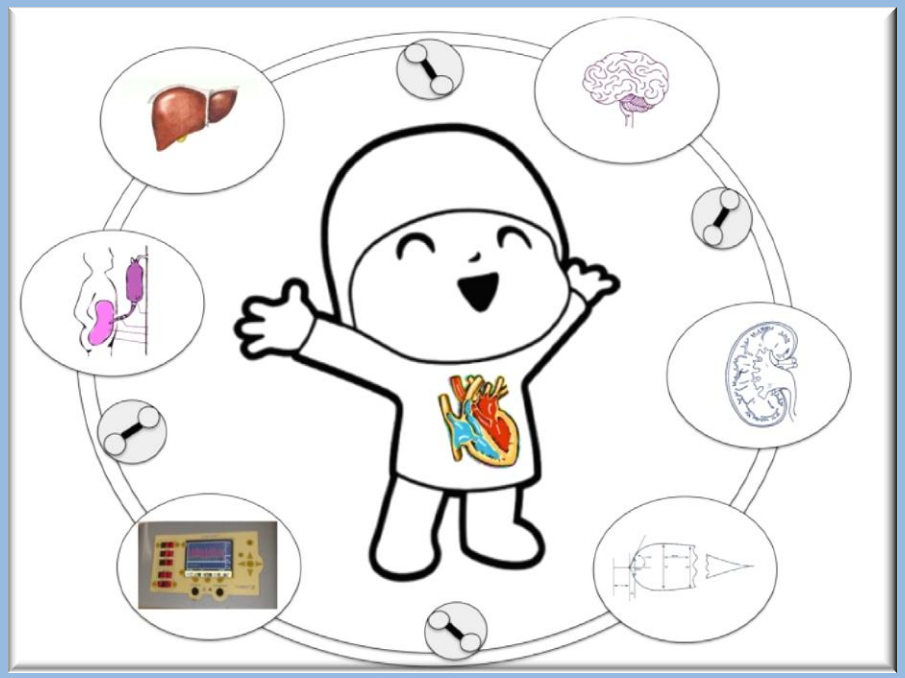
Vascular Access for CRRT



37th Vicenza Course on AKI & CRRT

May 28-30, 2019

Zaccaria Ricci

Dipartimento Medico Chirurgico
di Cardiologia Pediatrica

Bambino Gesù
OSPEDALE PEDIATRICO

Health-e-Child

Comune di Roma

Information Society Technologies

S. Bortolamius Vicenza Pietas et Cura

IRRIV International Renal Research Institute Vicenza

Nefrologia Dialisi e Trapianto Renale

VASCULAR ACCESS is the bottle neck of CRRT

CRRT vascular access is like Kryptonite

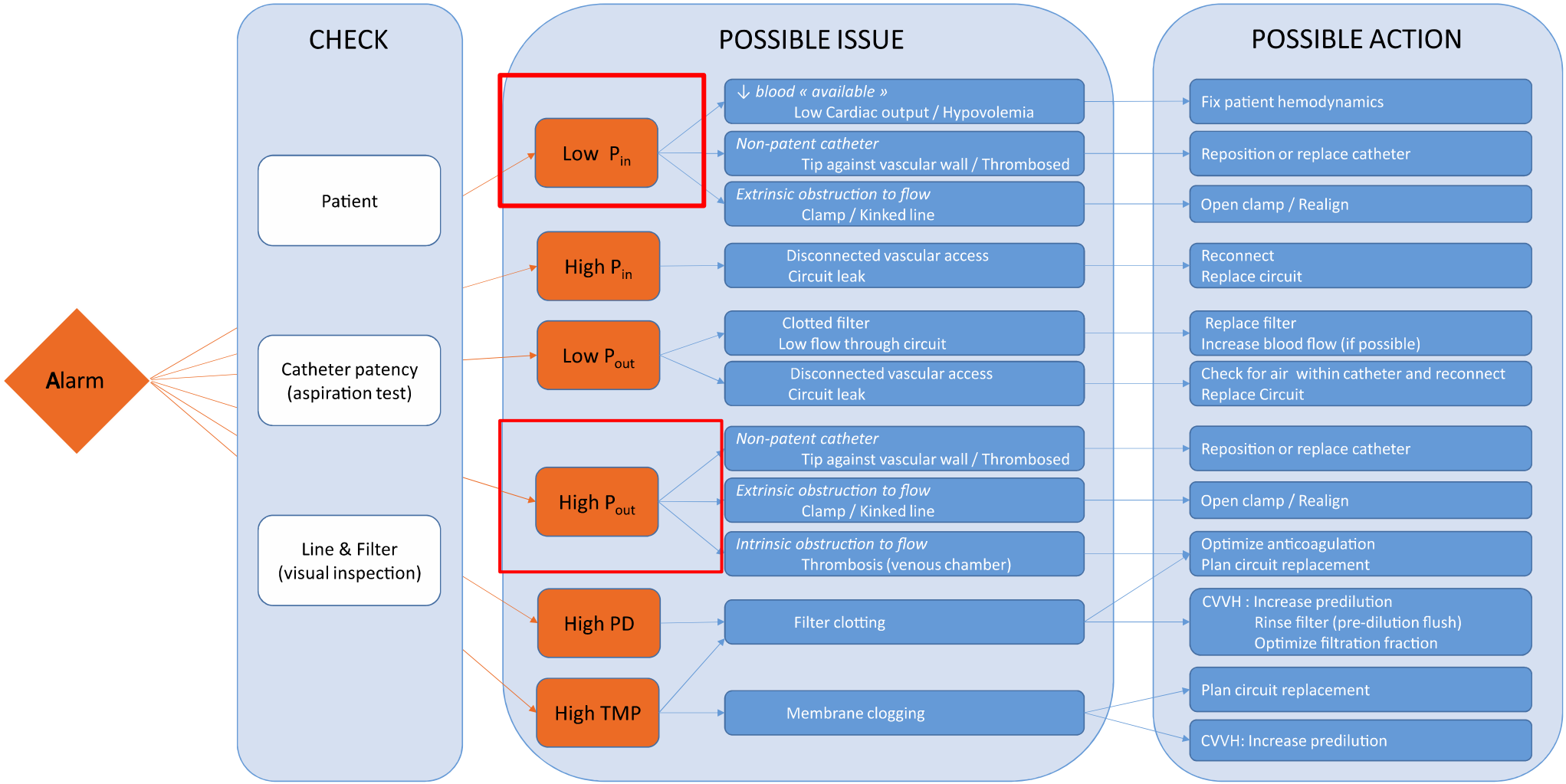
My heel is like a bilumen catheter

CURRENT OPINION

2018

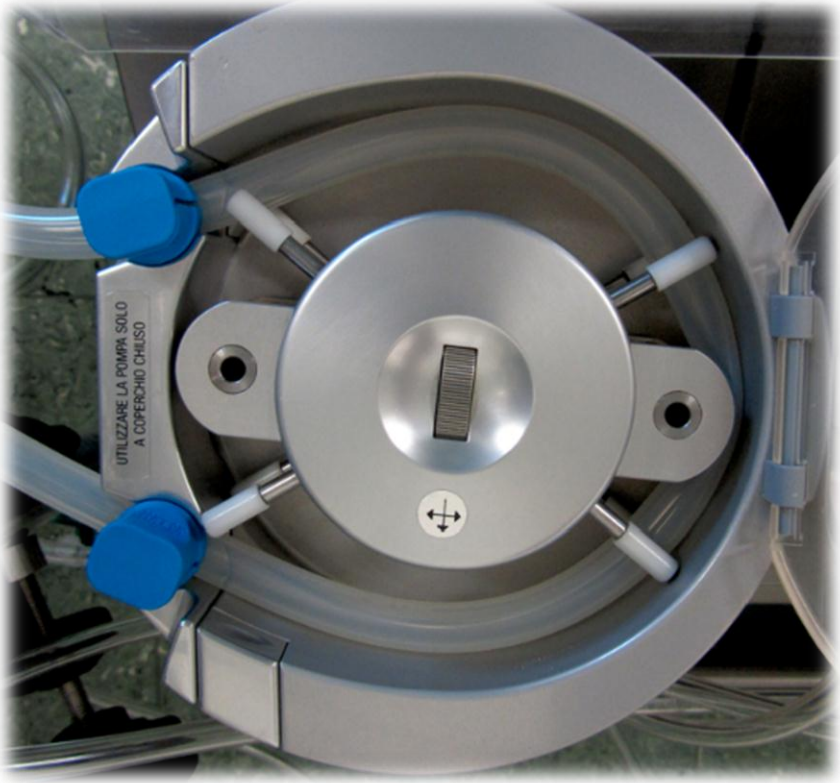
Continuous renal replacement therapy: understanding circuit hemodynamics to improve therapy adequacy

Thibault Michel[a], *Hatem Ksouri*[b], *and Antoine G. Schneider*[a]

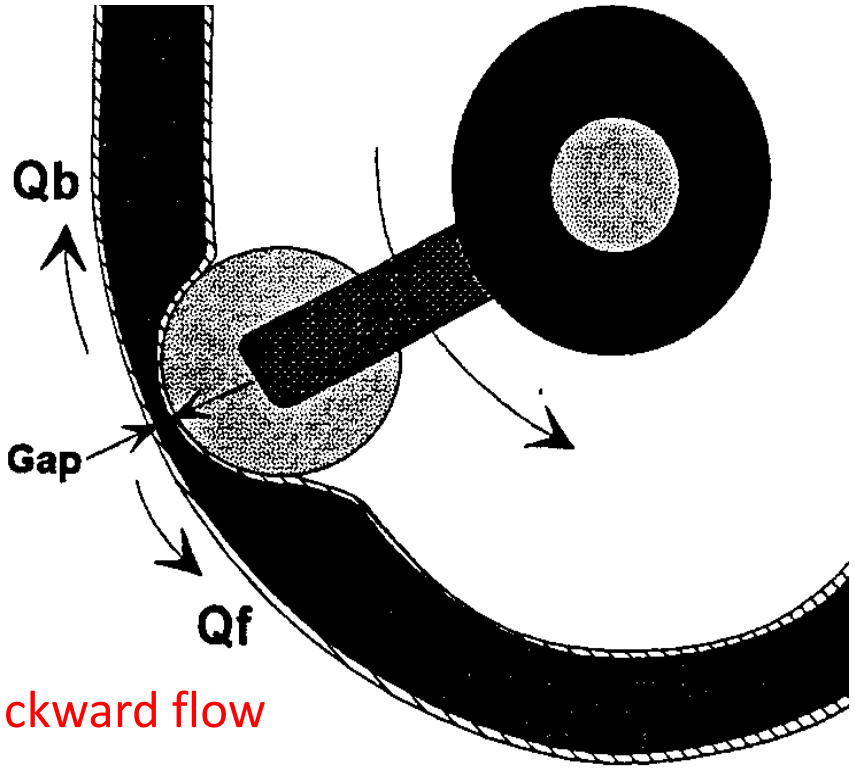


ROLLER PUMP

Rotating wheel with occluding rolls providing 2 to four strokes per route



Roller pumps. Why they may not deliver the desired blood flow !



Qb backward flow

Qf forward flow

After forward compression, the tubing will re-expand and refill with blood from the access catheter (A).

If patient access restricts flow, the tubing may not refill and remain partially collapsed. Stroke is reduced. Blood may also pass backwards before the compression stroke of the alternate wheel.

Flow reduction is therefore related to patient access, the revolutions of the roller (affecting refill time) the occlusion gap, and tubing re-expansion properties.

The tubing during compression stroke.

The tubing must re-expand following compression and fill with ‘fresh’ blood.
A failure to do so will alter the axis ratio and reduce the stroke volume of the pump.

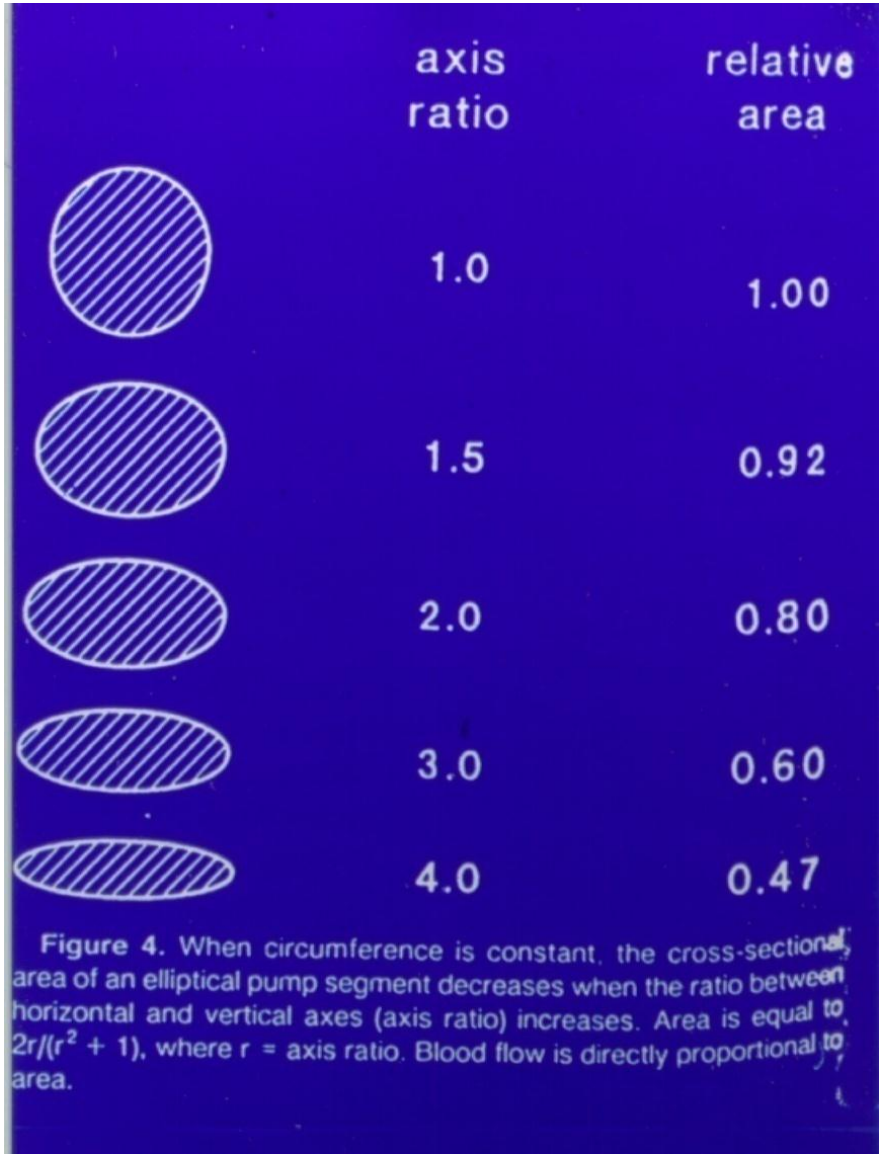
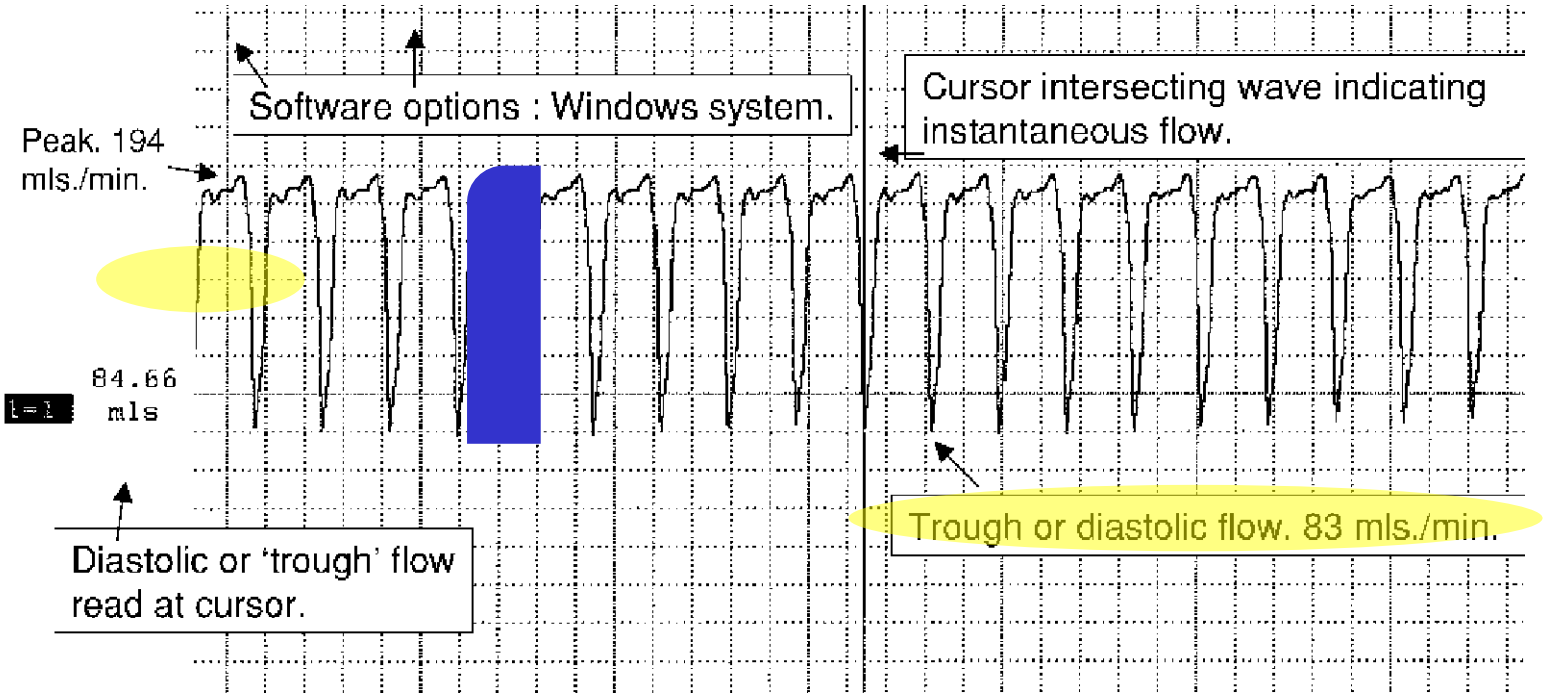


Figure 4. When circumference is constant, the cross-sectional area of an elliptical pump segment decreases when the ratio between horizontal and vertical axes (axis ratio) increases. Area is equal to $2r/(r^2 + 1)$, where r = axis ratio. Blood flow is directly proportional to area.

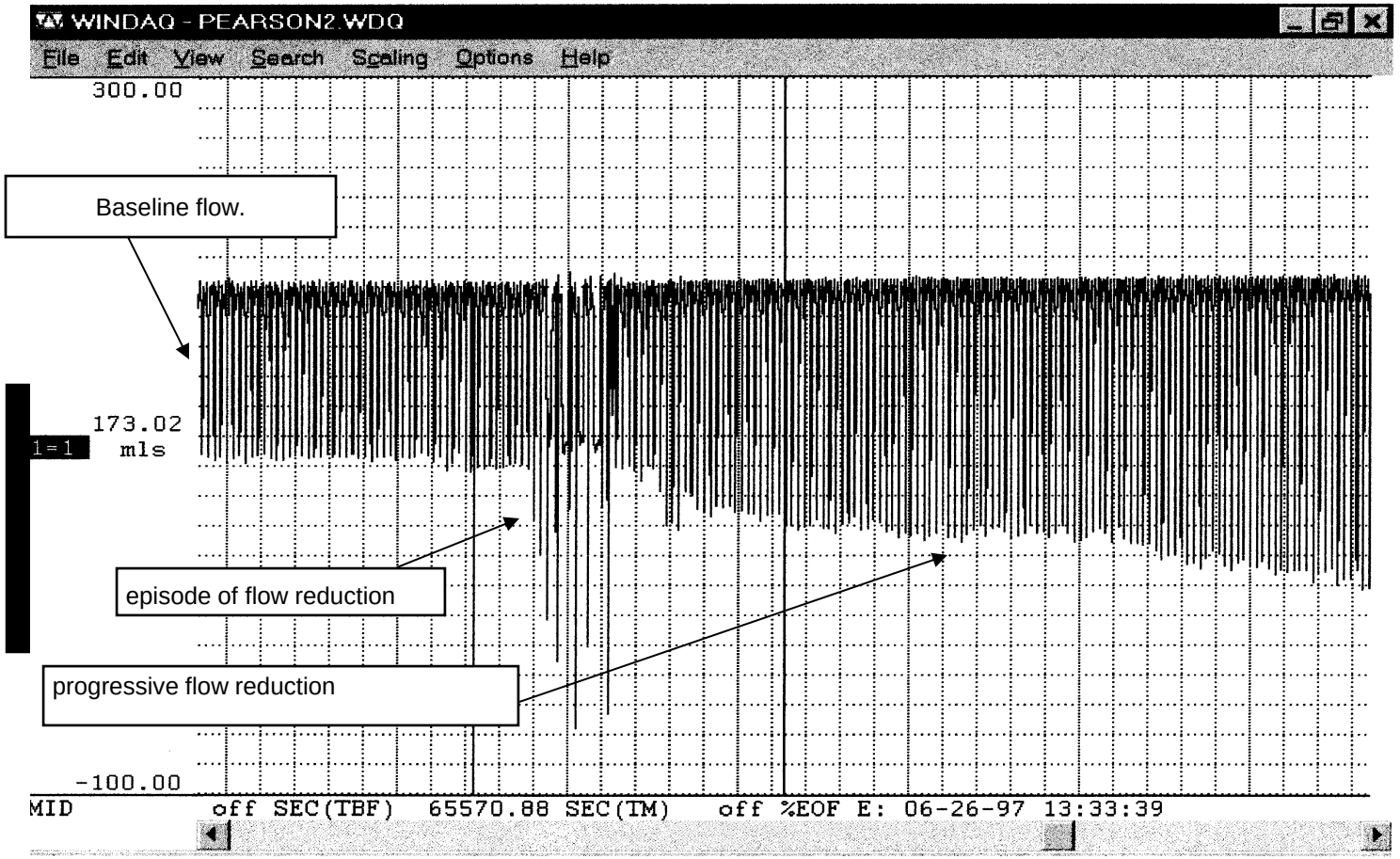
Roller pumps. Why they may <u>not deliver</u> the desired blood flow !

Set Qb 200 ml/min



Baldwin ICM 2002

Compressed wave demonstrating flow reductions increasing in severity with time.



Roller pumps. Why they may not deliver the desired blood flow !

Table 2 Distribution of flow reduction severity at three levels

Reduction	n
0–33%	139
34–66%	143
67–100%	32
Total	314

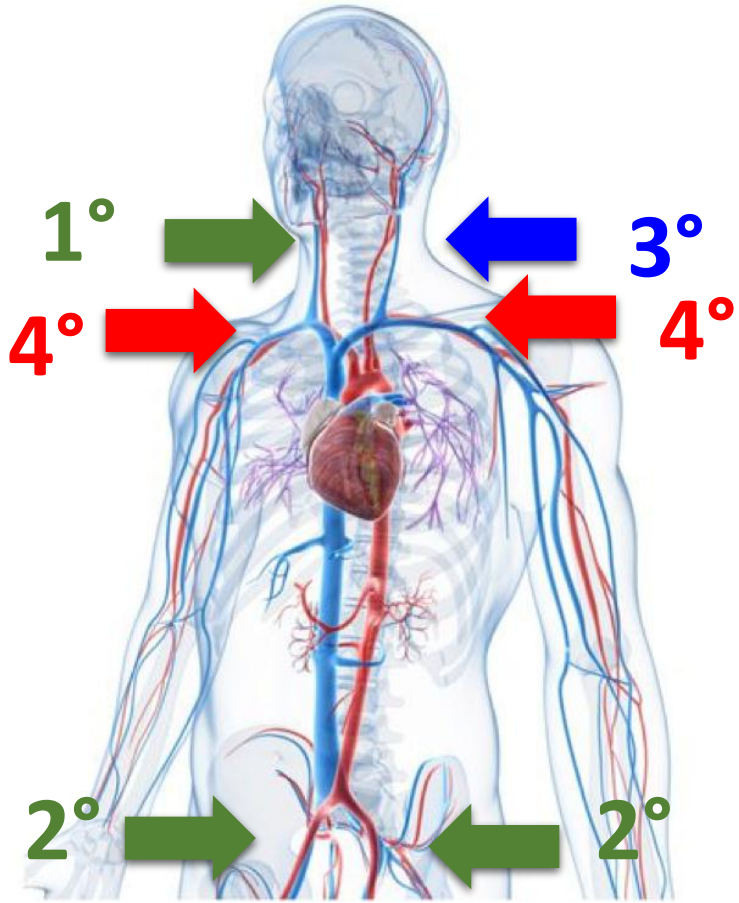
NO ALARM!!!

Baldwin ICM 2004

Jugular vein is the best access for RRT

When choosing a vein for insertion of a dialysis catheter in patients with AKI, consider these preferences (*Not Graded*):

- First choice: right jugular vein;
- Second choice: femoral vein;
- Third choice: left jugular vein;
- Last choice: subclavian vein with preference for the dominant side.



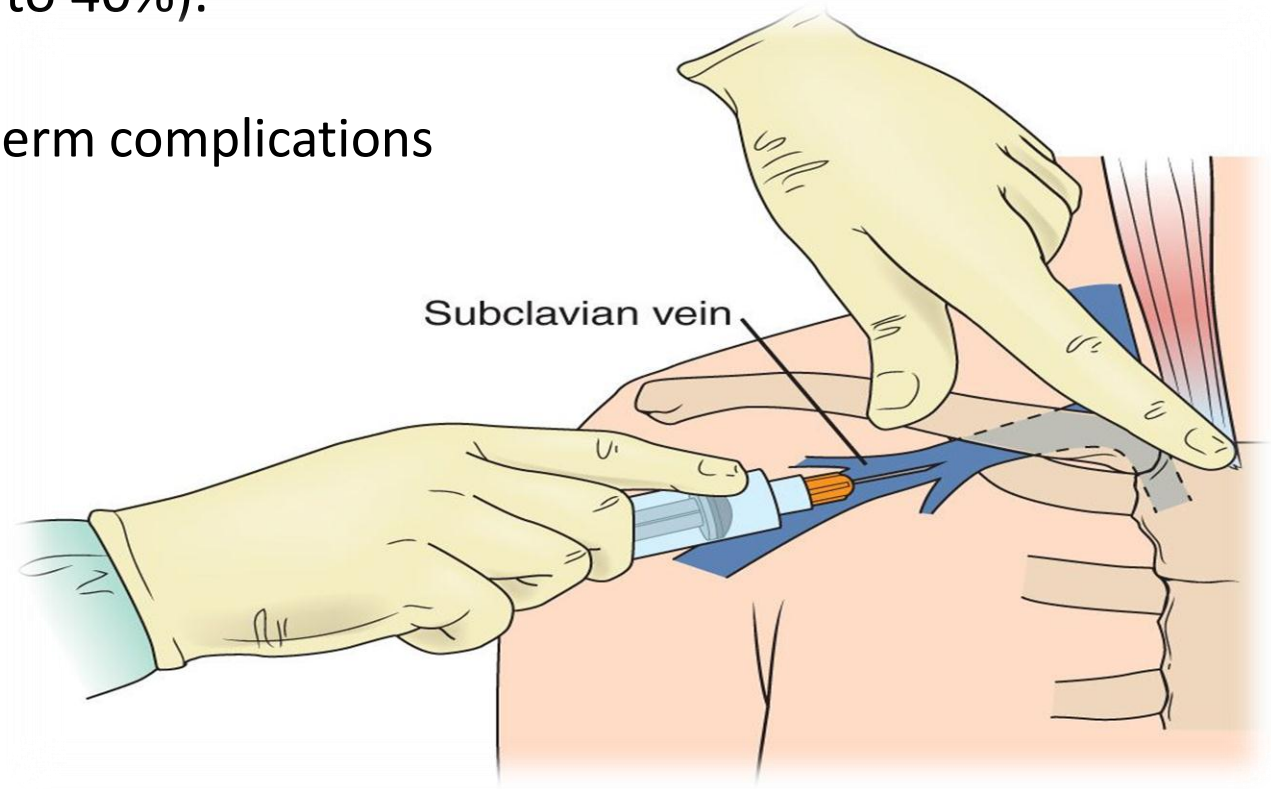
http://kdigo.org/home/guidelines/acute-kidney-injury/.

Jugular vein is the best access for RRT

Subclavian sites should be avoided because of a predisposition to venous stenosis (up to 40%).

Schillinger F, et al. Nephrol Dial Transplant 1991;6:722–4

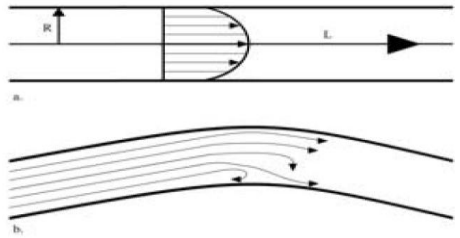
..long term complications

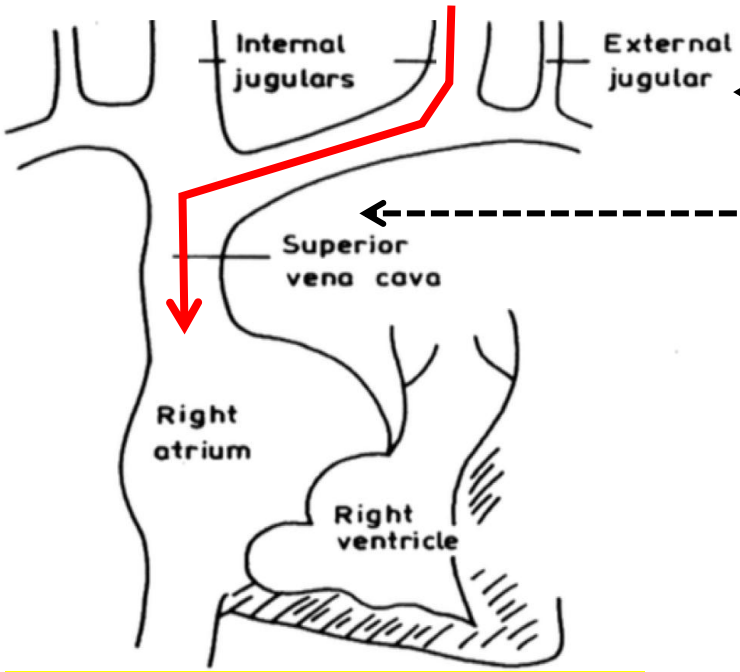


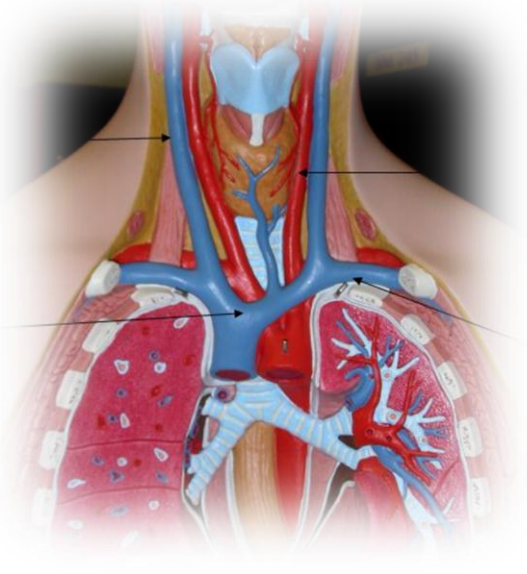
As AKI is strongly associated with end-stage kidney disease and consequently with the need for permanent vascular access, it is recommended to **preserve the subclavian sites**.

Jugular vein is the best access for RRT

In the jugular location, access via the **left internal jugular vein** is be related to a higher degree of **catheter dysfunction** because of anatomical reasons.





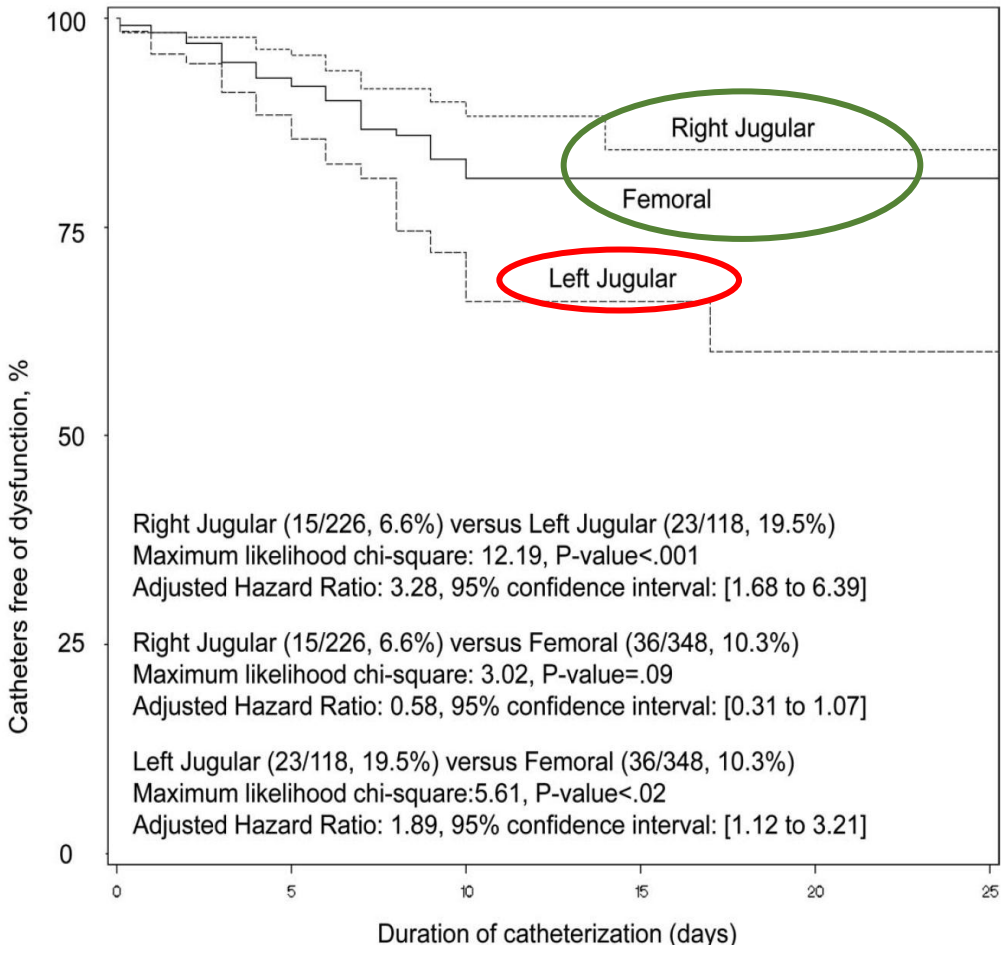


$$Qv = k\,(P \times R^4)/\,(L \times \eta)$$

Jean Léonard Marie Poiseuille LAW

Huriaux L et al. Anaesth Crit Care Pain Med (2017) 36:313-319

Jugular vein is the best access for RRT



In terms of **catheter dysfunction** and **dialysis performance** among critically ill adults requiring acute RRT, <u>jugular site did not significantly outperform femoral site</u> placement.

Catheter dysfunction and dialysis performance according to vascular access among 736 critically ill adults requiring renal replacement therapy: A randomized controlled study

Jean-Jacques Parienti, MD, PhD; Bruno Mégarbane, MD, PhD; Marc-Olivier Fischer, MD; Alexandre Lautrette, MD, PhD; Nicole Gazui, MD; Nathalie Marin, PharmD; Jean-Luc Hanouz, MD, PhD; Michel Ramakers, MD; Cédric Daubin, MD; Jean-Paul Mira, MD, PhD; Pierre Charbonneau, MD; Damien du Cheyron, MD, PhD; for Members of the Cathedia Study Group

Objective: To compare dialysis catheter function according to catheter site.

Design: Multicenter, open, randomized controlled trial.

Setting: Nine university-affiliated hospitals and three general hospitals in France.

Patients: Seven hundred thirty-six patients in intensive care units who required a first venous catheterization to perform either intermittent hemodialysis (470 patients with 1275 sessions) or continuous renal replacement therapy (266 patients with 1003 days).

Intervention: Patients randomly received either femoral (n = 370) or jugular (n = 366) catheterization. For the jugular site, right-side position (n = 252) was recommended.

Measurements and Main Results: Time to catheter ablation for dysfunction, urea reduction ratio (intermittent hemodialysis), and downtime (continuous renal replacement therapy) were assessed for all participants and evaluated by randomly assigned catheterization site (femoral or jugular). Baseline demography and dialysis prescriptions were similar between the site arms. In modified intent-to-treat, catheter dysfunction occurred in 36 of 348 (10.3%) and 38 of 342 (11.1%) patients in the femoral and jugular groups, respectively. The risk of catheter dysfunction did not significantly differ between randomized groups (hazard ratio, 1.06; 95% confidence interval, 0.67–1.68; $p = .80$). Compared to the femoral site, the observed risk of dysfunction decreased in the right jugular position (15 of 226; 6.6%; adjusted hazard ratio, 0.58; 95% confidence interval, 0.31–1.07; $p = .09$) and significantly increased in the left jugular position (23 of 118; 19.5%; adjusted hazard ratio, 1.89; 95% confidence interval, 1.12–3.21; $p < .02$). The postintermittent hemodialysis mean urea reduction ratio per session was 50.8% (standard deviation, 16.1) for femoral vs. 52.8% (standard deviation, 15.8) for jugular ($p = .30$) sites, and the median continuous renal replacement therapy downtime per patient-day was 1.17 hrs (interquartile range, 0.75–1.50) for both sites ($p = .98$).

Conclusions: In terms of catheter dysfunction and dialysis performance among critically ill adults requiring acute renal replacement therapy, jugular site did not significantly outperform femoral site placement. (Crit Care Med 2010; 38:1118–1125)

KEY WORDS: vascular access; catheter dysfunction; dialysis performance; randomized controlled trial

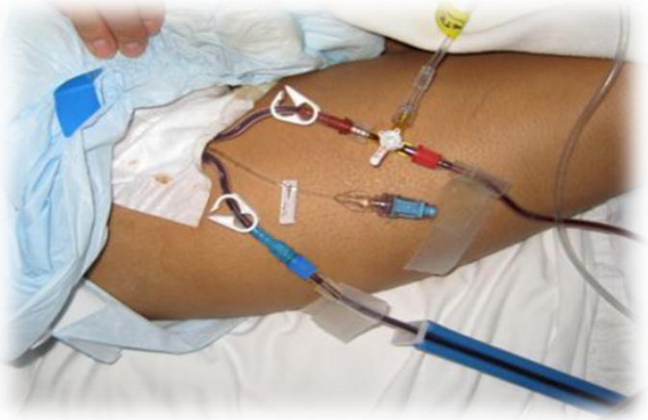
Parienti JJ et al. Crit Care Med (2010) 38:1118–1125

WARNING

DO NOT FORGET THAT …

In the **femoral** location, catheters **shorter than 24 cm** or with lower flow capacity may predispose to **catheter dysfunction**.

Parenti JJ et al. Crit Care Med (2010) 38:1118–1125
Bellomo R et al. Blood Purif (2016) 41:11–17



The recommended length for a femoral catheter is therefore 24 cm (or above)

KDIGO 2012; Dugué AE et al. Clin J Am Soc Nephrol CJASN (2012) 7:70–7

RIJV and femoral veins are the best accesses for RRT

Right Internal Jugular Vein

- Best flow
- No limitation to mobilization
- **Risk** on insertion (PNX, carotid puncture)
- Possibly already punctured and not available for dialysis cath

Left Internal Jugular Vein

- Limited flow do to **kinking**
- No limitation to mobilization
- **Risk** on insertion (PNX, carotid puncture)

Femoral Veins

- Good flow if adequate **length**
- **Easy** and fast to insert
- No significant differences in performance, infections and DVT incidence
- Limitation to mobilization

Subclavian Vein

- Good flow if adequate length
- Enhanced risk of **kinking** and **stenosis**
- **Difficult** insertion

Original Paper

Blood Purification

Blood Purif 2011;31:42–46
DOI: 10.1159/000322254

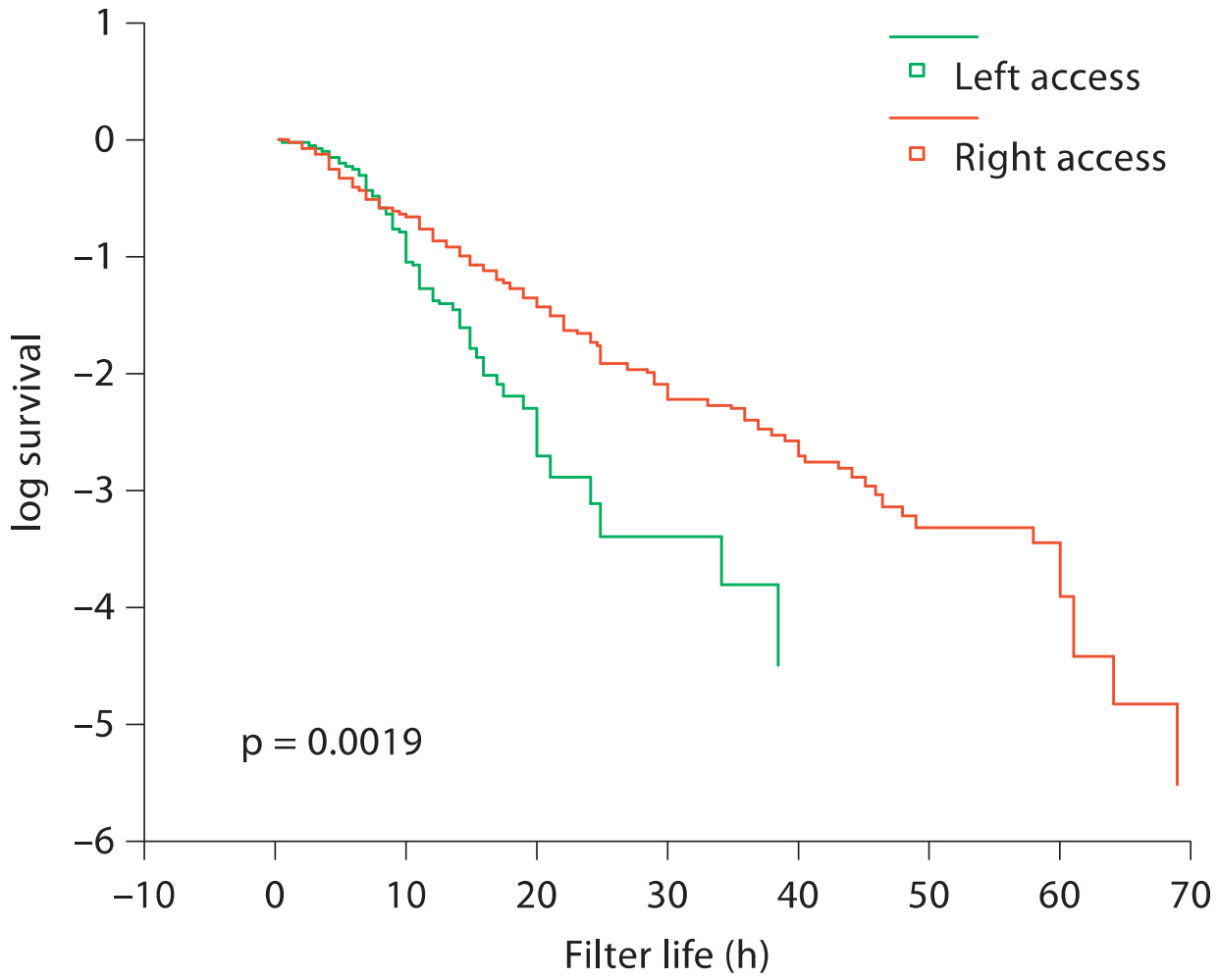
Received: October 6, 2010
Accepted: October 16, 2010
Published online: December 16, 2010

Insertion Side, Body Position and Circuit Life during Continuous Renal Replacement Therapy with Femoral Vein Access

In Byung Kim Nigel Fealy Ian Baldwin Rinaldo Bellomo

Department of Intensive Care Medicine, Austin Hospital, Melbourne, Vic., Australia

- 341 circuits in 50 patients
- The Niagara catheter 13.5 Fr, and the Dolphin catheter 13 Fr
- 73.6% right femoral vein
- Mean circuit life 15.0 ± 14.3 vs. 10.6 ± 7.4



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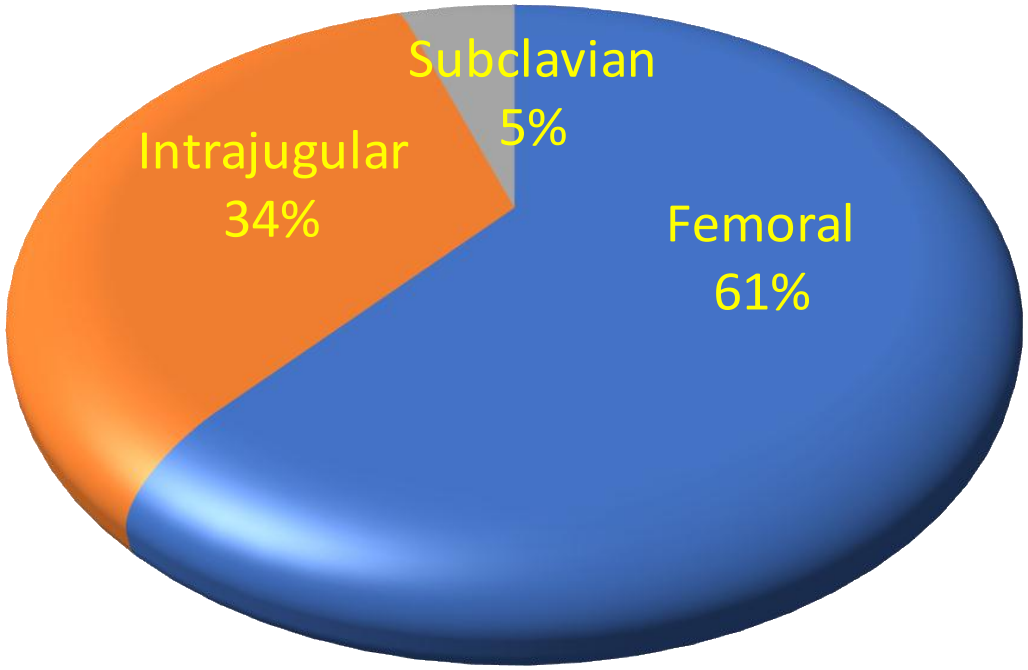
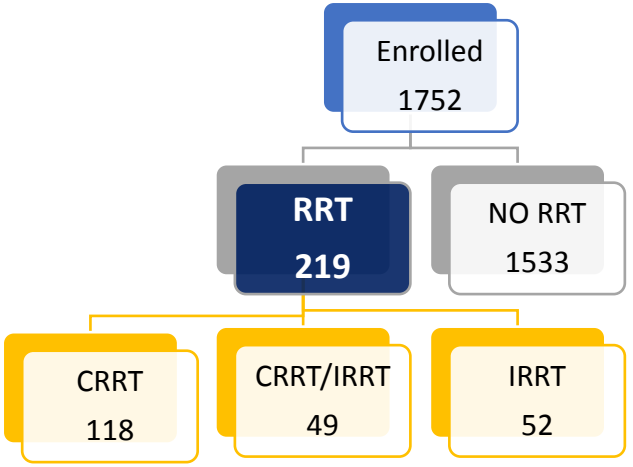
Dependent variable	Independent variables	Coefficient (95% CI)	p value
Circuit life	Anticoagulant	–0.610 (–5.820 to 3.070)	0.54
	CRRT mode	0.724 (–3.152 to 6.803)	0.47
	Vascular access site	–2.243 (–8.020 to –0.513)	0.03
	Total heparin dose	1.755 (0.000 to 0.001)	0.08
	Platelet	–2.243 (–8.020 to –0.513)	0.03
	INR	0.444 (–1.925 to 3.042)	0.66
	Hemoglobin	0.702 (–0.588 to 1.239)	0.48
	APTT	0.868 (–0.055 to 0.141)	0.39
	Left lying (%)	–0.744 (–1.378 to 0.089)	0.46
	Right lying (%)	0.896 (–0.082 to 0.218)	0.37
	Supine (%)	–0.522 (–0.180 to 0.104)	0.60
	Sitting (%)	–0.09 (–0.279 to 0.254)	0.93

DoReMIFA

Daily practice of CRRT





At first CRRT session

Courtesy of M Ostermann and F Garzotto, on behalf of DoReMiFa StudyGroup

Original Paper

Blood Purification

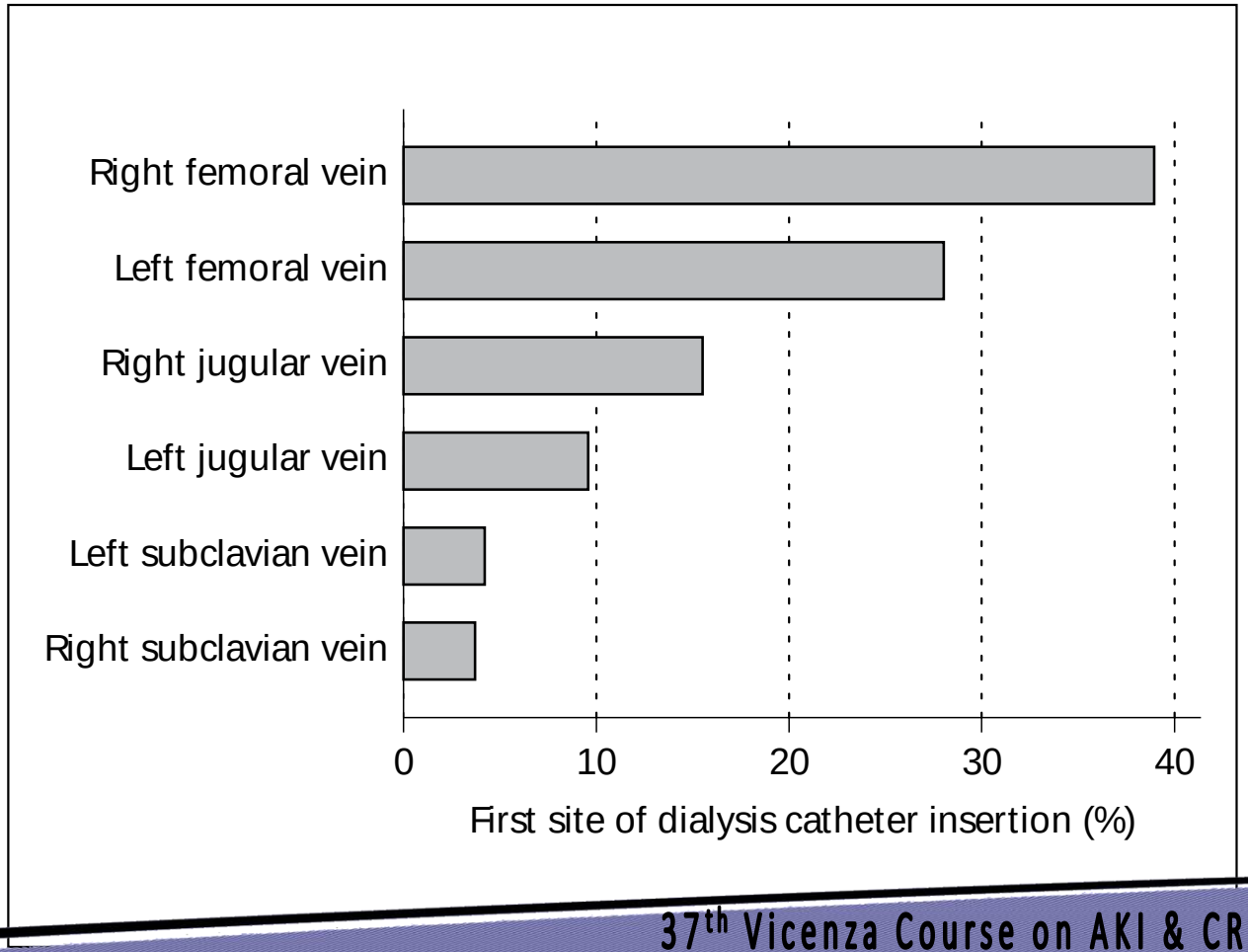
Blood Purif 2016;41:11–17
DOI: 10.1159/000439581

Received: June 4, 2015
Accepted: August 18, 2015
Published online: October 20, 2015

Femoral Access and Delivery of Continuous Renal Replacement Therapy Dose

Rinaldo Bellomo[a, b] Johan Mårtensson[b, c] Serigne Lo[d] Kirsi-Maija Kaukonen[a]
Alan Cass[e] Martin Gallagher[d] for the RENAL study investigators and the
Australian and New Zealand Intensive Care Clinical Trials Group

1399 patients



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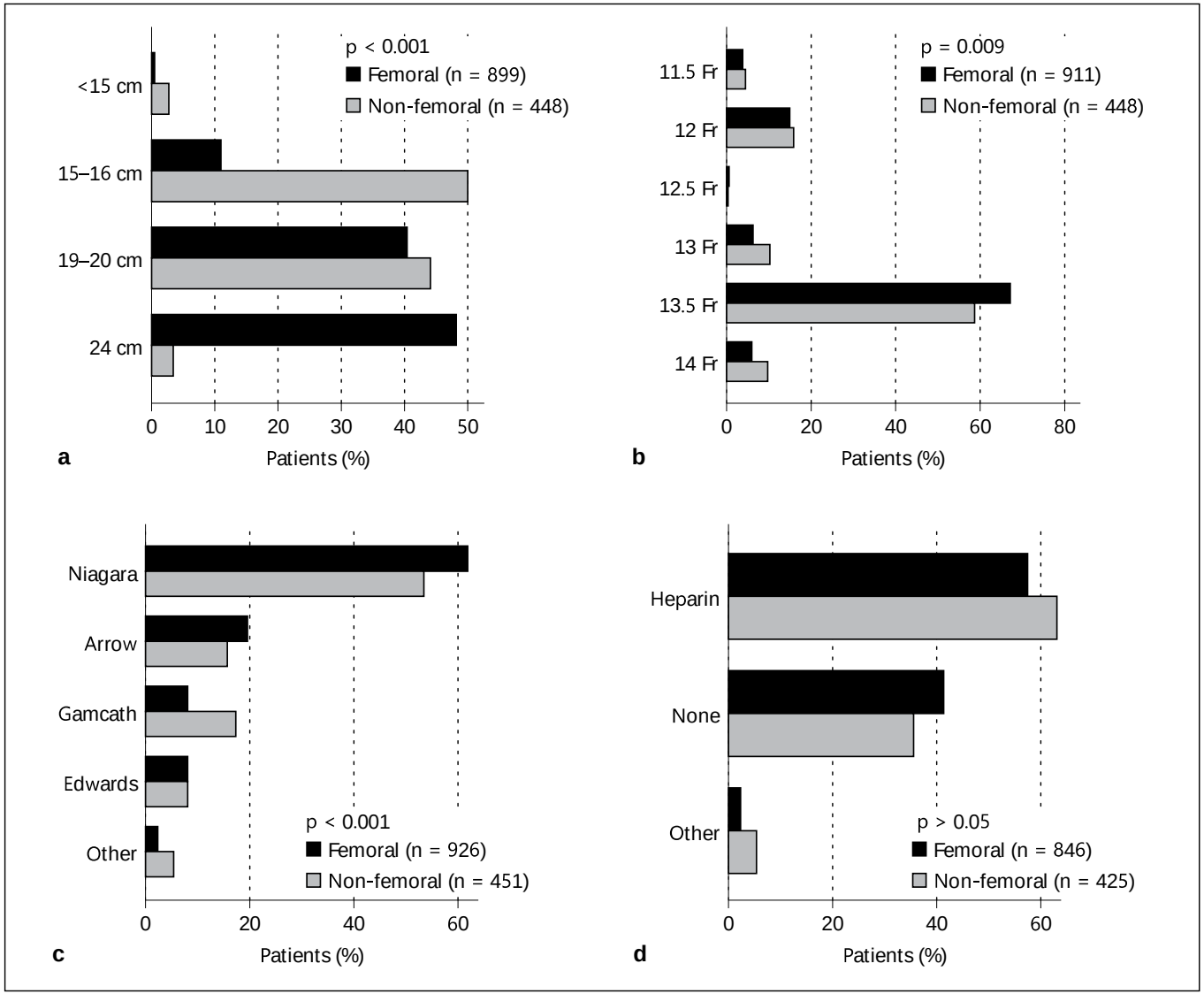

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Australian and New Zealand Intensive Care Clinical Trials Group

Variable	Coefficient, ±SE	p values[a]
Femoral catheter (vs. non-femoral)	–1.03±0.53	0.05
13.5 French catheter (vs. other gauges)	4.20±1.90	0.03
20- or 24-cm catheter (vs. other lengths)	1.88±1.68	0.3
Randomized to higher CRRT intensity	–26.32±1.27	<0.001

[a] Adjusted for age, sex, APACHE III score, body weight, oliguria, hyperkalemia, acidemia, oedema, urea, creatinine, catheter brand, CRRT machine use and mode of circuit anticoagulation.

The effect of vascular access location and size on circuit survival in pediatric continuous renal replacement therapy: A report from the PPCRRT registry

IJAO 2007

R. HACKBARTH[1], T. E. BUNCHMAN[1], A. N. CHUA[2], M. J. SOMERS[3], M. A. BAUM[3], J. M. SYMONS[4], P. D. BROPHY[5], D. BLOWEY[6], J. D. FORTENBERRY[7], D. CHAND[8], F. X. FLORES[9], S. R. ALEXANDER[10], J. D. MAHAN[11], K. D. MCBRYDE[12], M. R. BENFIELD[13], S. L. GOLDSTEIN[2]

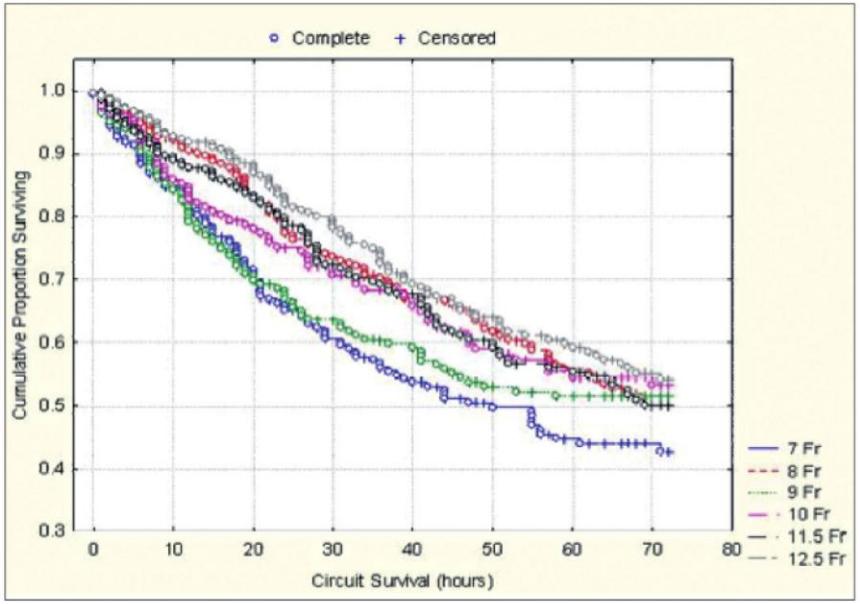


Fig. 3 - *Kaplan-Meier survival plots for circuits with catheter sizes 7-12.5 French. The data is limited to the first 72 hours of circuit life; 7 and 9 French catheters fared worse than others (p<0.002).*

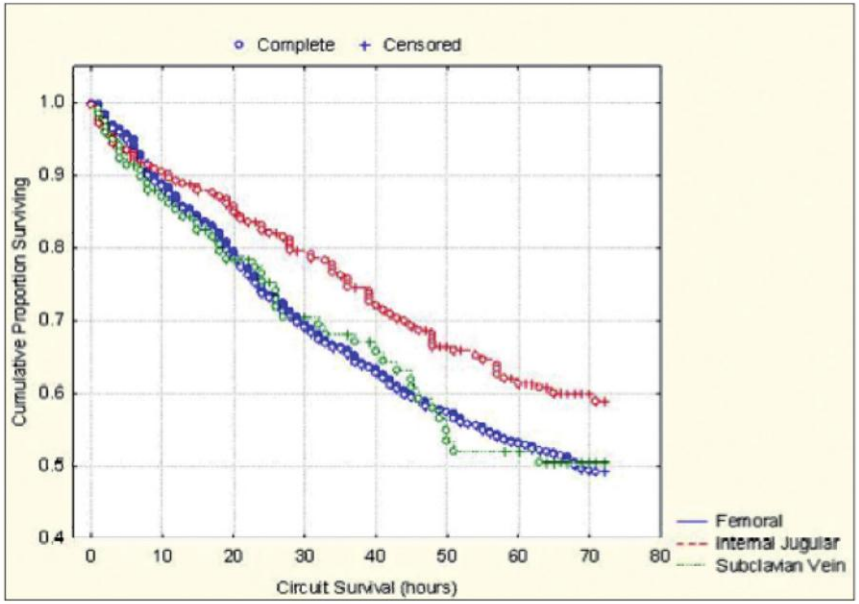
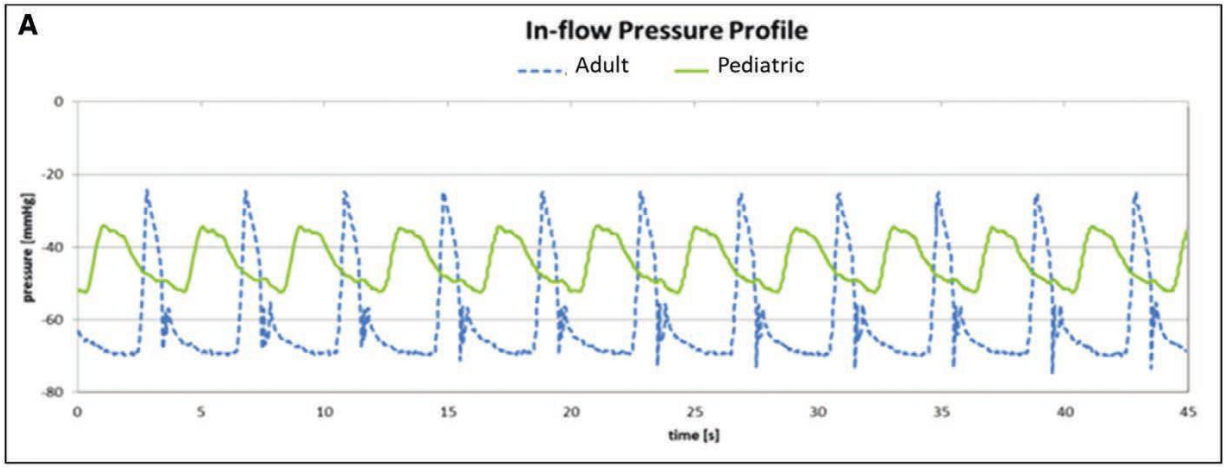


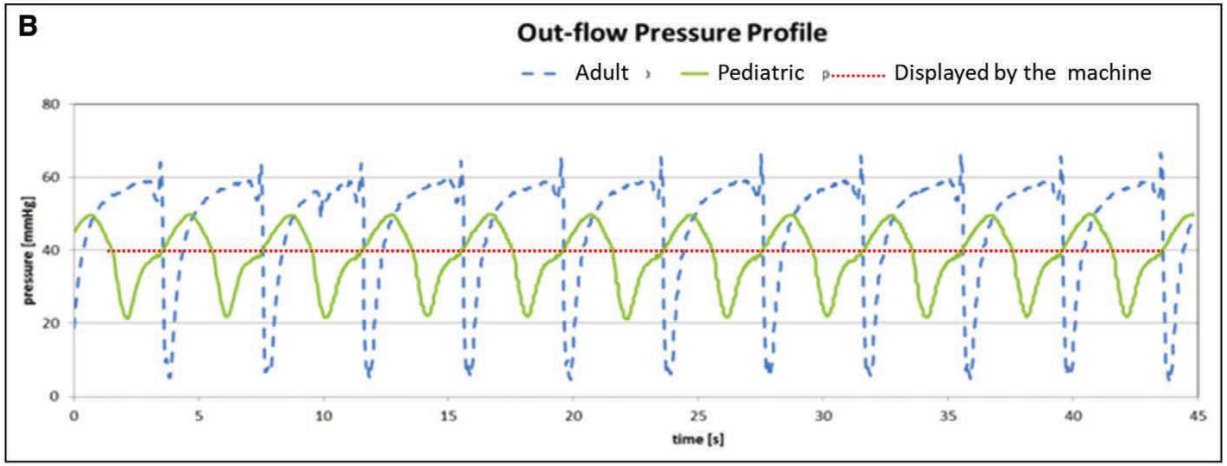
Fig. 4 - *Kaplan-Meier survival plots for circuits by vascular access site. Data for all catheter sizes, except 5 French, are included. The internal jugular access site favors longer survival (p<0.05).*

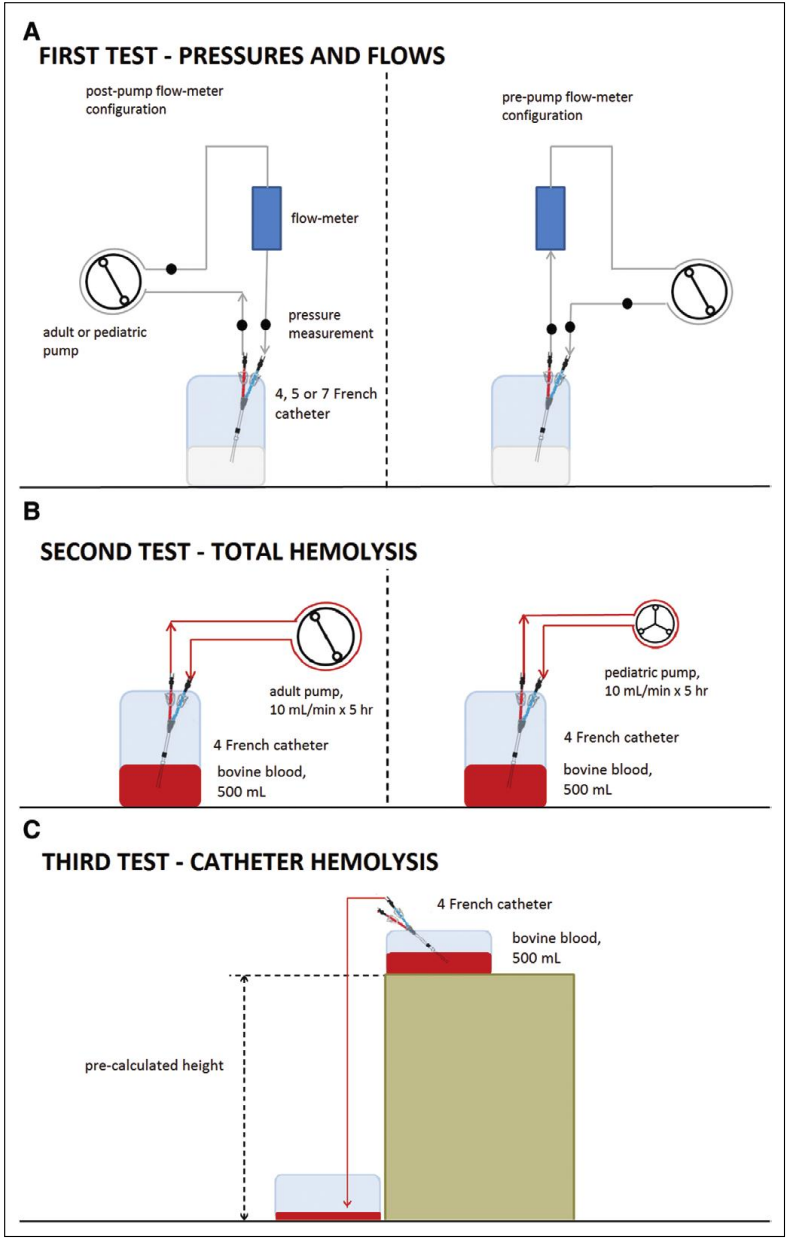
Choice of Catheter Size for Infants in Continuous Renal Replacement Therapy: Bigger Is Not Always Better

PCCM 2019

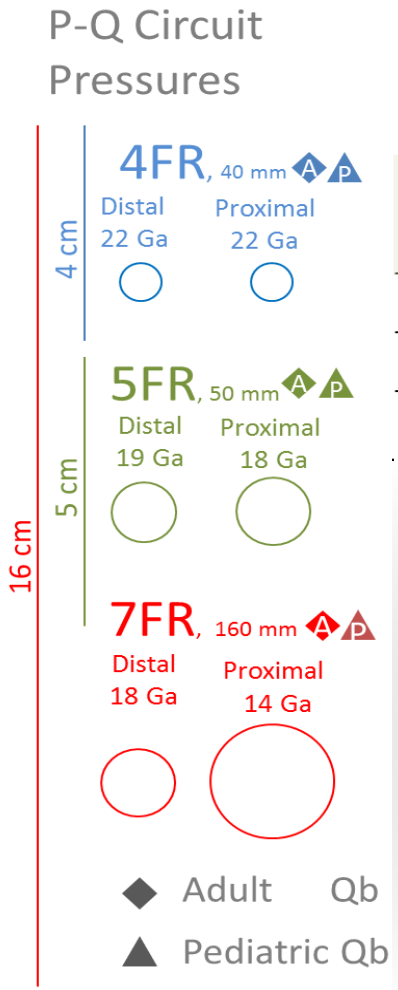
Francesco Garzotto, MSc[1–3]; Marta Zaccaria, MSc[4]; Enrico Vidal, MD, PhD[5]; Zaccaria Ricci, MD[6]; Anna Lorenzin, MSc[4]; Mauro Neri, MSc[4]; Luisa Murer, MD[5]; Federico Nalesso, MD, PhD[3,4]; Alfredo Ruggeri, MSc[7]; Claudio Ronco, MD[3,4]

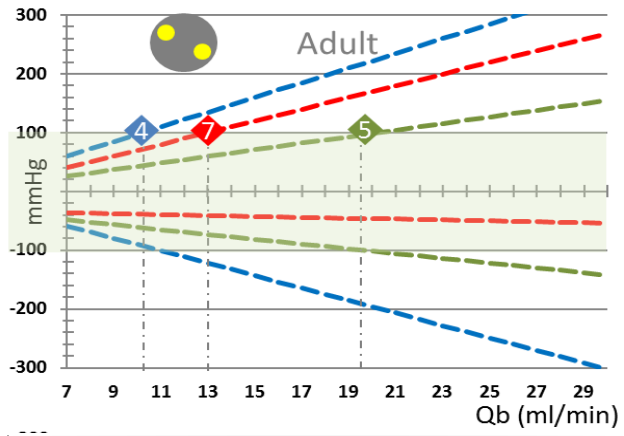


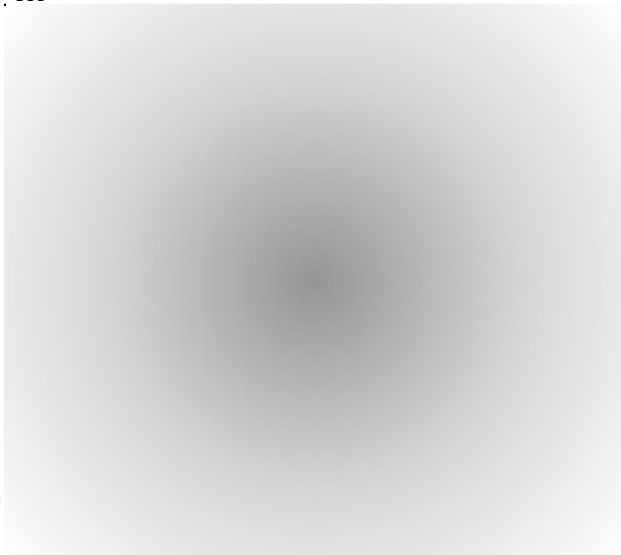




Adult VS Miniaturized Pump







The 3 roller miniaturized pump significantly optimized flows of 5 Fr bilumen catheters within the safety area (green)

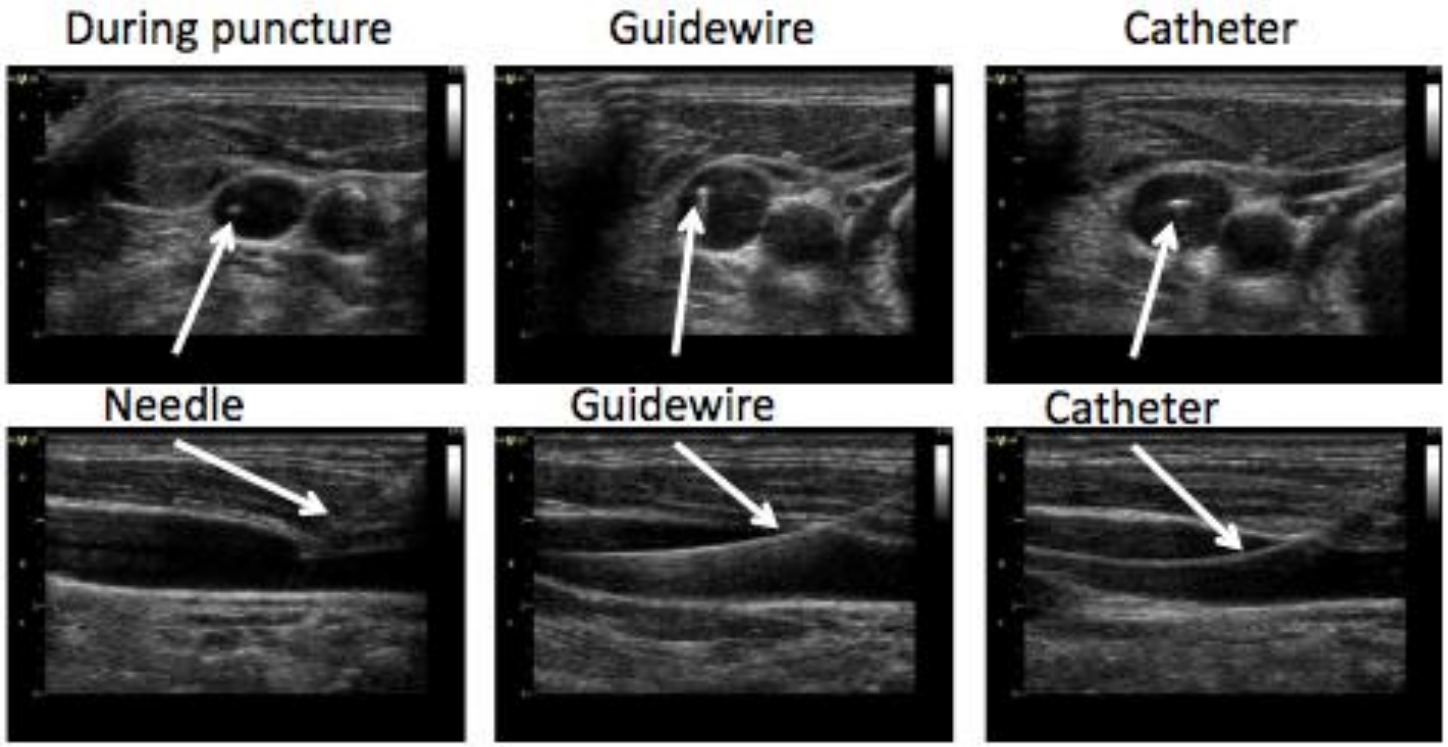
Garzotto F et al, PCCM 2019


CARPEDIEM
CVVHD
13:52:45
Nessun allarme
Durata
20 ml/min
Sangue
Calo peso
8 g
Tot. eparina
0.4 ml
ART
DROP
200
100
0
-100
-200
-300
<-H
<-L
400
300
200
100
0
-100
H->
L->
Parametri Trattamento
Standby
-45
25
45
Dati Trattamento
Allarmi e Bilance
Eparina Continua
Fine Trattamento
bellco
?
START
STOP

Position/site – technique

Kidney Disease: Improving Global Outcomes (2012)

5.4.3: We recommend using ultrasound guidance for dialysis catheter insertion. (*1A*)



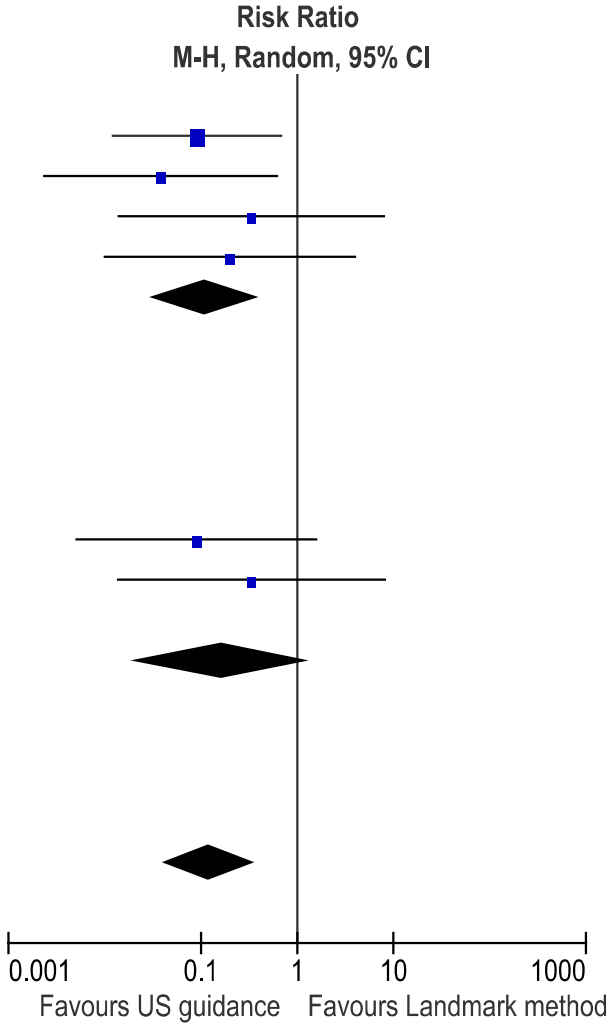
Catheter diameter should be less than 1/3 of vessel

Rule of thumb:
1 mm -> 1 Fr

Di Nardo M, et al PCCM 2014

http://kdigo.org/home/guidelines/acute-kidney-injury/.

Study or Subgroup	Real-time USS guidance Events	Total	Landmark method Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
1.1.1 Studies published in peer-reviewed publications						
Prabhu 2010	1	55	11	55	30.6%	0.09 [0.01, 0.68]
Nadig 1998	0	36	13	37	16.0%	0.04 [0.00, 0.62]
Korogolu 2006	0	40	1	40	12.3%	0.33 [0.01, 7.95]
Bansal 2005	0	30	2	30	13.8%	0.20 [0.01, 4.00]
Subtotal (95% CI)		**161**		**162**	**72.7%**	**0.11 [0.03, 0.40]**
Total events	1		27			
Heterogeneity: Tau² = 0.00; Chi² = 1.31, df = 3 (P = 0.73); I² = 0%						
Test for overall effect: Z = 3.33 (P = 0.0009)						
1.1.2 Studies published only as conference abstracts						
Zafar-Khan 1995	0	25	4	20	15.1%	0.09 [0.01, 1.57]
Kumwenda 2003	0	125	1	125	12.2%	0.33 [0.01, 8.10]
Ibrik 2000	0	139	0	73		Not estimable
Subtotal (95% CI)		**289**		**218**	**27.3%**	**0.16 [0.02, 1.36]**
Total events	0		5			
Heterogeneity: Tau² = 0.00; Chi² = 0.37, df = 1 (P = 0.54); I² = 0%						
Test for overall effect: Z = 1.68 (P = 0.09)						
Total (95% CI)		**450**		**380**	**100.0%**	**0.12 [0.04, 0.37]**
Total events	1		32			
Heterogeneity: Tau² = 0.00; Chi² = 1.79, df = 5 (P = 0.88); I² = 0%						
Test for overall effect: Z = 3.72 (P = 0.0002)						



Risk of catheter placement failure

	Diameter (mm)	Area (mm^2)
Common femoral vein	12	125
External iliac vein	14	150
Common iliac vein	16	200
Inferior vena cava	18–24	300–400

Parameter	Right side of neck	Left side of neck	*P* value
	Mean (SD)	Mean (SD)	
Transverse diameter of IJV (mm)	13.2 (3.1)	10.4 (2.9)	<0.0001
Anteroposterior diameter of IJV (mm)	9.1 (1.5)	8.9 (1.4)	NS (0.2867)
Depth of IJV (mm)	14.5 (2.7)	14.2 (2.5)	NS (0.3727)

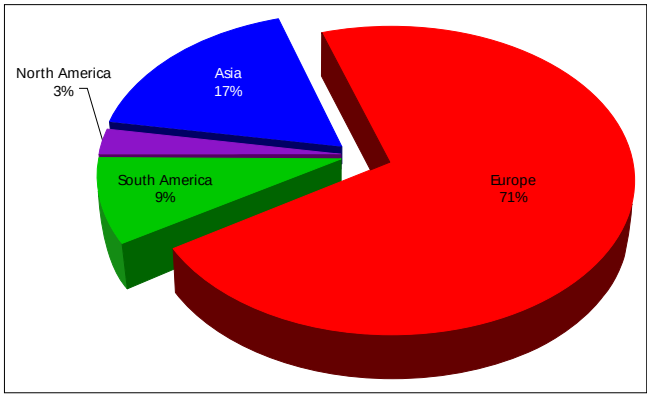
IJV = Internal jugular vein; SD = Standard deviation

Original Paper

Blood Purification

Blood Purif
DOI: 10.1159/000493724

Received: September 10, 2018
Accepted: September 10, 2018
Published online: September 28, 2018



International Survey on the Management of Acute Kidney Injury and Continuous Renal Replacement Therapies: Year 2018

Kumar Digvijay[a, b] Mauro Neri[a, b] Weixuan Fan[a, c] Zaccaria Ricci[d]
Claudio Ronco[a, b]

- TECHNIQUE= most of the participants responded to use the ultrasonography-guided Seldinger technique (76%) and blind Seldinger technique (21%).
- SIZE1= In 35% of cases, the selection of vascular access size appeared to depend on the size available in the ICU. 30% said they selected the vascular access site by ultrasonography, 20% by a general rule of “bigger” for femoral and “smaller” for internal jugular vein, whereas 3% showed to have a general rule of “bigger” for internal jugular vein and “smaller” for femoral.
- SIZE2= 12% said that it depended on the prescribed treatment (i.e., bigger catheters for intermittent dialysis and high volume CRRT, and smaller ones for standard dose CRRT).

Original Paper

Blood Purification

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International Survey on the Management of Acute Kidney Injury and Continuous Renal Replacement Therapies: Year 2018

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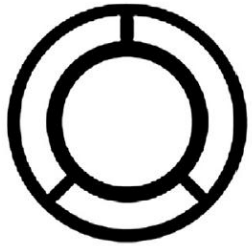
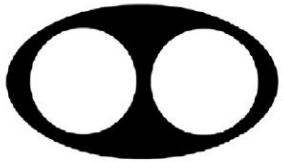
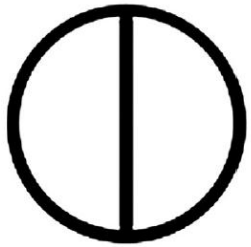
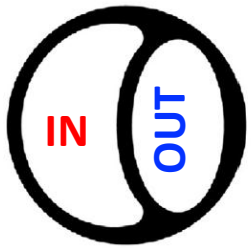
Claudio Ronco[a, b]

☞Vascular access placement is considered a routine procedure for 66% of attendees, 21% stated that the level of risk depended on available site for puncture, while 13% considered vascular access placement as a risky procedure in their unit.

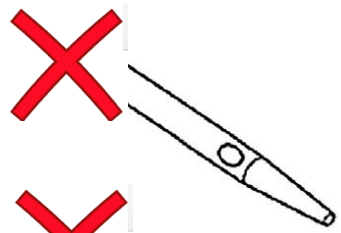
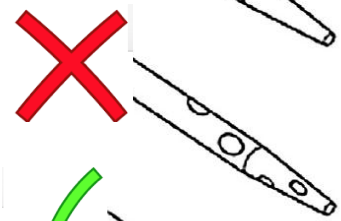
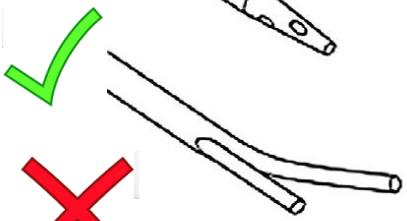
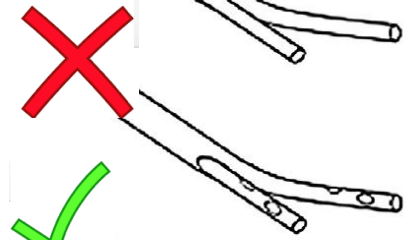
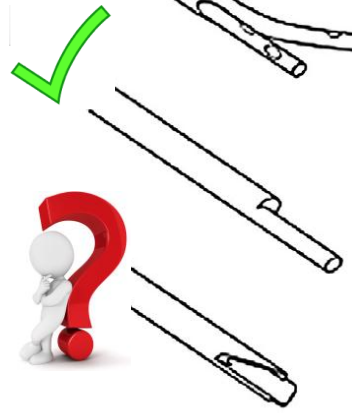
Design & shape - section

	Advantage	Disadvantage
 a. Co-axial	Small external diameter	Small inflow lumen Large blood contact surface Acute angles (turbulence)
 b. Double-O	Large lumens No angle (less turbulence)	Large external diameter
 c. Double-D	Large lumens	Large external diameter Acute angles along median wall
 d. Cycle-C	No acute angles Inflow lumen larger than outflow lumen Small external diameter	

the cycle-C or kidney-shape catheter seems to exhibit the optimal form

Courtesy of S Romagnoli

Design & shape – distal tip

	Type	Advantage	Disadvantage
	Pointed catheter	**Easy introduction**	Recirculation Side hole: (parietal suction)
	Multiperforated Pointed catheter	Easy introduction	Turbulence
	Split tip	Less recirculation Laminar flow	Difficult insertion
	Multiperforated Split tip		Turbulence
	**Shotgun tip catheter (step tip)** Symmetric or Side-by-side catheter	**Less recirculation** Less recirculation Lumen inversion allowed	Sometimes hard to insert

Courtesy of S Romagnoli

Recirculation

1. If proximal and distal lumens are switched, recirculation rate may increase to more than 20%, and delivered dialysis dose might be decreased
2. Also blood hematocrit running into the circuit may progressively increase
3. Citrate infusion can be recirculated or excessive calcium concentrations can re-enter the circuit

TO STOP OR TO TEMPORARILY REDUCE THE **RECIRCULATION PHENOMENON** (AND ITS PROGRESSIVE EFFECTS) TREATMENTS SHOULD BE **SHORTLY INTERRUPTED** (STOP REINFUSION, UFNET AND DIAL) **OR PAUSED** (SALINE FLUSHES OR SALINE RECIRCULATION) OR **LINES SWITCHING RESTORED** TO NORMAL

Recirculation

NO DATA AVAILABLE IN THE ACUTE SETTING REGARDING:

Does type of catheter matter on circuit duration?

Int J Artif Organs 2011; 34 (0): 000-000 DOI: 10.5301/IJAO.5000003

ORIGINAL ARTICLE

A comparison of the Niagara™ and Dolphin® catheters for continuous renal replacement therapy

Inbyung Kim, Nigel Fealy, Ian Baldwin, Rinaldo Bellomo

Department of Intensive Care Medicine, Austin Hospital, Melbourne - Australia

ABSTRACT

Purpose: *The choice of vascular access catheter may affect filter life during continuous renal replacement therapy (CRRT); specifically, a new surface-modified catheter has been reported to possibly prevent thrombosis and catheter malfunction.*

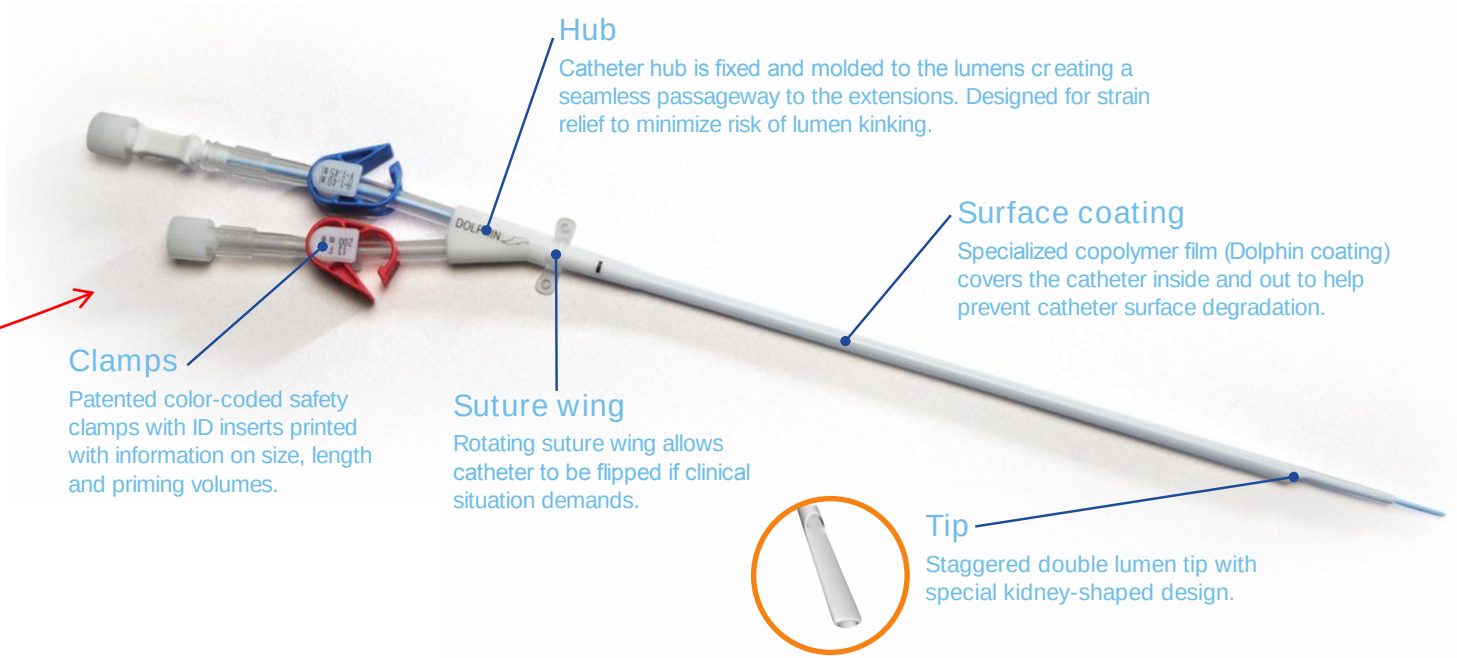
Design and setting: *A sequential, controlled study in a tertiary ICU.*

Aims: *To compare circuit life when CRRT was performed with a Bard®Niagara™ catheter or the surface-modified GamCath™ Dolphin® Protect 1320 catheter.*

Patients and measurements: *We studied 50 patients with acute kidney injury requiring CRRT, all delivered with catheters in the femoral position. We obtained information on age, gender, disease severity score (APACHE II and APACHE III), filter life, total heparin dose, hemoglobin concentration, platelet count, INR, and aPTT during CRRT.*

Results: *We studied 341 circuits in 50 patients; 30 patients (140 circuits) used the Niagara and 20 patients (201 circuits) used the Dolphin catheter. Mean of circuit life in two groups was 14.9 hours*

DOLPHIN



Hub

Catheter hub is fixed and molded to the lumens creating a seamless passageway to the extensions. Designed for strain relief to minimize risk of lumen kinking.

Surface coating

Specialized copolymer film (Dolphin coating) covers the catheter inside and out to help prevent catheter surface degradation.

Clamps

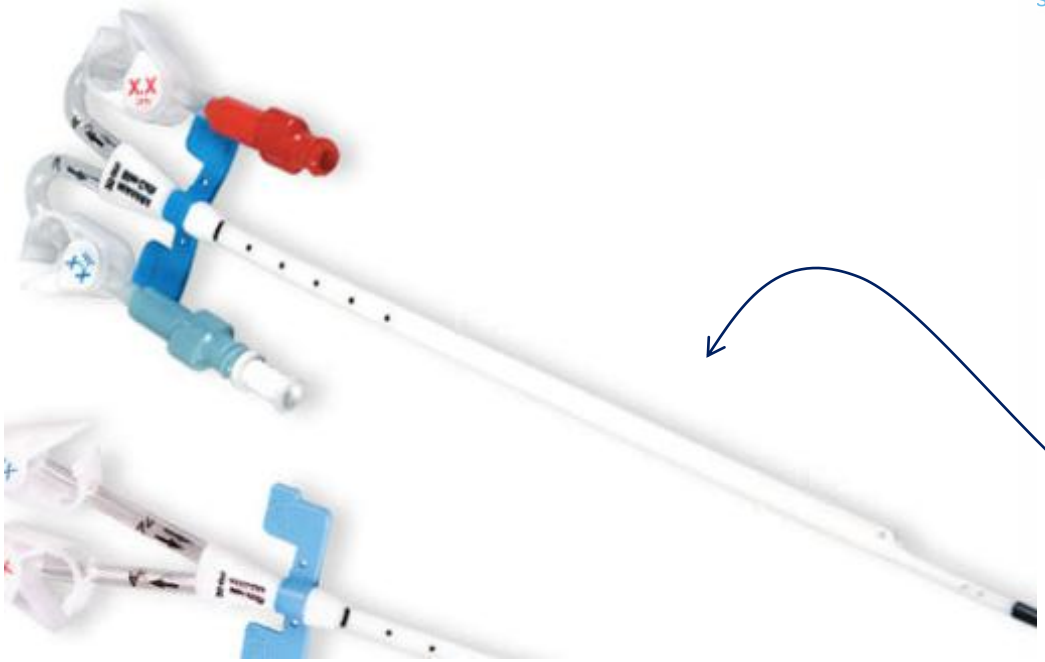
Patented color-coded safety clamps with ID inserts printed with information on size, length and priming volumes.

Suture wing

Rotating suture wing allows catheter to be flipped if clinical situation demands.

Tip

Staggered double lumen tip with special kidney-shaped design.



NIAGARA

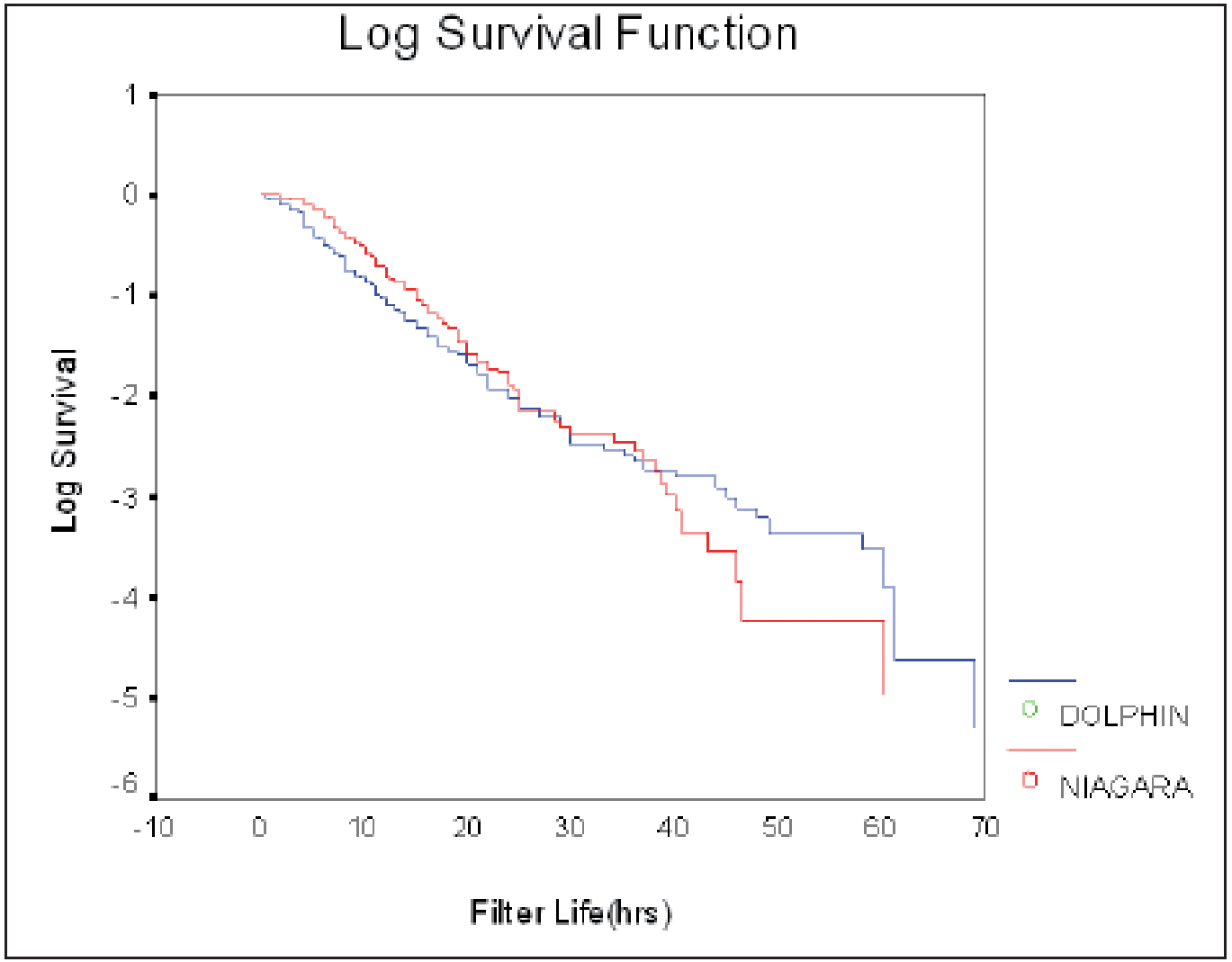


Fig. 2 - *Kaplan-Meier product limit survival plots of circuit life with the Niagara and Dolphin catheters.*

Does type of catheter matter on circuit duration?

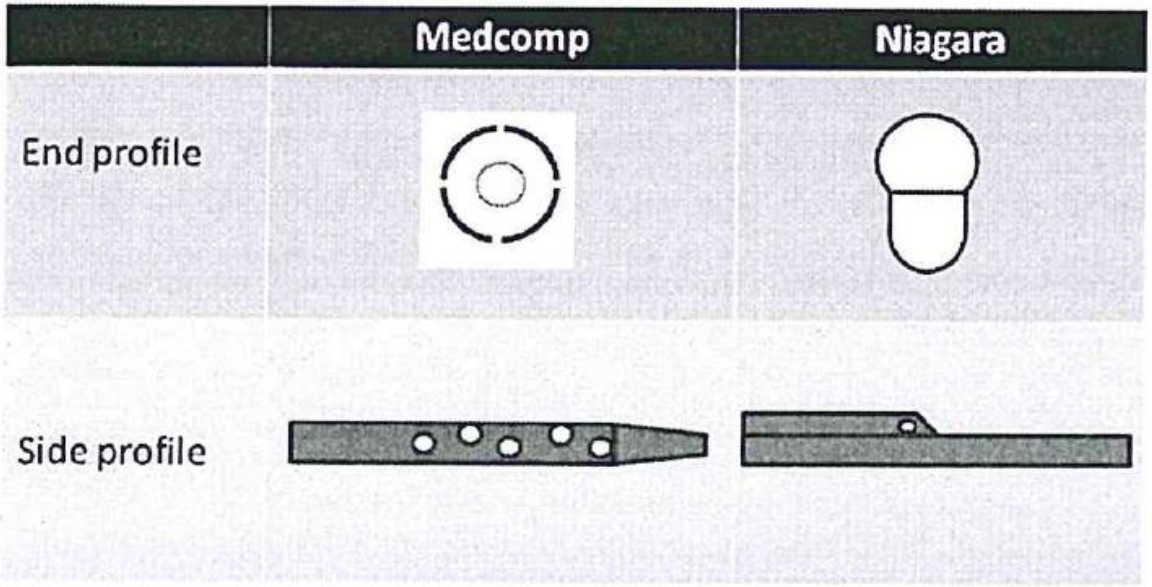
Renal Failure, 2013; Early Online: 1–6

ISSN 0886-022X print/1525-6049 online
DOI: 10.3109/0886022X.2012.757823

CLINICAL STUDY

A Comparison of the Niagara™ and Medcomp™ Catheters for Continuous Renal Replacement Therapy

Nigel Fealy[1], Inbyung Kim[2], Ian Baldwin[1], Antoine Schneider[1] and Rinaldo Bellomo[1]



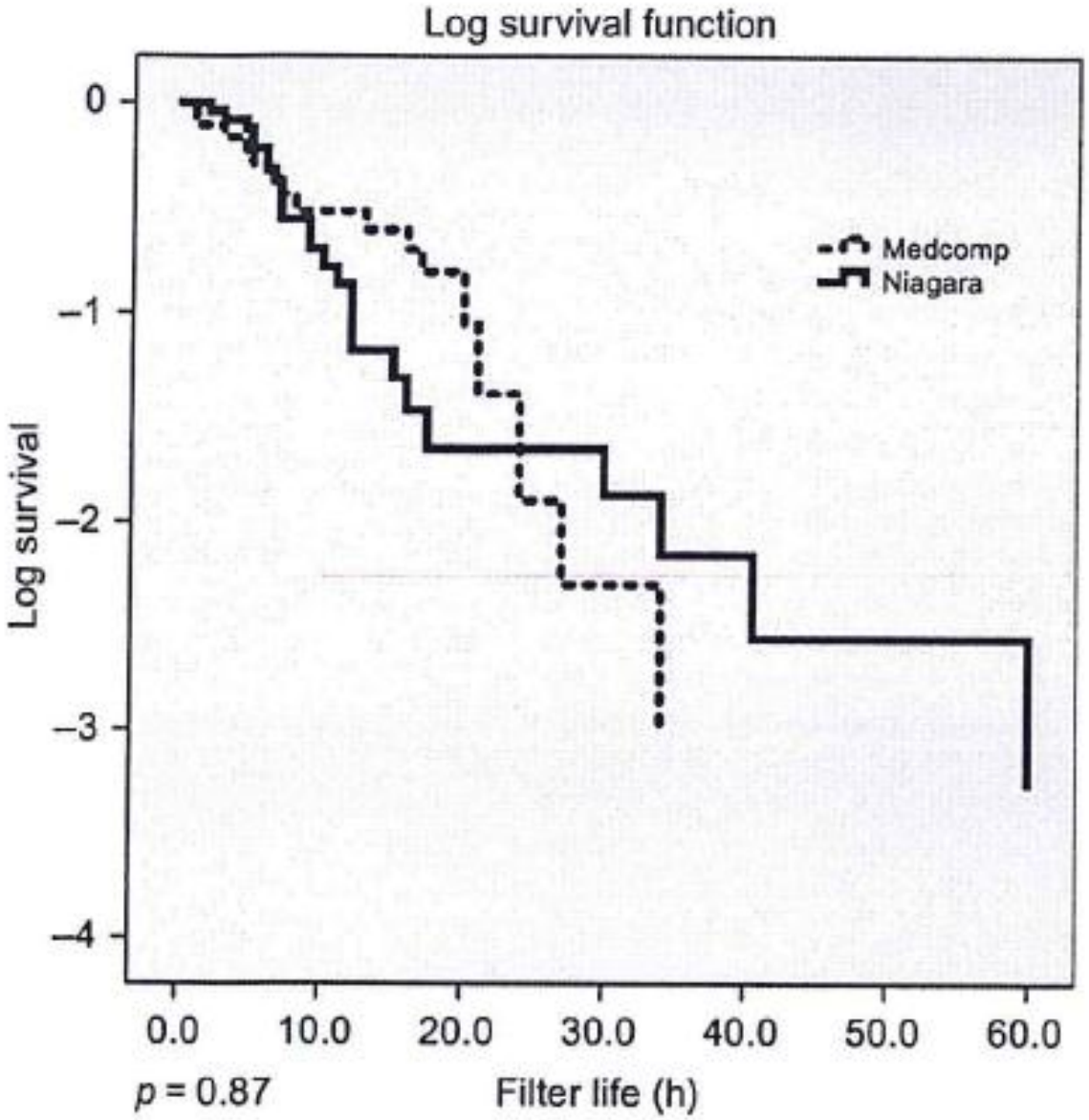
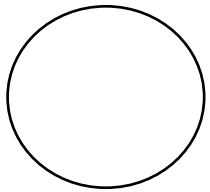


Figure 2. Kaplan–Meier product limit survival plots of circuit life with the Niagara and the Medcomp catheters.

Composition/materials

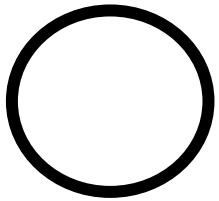
Haemodialysis catheters are made of **polyurethane** or **silicon**.

- Thin **polyurethane** catheter wall → larger internal diameter for a constant external diameter.



- Its **rigidity** makes insertion easier.
- Increased theoretical risk of vascular or atrial **trauma** during catheter insertion.
- Since these catheters are **thermoplastic**, they become more **flexible** at human body temperature. When the catheter is placed, it takes on the vessel shape and decreases trauma risk.

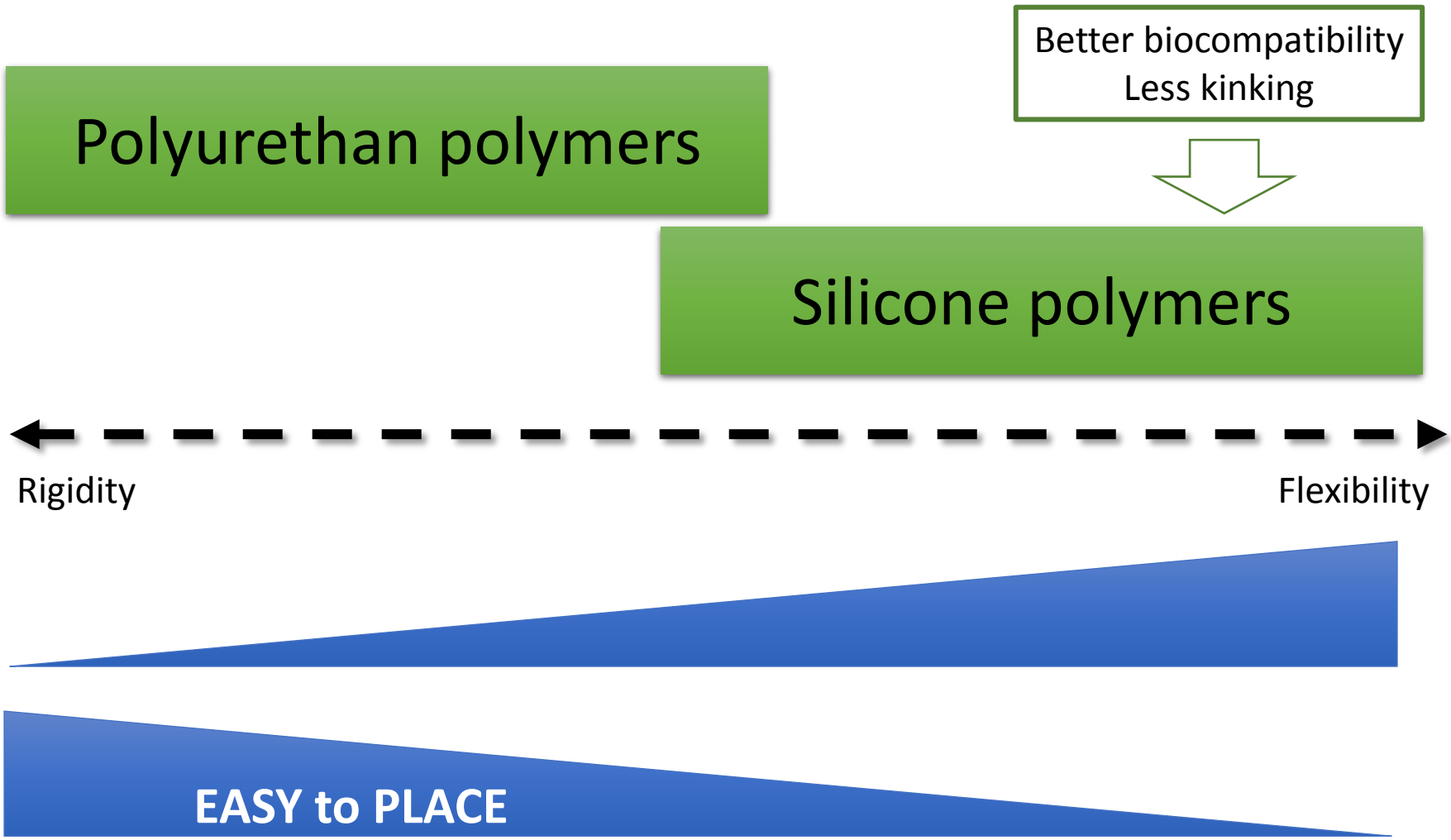
- **Silicon** - increased wall **thickness** → decreases the internal catheter diameter.



- More **flexible**, but their insertion is theoretically harder.
- Their flexibility decreases vessel trauma during insertion.
- Silicon **biocompatibility** makes catheters less thrombogenic.

Courtesy of S Romagnoli

Composition/materials



Courtesy of S Romagnoli

Risk of Catheter colonization

Femoral vs Jugular Venous Catheterization and Risk of Nosocomial Events in Adults Requiring Acute Renal Replacement Therapy

A Randomized Controlled Trial

JAMA 2008

Jean-Jacques Parienti, MD, DTM&H
Marina Thirion, MD
Bruno Mégarbane, MD, PhD
Bertrand Souweine, MD, PhD

Context Based on concerns about the risk of infection, the jugular site is often preferred over the femoral site for short-term dialysis vascular access.

Objective To determine whether jugular catheterization decreases the risk of nosocomial complications compared with femoral catheterization.

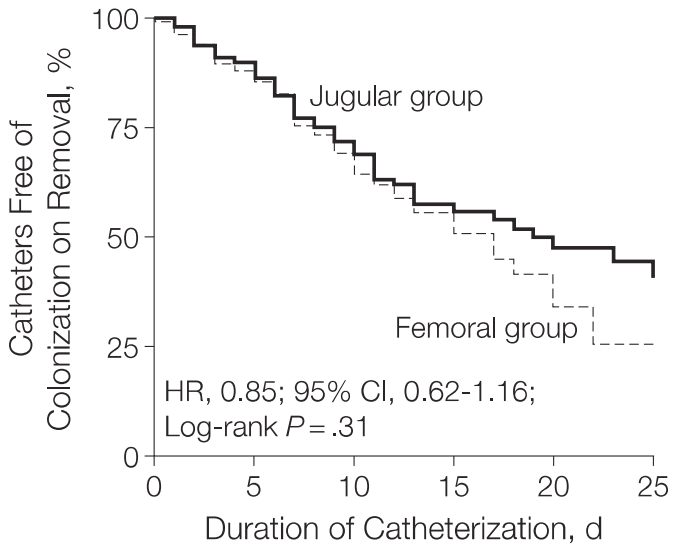
- 750 critically ill patients
- 9 ICUs in France
- 324 vs 313 pts randomized to either femoral or internal jugular vein
- Patients with coagulopathy, BMI>45, local skin infection, profound volume overload, chronic renal failure, patients with only 1 site available were not included

1. Primary end point: catheter colonization on removal
2. Secondary end point: catheter-related bloodstream infection

Overall no difference
Between femoral and jugular

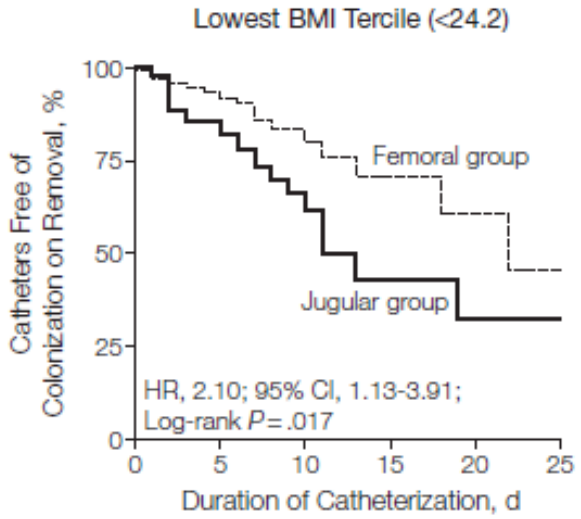
Characteristics	Femoral (n = 370)	Jugular (n = 366)	
No. of catheter colonizations	84	78	
Incidence per 1000 catheter-days (95% CI)	40.8 (29.3-55.4)	35.7 (25.0-49.5)	
Log_{10} CFU per mL, mean (95% CI)	3.77 (3.58-3.96)	3.59 (3.38-3.80)	
No. of catheter-related bloodstream infections	3	5	.50
Incidence per 1000 catheter-days (95% CI)	1.5 (0.1-6.4)	2.3 (0.3-7.7)	.42[b]
Catheter follow-up			
Days of insertion			
Mean (SD)	6.2 (5.5)	6.9 (7.5)	
Median (IQR)	5 (2-9)	5 (2-9)	
Reason for catheter ablation			
No more required	144 (38.9)	125 (34.2)	
Catheter dysfunction	36 (9.7)	38 (10.4)	
Suspicion of catheter infection	34 (9.2)	45 (12.3)	
Systematic	31 (8.4)	21 (5.7)	
Death	98 (26.5)	109 (29.8)	
Spontaneous catheter withdrawal	5 (1.4)	4 (1.1)	
Unknown or not inserted	22 (5.9)	24 (6.6)	

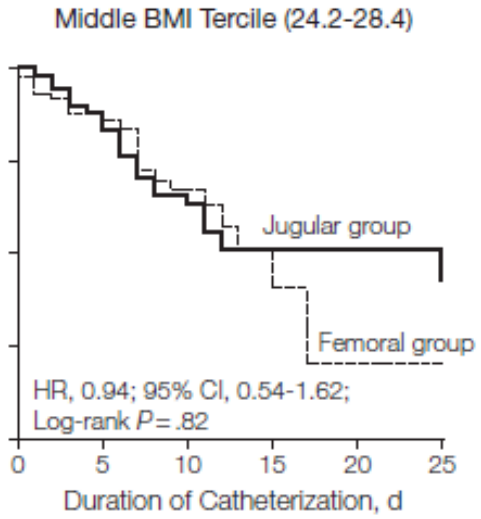
Figure 2. Overall Kaplan-Meier Curve of Time to Catheter Colonization on Removal

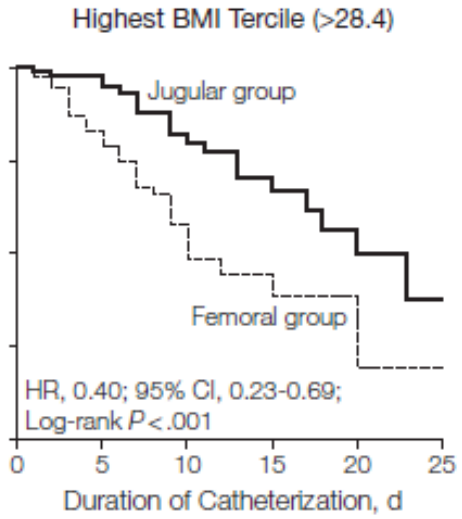


BMI effect: Jugular for fat people and femoral for thin people

Figure 3. Kaplan-Meier Curves of Time to Catheter Colonization on Removal Stratified According to BMI Terciles



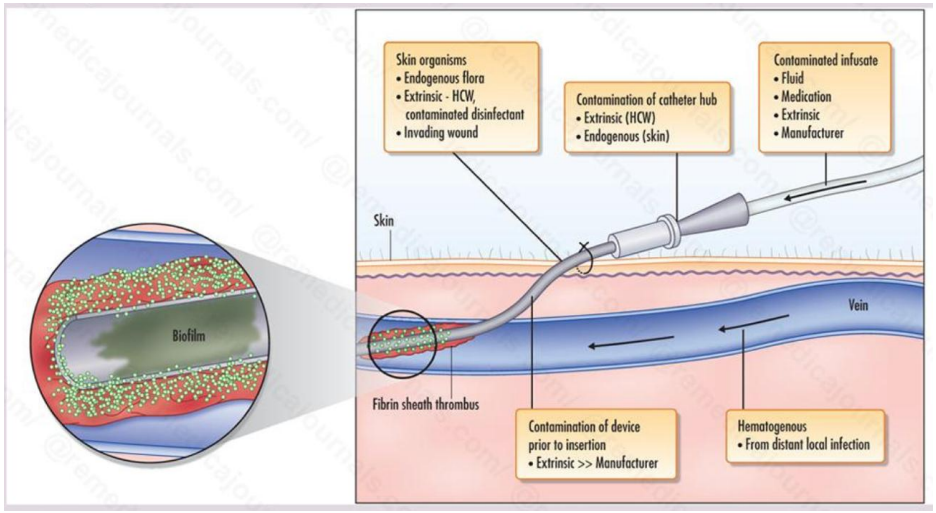


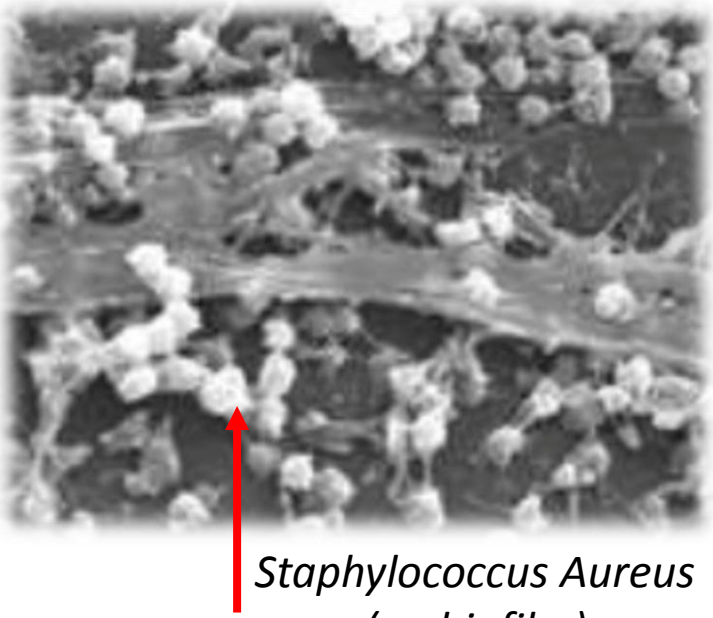


No. at risk					
Femoral group	101	50	14	5	3
Jugular group	94	62	25	9	5
	101	48	20	5	1
	101	57	23	9	8
	102	61	24	7	4
	100	66	36	18	9

Catheter Manteinance

The goal of a **prophylactic "lock" solution** is to decrease **thrombi** and **biofilm** formations that trigger catheter colonization and catheter-related bloodstream infections.

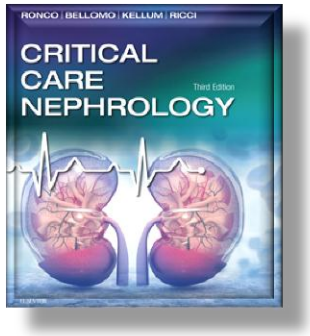




Staphylococcus Aureus (on biofilm)

Courtesy of S Romagnoli

Catheter-locking solutions based on **antithrombotic/antiseptic** or **antibiotic** or **fibrinolytic** mixtures have proved to be efficient in preventing endoluminal contamination by bacteria and reducing catheter-related bloodstream infections (CRBSI).



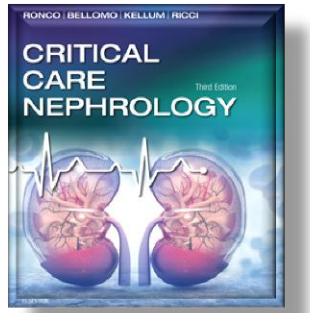
MC Weijmer et al. Nephrol Dial Transplant. 17:2189-2195 2002 12454232
M Allon. Clin Infect Dis. 36:1539-1544 2003 12802753
CW McIntyre et al. Kidney Int. 66:801-805 2004 15253736
M Agharazii et al. Nephrol Dial Transplant. 20:1238-1240 2005 15855206

Most of the studies concern tunneled haemodialysis catheters and extrapolation to non-tunneled catheters seems limited.

L. Huriaux et al. Anaesth Crit Care Pain Med 36 (2017) 313–319

Courtesy of S Romagnoli

Significant benefits of these approaches have been proved in randomized controlled prospective studies evaluating **citrate 4%** or **citrate/taurolidine** mixtures (SAE with high conc citrate).



R Boorgu et al. ASAIO J. 46:767-770 2000 11110278
B Bayes, et al. Nephrol Dial Transplant. 16:1521-1522 2001
MG Betjes, et al. Nephrol Dial Transplant. 19:1546-1551 2004 14993498
CE Lok et al. Nephrol Dial Transplant. 22:477-483 2007

- Catheter-locking solutions, using an antithrombotic, antiseptic, and fibrinolytic mixture of agents have **proved superior efficacy** to prevent thrombosis and/or infection.

- **Heparin is no longer the state-of-the-art** lock solution because it facilitates Staphylococcus aureus biofilm formation.

- All catheter-locking solutions (single or dual activity) must be evaluated in terms of **specific indications** (e.g., patients at risk, salvaging option) and cost-effectiveness or risk (antibiotic resistance) before they can be recommended for routine clinical practice.

Courtesy of S Romagnoli

SFAR
Société Française d'Anesthésie et de Réanimation

Anaesth Crit Care Pain Med 36 (2017) 313–319

Haemodialysis catheters in the intensive care unit

Laetitia Huriaux [a,*], Paul Costille [a], Hervé Quintard [b], Didier Journois [c], John A. Kellum [d], Thomas Rimmelé [a]

- The use of lock solutions could theoretically lead to increased costs as well as to bacterial resistance.
- To date, due to lack of evidence, we do not recommend lock solutions.
- The exception could be patients with long-term catheters who have a history of multiple catheter related bloodstream infections despite strict adherence to aseptic practices

Courtesy of S Romagnoli

CRBSI – Lock solutions

CDC guidelines **strongly recommend against** routinely using antibiotic lock solutions in CVC, because of their potential to promote fungal infections, antimicrobial resistance, and systemic toxicity.

5.4.6: We suggest not using antibiotic locks for prevention of catheter-related infections of nontunneled dialysis catheters in AKI requiring RRT. (2C)

Exceptions . .

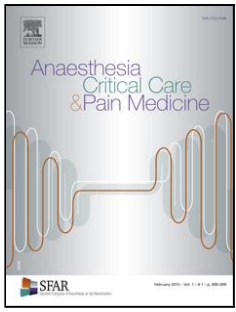
- long-term cuffed and tunneled catheters with history of multiple catheter-related bloodstream infections despite maximal adherence to aseptic technique
- […] or patients with heightened risk of severe sequelae from a catheter-related bloodstream infection

Courtesy of S Romagnoli

Conclusions

The "Ten commandments" of the ideal RRT catheter

1) Optimal external diameter according to vessel diameter: from 12 to 16 Fr
2) Optimal shape: cycle-C catheter
3) Optimal distal tip: shotgun tip catheter
4) Preferred insertion site: right jugular or femoral
5) Avoid left jugular and subclavian insertion sites
6) No line reversal (and/or monitor recirculation)
7) Use ultrasound guidance
8) Use biocompatible material
9) Correct position: aim to cavo-atrial junction (superior vena cava territory) or to iliac veins (femoral)
10) Remove it as soon as possible!



Huriaux L, Haemodialysis catheters in the intensive care unit, Anaesth Crit Care Pain Med. 2017