Chronic peritoneal dialysis in children: the role of ultrasound in the diagnosis of peritoneal catheter obstruction

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Abstract

Purpose Over the past two decades, continuous ambulatory peritoneal dialysis has emerged as the first-choice dialysis modality in children awaiting for transplantation. Despite the improvements observed in catheter survival over the past several years, the obstruction is one of the reasons for immediate catheter non-function. This study assessed usefulness of ultrasound (US) in visualizing the obstruction of chronic peritoneal dialysis (CPD) catheter and identifying the etiology.

Materials and methods Between January 2000 and November 2012, 38 patients (20 M, 18 F) were treated with CPD and examined with US. The type of catheter in all subjects was the straight two-cuff Tenckhoff catheter. We evaluated the typical sonographic signs of the most common CPD catheter complications.

Results We had 12/38 cases with catheter malfunction due to its obstruction. In eight patients, US showed the

presence of echogenic material fragmented into the lumen and around the distal tip of the catheter. In the other four patients, US demonstrated the displacement of catheter in bowel loops and an amorphous material as homogeneous echoic area around the distal tip.

Conclusions Our results confirm the effectiveness of US in the assessment of the complications related to intraperitoneal catheters. US is able to identify the catheter obstruction and recognize the etiology (endoluminal strands of fibrin, other materials or the omental wrapping), facilitating a correct therapeutic approach.

Keywords Ultrasound · Chronic peritoneal dialysis · Tenckhoff catheter

Riassunto

Obiettivo Nel corso degli ultimi due decenni la dialisi peritoneale è emersa come modalità di dialisi di prima scelta nei bambini in attesa per il trapianto. Nonostante i miglioramenti osservati nella sopravvivenza nel corso degli ultimi anni, l'ostruzione è uno dei motivi di mancato funzionamento. Scopo dello studio è valutare il ruolo dell'ecografia nell'identificare condizioni patologiche ostruttive catetere-correlate, nella popolazione pediatrica, identificandone la causa eziologica.

Materiali e Metodi Dal Gennaio 2000 e Novembre 2012 abbiamo valutato periodicamente un gruppo di 38 pazienti (20 M, 18 F) sottoposti a dialisi intraperitoneale e monitorizzati con esame ecografico. Il catetere utilizzato era del tipo Tenckhoff dritto a due cuffie. Abbiamo valutato i segni ecografici tipici delle più comuni complicazioni ostruttive correlate al catetere per dialisi peritoneale.

Risultati Abbiamo documentato 12/38 casi di malfunzionamento del catetere su base ostruttiva. In otto pazienti, l'ecografia documentava la presenza di materiale ecogeno

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frammentato nel lumeed intorno alla punta distale del catetere. In altri quattro pazienti, l'ecografica documentava l'intrappolamento del catetere in anse intestinali ed un materiale amorfo omogeneamenteecogeno intorno alla punta distale.

Conclusioni I nostri risultati confermano l'efficacia dell'ecografia nel rilevare complicanze ostruttive catetere-correlate. L'ecografia ha permesso di riconoscere non solo la presenza dell'occlusione del catetere ma di discriminare l'eziologia riportando elementi utili per distinguere fra deposizione di materiale fibrotico ed incarceramento del catetere da parte di aderenze peritoneali con adesione dell'omento ai fori o scivolamento nel lume del catetere, orientando per un corretto approccio terapeutico.

Introduction

Chronic peritoneal dialysis (CPD) is an established treatment option for patients with end-stage renal disease (ESRD) [1]. Over the past two decades, CPD has emerged as the first-choice dialysis modality in children awaiting for transplantation, especially since automated peritoneal dialysis has become available. CPD is preferred over haemodialysis, because it offers to the young patient more freedom and independence; moreover, it allows a more liberal dietary intake of protein, potassium, and sodium, ensuring longer biochemical stability. It is associated with fewer symptoms of haemodynamic instability during dialysis; moreover, it has been demonstrated that CPD patients enjoy a better quality of life [2]. Despite the improvements observed in catheter survival over the past several years, some complications are frequent causes of morbidity and treatment failure in children on CPD and often of forced cessation of PD [3]. Catheter infections, specifically exit-site infection (ESI) and tunnel infection (TI), and peritonitis remain the most common complications of CPD [4]. Over 25 % of children on CPD are reported to have had ESI/TI within the first 6 months of CPD, and children with ESI/TI have twice the risk of peritonitis compared with children who do not experience ESI/TI [5]. Non-infectious catheter-related problems are the second most common complication. Among these, there is dialysate leakage, followed by catheter malfunction. Catheter malfunction could be related to different reasons, such as migration of catheter tip and occlusion by bowel, clot, or omentum [6]. The obstruction of the catheter can be partial ("one-way obstruction") that means only poor outflow of dialysate, or total ("two-way obstruction") that means poor inflow and outflow of dialysate [7]. Blood clot or fibrin strands are able to produce a blockage either within the lumen of the catheter or around it surrounding lateral holes of the intra-

abdominal tract. The intrinsic properties of the greater omentum are such that if it comes into contact with a CAPD catheter, it will wrap around the catheter in an attempt to isolate this foreign body from the rest of the peritoneal cavity. The omentum may then partially or totally occlude the lumen of the catheter or pull the tip of the catheter out of the pelvis [8]. Diagnostic imaging techniques play a crucial role in the management of patients undergoing to CPD, mainly in the diagnosis of potential catheter-related complications, because such evaluation can aid in the treatment decision process. Visualizing the obstruction and understanding the real etiology of that are crucial for a correct management of the patient and can also help in determining subsequent therapeutic strategies. In this study, we examined the usefulness of ultrasound (US) in visualizing the obstruction of CPD catheter and identifying the etiology.

Materials and methods

Between January 2000 and November 2012, 38 patients (20 M, 18 F; mean age 4.8 ± 2.8 ; age range 11 months–9 years) were treated with chronic peritoneal dialysis and examined with ultrasonography. All young patients treated with CPD suffered from chronic renal disease due to congenital birth defects, hereditary diseases, and glomerular diseases. The mean duration of dialysis was 3 ± 1.2 years. During the 12-year period, the number of dropouts was 23 (14 transplantations, five transfers to hemodialysis, four deaths); 15 patients are currently on CPD. The type of catheter in all subjects was the straight two-cuff Tenckhoff catheter. The Tenckhoff catheter is a thin, non-irritating, flexible tube, made of silastic Teflon. It is 35-cm long and has two Dacron-felt cuffs, which are bonded to the catheter and divide it into three parts: intra-abdominal, subcutaneous (between the two cuffs), and external. The intra-abdominal part has numerous spaced holes of 0.5 mm diameter that allow the inflow and the outflow of the dialysate throughout the peritoneal cavity. The end of the catheter is open (Fig. 1). Through tissue ingrowth into the Dacron, the cuffs stabilize the catheter and prevent leakage of dialysate and bacterial invasion along the subcutaneous tunnel. The Tenckhoff catheter was surgically placed under general anaesthesia in the lateral wall with the exit-site above the point of entry in peritoneum. All patients (every 15 days for the first month, every 20 days for the following 2 months, and finally once a month) performed US with the aim to verify the functionality of the catheter, and both in the normal state and at the onset of catheter complications suspected on clinical ground; in this latter case, US was established as the first-line exam. Prospective data recorded for each patient

Fig. 1 Double-cuffed straight Tenckhoff catheter. **a** Two Dacron-felt cuffs (arrows) bond the silicon tube and divide it into three parts: intra-abdominal, subcutaneous (between the two cuffs), and external. **b** Numerous spaced holes of 0.5 mm diameter are visible on the intra-abdominal part

included length of time on dialysis, need for catheter removal, and treatment regimen. Real-time US examination was always performed by two experienced radiologists using the ESAOTE My Lab Twice scanner with a convex and/or linear transducer (5–18 MHz). For the purposes of the examination, the patient was placed in the supine position, and longitudinal and transverse views along the catheter tract were displayed and stored on a video printer. We evaluated the position of the catheter in the peritoneal cavity, the lumen of the catheter, the presence/absence of fluid collections between the catheter tube or cuff and the surrounding soft tissues, and the presence of free fluid in peritoneal recessus explored.

Results

There were no significant intraoperative complications related to the insertion of the catheter; early complications, defined as complications within 30 days of the operation, did not occur in any patient. All young patients periodically underwent US examination. In all cases, it was well tolerated and painless. In all patients, US scanning has given a clear picture of the peritoneal catheter, allowing us to visualize it along all its length into peritoneal cavity, its lumen and all its tracts, including external, subcutaneous, and intra-abdominal segments as well as the holes of the intra-abdominal catheter thanks to an adequate image resolution because children's smaller body habitus than adults. Sonographically, the silicon tube throughout its length was visualized as a 'sandwich structure' consisting of a double-layered hyperechoic band representing the anterior and posterior sides of the catheter (Fig. 2). Both the external and internal cuffs were hyperechoic and had a characteristic acoustic shadow (Fig. 3). In the follow-up, no patient showed migration of the tip of the catheter out of the pelvis; in some cases of abdominal pain for a suspected malposition of the catheter, ultrasonography allowed to clearly exclude its migration and to orientate toward other causes. We observed 12 cases with catheter

Fig. 2 Tenckhoff catheter: ultrasound visualization in longitudinal scan. The silicon tube looks like a 'sandwich structure' consisting of a double-layered hyperechoic band representing the anterior and posterior sides of the catheter

malfunction related to its obstruction. Clinical suspect of obstruction was based on persistent resistance to "inflow" and/or "outflow" of the dialysate. US was performed and demonstrated the catheter obstruction. In eight patients, US showed the presence of echogenic material fragmented into the lumen and around the distal tip of the catheter (Fig. 4). In the other four patients with a clinical suspect of catheter obstruction, US demonstrated the displacement of catheter in bowel loops and an amorphous material as homogeneous echoic area around the distal tip. This material appeared strongly stuck to the catheter with attitude to creep into the lumen of the catheter for about 2 cm (Fig. 5). In eight patients, in which US demonstrated the presence of fragmented material in the lumen of the catheter, treatment was conservative, based on forceful irrigation with saline solution and fibrinolytic agents (urokinase 5000 U) for two consecutive days. Subsequently, the catheter showed excellent flow in both directions; in the next follow-up period, US revealed a progressive reduction of the echogenic material

Fig. 3 Ultrasound visualization of the cuff in both the transverse (a) and longitudinal (b) scan. The cuff (arrows), located in the subcutaneous tissue, appears hyperechoic and has a characteristic acoustic shadow

Fig. 4 Ultrasound images show the presence of echogenic material fragmented into the lumen (a) and around the distal tip (b) of the catheter

Fig. 5 Ultrasound images show an amorphous material as homogeneous echoic area into the lumen of the catheter (a) and around distal tip (b)

fragmented into the catheter (Fig. 6). This finding leads us to the hypothesis of intraluminal fibrin strands as a possible cause of the catheter obstruction. In the other four patients, treatment was initially conservative, consisting in the administration IV of fibrinolytic agents (urokinase 5000). After various unsuccessful attempts, the patient underwent the surgery. Under direct vision, the catheter was found to be wrapped around with omentum from the anterior abdominal wall to the right iliac fossae. Even the distal end

of the catheter was partially filled-in with omentum fat through its holes. The catheter was surgically stripped from the omentum and then repositioned in the abdominal cavity directly to the Douglas peritoneal sac. Further US examination in the postoperative period confirmed that the catheter restarted to work properly. This finding leads us to the diagnosis of omental wrapping and peritoneal adhesion around the catheter that had caused the subsequent obstruction.

Fig. 6 Ultrasound control after fibrinolytic treatment. The image shows a reduction of the echogenic material fragmented into the lumen of the catheter (arrows)

Discussion

It is well known that some different complications can occur after catheter implantation and represent one of the most common causes of treatment failure in patients on CPD. An early diagnosis is crucial for the subsequent therapeutic management approach, which can be conservative, surgical with the aim of salvage problematic catheters or radical consisting in definitive catheter removal. The clinical evaluation plays the main role in the detection of complications of peritoneal dialysis, but it is almost incomplete in a wide range of problems. In these cases, radiological investigations can be helpful and may significantly improve both morbidity and mortality in CPD patients. Until now, the role of US in detecting the site and the extent of catheter infections has been demonstrated. Sonographic indicators of a tunnel infection include subcutaneous peri-catheteric fluid collection/s and peri-catheteric hyperaemia on colour Doppler [9, 10]. A proportion of patients develop occult infection in the subcutaneous tract. Although adequate for an exit-site infection, physical examination does not assess the status of tunnel or cuff infection, particularly at an early stage. US is the most appropriate method for the assessment of these patients. Infection of the tunnel or cuff catheter significantly increases the risk of catheter loss [11]. Indeed, positive evidence on US of fluid collection at the catheter tunnel or cuff sites has been documented to be a useful predictor of catheter loss. Among the non-infectious complications of CPD catheters, another relatively common cause is catheter “malfunction.” There can be many reasons for catheter malfunction, first of all, the migration of the catheter tip outside of the pelvis, followed by intraluminal occlusion by

bowel, clot, and omental wrapping. The obstruction of the catheter is one of the reasons for immediate catheter non-function; the incidence has been reported ranging from 4.5 to 15 % [6]. Up to now, there are a few data concerning the role of imaging techniques in the diagnosis of catheter occlusion. In most cases, the diagnosis of occlusion was only made after the exclusion of all other most common causes of catheter non-function; omental attachment of the catheter has been suspected after various attempts with forceful irrigation and/or fibrinolytic agents and demonstrated only after surgical approach. In our patient population, the incidence of catheter obstruction has been 12/38 (31 %). In disagreement with literature data, we did not report any case of catheter infection/peritonitis; on the other hand, our patient population is not large enough to be statistically compared with other studies. In all 12 patients, US has been able to detect the obstruction of the catheter and has been helpful in understanding the etiology, discerning the omental wrapping from fibrin strands. The use of a high-frequency transducer allows high-resolution images of the track of the catheter [12]. Although the silastic walls of the catheter are relatively echogenic and reflect sound, they do not cause acoustic shadow deep to the catheter; therefore, we are able to study the lumen and its opening. Among the advantages, US is able to identify the correct position of the catheter, intraperitoneal free fluid, and fluid collections at the catheter tunnel or cuff sites, which can address the diagnosis towards catheter infection. US provides a real-time imaging, making it a good tool not only for localizing a collection, but also for accurately defining obstructions of the catheter lumen, to determine the length and describe the obstruction material (the presence of endoluminal strands of fibrin and/or other materials as scattered internal echoes or omental wrapping as homogeneous echoic area around the distal tip). US appears as an effective tool in trying to understand the etiology of the obstruction. This has a strong influence for the subsequent therapeutic approach, varying from a conservative therapy in the case of fibrin strands to surgery in the case of omental wrapping. US can early detect the onset of this kind of complication, and this allows to carry out a tempestive therapy: in some different problematic catheters, surgical salvage procedures could be realized, thus avoiding a surgical removal or even the catheter loss.

Conclusions

Although the limitation of this study is the small sample size, our data based on 12 patients indicate that US represents the first-choice imaging technique in monitoring a patient on CPD because of its repeatability, non invasivity, and the absent exposure to ionizing radiations. On the other

hand, CT in children should only be reserved to selected patients because of its panoramic view and the opportunity to perform a CT-guided aspiration. Moreover, our data reveal a prognostic role of US in monitoring the functionality of the CPD catheter: on the basis of its ability to study very well the lumen of the catheter, US is also able to evaluate the presence of endoluminal fibrin strands (detritus) and/or other materials, thus allowing to practice further therapeutic strategies that could be helpful to prevent the occlusion of the catheter.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, and its late amendments.

Human and animal rights This study does not contain any studies with human or animal subjects performed by any of the authors.

Informed consent Additional informed consent was obtained from all patients for which identifying information is not included in this study.

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