species, species-specific internal transcribed spacer region (ITS1/ITS2)-based molecular identification was performed (Fujita *et al.*, 2001; Hinrikson *et al.*, 2005). A similarity of 100 % to the *N. pseudofischeri* sequence with GenBank accession number EF669966.1 (ITS1/2) was determined.

Etest. An Etest (AB Biodisk) for voriconazole was used for MIC determination on RPMI agar plates (Viva Diagnostika). The Etest strips were incubated at room temperature for 20 min due to the storage temperature of -20 °C. The Etest was performed according to the manufacturer's instructions. Briefly, each RPMI plate was inoculated with 400 μ l undiluted stock inoculum (ranging from 1×10^6 to 5×10^6 c.f.u. ml^{-1}) (Guinea *et al.*, 2008). Plates were incubated at 35 °C in a humid atmosphere, and MICs were determined following incubation times of 24 and 48 h. The MIC with the Etest was defined as the lowest voriconazole concentration at which the border of the elliptical inhibition zone intercepted the scale on the Etest strip. For *Aspergillus* spp. and the remaining moulds no breakpoints for the new triazoles have been established. For *Candida* spp., the classification of the strains for the MIC breakpoint for voriconazole was as follows: susceptible, breakpoint of $<1 \mu$ g ml^{-1} ; susceptible dose dependent, 2μ g ml^{-1} ; resistant, $>4 \mu$ g ml^{-1} (Pfaller *et al.*, 2006). For our isolate of *N. pseudofischeri* the MIC for

Fig. 1. Patient's abdominal CT scan on eighth day after first examination (after removal of the catheter); the white arrow indicates the oedematous inflammation of the peritoneum (peritonitis) due to *N. pseudofischeri*.

voriconazole was 1.0 (0.5–1.0) $\mu\text{g ml}^{-1}$. Where the elliptical inhibition zone intercepted the scale on the Etest strip between two MIC values, the MIC end point was taken as the higher value.

The determination of other antifungal MICs was carried out with the commercially available ATB fungus test (bioMérieux). The MICs obtained were $>64 \mu\text{g ml}^{-1}$ for flucytosine, $>128 \mu\text{g ml}^{-1}$ for fluconazole, $0.500 \mu\text{g ml}^{-1}$ for amphotericin B and $1.0 \mu\text{g ml}^{-1}$ for itraconazole.

Discussion

In general, FP has a prevalence of 0.1 to 10 %, with *Candida albicans* being the predominating aetiological agent (Bibashi *et al.*, 2003; Ram *et al.*, 2008). However, FP caused by filamentous fungi is much less common (Bibashi *et al.*, 2003). Fungi can enter the peritoneal cavity through a catheter intraluminally or periluminally, but in a few cases a vaginal route of infection has also been observed (Stuck *et al.*, 1986). FP is associated with a mortality rate of 5 to 25 % (Bibashi *et al.*, 1993). Risk factors for FP include recent exposure to antibiotics, immunosuppressive therapy, recent bacterial peritonitis and the presence of bowel perforation (Eisenberg *et al.*, 1986; Ujhelyi *et al.*, 1990).

The case we report is believed to be the first case of *Neosartorya* peritonitis in an elderly patient (Matsumoto *et al.*, 2002). The clinical presentations of other reported peritonitis cases are summarized in Table 1. A variety of *Aspergillus*-associated peritonitis cases have been documented (Ross *et al.*, 1968; Arfania *et al.*, 1981; Carpenter *et al.*, 1982; Sridhar *et al.*, 1990; Perez-Fontan *et al.*, 1991;

Bibashi *et al.*, 1993; Tanis *et al.*, 1995; Miles & Barth, 1995; Geiss, 1995; Park *et al.*, 1996). Risk factors included recent antibiotic therapy, steroid therapy, recurrent peritonitis, an immunosuppressed state and hospitalization. A high mortality for FP has been reported, generally in cases where diagnosis was delayed and the catheter not removed (Tsai *et al.*, 1991; Miles & Barth, 1995). Over the last four decades among our 19 selected FP cases (Table 1) in 3 cases with an outcome of death the catheter was not removed, 2 patients were treated with amphotericin and the third patient had no antimycotic treatment. Only voriconazole treatment was administered in our peritonitis patient, although Balajee *et al.* (2005) reported that three isolates of *N. pseudofischeri* had higher MICs to voriconazole *in vitro* compared to *A. fumigatus*. In previous cases other antimycotics were given, preferentially amphotericin B. Another *N. pseudofischeri* isolate from a different case in our clinic (data not shown) also presented a low MIC ($<0.5 \mu\text{g ml}^{-1}$) to voriconazole as in the case presented here.

Diagnosis can be quite difficult, since the symptoms are identical to bacterial peritonitis. A Gram stain can occasionally reveal the typical hyphae of *Aspergillus*. Otherwise, a positive culture result must be obtained, and preferably a positive result from repeated cultures, since *Aspergillus* can occur as a laboratory contaminant (Geiss, 1995). In most cases, positive cultures are obtained after 5 and 10 days. However, since delayed treatment has an increased mortality, one should not wait for the results of repeated cultures; intravenous treatment with vorico-

Table 1. A selection of reported cases of *Aspergillus* and *Neosartorya* peritonitis

Age of patient (years)	Sex	Fungal species	Catheter removal	Antimycotic	Outcome	Reference
22	F	<i>A. fumigatus</i>	No	None	Death	Ross <i>et al.</i> (1968)
61	F	<i>A. fumigatus</i>	No	Amphotericin B (i.v., i.p.)	Death	Arfania <i>et al.</i> (1981)
64	M	<i>A. flavus</i>	No	Amphotericin B (i.v.)	Death	Carpenter <i>et al.</i> (1982)
40	M	<i>A. niger</i>	Yes	Amphotericin B (i.v.)	Death	Rodriguez-Tudela <i>et al.</i> (1988)
66	M	<i>A. niger</i>	Yes	Amphotericin B (i.v.)	CAPD	Prewitt <i>et al.</i> (1989)
49	F	<i>A. niger</i>	Yes	Amphotericin B (i.v.)	HD	Sridhar <i>et al.</i> (1990)
68	F	<i>A. fumigatus</i>	Yes	Amphotericin B (i.v.)	HD	Stein <i>et al.</i> (1991)
69	M	Unidentified	Yes	Amphotericin B (i.v., i.p.) + ketoconazole	CAPD	Perez-Fontan <i>et al.</i> (1991)
35	F	<i>A. niger</i>	Yes	Amphotericin B (i.v.) + fluconazole	CAPD	Bibashi <i>et al.</i> (1993)
68	M	<i>A. fumigatus</i>	Yes	Amphotericin B (i.v.) + itraconazole	CAPD	Tanis <i>et al.</i> (1995)
61	M	<i>A. fumigatus</i>	Yes	Amphotericin B (i.v.) + fluconazole	Death	Tsoufakis <i>et al.</i> (1995)
37	M	<i>A. niger</i>	Yes	Amphotericin B (i.v.) + itraconazole	HD	Kitiyakara <i>et al.</i> (1996)
60	F	<i>A. fumigatus</i>	Yes	Ketoconazole	HD	Bren (1998)
64	M	<i>A. fumigatus</i>	Yes	Amphotericin B (i.v.)	Death	Bren (1998)
30	F	<i>Aspergillus</i> sp.	Yes	Amphotericin B (i.v.) + flucytosine	Death	Bren (1998)
52	F	<i>A. niger</i>	Yes	Amphotericin B (i.v.) + fluconazole	HD	Basok <i>et al.</i> (2000)
8	F	<i>N. pseudofischeri</i>	Yes	Liposomal amphotericin B (i.v.) + itraconazole	HD	Matsumoto <i>et al.</i> (2002)
45	F	<i>A. fumigatus</i>	Yes	Amphotericin B (i.v.)	CAPD	Schattner <i>et al.</i> (2006)
60	F	<i>N. pseudofischeri</i>	Yes	Voriconazole (i.v.)	HD	This study

A., *Aspergillus*; F, female; HD, haemodialysis; i.v., intravenous; i.p., intraperitoneal; M, male.

nazole or amphotericin B should be administered immediately. Susceptibility testing revealed that amphotericin B is also an antifungal agent to which the organism had a low MIC of 0.5 µg ml⁻¹. On the other hand, *N. pseudofischeri* had a high MIC for fluconazole and flucytosine. With respect to the removal of the catheter, there is general agreement in the literature that this is mandatory and should be performed as soon as possible (Stein *et al.*, 1991; Perez-Fontan *et al.*, 1991; Tanis *et al.*, 1995; Miles & Barth, 1995; Park *et al.*, 1996).

In summary, we conclude that *Neosartorya* peritonitis is a severe form of peritonitis in CAPD patients. The need for more effective treatment and prophylaxis for fungal infections in CAPD is obvious; which means in cases where bacterial culture of peritoneal fluid is negative, this may indicate the possibility of fungal infection. If a positive fungal culture is obtained, antimycotic therapy should be started immediately, and the Tenckhoff catheter removed as quickly as possible, preferably within 24 h of the diagnosis, as it is mostly impossible to eradicate the infection without removing the catheter. In addition to blood agar, Sabouraud dextrose agar for *Aspergillus* species and *Candida* chromogenic agar should be used for the initial culture. A recent bacterial infection treated with antibiotics could be a predisposing factor for FP. An earlier CT scan might help raise suspicion of a fungal inflammation being present and indicate the need for administration of antimycotics as well as antibiotics. The prompt diagnosis of FP and the early institution of therapy (e.g. amphotericin B) decrease the rates of morbidity and mortality. As in our case, the removal of the catheter alone did not resolve the peritoneal inflammation within a few days (up to 1 week), which would support the administration of antimycotic therapy simultaneously to catheter removal.

References

- Arfania, D., Everett, E. D., Nolph, K. D. & Rubin, J. (1981). Uncommon causes of peritonitis in patients undergoing peritoneal dialysis. *Arch Intern Med* **141**, 61–64.
- Balajee, S. A., Gribskov, J., Brandt, M., Ito, J., Fothergill, A. & Marr, K. A. (2005). Mistaken identity: *Neosartorya pseudofischeri* and its anamorph masquerading as *Aspergillus fumigatus*. *J Clin Microbiol* **43**, 5996–5999.
- Basok, A., Schneider, E., Hausmann, M. & Rapoport, J. (2000). *Aspergillus* peritonitis in continuous ambulatory peritoneal dialysis patients. *Am J Nephrol* **20**, 329–331.
- Bibashi, E., Papagianni, A., Kelesidis, A., Antoniadou, R. & Papadimitriou, M. (1993). Peritonitis due to *Aspergillus niger* in a patient on continuous ambulatory peritoneal dialysis shortly after kidney graft rejection. *Nephrol Dial Transplant* **8**, 185–187.
- Bibashi, E., Memmos, D., Kokolina, E., Tsakiris, D., Sofianou, D. & Papadimitriou, M. (2003). Fungal peritonitis complicating peritoneal dialysis during an 11-year period: report of 46 cases. *Clin Infect Dis* **36**, 927–931.
- Bren, A. (1998). Fungal peritonitis in patients on continuous ambulatory peritoneal dialysis. *Eur J Clin Microbiol Infect Dis* **17**, 839–843.
- Carpenter, J. L., Foulks, C. J. & Weiner, M. H. (1982). Peritoneal dialysis complicated by *Aspergillus flavus* peritonitis: a role for fungal antigen serodiagnosis. *Nephron* **32**, 258–260.
- Chan, T. M., Chan, C. Y., Cheng, S. W., Lo, W. K., Lo, C. Y. & Cheng, I. K. (1994). Treatment of fungal peritonitis complicating continuous ambulatory peritoneal dialysis with oral fluconazole. *Nephrol Dial Transplant* **9**, 539–542.
- De Hoog, G. S., Guarro, J., Gené, J. & Figueras, M. J. (2000). *Atlas of Clinical Fungi*, 2nd edn. Utrecht & Reus: Centraalbureau voor Schimmelcultures & Universitat Rovira i Virgili.
- Donnelly, J. P. (2002). Symptoms and diagnosis of nosocomial fungal infections – state-of-the-art. *Eur J Med Res* **7**, 192–199.
- Eisenberg, E. S., Leviton, I. & Soeiro, R. (1986). Fungal peritonitis in patients receiving peritoneal dialysis: experience with 11 patients and review of the literature. *Rev Infect Dis* **8**, 309–321.
- Fujita, S. I., Senda, Y., Nakaguchi, S. & Hashimoto, T. (2001). Multiplex PCR using internal transcribed spacer 1 and 2 regions for rapid detection and identification of yeast strains. *J Clin Microbiol* **39**, 3617–3622.
- Garcia-Martos, P., Diaz, J., Castano, M., Perez, M. & Martin, P. (1991). Peritonitis caused by *Candida lusitanae* in a patient of continuous ambulatory peritoneal dialysis (CAPD). *Clin Nephrol* **36**, 50.
- Geiss, H. K. (1995). Peritoneal aspergillosis – pitfalls in the diagnosis of a rare disease. *Nephrol Dial Transplant* **10**, 1124–1125.
- Gloor, H. J., Pandolfi, S. & Ruttimann, S. (2003). 20 years of peritoneal dialysis in a mid-sized Swiss hospital. *Swiss Med Wkly* **133**, 619–624.
- Guarro, J., Kallas, E. G., Godoy, P., Karenina, A., Gene, J., Stchigel, A. & Colombo, A. L. (2002). Cerebral aspergillosis caused by *Neosartorya hiratsukae*, Brazil. *Emerg Infect Dis* **8**, 989–991.
- Guinea, J., Peláez, T., Recio, S., Torres-Narbona, M. & Bouza, E. (2008). In vitro antifungal activities of isavuconazole (BAL4815), voriconazole, and fluconazole against 1,007 isolates of zygomycete, *Candida*, *Aspergillus*, *Fusarium*, and *Scedosporium* species. *Antimicrob Agents Chemother* **52**, 1396–1400.
- Hinrikson, H. P., Hurst, S. F., De Aguirre, L. & Morrison, C. J. (2005). Molecular methods for the identification of *Aspergillus* species. *Med Mycol* **43** (Suppl. 1), S129–S137.
- Hong, S.-B., Shin, H.-D., Hong, J., Frisvad, J. C., Nielsen, P. V., Varga, J. & Samson, R. A. (2008). New taxa of *Neosartorya* and *Aspergillus* in *Aspergillus* section *Fumigati*. *Antonie Van Leeuwenhoek* **93**, 87–98.
- Iqbal, M. M., Sattar, H., Islam, M. N., Ahmed, A. H., Rahman, M. H., Rashid, H. U. & Mohsi, M. (2008). Spectrum of organisms causing peritonitis in peritoneal dialysis patients – experience from Bangladesh. *Adv Perit Dial* **24**, 40–43.
- Kitiyakara, C., Sakulsangprapha, A. & Domrongkitchaiporn, S. (1996). The role of surgery and itraconazole in *Aspergillus* peritonitis in CAPD. *Nephrol Dial Transplant* **11**, 1498.
- Malloch, D. & Cain, R. F. (1972). The Trichocomaceae: ascomycetes with *Aspergillus*, *Paecilomyces*, and *Penicillium* imperfect states. *Can J Bot* **50**, 2613–2628.
- Matsumoto, N., Shiraga, H., Takahashi, K., Kikuchi, K. & Ito, K. (2002). Successful treatment of *Aspergillus* peritonitis in a peritoneal dialysis patient. *Pediatr Nephrol* **17**, 243–245.
- Melez, K. A., Cherry, J., Sanchez, C., Ettinger, R. B. & Walsh, T. J. (1995). Successful outpatient treatment of *Trichosporon beigeli* peritonitis with oral fluconazole. *Pediatr Infect Dis J* **14**, 1110–1113.
- Miles, A. M. & Barth, R. H. (1995). *Aspergillus* peritonitis: therapy, survival, and return to peritoneal dialysis. *Am J Kidney Dis* **26**, 80–83.

- Park, S. B., Kim, K. H., Joo, I. & Kim, H. C. (1996). Scanning electron microscopy studies of peritoneal catheter in CAPD peritonitis due to *Aspergillus fumigatus*. *Perit Dial Int* 16, 81–83.
- Perez-Fontan, M., Rodriguez-Carmona, A., Fernandez-Rivera, C. & Moncalian-Lenon, J. (1991). *Aspergillus* peritonitis complicating ambulatory peritoneal dialysis. *Nephron* 57, 493–494.
- Pfaller, M. A., Diekema, D. J., Rex, J. H., Espinel-Ingroff, A., Johnson, E. M., Andes, D., Chaturvedi, V., Ghannoum, M. A., Odds, F. C. & other authors (2006). Correlation of MIC with outcome for *Candida* species tested against voriconazole: analysis and proposal for interpretive breakpoints. *J Clin Microbiol* 44, 819–826.
- Pimentel, J. D., Mahadevan, K., Woodgyer, A., Sigler, L., Gibas, C., Harris, O. C., Lupino, M. & Athan, E. (2005). Peritonitis due to *Curvularia inaequalis* in an elderly patient undergoing peritoneal dialysis and a review of six cases of peritonitis associated with other *Curvularia* spp. *J Clin Microbiol* 43, 4288–4292.
- Piraino, B. (1998). Peritonitis as a complication of peritoneal dialysis. *J Am Soc Nephrol* 9, 1956–1964.
- Polo, J. R., Luño, J., Menarguez, C., Gallego, E., Robles, R. & Hernandez, P. (1989). Peritoneal mucormycosis in a patient receiving continuous ambulatory peritoneal dialysis. *Am J Kidney Dis* 13, 237–239.
- Prewitt, K., Lockard, J., Rodgers, D. & Harsbargen, J. (1989). Successful treatment of *Aspergillus* peritonitis complicating peritoneal dialysis. *Am J Kidney Dis* 13, 501–503.
- Ram, R., Swarnalatha, G., Neela, P. & Murty, K. V. (2008). Fungal peritonitis in patients on continuous ambulatory peritoneal dialysis: a single-centre experience in India. *Nephron Clin Pract* 110, 207–212.
- Rodriguez-Tudela, J. L., Barros, C., Aguado, J. M., Gomez-Garcés, J. L., Velo, M. & de Arriba, G. (1988). *Aspergillus niger* peritonitis. *Nephrol Dial Transplant* 3, 232.
- Ross, D. A., Anderson, D. C., Macnaughton, M. C. & Stewart, W. K. (1968). Fulminating disseminated aspergillosis complicating peritoneal dialysis in eclampsia. *Arch Intern Med* 121, 183–188.
- Schattner, A., Kagan, A. & Zimhony, O. (2006). *Aspergillus* peritonitis in a lupus patient on chronic peritoneal dialysis. *Rheumatol Int* 26, 762–764.
- Sridhar, R., Thornley-Brown, D. & Kant, K. S. (1990). Peritonitis due to *Aspergillus niger*: diagnostic importance of peritoneal eosinophilia. *Perit Dial Int* 10, 100–101.
- Stein, M., Levine, J. F. & Black, W. (1991). Successful treatment of *Aspergillus* peritonitis in an adult on continuous ambulatory peritoneal dialysis. *Nephron* 59, 145–147.
- Stuck, A., Seiler, A. & Frey, F. J. (1986). Peritonitis due to an intrauterine contraceptive device in a patient on CAPD. *Perit Dial Int* 6, 158.
- Tanis, B. C., Verburgh, C. A., Van't Wout, J. W. & Van der Pijl, J. W. (1995). *Aspergillus* peritonitis in peritoneal dialysis: case report and a review of the literature. *Nephrol Dial Transplant* 10, 1240–1243.
- Tsai, T. J., Chen, Y. M., Hsieh, B. S., Chen, W. Y. & Yen, T. S. (1991). Can intracatheter retention of antifungal agents cure fungal peritonitis? Two cases successfully treated without catheter removal. *Perit Dial Int* 11, 355–356.
- Tsoufakis, G. E., Iatrou, C. E., Petropoulou, M., Zerbala, S. C., Vayiakou, H. A., Polychronopoulou, C. A. & Ziroyanis, P. N. (1995). *Aspergillus fumigatus* peritonitis in a patient on CAPD. *Perit Dial Int* 15, 184–185.
- Ujhelyi, M. R., Raasch, R. H., Van der Horst, C. M. & Mattern, W. D. (1990). Treatment of peritonitis due to *Curvularia* and *Trichosporon* with amphotericin B. *Rev Infect Dis* 12, 621–627.
- Varga, J., Vida, Z., Tóth, B., Debets, F. & Horie, Y. (2000). Phylogenetic analysis of newly described *Neosartorya* species. *Antonie Van Leeuwenhoek* 77, 235–239.