Outcome of tunnelled central venous catheters used for haemodialysis in children weighing less than 15 kg

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ABSTRACT

Purpose: Central venous catheters (CVC) are frequently used for haemodialysis (HD) in children. However, there is paucity of information on the outcomes of CVCs when used for HD in very young patients. Our objective is to report the success, safety and complication rates of CVCs used for HD in children weighing less than 15 kg.

Materials and methods: This is a single-center retrospective study of all patients with end-stage renal disease (ESRD) weighing <15 kg who underwent a tunneled CVC placement for HD, between July 2006 and June 2012 at our institution. Analysed data included clinical background, age and weight at initiation of HD, outcome of HD, CVC vein insertion site, reason for removal, and catheter survival (in days).

Results: Thirty-one CVC were placed in 11 patients weighing <15 kg, 8 males and 3 females. The main causes of ESRD were renal dysplasia and congenital nephrotic syndrome. At the beginning of HD, mean age was 27.5 (range 5–60) months and mean weight was 10.4 kg (4.5–13 kg). The preferred insertion site was the right internal jugular vein (90%). Mean duration of HD was 312 days. Mechanical factors were the main reason for catheter removal (39%). Mean catheter survival was 110 days/catheter.

Conclusions: We believe our study provides relevant information and encouraging data to support the use of CVC for HD in this cohort of infants; however, further improvement in prevention of catheter thrombosis and management of infections needs to be achieved.

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Over the past two decades, technological advances have made dialysis a viable long-term option for pediatric patients with end-stage renal disease (ESRD), but it still carries a significant morbidity and mortality risk [1–3]. Successful kidney transplant remains the treatment of choice for ESRD; however, the majority of pediatric patients require chronic dialysis while they wait for a transplant, for periods that can last several years [2,4–6].

In children with ESRD, the first option for renal replacement therapy is peritoneal dialysis (PD) and it constitutes 91%–97% of dialysis care in children <1 year of age [4,7]. Haemodialysis (HD) is reserved only for cases in which PD has failed or is impossible owing to anatomical or social reasons [1,2,5–7]; however, it may become necessary to complement PD, when infections or other PD-related complications are being treated. In North America and Europe, only 31% of children receive haemodialysis [7–9] and HD rates are similar in our country [10,11].

In pediatric patients undergoing HD, the vascular access is of vital importance. The use of CVC has become more common in children with ESRD [12,13] and it is currently the first choice for pediatric haemodialysis, especially in patients weighing less than 15 kg [1,2,14]. However, there is considerable morbidity associated with these catheters, mainly related to the patient’s disease and the small size of their vessels, and their maintenance requires a lot of manipulation by the surgeons and much care by the nursing staff and parents [13,15–17]. Arteriovenous fistulas (AVF) are associated with a lower failure rate and fewer complications, but they are used only in patients weighing more than 20 kg in most centres [6,12–14,18], mainly because of technical difficulties involved in creating and maintaining the fistula.

There are little data on life expectancy and long-term complications of CVC in children, and there are even fewer reports in children weighing <15 kg [2,14,15,18]. Considering that the difficulties associated with using a CVC for pediatric HD are related mainly to patient weight rather than chronological age [1,2], we studied the use of CVC for haemodialysis in children weighing less than 15 kg. We assessed demographic factors, life expectancy and complications, in order to determine whether the technique is safe in this pediatric population subgroup.
1. Patients and methods

We conducted a retrospective review of the medical records of all patients with ESRD who had HD for at least 1 month, between July 2006 and June 2012 at the Nephrology and Urology Service of the Exequiel González Cortés Pediatric Hospital. Information about demographics, underlying cause of renal disease, age at initiation of HD, site and form of vascular access, number of catheters per patient, reason for removal, complications and catheter survival, duration of HD and outcome was recorded and analysed. For children who remained on HD, data were calculated until December 2012.

All children who weighed less than 15 kg and underwent a tunneled CVC placement for HD during that period were included in our study. CVC were placed by Paediatric Surgeons using Seldinger’s Technique and all procedures were performed in the operation theatre, under general anaesthesia. All of our patients received prophylactic antibiotics immediately before surgery.

A uniform percutaneous needle vein puncture was performed in all patients under strict aseptic precautions. Blind puncture based in anatomic landmarks was used because Doppler ultrasound guidance was not available. After venous access was obtained, confirmed by blood backflow, the guide wire was introduced into the needle and advanced. The needle was then removed, leaving the wire in place, and a dilator was advanced over the guide. Once the tract was dilated, the dilator was removed and the catheter threaded over the wire into the vessel. The catheter was tunneled subcutaneously to the venipuncture site and inserted into the vein with the tip near the level of the third rib. The guide wire was removed, blood return was confirmed and the catheter was flushed with 1 ml of heparinised saline (5000 U/5 ml normal saline) to fill the lumen. All CVC were covered with sterile dressings at the end of the procedure. Intraoperative fluoroscopy was used to confirm guide wire placement and final position of the catheter tip, and further assessment of the position of the catheter with a postoperative chest x-ray was routinely performed.

All patients underwent catheter heparin locks between haemodialysis sessions to ensure maintenance of patency. This involves instillation of heparin into the catheters lumens in a volume sufficient to fill to the lumen tip (1000 U).

Only descriptive statistics were calculated owing to the small number of patients.

2. Results

Over a period of approximately 6 years, 31 CVC were placed in 11 patients weighing less than 15 kg. There were 3 girls and 8 boys.

Group characteristics are shown in Table 1. At initiation of HD, mean age was 27.5 (range 5–60) months and weight 10.4 (4.5–13) kg, with 4 patients weighing less than 10 kg. The main causes of ESRD were renal dysplasia, with or without associated urological malformation (n = 4), and congenital nephrotic syndrome, secondary to diffuse mesangial sclerosis (n = 2), focal and segmentary glomerulosclerosis (n = 1), and Denneys-Drash Syndrome (n = 1). The main reasons for haemodialysis initiation were: failed PD owing to recurrent peritonitis (n = 8); social reasons (n = 3) and impossibility of using peritoneal dialysis because of prior abdominal surgeries (n = 1). The mean duration of HD was 312 days (range 26–840).

2.1. Vascular access

A Pediatric Split Cath® LT or Hemo-Cath® LT haemodialysis catheter (Medcomp®, Harleysville, PA, USA) was used for long-term vascular access in all patients. Because of the low weight and small size vessels of our patients, most catheters used were 8Fr/18 cm (25 catheters in 9 patients) and 10Fr/18 cm (5 catheters in 2 patients). Only one patient required a bigger catheter, a 10Fr/24 cm, owing to occlusion of the ones used before.

The most common CVC insertion site was the internal jugular vein (n = 28; 90%), with the right jugular vein used more frequently than the left. (Table 2). Only 3 patients underwent CVC placement at another site (subclavian vein, n = 2, and femoral vein, n = 1), in all cases owing to thrombosis of both jugular veins. The mean number of catheters placed per patient was 2.5 (range 1–5). Mean catheter survival was 110 days/catheter (range 26–586).

The main reason for removing the catheters was mechanical factors (39%) such as occlusion, owing to thrombosis and kinking, displacement and fracture (Fig. 1), followed by infections (13%), which occurred in 4 catheters. CVC occlusion was suspected when inadequate blood flow was observed. Before catheter removal, a trial with local infusion of streptokinase was made. Five catheter thromboses were proven in 4 patients. After fibrinolytic treatment, there was partial response in 2 cases, with only transitory increase in catheter permeability, and no response in the remaining 3. All CVCs had to be replaced.

### Table 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Renal disease</th>
<th>Gender</th>
<th>Age at initiation of HD (mo)</th>
<th>Weight at initiation of HD (kg)</th>
<th>Duration of HD (d)</th>
<th>No. of AV</th>
<th>Outcome of HD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CNS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>M</td>
<td>28</td>
<td>11.8</td>
<td>162</td>
<td>5</td>
<td>Successful transplant</td>
</tr>
<tr>
<td>2</td>
<td>FSGS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>M</td>
<td>0.4</td>
<td>6.3</td>
<td>312</td>
<td>5</td>
<td>Successful transplant</td>
</tr>
<tr>
<td>3</td>
<td>PKD&lt;sup&gt;c&lt;/sup&gt;</td>
<td>M</td>
<td>61</td>
<td>12.4</td>
<td>186</td>
<td>2</td>
<td>Successful transplant</td>
</tr>
<tr>
<td>4</td>
<td>Renal dysplasia</td>
<td>M</td>
<td>60</td>
<td>13</td>
<td>216</td>
<td>4</td>
<td>Moved to AVF</td>
</tr>
<tr>
<td>5</td>
<td>CNS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>M</td>
<td>20</td>
<td>10.5</td>
<td>30</td>
<td>1</td>
<td>Moved to PD&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>DMS&lt;sup&gt;e&lt;/sup&gt;</td>
<td>M</td>
<td>42</td>
<td>11.7</td>
<td>586</td>
<td>1</td>
<td>Successful transplant</td>
</tr>
<tr>
<td>7</td>
<td>Renal dysplasia</td>
<td>M</td>
<td>5</td>
<td>5.5</td>
<td>840</td>
<td>3</td>
<td>Successful transplant</td>
</tr>
<tr>
<td>8</td>
<td>Prune belly syndrome</td>
<td>M</td>
<td>9</td>
<td>7</td>
<td>216</td>
<td>2</td>
<td>Expired</td>
</tr>
<tr>
<td>9</td>
<td>Renal dysplasia</td>
<td>F</td>
<td>30</td>
<td>13</td>
<td>420</td>
<td>5</td>
<td>Moved to PD&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>10</td>
<td>CNS&lt;sup&gt;a&lt;/sup&gt; Denys-Drash syndrome</td>
<td>M</td>
<td>6</td>
<td>4.5</td>
<td>243</td>
<td>1</td>
<td>In HD</td>
</tr>
<tr>
<td>11</td>
<td>Renal dysplasia</td>
<td>M</td>
<td>34</td>
<td>11.1</td>
<td>216</td>
<td>2</td>
<td>In HD</td>
</tr>
</tbody>
</table>

<sup>a</sup> CNS: Congenital nephrotic syndrome.
<sup>b</sup> FSGS: focal segmental glomerulosclerosis.
<sup>c</sup> VUR: Vesicoureteral reflux.
<sup>d</sup> PKD: polycystic kidney disease.
<sup>e</sup> DMS: diffuse mesangial sclerosis.
<sup>PD</sup>: peritoneal dialysis.
When considering the site of insertion, loss of jugular vein access was mostly associated with mechanical factors (Table 3).

Infection was defined by the presence of fever, with no other possible cause, and a positive blood culture. Only 2 cases involved a secondary bacterial infection, and the main bacteria isolated were coagulase-negative Staphylococcus (Staphylococcus aureus and Staphylococcus epidermidis) and Pseudomonas spp. In both cases, intravenous antibiotic treatment was initiated but failed, and therefore catheter was removed. Catheter-related infection rate was 1.37 per 1000 patient days.

2.2. Catheter outcome (Fig. 1)

The CVC remain active in 2 patients. Eight catheters were discontinued because they were no longer necessary. Five of eight patients underwent a successful kidney transplant. In one patient, an AVF was created after the patient reached 20 kg, and he continues to receive HD without problems. In 2 patients, because of an unsafe social situation, the decision was made to move to peritoneal dialysis. There was only one death during the study; an infant with Prune Belly Syndrome, owing to sepsis and multiorgan failure. He had functioning HD access for almost 220 days.

3. Discussion

Over a period of 6 years, 11 patients weighing less than 15 kg were subjected to HD via tunnelled central venous catheters. To date, there have only been a few studies assessing the outcome of CVCs used for long-term HD in low-weight pediatric patients [2,7,16,17,19,20]. Our study focuses specifically on the outcome of chronic HD via tunnelled CVC in children weighing less than 15 kg, and aims to enable a better understanding of morbidity, complications and outcome in these cases.

The most common underlying causes of ESRD in our series were renal dysplasia and congenital nephrotic syndrome (CNS), secondary to focal segmentary glomerulosclerosis (FSGS) or diffuse mesangial sclerosis (DMS). These results are consistent with those previously published, in which the main underlying conditions were renal dysplasia and CNS. Even though FSGS has been reported to be the main cause of CNS, in our study group the incidence of DMS was higher because the patients were siblings [1,2,7,8,21].

Although PD has become the first choice for dialysis treatment in children, there are no data to suggest its superiority over HD [8]. The popularity of PD relies on its suggested advantage for growth and development, and PD availability at home. HD in small children is associated with technical difficulties related to size of the patient, insufficient vascular access, malnutrition, growth retardation, difficulties in social adjustment and psychological problems [19,20].

In pediatric patients undergoing HD, preservation of vascular access is critical, as children with ESRD may need HD for several years prior to transplant. Haemodialysis may be via central venous catheters or arteriovenous fistulas [2,5,13,18]. Because of the multiple difficulties associated with AVF in children weighing less than 20 kg, the use of CVC has become more common in children with ESRD, representing the initial vascular access in 62–78% of all patients undergoing HD [1,2,5,17,22]. AVF construction in this age group is hampered by vessel caliber and shorter length [6] and they do not have adequate-sized arteries or veins to support a subcutaneous shunt [12–16,18].

A double lumen cuffed catheter, at least 8Fr, is mostly preferred in children and has been reported to have a survival rate as high as 60–85% at one year [23]. The Adult Dialysis Outcome Quality Initiative (K/DOQI) [24] guidelines have established that the ideal puncture site for CVCs is the right jugular vein as it offers more direct access to the right ventricle and is associated with a lower rate of complications. Left jugular vein catheters are associated with higher rates of stenosis and thrombosis, and femoral vein catheters have a higher rate of infection. Kovalski [1] and Shroff [19] quote the subclavian vein as the most frequently used site, based on the previous conventional wisdom of it being the ideal puncture site, as it allows for a straight trajectory and exit of the CVC [1,19]. Subclavian catheters have a higher rate of stenosis and infection and there is a considerable risk of subclavian stenosis following removal [15,16,24]. In our center, the majority of CVC were inserted in the right jugular vein (90%). A different site was used only in 3 patients, when jugular vein was inaccessible. The femoral vein was used as a last resort, as this site should be kept free of complications awaiting future kidney transplantation.

The maximum catheter survival was 586 days, with an average duration of 110 days/catheter. In comparison to previous similar studies, the longevity of our lines is promising. Lumsden et al. [22] reported a mean catheter lifespan of 56.7 days and the study by Kovalski et al. [1] showed a mean catheter lifespan of 64.2 days. However, a recent study conducted by Quinlan et al. [2], shows a higher mean survival of 396 days. This study included all types of vascular access used for HD, and therefore the results are not comparable.

Poor line function owing to mechanical factors or frequent line infections are often the limiting factor for the continuation of HD. The main reasons for catheter removal in our group were similar to those reported by Kovalski et al. [1], with mechanical factors accounting for 39% of cases. During our study, 5 catheter thromboses were proven in 4 patients. After treatment with streptokinase, there was partial response in 2 cases, with only transitory increase in catheter permeability, and no response in the remaining 3. All CVC had to be replaced. Better results were published by Quinlan et al.

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**Table 2**

Location of haemodialysis catheters.

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of catheters</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jugular vein</td>
<td>28</td>
<td>90.3</td>
</tr>
<tr>
<td>Subclavian</td>
<td>2</td>
<td>6.4</td>
</tr>
<tr>
<td>Femoral vein</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 3**

Complications related to site insertion.

<table>
<thead>
<tr>
<th>Location</th>
<th>Total number of catheters</th>
<th>Infection (number of catheters)</th>
<th>Mechanical factors (number of catheters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left internal JV</td>
<td>9</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Right internal JV</td>
<td>19</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Subclavian</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Femoral vein</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

![Fig. 1. Outcome of central venous catheters. PD: peritoneal dialysis, AVF: Arteriovenous fistula, Tx: Transplantation.](attachment:image)
[2], with only 2 cases of thrombosis, both successfully managed with subcutaneous tinzaparin.

No hypercoagulable states were reported in our series; however, blood coagulation studies were not performed routinely in our center. Two patients (1 Denys-Drash Syndrome and 1 FSGS) had steroid resistant nephrotic syndrome, which is considered a procoagulant state itself, and one of them had a proven CVC thrombosis, which responded only partially to local infusion of streptokinase, and catheter had to be replaced after 30 days. The authors are aware that use of streptokinase in children has not been proven to be safe and that other fibrinolytics drugs (alteplase) are currently being used for the treatment of catheter thrombosis, but our institution does not have access to them.

Catheter survival has increased owing to improved techniques of catheter insertion, manipulation and nursing care focused on reducing infection rates [1,2,24–27]. In hospital catheter care includes aseptic precautions, periodic flushing of catheter before and after use, and change of dressings with strict sterile technique always by trained specialized haemodialysis nurses. In the presence of suspected infection the child was treated with IV antibiotics for 48 hours, until confirmation of a negative blood culture. In case of infection by S. aureus or treatment failure, the catheter was removed. Quinlan et al. published similar recommendations for the prevention of infections [2]. However, other publications call for the routine use of antimicrobial CVC locks and topical antimicrobials and the wearing of masks by both nurses and patients [27,28].

Despite all these preventive measures, infection remains a frequent complication of HD catheters. In the study by Kovalski et al. [1], 15.6% of catheters were removed because of infection, mainly owing to coagulase-negative Staphylococcus bacteriaemia and the rate of catheter-related bacteriaemia was 1.3 infections per 1000 patient days. In our case series, the infection rate was slightly higher, with 1.37 episodes per 1000 patient days, and the main etiological agents were coagulase-negative Staphylococcus and Pseudomonas aeruginosa.

Better results were published by Quinlan et al. [2], with an infection rate of 0.52 infections per 1000 patient days and no lines removed for this reason. Most frequent causative organisms were also coagulase-negative Staphylococcus and Streptococcus spp.

That same study [2], reported a median time on HD of 27 months, with three children still on renal replacement therapy. Four of their 9 patients underwent successful renal transplantation and two children were recommenced on PD. However, their cohort was free of significant comorbidities, which may have contributed positively to their outcomes. The average duration of HD in our group was 10.4 months (312 days). In 5 patients, haemodialysis was discontinued after kidney transplant, 1 patient required creation of an AVF owing to recurrent CVC infection, and 2 patients were move to PD, owing to risky social conditions. Towards the end of our study, two patients continued on HD, and there was only one death, an infant with Prune Belly Syndrome.

The authors are aware of the limitations of this study; its retrospective design, the small number of patients and the long time period it covered.

4. Conclusion

Despite the difficulties associated with the use of central venous catheters in low-weight children, the constant fraught with mechanical and infectious complications, and the need for frequent catheter replacements, HD remains the only viable alternative in patients for whom PD is inappropriate and who are awaiting definitive treatment. Catheters often need treatment for thrombosis or replacement with multiple procedures; however, with comprehensive nursing care and through a lot of catheter manipulation by surgeons, access can be maintained to bridge these children to transplantation. Since there is a high complication rate and multiple catheters are necessary, health care providers and families need to be made aware of these issues.

We believe our study provides relevant information and encouraging data to support the use of CVC for HD in this cohort of infants; however, further improvement in prevention of catheter thrombosis and management of infections needs to be achieved.

References