بسم الله الرحمن الرحيم

Principles of neonatal kidney support in AKI

Ihab El-Hakim

Professor of Pediatric Nephrology

Ain Shams University

Agenda

- When to start RRT in neonates with AKI?
- How to choose the suitable technique?
- What about the outcome?

Impact of fluid balance in critically ill newborn Prof. Hafez Bazaraa (Cairo University- Egypt)	Risk/prevention /treatment
Principles of neonatal kidney support in AKI Prof. Ihab Elhakim (Ain Shams University- Egypt)	Treatment
Renal consequences of preterm birth Prof. Iman Iskander (Cairo University- Egypt)	Risk
Kidney in hypoxic-ischemic encephalopathy Prof. Hesham Awad (Ain Shams University- Egypt)	Risk
Predictors of good & bad prognosis of AKI in NICU Prof. Alaa Thabet (Alexandria University - Egypt)	Prognosis
CAKUT (congenital anomalies of kidney & urinary tract) Prof. Happy Sawires (Cairo University - Egypt)	Risk

Neonatal Acute Kidney Injury: A Survey of Neonatologists' and Nephrologists' Perceptions and Practice Management

Am J Perinatol. ,2017

A. L. Kent, BMBS, FRACP, MD[1,*] J. R. Charlton, MSc, MD[2,*] R. Guillet, MD, PhD[3] K. M. Gist, DO, MSc[4]
M. Hanna, MD[5] A. El Samra, MD[6] J. Fletcher, MBBS, FRACP, PhD[7] D. T. Selewski, MD, MS[8]
C. Mammen, MD, MHSc[9]

Three hundred and seventy-five physicians

(244 neonatologists and 131 pediatric nephrologists).

Table 5 Factors considered important by clinicians in neonatal renal dialysis

	Very important	Somewhat important	Not very important	Irrelevant	*p*-Value
Peak SCr					
Neonatologist (%)	49	44	5	2	0.00005
Nephrologist (%)	25	45	25	5	
Duration/Elevation of SCr					
Neonatologist (%)	62	34	2	2	0.03
Nephrologist (%)	48	41	11	1	
Presence/Duration oliguria					
Neonatologist (%)	76	23	0.5	0.5	0.55
Nephrologist (%)	84	15	1	0	
Elevated BUN					
Neonatologist (%)	25	51	21	4	0.57
Nephrologist (%)	30	53	14	3	
Elevated potassium					
Neonatologist (%)	84	15	1	0	0.77
Nephrologist (%)	84	13	3	0	
Metabolic acidosis					
Neonatologist (%)	47	45	7	2	0.15
Nephrologist (%)	63	33	4	0	
Size of infant					
Neonatologist (%)	48	37	14	1	0.81
Nephrologist (%)	43	42	13	2	
Fluid overload					
Neonatologist (%)	58	37	5	0	<0.00001
Nephrologist (%)	93	6	1	0	

An important finding of this survey was that neonatologists and nephrologists significantly differed in their view of the indications for dialysis and the relative importance of fluid overload. Fluid overload currently represents the most common indication for initiation of dialysis in critically ill children. Furthermore, the degree of fluid overload has been shown to adversely impact outcomes. At this time, little is known about the impact of fluid overload on outcomes in neonates, and further study is warranted to understand its contribution to outcomes and as a therapeutic target.

Agenda

- **When to start RRT in neonates with AKI?**
- How to choose the suitable technique?
- What about the outcome?

Indications for RRT in AKI

- Fluid overload ≥ 10-15 percent
- Non-obstructive oliguria not responsive to diuretics
- Uremic organ involvement (pericarditis, encephalopathy)
- Escalating ventilatory requirements, especially if related to volume status
- Overdose with a dialyzable drug
- Need for adequate nutrition, especially when compromised by fluid restriction or electrolyte abnormalities
- Need for provision of large volumes of medications or blood products in a patient already >10 percent fluid overloaded
- BUN 80-100 mg/dL (lower than children due to muscle mass)
- Life-threatening metabolic derangements refractory to medical management (hyperkalemia, acidosis, dysnatremia or hyperammonemia).
- Refractory edema not responding to high-dose diuretics.

NEPHROLOGY AND FLUID/ELECTROLYTE PHYSIOLOGY

Neonatology Questions and Controversies

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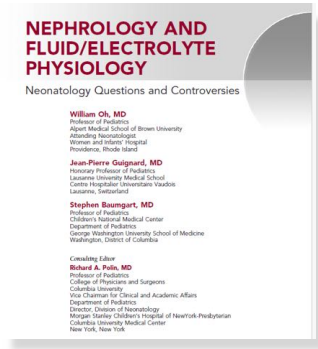
2012



The indications to initiate RRT are not absolute and take into consideration:

- The cause of kidney injury
- The rapidity of the onset of kidney injury
- The severity of fluid and electrolyte abnormalities
- The nutritional needs of the neonate

KI REPORTS KIReports.org Kidney International Reports (2022) 7, 2108–2111 · RESEARCH LETTER

STARZ Neonatal AKI Risk Stratification Cut-off Scores for Severe AKI and Need for Dialysis in Neonates

Sidharth Kumar Sethi[1,7], Rupesh Raina[2,7], Sanjay Wazir[3], Gopal Agrawal[3], Ananya Vadhera[4], Nikhil Nair[5,6], Kritika Soni[1], Abhishek Tibrewal[2], and on behalf of the TINKER Working Group[8]

Table 1. STARZ scoring model

Variables		Assigned score
Age at entry in NICU (hs)	<25.5	6
	≥25.5	0
PPV in the delivery room	Yes	7
	No	0
Gestational age (wks)	<28	7
	≥28	0
Sepsis (during the NICU stay)	Yes	6
	No	0
Significant cardiac disease	Yes	10
	No	0
Urine output[a] (ml/kg/h)	<1.32	7
	≥1.32	0
Serum creatinine[a] (mg/dl)	≥0.98	20
	<0.98	0
Use of nephrotoxic drugs	Yes	11
	No	0
Use of furosemide	Yes	9
	No	0
Use of inotropes	Yes	17
	No	0

STARZ model (0–100)

A value of ≥31.5 indicates greater probability of AKI incidence within 7 days post NICU admission

To summarize, we found the following cut-offs for neonatal AKI prediction:

- STARZ score > 31.5 predicts high probability of AKI
- STARZ score > 59 predicts high probability of severe AKI
- STARZ score > 66 predicts high probability of severe AKI with the need for PD.

Agenda

- When to start RRT in neonates with AKI?
- **How to choose the suitable technique?**
- When to stop?

	PD	HD	CVVH or CVVHD
Solute removal	Good	Excellent	Fair (excellent)
Fluid removal	Good	Excellent	Excellent (excellent)
Toxin removal	Fair	Excellent	Fair (good)
Removal of potassium	Fair	Excellent	Fair (good)
Removal of ammonia	Fair	Excellent	Fair (good)
Need for hemodynamic stability	No	Yes	No (no)
Need for anticoagulation	No	Yes	Variable (variable)
Ease of access	Easy	Variable	Variable (variable)
Continuous	Yes	No	Yes (yes)
Respiratory compromise	Occasional	No	No (no)
Risk for peritonitis	Yes	No	No (no)
Risk for hypotension	Low	High	High (high)
Disequilibrium	No	Yes	No (no)
Reverse osmosis water	No	Yes	No (no)

Dialysis modality in AKI

Variable	PD	IHD	CRRT
Continuous therapy	Yes	No	Yes
Hemodynamic stability	Yes	No	Yes
Fluid balance achieved	Yes/No, Cycle dependent	Yes/No, Intermittent	Yes, pump controlled
Ease of use	Yes	No	No
Adequate nutrition delivery	variable	variable	Yes
Solute control	Yes	Yes	Yes
Ultrafiltration control	Variable	Yes	Yes
Anticoagulation	No	Yes	Yes
Acute ingestion removal	No	Yes	Variable
Continuous toxin removal	Variable	No	Yes
ICU nursing needs	Low	High	High
Patient mobility	No	Yes	No
Cost	Low	High	High
Vascular access need	No	Yes	Yes
Infection potential	Yes	Yes	Yes
Use in inborn-errors of metabolism	No	Yes	Yes

PD

PERITONEAL DIALYSIS INTERNATIONAL

Peritoneal Dialysis International
1–19

DOI: 10.1177/0896860820982120
journals.sagepub.com/home/ptd
SAGE

ISPD guidelines for peritoneal dialysis in acute kidney injury: 2020 Update (paediatrics)

Peter Nourse[1], Brett Cullis[2], Fredrick Finkelstein[3], Alp Numanoglu[4], Bradley Warady[5], Sampson Antwi[6] and Mignon McCulloch[1]

1.1 Peritoneal dialysis is a suitable renal replacement therapy modality for treatment of acute kidney injury in children. (**1C**)

2. Access and fluid delivery for acute PD in children.

2.1 We recommend a Tenckhoff catheter inserted by a surgeon in the operating theatre as the optimal choice for PD access. (**1B**) (**optimal**)

2.2 Insertion of a PD catheter with an insertion kit and using Seldinger technique is an acceptable alternative. (**1C**) (**optimal**)

2.3 Interventional radiological placement of PD catheters combining ultrasound and fluoroscopy is an acceptable alternative. (**1D**) (**optimal**)

2.4 Rigid catheters placed using a stylet should only be used when soft Seldinger catheters are not available, with the duration of use limited to <3 days to minimize the risk of complications. (**1C**) (**minimum standard**)

2.5 Improvised PD catheters should only be used when no standard PD access is available. (**practice point**) (**minimum standard**)

2.6 We recommend the use of prophylactic antibiotics prior to PD catheter insertion. (**1B**) (**optimal**)

2.7 A closed delivery system with a Y connection should be used. (**1A**) (**optimal**) A system utilizing buretrols to measure fill and drainage volumes should be used when performing manual PD in small children. (**practice point**) (**optimal**)

2.8 In resource limited settings, an open system with spiking of bags may be used; however, this should be designed to limit the number of potential sites for contamination and ensure precise measurement of fill and drainage volumes. (**practice point**) (**minimum standard**)

2.9 Automated peritoneal dialysis is suitable for the management of paediatric AKI, except in neonates for whom fill volumes are too small for currently available machines. (1D)


Merocath
Catheter ID

4. Prescription of acute PD in paediatric patients

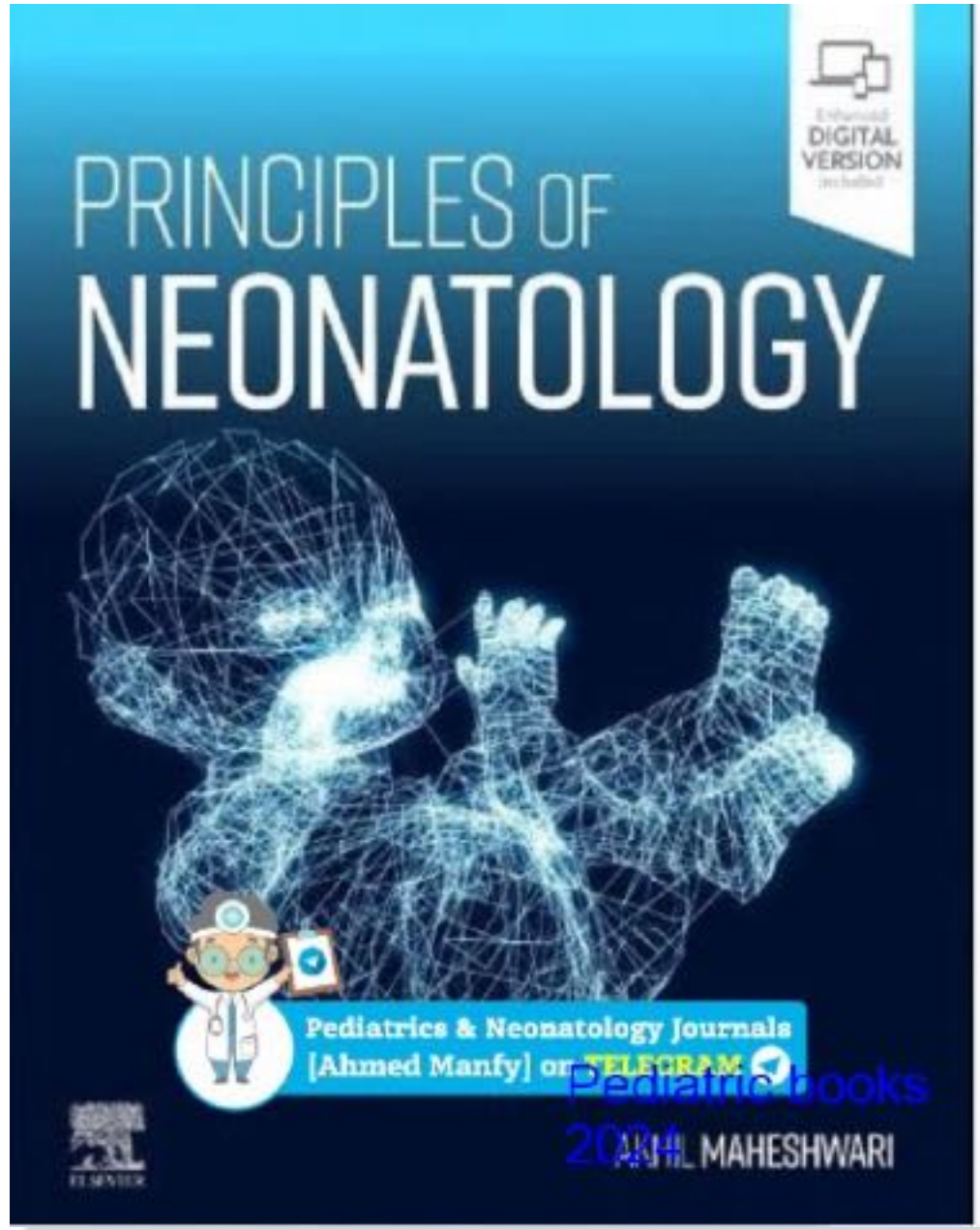
4.1 The initial fill volume should be limited to 10–20 ml/kg to minimize the risk of dialysate leakage; a gradual increase in the volume to approximately 30–40 ml/kg (800–1100 ml/m^2) may occur as tolerated by the patient. (**practice point**)

4.2 The initial exchange duration, including inflow, dwell and drain times, should generally be every 60–90 min; gradual prolongation of the dwell time can occur as fluid and solute removal targets are achieved. In neonates and small infants, the cycle duration may need to be reduced to achieve adequate ultrafiltration. (**practice point**)

4.3 Close monitoring of total fluid intake and output is mandatory with a goal to achieve and maintain normotension and euvolemia. (**1B**)

4.4 Acute PD should be continuous throughout the full 24-h period for the initial 1–3 days of therapy. (**1C**)

4.5 Close monitoring of drug dosages and levels, where available, should be conducted when providing acute PD. (**practice point**)


DIGITAL VERSION
PRINCIPLES OF
NEONATOLOGY
Pediatrics & Neonatology Journals
[Ahmed Manfy] on TELEGRAM
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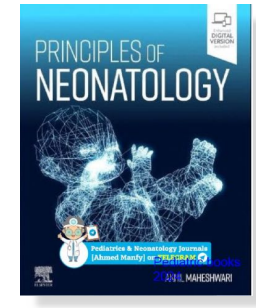
MAHESHWARI



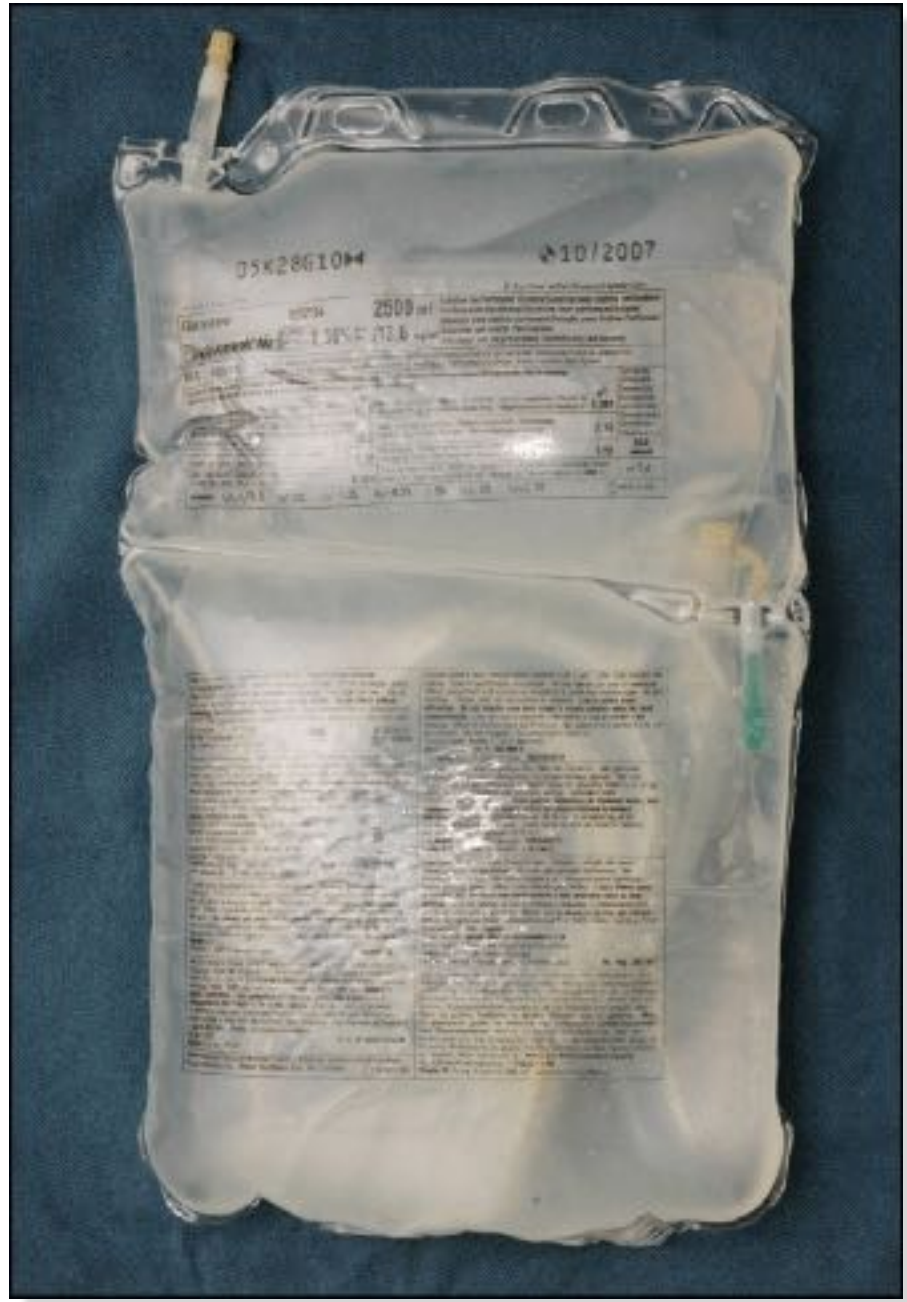
Prescription:

- Fill volume 5-10 mL/kg body weight then gradually increased as needed.
- Use commercially available 1.5% or 4.25% glucose solutions warmed to body temperature.

Table 59.2 Composition of a Typical Commercially Available PD Fluid[a]	
OSMOTIC AGENTS	
Dextrose	1.5–4.25 g/dL
Icodextrin	7.5 g/dL
Amino acids	1.1 g/dL
ELECTROLYTES	
Sodium	135 mmol/L
Calcium	1.25 mmol/L
Magnesium	0.25–0.75 mmol/L
Chloride	96–109 mmol/L
BUFFER	
Lactate	35–40 mmol/L
Bicarbonate	25 mmol/L
Lactate/bicarbonate	30–40 mmol/L

[a]The dialysis fluid is generally composed of an osmotic agent, a buffer, and electrolytes. These components can be modified to affect blood purification and fluid removal via ultrafiltration.

PD, Peritoneal dialysis.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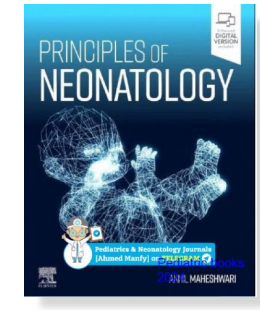
2500 ml



Relative contraindications:

- recent abdominal surgery
- massive organomegaly
- intraabdominal masses
- Ostomies

Complications of Peritoneal Dialysis

- Technical complications
  - Catheter-related problems
  - Mechanical complications
    - Inflow pain
    - Outflow failure
- Clinical complications
  - Complications related to increased intra-abdominal pressure:
    - Hernia
    - Genital and abdominal edema
    - Leakages
    - Hydrothorax
    - Alterations of respiratory function
  - Metabolic complications
    - Hyperglycemia
    - Hypo/Hypernatremia
    - Hypo/Hyperkalemia
    - Acidosis/Alkalosis
    - Protein and amino acid losses
  - Infectious complications
    - Peritonitis
    - Exit site infection
    - Tunnel infection

Peritoneal Dialysis International, Vol. 37, pp. 389–396
www.PDIConnect.com

0896-8608/17 $3.00 + .00

PERITONEAL DIALYSIS IN VERY LOW BIRTH WEIGHT NEONATES

Vesna D. Stojanović,[1] Svetlana S. Bukarica,[2] Jelena B. Antić,[2] and Aleksandra D. Doronjski[3]

Ten VLBW neonates were treated by PD, 3 male and 7 female. The patient clinical and treatment characteristics are presented in Table 1. Mean age at the moment of starting PD was 14.9 ± 9.3 days (range 2 – 28 days), mean BW was 825 ± 215g (range 470 – 1,210 g), and the average gestational age was 26.3 ± 1.1 weeks (range 25 – 28 weeks). The average duration of dialysis was 20.5 ± 14.7 h (range 3 – 36 h). The exchanges were done every 10 – 60 minutes. The average UF was 7.7 ± 4.2 mL/kg/h. All the patients were intubated and on mechanical ventilation.

Survival 20%.

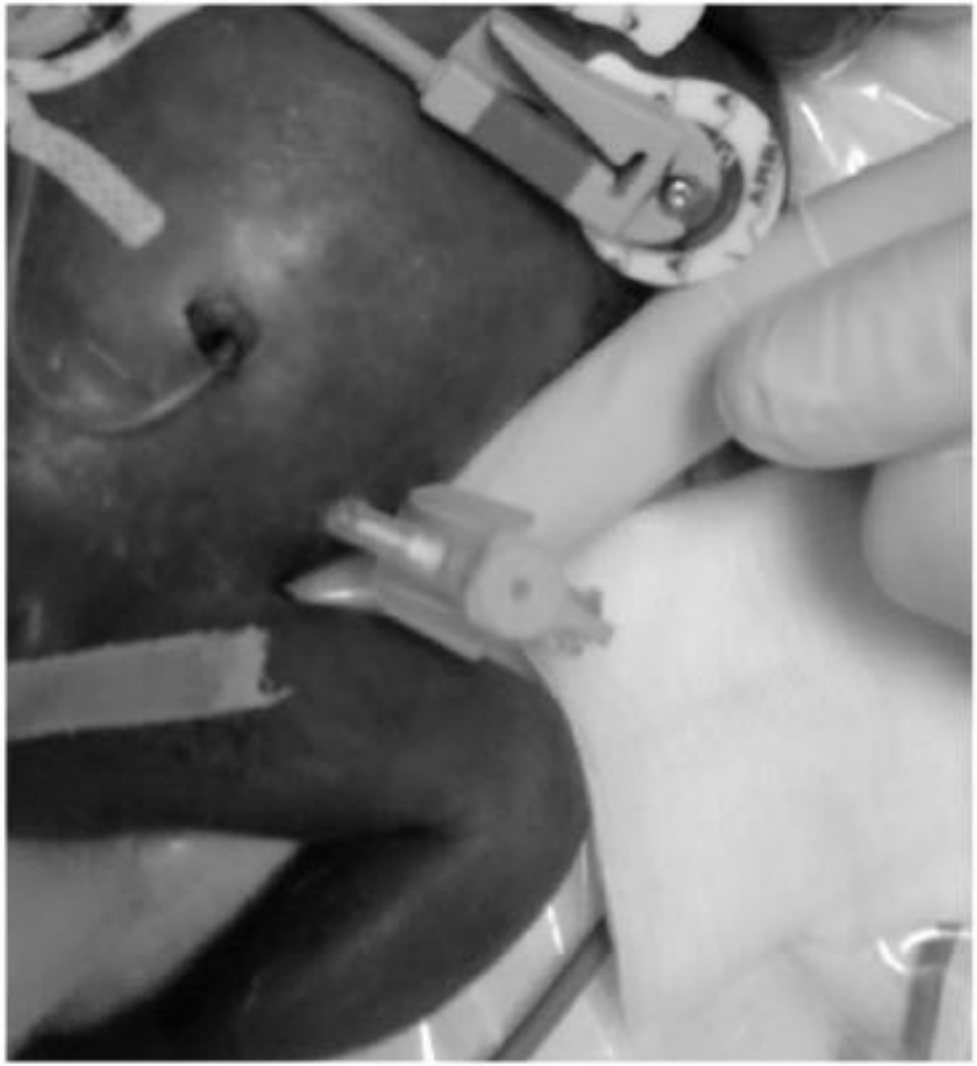


Figure 1 — Intravenous cannula was placed in the peritoneal cavity on the left side of the abdomen, using the blind technique. After the intravenous cannula insertion, the tissue adhesive Epiglu was applied to the entry point.

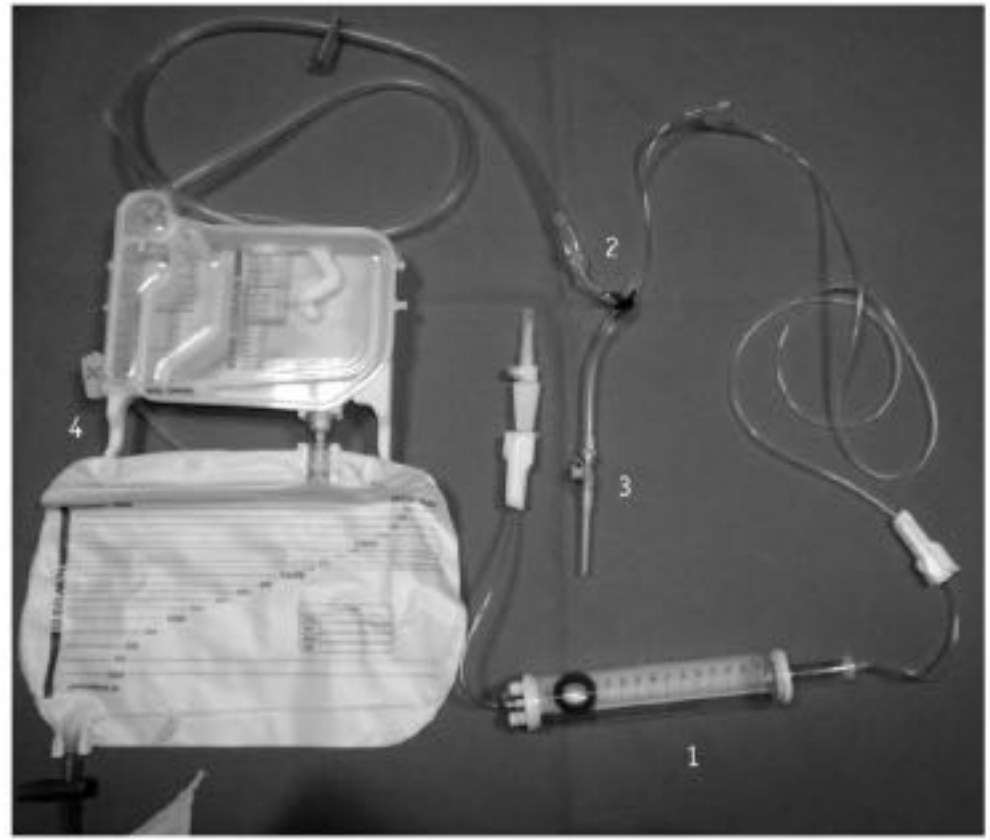


Figure 2 — The improvised PD system. 1) Dosifix 2) 3-way cannula 3) IV cannula 4) Ureofix. PD = peritoneal dialysis; IV = intravenous.

The Turkish Journal of Pediatrics 2020; 62: 1069-1076
https://doi.org/10.24953/turkjped.2020.06.020

Case Report

Peritoneal dialysis as a life-saving procedure in an extremely low birth weight infant: case report and review of the literature

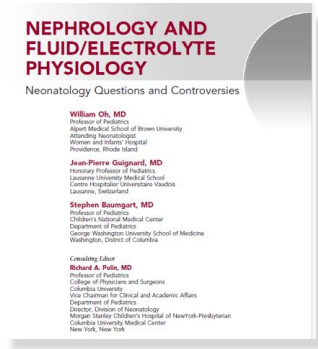
Merih Çetinkaya[1], Tuğba Erener Ercan[2], Sevgi Yavuz[3], Seyithan Özaydın[4]

A female infant was born at 24 weeks with a birth weight of 460 grams.

A neonatal, straight 10Fr single-cuff Tenckhoff catheter (Cook Medical Bloomington, USA) with a length of 8 cm was inserted with a left paramedian entry site above the umbilicus at the bedside by a pediatric surgeon.

In conclusion PD is a relatively safe, effective and a feasible therapy in the neonatal population even in the smallest infants. This also suggests that PD may be a live-saving procedure in ELBW infants with severe AKI.

iHD



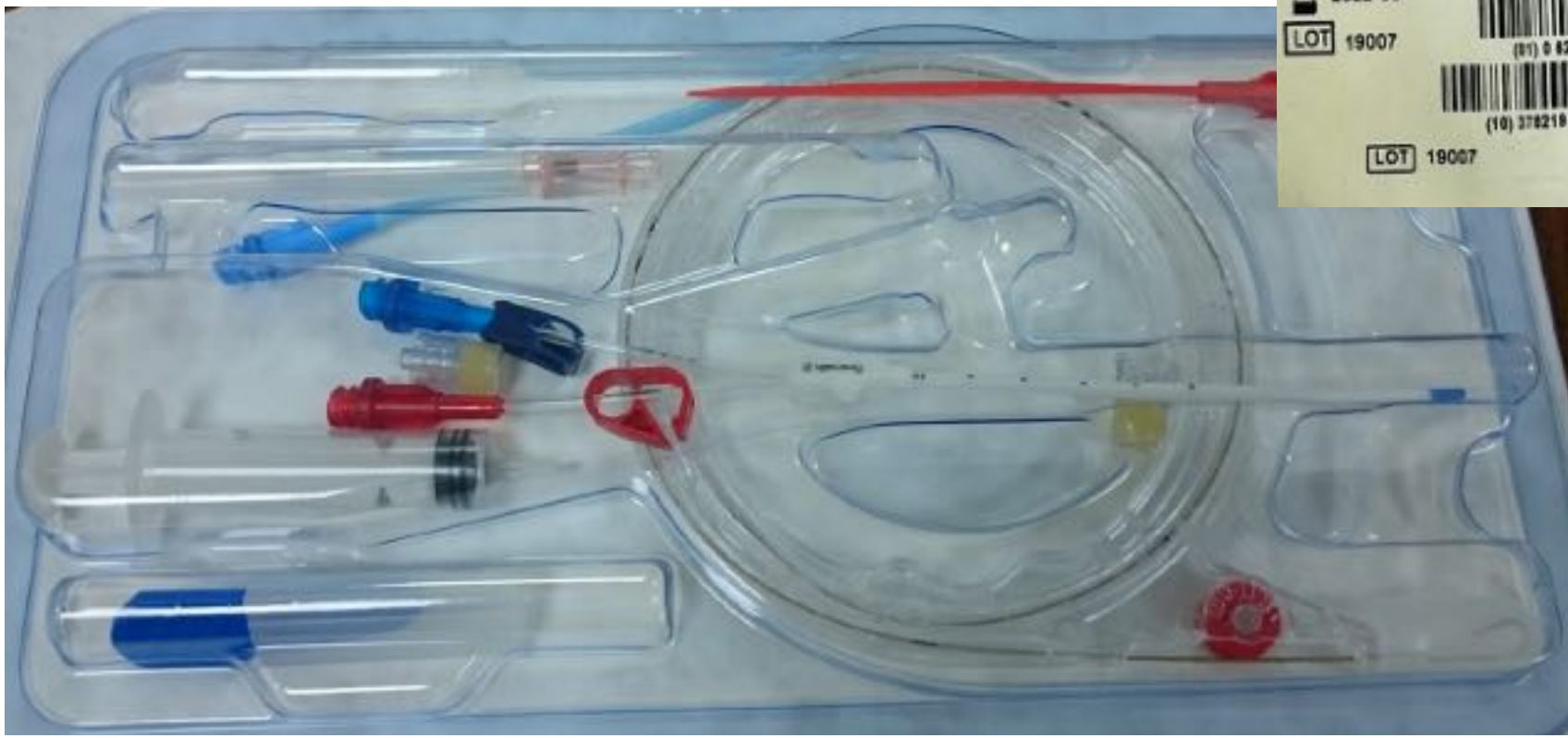
- Vascular access in newborns can be provided by umbilical vessels.
- To avoid hypotension, the total volume of the dialysis circuit should not exceed 10% of the infant blood volume.
- Blood flow rates 1.5-3.0 mL/kg/min.
- frequent hemodialysis (as often as daily) may be needed in neonates.

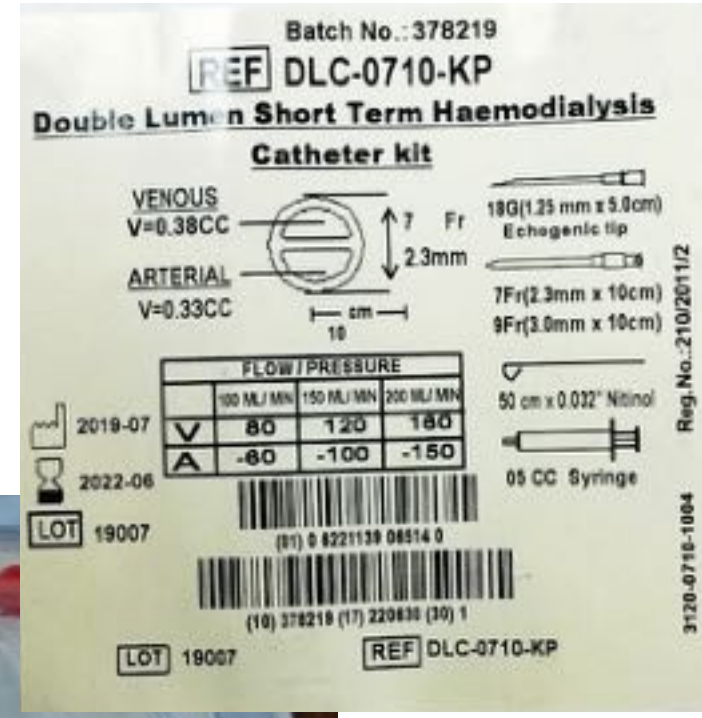
Table 20 | Catheter and patient sizes

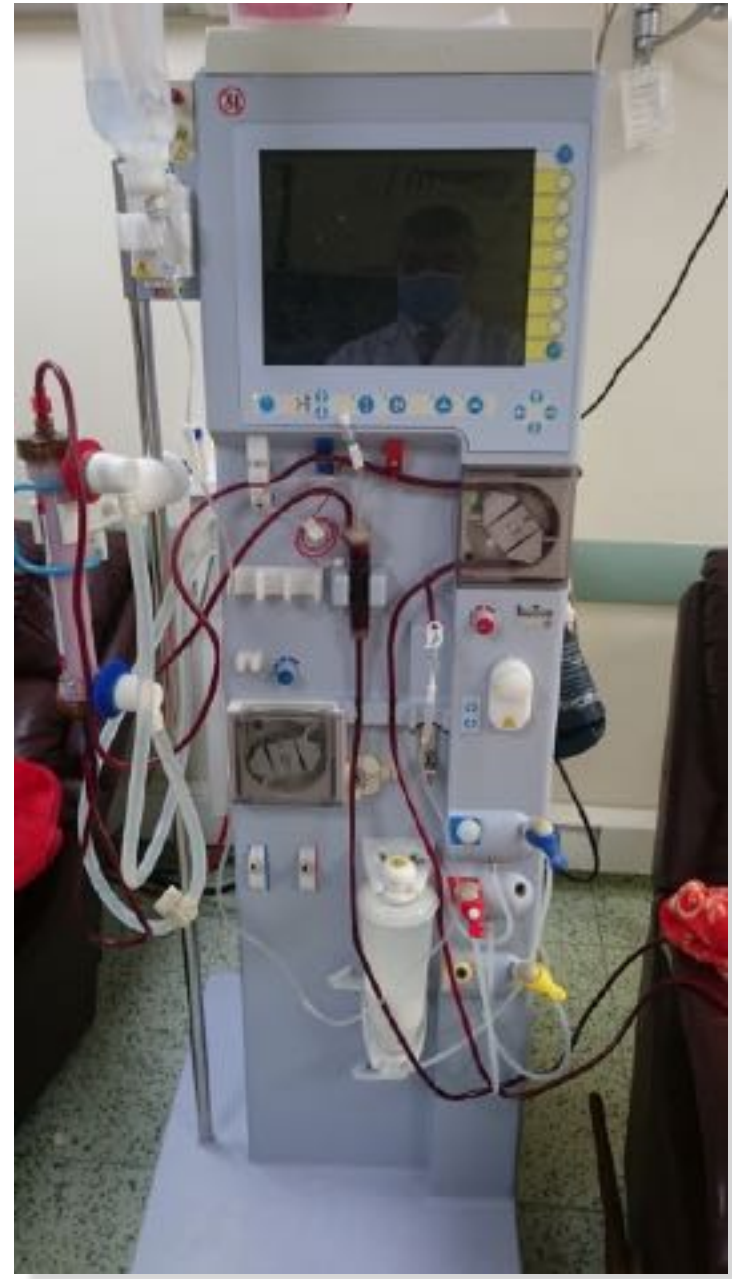
Patient size	Catheter size	Site of insertion
Neonate	Double-lumen 7F	Femoral artery or vein
3-6 kg	Double- or triple-lumen 7F	Jugular, subclavian, or femoral
6–30 kg	Double-lumen 8F	Jugular, subclavian, or femoral
>15 kg	Double-lumen 9F	Jugular, subclavian, or femoral
>30 kg	Double-lumen 10F or triple-lumen 12F	Jugular, subclavian, or femoral

Reprinted from Bunchman TE, Brophy PD, Goldstein SL. Technical considerations for renal replacement therapy in children. Semin Nephrol 2008; 28: 488–492 [687], copyright 2008, with permission from Elsevier; accessed http://www.seminarsinnephrology.org/article/S0270-9295(08)00117-4/fulltext

Double lumen 7F, 10 cm

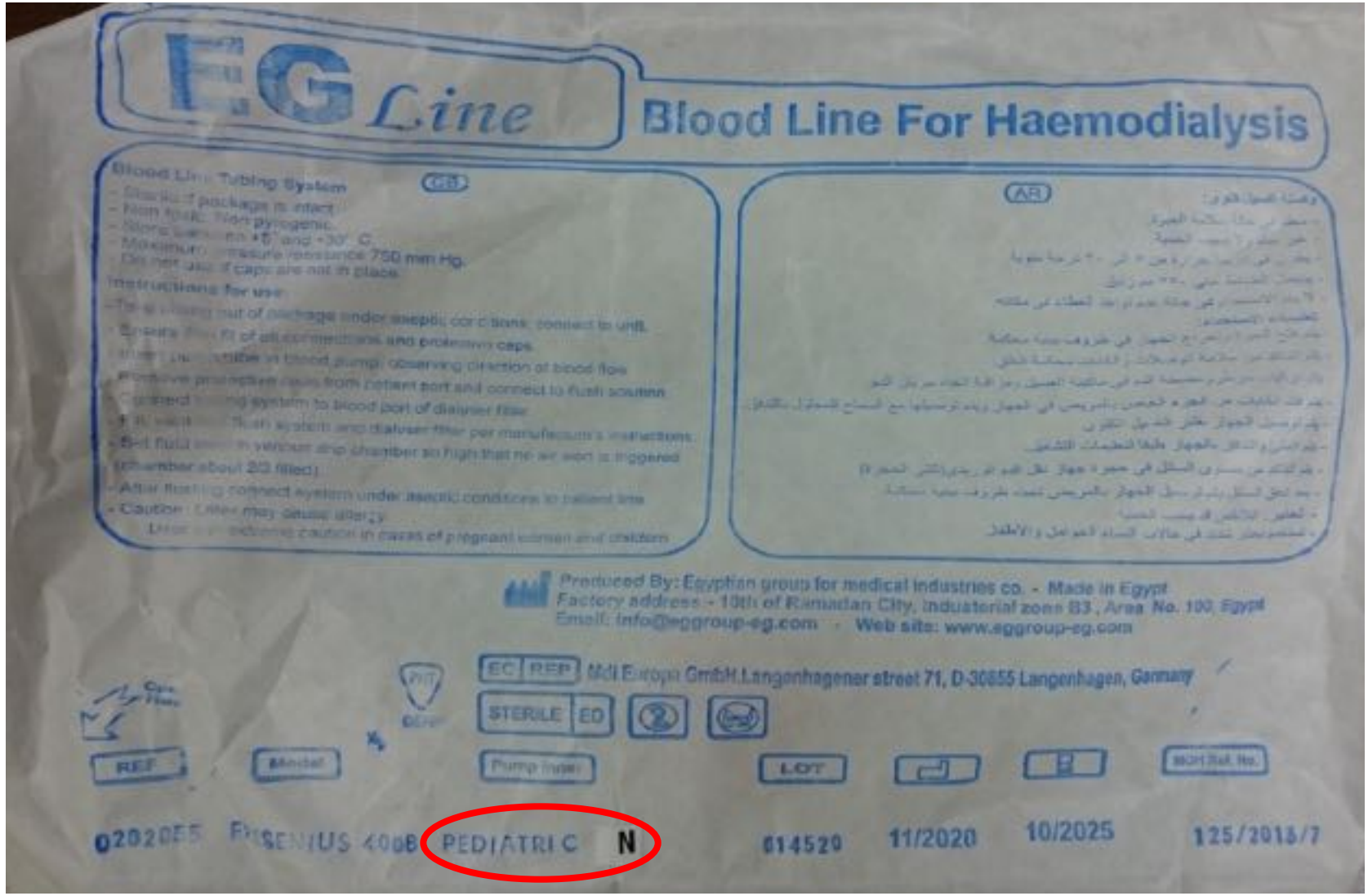






Pediatric line PV 117 mL

Neonatal line PV 56 mL



SA 0.2m², PV 18 mL

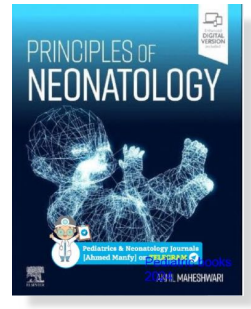
Total extracorporeal circuit volume = 18+56 = 74 mL

A full-term neonate 3 Kg has a total blood volume = 3 x 85 = 255 mL

Major Complications of Intermittent Hemodialysis

Clinical complications
Hypotension
Hypovolemia
Cardiovascular response to hypovolemia
Dialyzer reactions
Hypoxemia
Dialysis disequilibrium syndrome
Febrile reactions
Bleeding
Arrhythmias
Technical complications
Air embolism
Hemolysis
Inappropiate electrolyte composition of dialysate
Low or high sodium content
Low or potassium-free content
Low calcium content
Hard water syndrome

CRRT



Prescription:

- The blood flow rate: start at 6 mL/kg/min and may reach 8 to 12.
- The combined dialysis and replacement rate is 2000-3000 mL/hour/1.73 m^2.
- Anti-coagulation: regional citrate or heparin (bolus of 10 U/kg then infusion 5-20 U/kg/hour)

Advantages:

- continuous procedure
- Hemodynamic stability is not a requirement
- Allow good control of fluid, electrolyte, and acid-base balance
- Can be performed in neonates on ECMO

Disadvantages:

- Need for vascular access
- Need for anticoagulation
- potential for severe fluid and electrolyte abnormalities

Received: 21 April 2020 | Revised: 12 August 2020 | Accepted: 13 August 2020

DOI: 10.1111/apa.15539

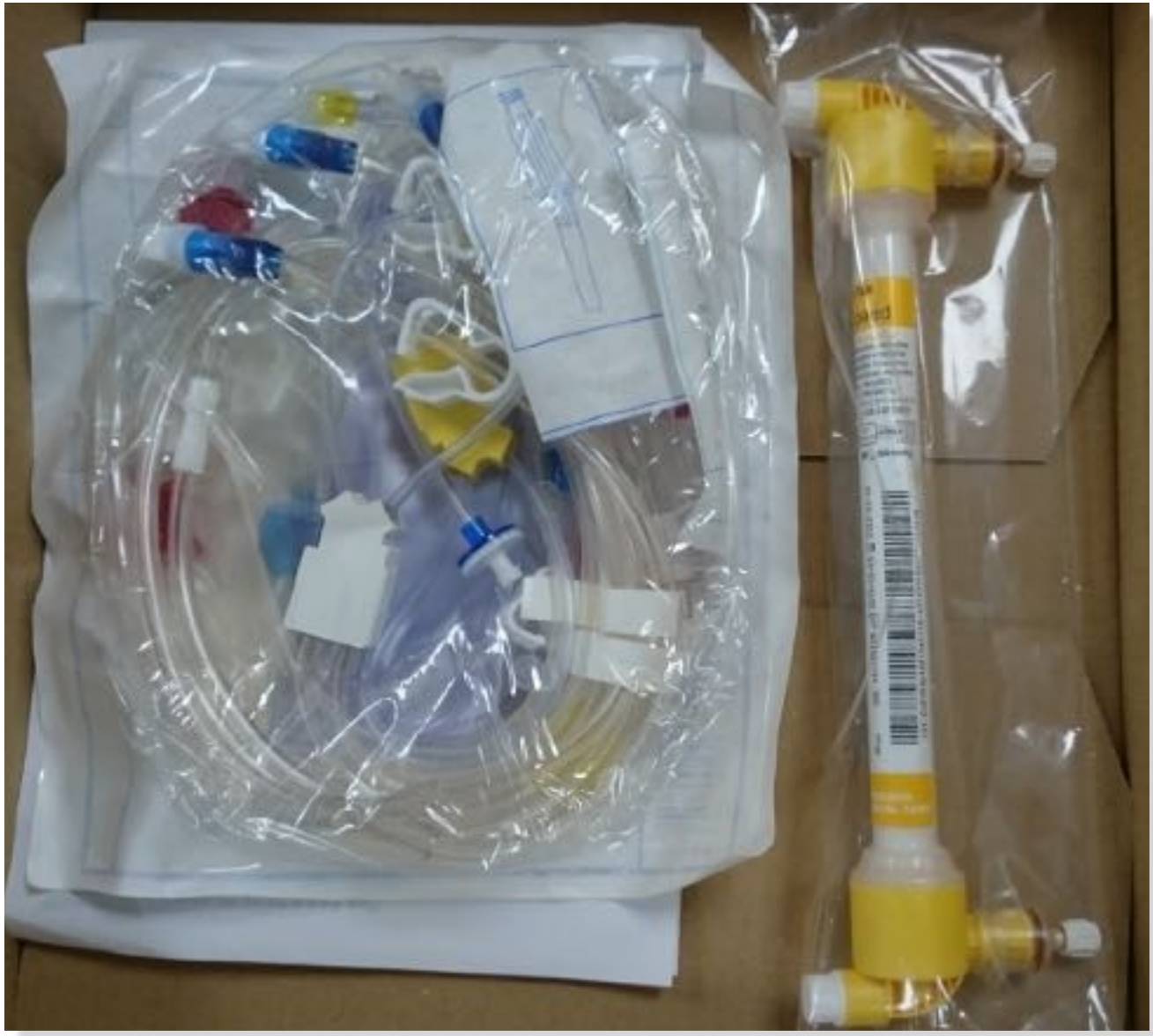
MINI REVIEW

ACTA PÆDIATRICA WILEY

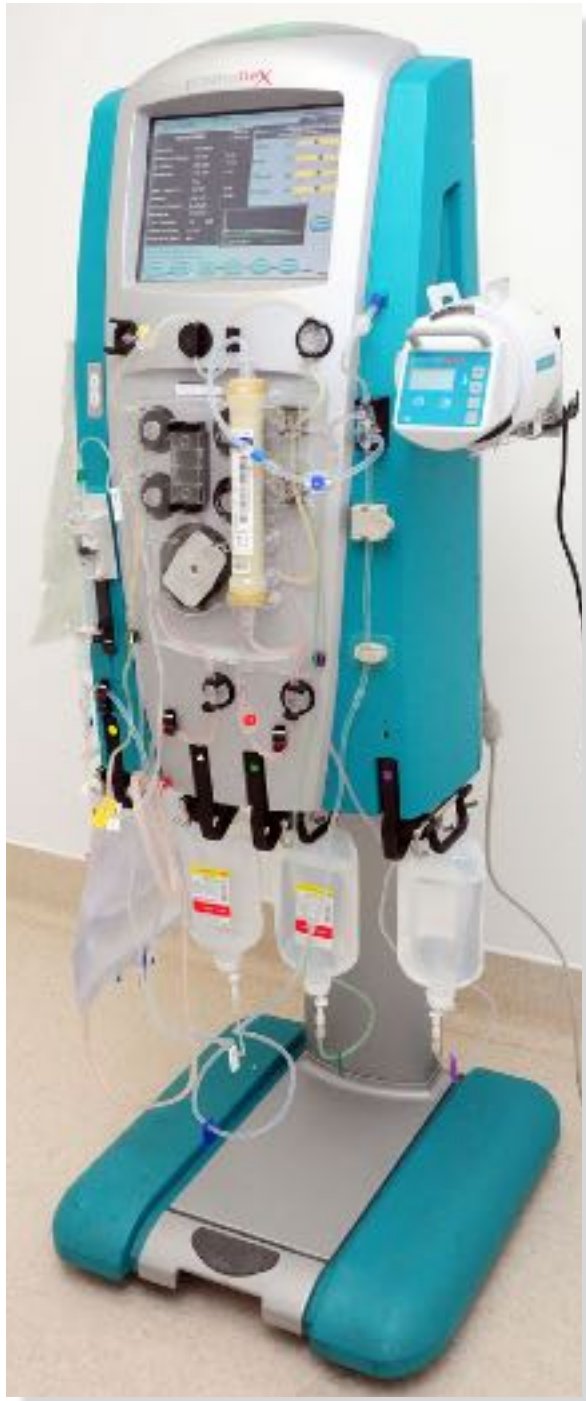
Review: Neonatal dialysis is technically feasible but ethical and global issues need to be addressed

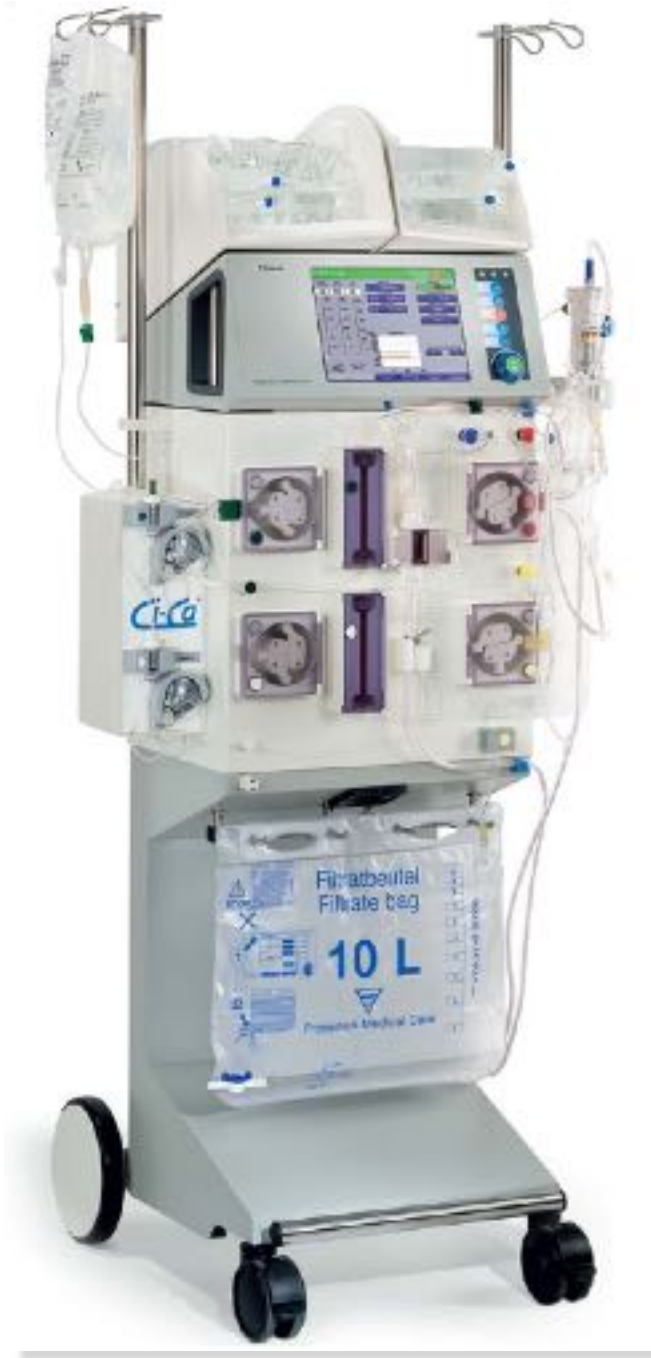
Bruno Ranchin[1] | Franck Plaisant[2] | Delphine Demède[3] | Jean-Marie de Guillebon[1] | Etienne Javouhey[4,5] | Justine Bacchetta[1,5,6]

Device	Extracorporeal volume (ml)
Gambro Prismaflex (Baxter Healthcare, Deerfield, Illinois, USA)	62
Fresenius Multifiltrate (Fresenius Medical Care AG & Co., Bad Homburg vor der Höhe, Germany)	72
Nikkiso Aquarius (Nikkiso Co., Tokyo, Japan)	93
Asahi Kasei Medical Co ACH-Σ (Asahi Kasei Medical Co., Tokyo, Japan)	69
Asahi Kasei Medical Co Plasauto-iQ21 (Asahi Kasei Medical Co., Tokyo, Japan)	45
Infomed HF440 (Infomed, Geneva, Switzerland)	55
Gambro AK98 with Polyflux 2H filter (Baxter Healthcare, Deerfield, Illinois, USA)	55
Gambro AK200S with Polyflux 2H filter (Baxter Healthcare, Deerfield, Illinois, USA)	53
Nikkiso DBB-07 (Nikkiso Co., Tokyo, Japan) with Polyflux 2H filter (Baxter Healthcare, Deerfield, Illinois, USA)	73
Aquadex adapted (CHF Solutions Inc, Eden Prairie, Minneapolis, USA)	33
NIDUS	9 to 17
CARPEDIEM	27, 33 or 42



The total extra-corporeal blood volume is 72 mL
AV paed set (54 mL)
+ Ultraflux® AV Paed (18 mL, SA 0.2 m^2).

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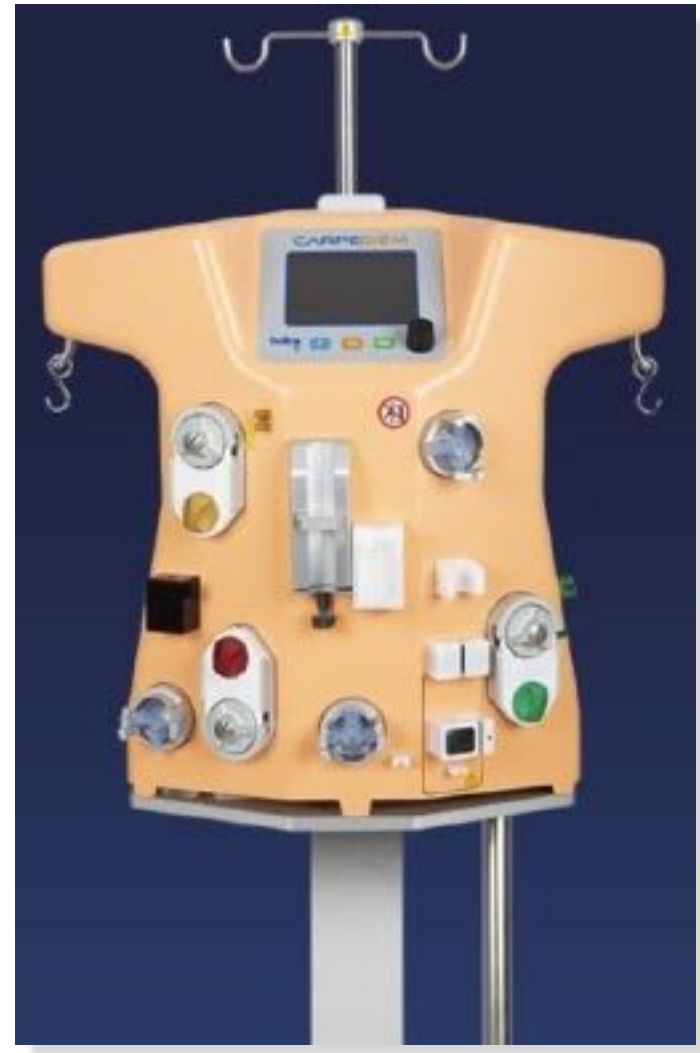
Filtrate bag
10 L

Newcastle, Allmed



Ronco, Medtronic

Table 38.1 Characteristics of the minifilters

	First prototype	Minifilter	Minifilter plus
Overall length (cm)	13	13	17
Effective length (cm)	7	12.7	12.7
Diameter (cm)	1.5	1.7	2.5
Membrane type	Assymm. PSF	Assymm. PSF	Assymm. PSF
Membrane area (cm^2)	50	210	800
Fiber int. diameter (μm)	1100	1100	570
Priming volume (mL)	2.8	7.6	15
Pr drop (50 mL/min) (mmHg)	2.5	3.5	5
Number of fibers	25	60	450
Range of ultraf. (mL/min)	0.2–0.5	1–2.5	1–8

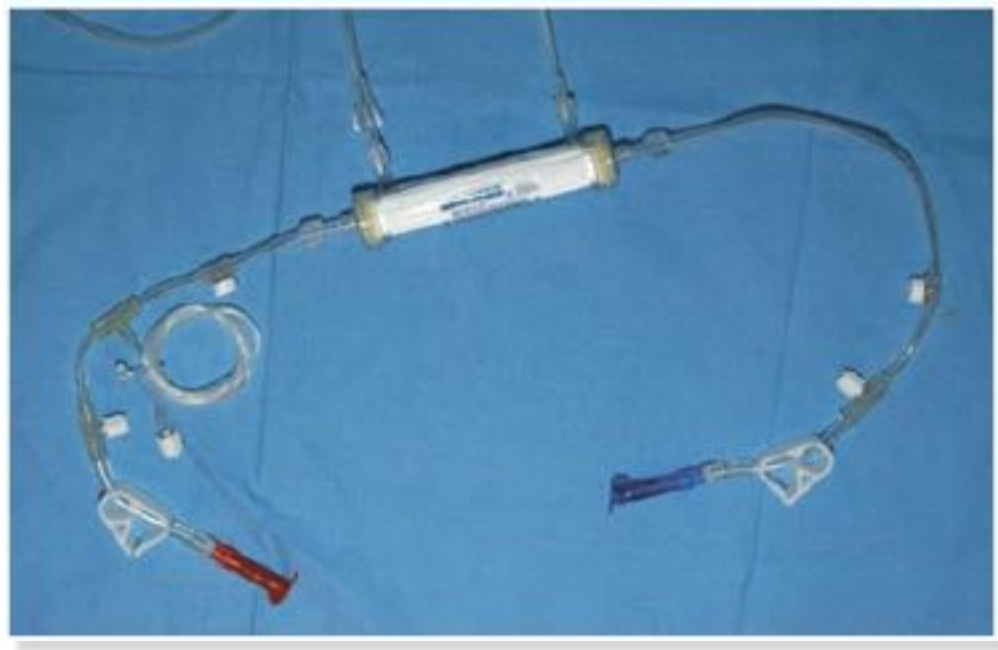


Table 7.1 Comparison of techniques [12]

	IHD	CVVH	CVVHD	CVVHDF	SLEDD	SCUF
Membrane permeability	Variable	High	High	High	Variable	High
Blood flow rate (ml/min)	250–400	200–300	100–300	200–300	100–200	100–200
Dialysate flow rate (ml/min)	500–800	0	16–35	16–35	100–300	0
Filtrate (l/day)	0–4	24–96	0–4	24–48	0–24	0–24
Replacement fluid (l/day)	0	21–90	0	23–44	0	0
Effluent saturation (urea, %)	15–40	100	85–100	85–100	60–70	100
Solute clearance	Diffusion	Convection	Diffusion	Diffusion + convection	Diffusion	Convection (minimal)
Urea clearance (ml/min)	180–240	17–67	22	30–60	75–90	1.7
Duration (h)	3–6	> 24	> 24	> 24	Variable	Variable

Potential Complications of Infant CRRT

- Volume related problems
- Biochemical and nutritional problems
- Hemorrhage, infection
- Thermic loss
- Technical problems
- Logistical problems

Agenda

- When to start RRT in neonates with AKI?
- How to choose the suitable technique?
- **What about the outcome?**

Original Article

Pediatrics and Neonatology (2018) 59, 474–480

Renal replacement therapy in the neonatal intensive care unit

Tze Yee Diane Mok [a], Min-Hua Tseng [b], Ming-Chou Chiang [a], Ju-Li Lin [a], Shih Ming Chu [a], Jen-Fu Hsu [a], Reyin Lien [a,*]

	CRRT (n = 12)	PD (n = 5)	P value
Demographic variables			
Male patients	5 (42%)	4 (80%)	0.438
Gestational age (weeks)	37 (32–39)	38 (33–39)	0.525
Mortality (%)	7 (58%)	4 (80%)	0.171
RRT Clinical Data			
Body weight at initiation (kg)	2.8 (1.9–3.6)	2.7 (1.5–2.8)	1.000
Age at initiation (days)	4 (2–30)	9 (4–26)	0.569
Duration of RRT (days)	7.5 (1–65)	25 (2–84)	0.77
Serum BUN at initiation	20.8 (6.8–55)	60.5 (8–79)	0.569
Serum Cr at initiation	1.7 (0.36–3.87)	3.73 (0.35–6.02)	0.569
Length of stay (days)	40 (3–330)	57 (13–98)	0.192

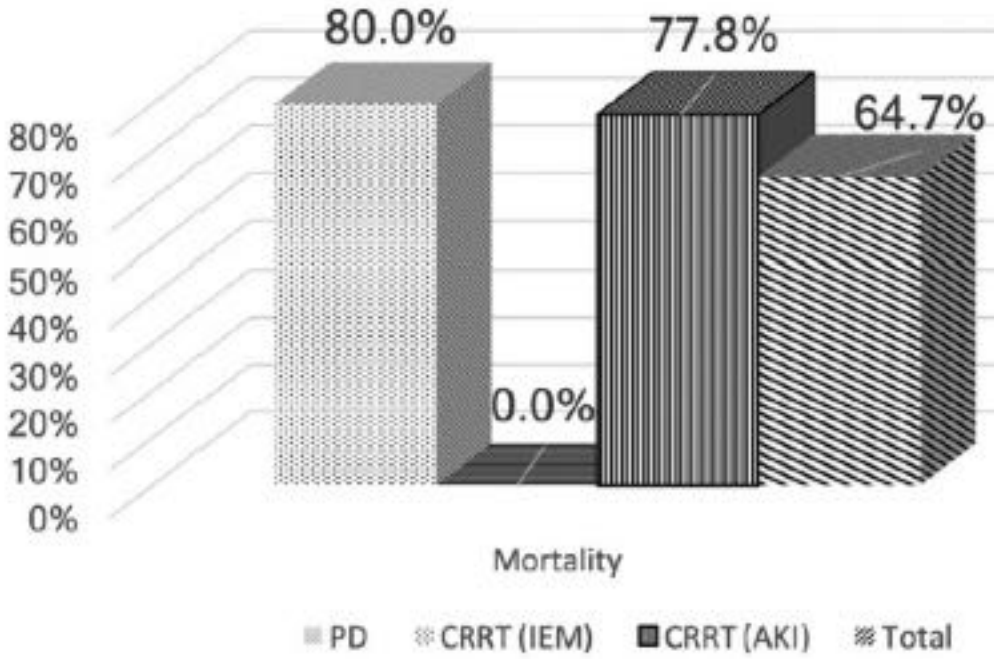


Table 3 Complications of renal replacement therapy.

	CRRT n (%)	PD n (%)
Hypotension	2 (16)	0 (0)
Electrolyte disturbances		
Hypocalcemia (<8.4)	9 (75)	4 (80)
Hypophosphatemia (<3.8)	8 (66)	1 (20)
Hypokalemia (<3.5)	9 (75)	5 (100)
Catheter related		
Catheter related infection	2 (16)	2 (40)
Catheter malfunction	0 (0)	3 (60)
Catheter leakage	0 (0)	2 (40)

Conclusions

RRT in the form of CRRT and PD is feasible in neonates, even in those weighing less than 2 kg. CRRT appears to have high efficacy in neonates with non-AKI etiologies, and its associated complications are mostly reversible with no severe clinical consequences. Both PD and CRRT are associated with high mortality rates in neonates with AKI. The recommendation of the RRT modality and timing of therapy in such cases must be verified by further studies in larger patient populations.

THE JOURNAL OF PEDIATRICS J Pediatr 2022;242:159-65 ORIGINAL ARTICLES

Mortality Risk Factors among Infants Receiving Dialysis in the Neonatal Intensive Care Unit

Keia R. Sanderson, MD, MSCR[1], Bradley Warady, MD[2], William Carey, MD[3], Veeral Tolia, MD[4,5], Marcella H. Boynton, PhD[6,7], Daniel K. Benjamin, PhD[8], Wesley Jackson, MD[9], Matthew Laughon, MD[9], Reese H. Clark, MD[4,10], and Rachel G. Greenberg, MD, MB, MHS[11,12]

The probability of death was greater in:

- Infants born at ≤32 weeks of gestation
- Black infants
- NEC
- Dialysis within the first 7 days of life
- Vasopressor exposure.
- Absence of kidney anomalies.

Most pediatric kidney transplant recipients are teenagers, but the surgery can be done on children as young as a year old and as small as 22 pounds. Babies who are below those benchmarks may be considered for transplants case by case, or they may receive kidney dialysis until they grow a bit more.

The best PD access recommended by the ISPD for pediatric patients is:

A. Rigid acute PD catheter introduced blindly with a stylet

B. Tenckhoff catheter introduced by radiologist under screen

C. Tenckhoff catheter surgically introduced

D. A single lumen vascular femoral catheter

Which of the following is **NOT** an indication for RRT in a neonate with AKI:

A. Hypernatremia refractory to medical management

B. Fluid overload ≥ 5 percent

C. Non-obstructive oliguria not responsive to diuretics

D. Uremic organ involvement (pericarditis, encephalopathy)

Which of the following is a true statement concerning neonatal iHD?

A. Vascular access in newborns can be provided by umbilical vessels.

B. To avoid hypotension, the total volume of the dialysis circuit should not exceed 3% of the infant blood volume.

C. Blood flow rates 15-30 mL/kg/min.

D. Frequent hemodialysis (as often as daily) is not recommended in neonates.