Journal of Pediatric Surgery 53 (2018) 553–557

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Hybrid interventions for catheter placement in pediatric intestinal rehabilitation patients with end-stage venous access

Ludger Sieverding [a], Andreas Busch [b], Jens Gesche [c], Gunnar Blumenstock [d], Ekkehard Sturm [b], Ilias Tsiflikas [e], Femke Piersma [b], Anja Hauser [a], Gesa Wiegand [a], Steffen Hartleif [b], Michael Hofbeck [a], Jörg Fuchs [c], Steven W. Warmann [c,*]

[a] Department of Pediatric Cardiology, University Children's Hospital Tuebingen
[b] Pediatric Gastroenterology and Hepatology, University Children's Hospital Tuebingen
[c] Department of Pediatric Surgery and Pediatric Urology, University Children's Hospital Tuebingen
[d] Department of Clinical Epidemiology and Applied Biometry, University of Tuebingen
[e] Department of Diagnostic and Interventional Radiology, University Hospital Tuebingen

ARTICLE INFO

Article history:
Received 10 January 2017
Received in revised form 23 February 2017
Accepted 19 March 2017

Key words:
Short bowel syndrome
Pediatric intestinal rehabilitation
Hybrid interventions
Central
Venous catheter

ABSTRACT

Purpose: The purpose of this study is to analyze the combined approach of endovascular and open surgical procedures for insertion of permanent central venous catheters in children with intestinal failure and end-stage venous access.
Methods: Data of 14 children (16 interventions) with intestinal failure and end-stage venous access, treated within the pediatric intestinal rehabilitation program at our institution between September 2011 and November 2016, were retrospectively reviewed. The patients underwent hybrid endovascular/open surgical approaches for insertion of central venous catheters. Access to central veins was established through endovascular intervention; catheter placement was achieved with combined interventional and surgical measures depending on the individual vascular conditions.
Results: Median age at intervention was 47 months (interquartile range (IQR),29–74), median time for interventions was 66 min (IQR,42–111). Catheter placement was successfully achieved in all patients. The median dose of irradiation during angiography was 0.2 Gy*cm^2 (IQR, 0.2–0.6), no complications occurred during or after interventions.
Conclusions: Hybrid endovascular/open surgical procedures can be successfully applied for restoring or maintaining permanent central venous catheters in children with intestinal failure and end-stage venous access. These approaches are a valuable contribution in intestinal rehabilitation programs contributing to a further decrease of the need for intestinal transplantation in affected patients.
Type of study: Treatment Study.
Level of evidence: Level IV.

Children with chronic intestinal failure or short bowel syndrome are more and more often treated within comprehensive clinical programs for intestinal rehabilitation [1,2]. These programs address the central aspects of clinical care for affected patients; the success of this development has been documented lately with improved rates of achieving intestinal autonomy, improved survival rates, and a decreasing need for intestinal transplantation [3–5]. However, various threats still remain for affected children, a relevant number of them being associated with the inevitable permanent central venous line. Infection, dislocation or malfunctions of the central catheters regularly make removal and/or replacement of catheters necessary. These catheter complications are associated with the risk of thrombosis within related central veins; over time, children have a relevant risk for loosing vessels suitable for catheter placement [6,7]. According to the criteria for small bowel transplantation as formulated in 2001 by the American Society of Transplantation, loss of more than 50% of central venous catheter sites has been listed as indication for bowel transplantation in affected children [8–10]. Consecutively, preservation or restoration of central veins for catheter placement has a high priority for pediatric intestinal rehabilitation patients.

Few case reports or studies on small patient cohorts have described catheter placement in conditions of end-stage venous access [11–14]; some of these approaches include high-risk surgical procedures or

* Corresponding author at: Department of Pediatric Surgery and Pediatric Urology, University Children's Hospital Tuebingen, Hoppe-Seyler-Str. 3, 72076 Tuebingen, Germany. Tel.: +49 7071 2986621; fax: +49 7071 294046.
E-mail address: steven.warmann@med.uni-tuebingen.de (S.W. Warmann).

http://dx.doi.org/10.1016/j.jpedsurg.2017.03.051
0022-3468/

high-risk interventional methods. However, a systematical approach for this condition has so far not been reported.

In this article we describe our experiences with hybrid interventions combining surgical and interventional procedures for central catheter placement in a series of pediatric intestinal rehabilitation patients with end-stage venous access.

1. Materials and methods

We analyzed hybrid interventions for permanent central line placement in 14 children at our institution's pediatric intestinal rehabilitation program between September 2011 and November 2016. Indications for catheter placement included catheter dislocation, malfunction, disruption or requirement following previous removal caused by infection.

All children with a history of multiple (more than 2) previous central venous catheter placements as well as those children with evidence for vascular thrombosis of their central veins underwent ultrasound scan of their vascular system. If thrombosis of a large vein was identified or if the vascular status of the upper central veins could not be clarified via ultrasound, children underwent contrast enhanced cross-section imaging analysis. The decision to perform catheter placement as hybrid intervention was taken on an interdisciplinary platform based on the clinical course of children so far, especially regarding their vascular conditions at the time of evaluation for catheter placement. Evaluation of the diagnostic workup as well as determination of the interventional strategy was undertaken in consensus reading between a pediatric surgeon, pediatric cardiologist, and pediatric radiologist.

All hybrid interventions were performed under general anesthesia. Depending on the patients' size a 4.2 or 6.6 single lumen permanent central venous catheter was implanted. Children received a single shot i.v. antibiotic prophylaxis at the beginning of intervention.

In case of an existing catheter within the vessel (whether displaced or not), the catheter was surgically dissected at the site of entrance into the vessel and was then cut through. Using the Seldinger technique, a split cannula was introduced into the vessel either directly or via a vascular lock. Once the split cannula was in place, the placement of the new permanent central catheter was performed surgically via the classical way with thoracal insertion, subcutaneous tunneling, and intravascular placement through the split cannula.

If a new access to the vessel had to be established, this was performed via stereotactic puncture of the central vein or an accessible collateral vessel. If necessary, central vessels were re-canalized for placement of the split cannula. Vascular management in such cases included various techniques such as balloon dilatation after guide-wire placement or stent management. When not possible otherwise, angiography and/or re-canalization was performed using the access via the femoral and inferior cava vein.

Data analysis was carried out with regard to patient related data, clinical and intervention-specific data, as well as complications, and outcome. Written informed consent for interventions was obtained from the parents of all patients; the study was approved by the institution's internal review board,

1.1. Statistical analysis

Data analysis was performed using the JMP® 11.2 statistical software (SAS Institute, Cary, NC). Quantitative data are summarized with the median, interquartile range (IQR), and minimum and maximum values.

2. Results

2.1. Patients' related data (Table 1)

During the study period 187 children were registered within the institution's pediatric intestinal rehabilitation program. Permanent central line placement was performed in 32 children; hybrid interventions were used in 14 patients.

Table 1
Baseline patient characteristics and intervention specific data (BSA: body surface area).

	Median	Interquartile range	Min–Max
Age at examination [M]	49	32–148	11–198
Height [cm]	98	86–120	73–160
Weight [kg]	14	9–22	6–37
BSA [m^2]	0.63	0.46–0.86	0.39–1.31
Intervention time [min]	66	49–110	24–217
Fluoroscopy time [s]	198	128–416	63–574
Fluoroscopy dose [Gy*cm^2]	0.3	0.1–0.9	0.0–2.1
Contrast agent (n = 8) [ml]	10	4–26	2–60

These 14 children underwent 16 hybrid interventions combining interventional and surgical techniques. Median age of the patients at intervention was 49 months, median weight was 14 kg, and median body surface area was 0.63 m^2. All children had thrombosis of more than 50% of central venous catheter sites (Table 2), the number of previously inserted central venous catheters ranged from 4 to 12.

Of the 14 patients, 9 had anatomical short bowel syndrome as underlying disease (5 after necrotizing enterocolitis, 3 after gastroschisis, 1 after volvulus). Short bowel length in these 9 patients ranged between 25 and 85 cm. Chronic intestinal failure was the underlying disease in the remaining 5 children (1 after infection, 1 after intestinal ischemia, 1 after stem cell transplant for lymphohistiocytosis, and 2 with Microvillus Inclusion Disease, MVID). Amount of parenteral nutrition-administered energy ranged between 85 and 100%.

Of the 16 interventions, 7 catheter exchanges were necessary because of catheter dislocation, malfunction or disruption. In these cases the Seldinger technique was applied as described above. In 9 of the 16 interventions a completely new catheter placement was necessary. In these cases, vascular access was realized after stereotactic puncture of the central vessel, a remaining vascular stump (Fig. 1) or a collateral vessel (Fig. 2).

2.2. Intervention-related data (Table 1)

The median intervention time in all children was 66 min; the median time of fluoroscopy was 198 s. The median dose of irradiation during fluoroscopy was 0.3 Gy*cm^2. Contrast medium was used in 8/16 interventions with a median amount of 10 ml. Additional endovascular

Table 2
Patency of major veins per patient before hybrid intervention.

Pat. No.	SVC	rEJV	lEJV	rIJV	lIJV	rSV	lSV	rBV	lBV	AV
1	o	x	x	o	x	x	~	o	x	o
2	~	o	o	x	x	~	o	o	o	x
3	o	x	o	o	x	o	x	o	x	o
4	x	x	x	x	x	o	o	o	x	x
5	o	x	o	x	x	x	o	~	o	~
6	o	x	x	x	x	x	o	o	x	x
7	o	x	x	x	o	o	o	o	o	o
8	o	x	x	o	o	x	~	o	o	x
9	o	x	x	x	x	o	o	x	o	o
10	o	x	o	x	x	o	o	o	o	o
11	o	x	x	x	~	o	x	o	x	x
12	o	o	x	x	x	~	x	o	o	o
13	o	x	x	x	o	o	o	o	o	o
14	o	x	x	x	x	o	o	x	o	o
Occluded ∑	1	12	10	11	10	4	3	2	5	5

Vascular status: o = patent vessel; x = occluded vessel, ~ = stenotic vessel.
Vessels: SVC superior vena cava; rEJV right external jugular vein; lEJV left external jugular vein; rIJV right internal jugular Vein; lIJV left internal jugular vein; rSV right subclavia vein, lSV left subclavia vein; rBV right brachiocephalic vein; lBV left brachiocephalic vein, AV anonyma vein.
Two patients received 2 interventions; their vascular status was the same before both interventions.