Les Hôpitaux Universitaires de STRASBOURG

Cathéters : Lequel choisir ? Design, matériau, performance

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Conflits d'intérêts

- Comité d'experts :
  - Hemotech
  - Sanofi

- Frais de déplacements à des congrès :
  - Hema-T

Cathéter comme alternative à la FAV

- Je ne parlerai donc que des cathéters tunnelisés

Qu’est-ce qui fait la qualité d’un cathéter ?

- Biocompatibilité
  - Faible réaction inflammatoire
  - faible thrombogénicité
- Performances
  - Débit sanguin obtenu élevé
  - Faible recirculation
- Risque infectieux réduit
- Confort
  - Pour le patient
  - Pour l’équipe paramédicale
- Sécurité
  - Traumatismes à la pose
  - Déconnexions

Le matériau des cathéters

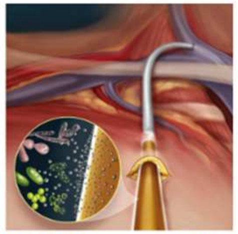
- Silicone (Hemo-Cath de Medcomp, Vygon)
  - Plus souple, donc probablement moins traumatisant pour les veines centrales
  - Mais plus épais (lumière plus fine à calibre externe identique)

- Polyuréthane (Medcomp, Teleflex, BD), Carbothane (Medtronic, MeritMedical, Amecath) ou Durathane (Angiodynamics)
  - Plus rigide donc insertion plus aisée
  - Peut-être plus traumatisants pour les veines centrales mais thermosensibles
  - Diamètre interne plus important

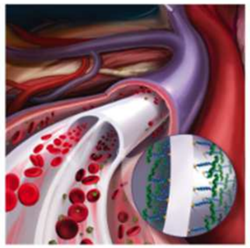
Les traitements de surface

- Silver Ion (Palindrome)
- Chlorexhidine + silver sulfadiazine (Teleflex)
- Endexo (Angiodynamics)
- Bismuth
- Minocycline-rifampicine

- Héparine (Palindrome)



Silver ion antimicrobial sleeve



Heparin coating

Systematic review of antimicrobials for the prevention of haemodialysis catheter-related infections

Kannaiyan S. Rabindranath[1], Tarun Bansal[2], James Adams[3], Ruma Das[4], Ranjit Shail[5], Alison M. MacLeod[6], Carol Moore[7] and Anatole Besarab[7]

Study ID	Country	Time period of study	No. of patients	Mean age (years)	Diabetics (%)	Tunnelled or non-tunnelled catheter	Catheter vintage	Experiment intervention (s)	Control Intervention	Co-interventions
Antimicrobial-coated catheters or catheter components										
Chatzinikolou 2005 [27]	USA	May 2000–March 2002	130	56.50	NA	Non-tunnelled	New	Minocycline–rifampicin impregnated catheters	None	Exit-site application of povidone–iodine
Dahlberg 1995 [29]	USA	Not mentioned	101	63.40	32.70	Tunnelled	New	Silver impregnated cuff over catheter	None	Exit-site application of Polyantibiotic ointment
Trerotola 1998 [19]	USA	Not mentioned	91	51.50	NA	Non-tunnelled	New	Silver-coated catheters	None	Application of povidone–iodine ointment

Study ID	No. of patients	Experiment intervention (s)	Control intervention	No. of catheter days: Experimental intervention	No. of catheter days: Control intervention	No. of CRB events per 1000 catheter-days: Experimental intervention	No. of CRB events per 1000 catheter-days: Control intervention
Antimicrobial-coated catheters or catheter components							
Chatzinikolou 2005 [27]	130	Minocycline–rifampicin impregnated catheters	None	528	512	0	5.86
Dahlberg 1995 [29]	101	Silver impregnated cuff over catheter	None	1639	2241	1.22	0.89
Trerotola 1998 [19]	91	Silver-coated catheters	None	2846	5507	1.76	0.91

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Does Heparin Coating Improve Patency or Reduce Infection of Tunneled Dialysis Catheters?

Gaurav Jain,* Michael Allon,* Souheil Saddekni,[†] Jill Barker-Finkel,[‡] and Ivan D. Maya*
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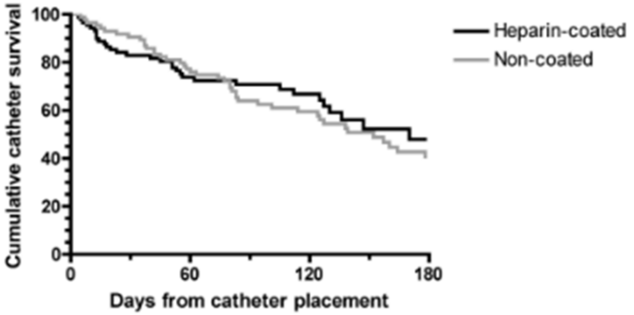
Clin J Am Soc Nephrol 4: 1787–1790, 2009.



N at risk	0	60	120	180
Hep-coated	89	53	29	7
Non-coated	86	61	37	21

Table 2. Catheter outcomes in the study population

	Heparin Coated	Noncoated
Number of patients	89	86
Catheter malfunction [*N* (%)]	17 (19%)	13 (15%)
Catheter-related bacteremia [*N* (%)]	30 (34%)[a]	52 (60%)
Elective removal [*N* (%)]	31 (35%)	17 (20%)
Remained patent [*N* (%)]	11 (12%)	4 (5%)
tPA instillations per 1000 catheter-days	1.8	1.8

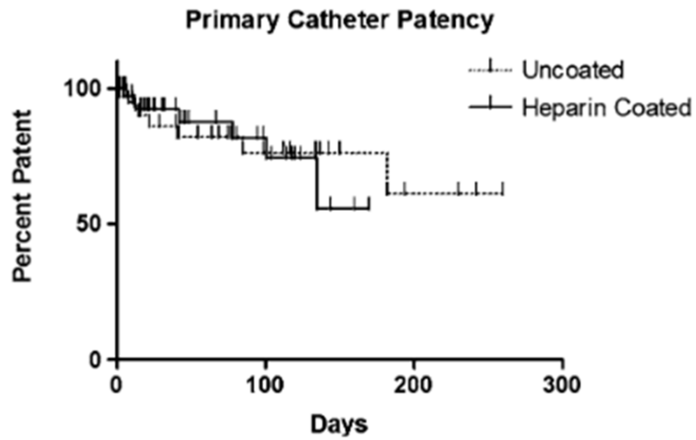
Table 3. Dialysis blood flows in the study catheters

	Heparin Coated	Noncoated	*P* Value
Number of patients	89	86	
Blood flows at 30 days (ml/min)	426 ± 47	380 ± 43	<0.001
Blood flows at 60 days (ml/min)	425 ± 49	383 ± 57	<0.001
Blood flows at 90 days (ml/min)	432 ± 47	390 ± 58	<0.001

Comparison of Heparin-Coated and Conventional Split-Tip Hemodialysis Catheters

Timothy W. I. Clark · David Jacobs ·
Hearns W. Charles · Sandor Kovacs ·
Theresa Aquino · Joseph Erinjeri · Judith A. Benstein

Cardiovasc Intervent Radiol (2009) 32:703–706



Blood compatibility of widely used central venous catheters; an experimental study

Hulda Thorarinsdottir[1,2], Thomas Kander[1,2✉], Dorota Johansson[3,6], Bo Nilsson[4], Bengt Klarin[1,2,7] & Javier Sanchez[5,7]

Type	Brand	Abbreviation	Material(s)
Uncoated	MedComp, CHC, Hemo-cath ST	Si-1	Silicone
	MeritMedical, CVC, Careflow®	PU-1	Polyurethane
	Teleflex, CVC, Arrow MultiLumen CVC with Blue Tip®	PU-2	Polyurethane
Coated	Teleflex, CVC, ARROWg + ard Blue® with Blue Tip	PU-2 + CHSS	Polyurethane coated with chlorohexidine and silver sulfadiazine
	Argon Medical, CVC, Hydrocath Assure™	PU-3 + BZC	Polyurethane with a hydrophilic matrix impregnated with benzalkonium chloride
	Bactiguard, CVC, Infection Protection Central Venous Catheter	PU4 + NbMC	Polyurethane coated with noble metals (Pd, Au, and Ag)

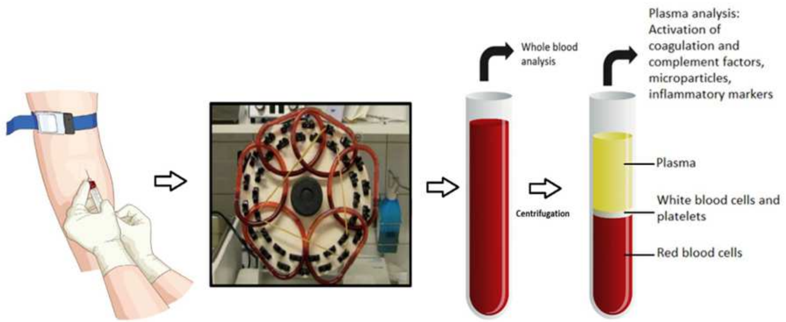
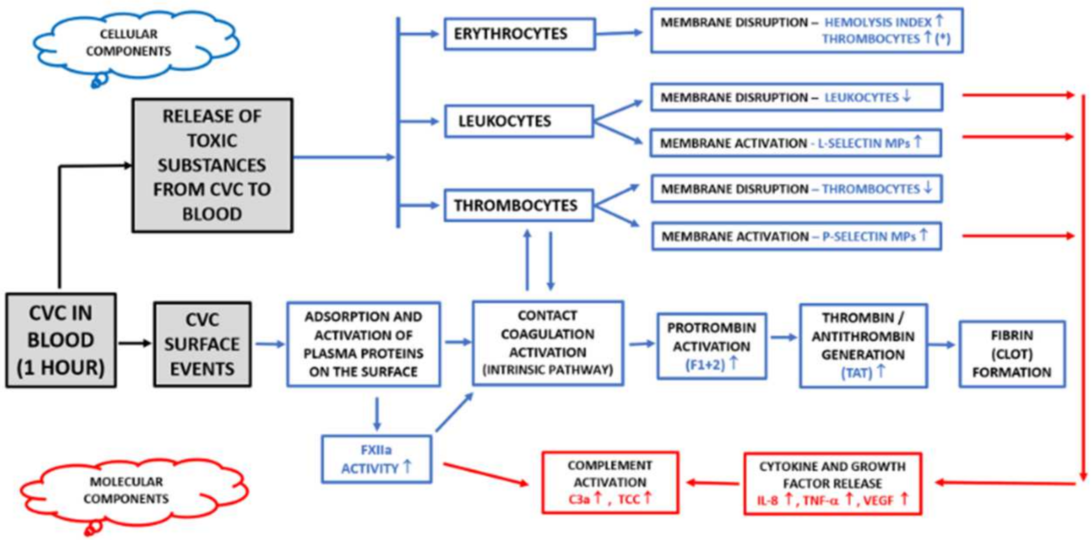


Figure 2. The Chandler loop model. The model imitates the flow of blood in a vein.



Blood compatibility of widely used central venous catheters; an experimental study

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	The blood cell and coagulation system							
	Erythrocytes	Leukocytes		Platelets and coagulation				
	Hemolysis index (%) (membrane disruption)	Remaining leukocytes (%) (membrane disruption and activation)	L-Selectin (mp/mL) (leukocyte activation)	Remaining platelets (%) (aggregation, membrane disruption)	P-Selectin (mp/mL) (thrombocyte activation)	FXIIa Activity (Abs 450 nm) (surface activation)	Prothrombin fragment F1+2 (pmol/mL)	TAT (mg/L) (coagulation activation, TAT is pre-stage for clot)
n	10	10	5	10	8	6	6	10
Control loop	0.75 (0.40–0.98)	97 (93–102)	37 (4–87)	94 (88–101)	31 (11–141)	n.a.	300 (158–358)	48 (19–74)
Uncoated catheters								
Si-1	0.62 (0.21–1.21)	97 (90–100)	37 (12–108)	72 (44–82)	309 (191–1365)	0.24 (0.17–0.32)	1078 (556–2410)	218 (118–558)
PU-1	0.90 (0.47–1.47)	99 (95–104)	17 (13–38)	81 (72–88)	178 (24–673)	0.25 (0.15–0.29)	617 (154–1563)	370 (300–479)
PU-2	0.93 (0.45–1.28)	100 (97–105)	25 (4–36)	79 (51–87)	228 (122–545)	0.07 (0.04–0.08	719 (272–1576)	132 (105–170)
Coated catheters								
PU-2+CHSS	29.0 (21.3–47.6)	93 (90–100)	65 (18–134)	110* (73–130)	337 (42–752)	0.07 (0.06–0.11)	514 (180–983)	250 (186–333)
PU-3+BZC-H	0.90 (0.43–1.27)	97 (93–104)	282 (1–374)	94 (77–104)	75 (14–238)	0.04 (0.02–0.10)	660 (16 –1112)	183 (113–238)
PU-4+NbMC	0.91 (0.51–1.41)	98 (92–107)	25 (11– 135)	86 (67–99)	162 (20–679)	0.06 (0.04–0.08)	666 (250–865)	185 (146–259)

	The innate immune system				
	Complement activation by FXII or leukocytes		Acute immune reaction: cytokine and growth factors released from leukocytes/platelets		
	C3a (ng/mL) (anaphyla-toxin)	sC5b-9 (ng/mL) (membrane lysis)	IL-8 (pg/mL) (chemotaxis, phagocytosis)	TNF-α (pg/mL) (acute phase)	VEGF (pg/mL) (angio-genesis)
n	10	10	10	10	8
Control loop	854 (228–984)	282 (168–420)	2.09 (1.1–7.4)	1.54 (0.88–3.64)	36 (8–70)
Uncoated catheters					
Si-1	873 (665–1926)	626 (419–1576)	5.53 (2.3–20.7)	1.59 (1.17–4.25)	71 (27–144)
PU-1	853 (652.1–1009)	626 (370–904)	3.64 (2.0–7.2)	1.34 (1.09–4.35)	42 (16–62)
PU-2	837 (562–978)	637 (323–816)	4.20 (2.5–7.5)	1.34 (1.07–4.03)	44 (16–75)
Coated catheters					
PU-2+CHSS	1528 (809–1876)	1218 (466–1859)	12.50 (3.5–26.8)	6.64 (3.40–17.7)	47 (42–87)
PU-3+BZC-H	920 (710–1132)	621 (378–896)	2.41 (1.5–5.1)	1.25 (0.77–7.17)	34 (12–70)
PU-4+NbMC	834 (752–1341)	672 (423–832)	3.74 (2.0–8.6)	1.60 (0.81–3.33)	44 (15–63)

Loi de Poiseuille-Hagen

- Qb = $(\pi \times r^4 \times \Delta P) / (8 \times \mu \times L)$
  - Qb = débit sanguin
  - r = rayon interne
  - ΔP = Pression entrée (PVC) – Pression sortie («Pression artérielle» du circuit)
  - μ = viscosité
  - L =longueur du cathéter

- Pour un régime circulatoire de type laminaire, or dans un cathéter ce n’est pas le cas, la vélocité est donc moindre

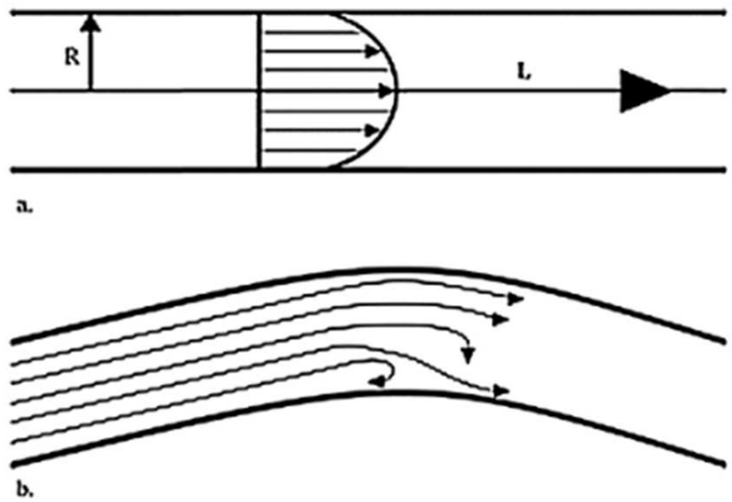


Fig. 1. Laminar flow in linear channel (a) and turbulent flow in curved channel (b). Poiseuille's law: $Q_v = k$ $(P \times R^4)/(L \times \eta)$ (Q_v = volumetric flow rate, k = proportionality constant, P = drop pressure between catheter extremities, R = catheter radius, L = catheter length, η = blood viscosity).

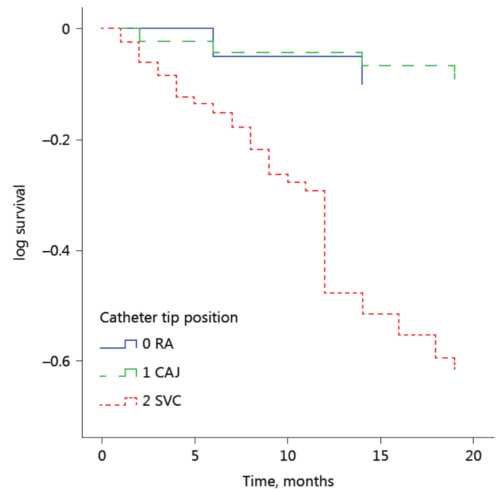
The Different Impacts on the Long-Term Survival of Tunneled Internal Jugular Hemodialysis Catheters Based on Tip Position and Laterality

Vedran Premuzic[a] Drazen Perkov[b] Ranko Smiljanic[b]
Bruna Brunetta Gavranic[a] Bojan Jelakovic[a]

Table 3. Characteristics of catheter survival between different catheter tip positions and laterality

	SVC	CAJ	Right atrium	*p* value
VJR, n (%)				
Functional catheters	34/60 (56)	28/30 (93)	11/12 (92)	<0.001
Complications				
Thrombosis	10 (16.6)	1 (3.3)	0 (0)	<0.001
Infection	1 (1.6)	0 (0)	1 (8.3)	>0.05
Dysfunction	15 (25)	1 (3.3)	0 (0)	<0.001
VJL, n (%)				
Functional catheters	13/28 (46)	15/17 (88)	8/9 (89)	<0.001
Complications				
Thrombosis	7 (25)	1 (5.8)	0 (0)	<0.001
Infection	2 (7.1)	0 (0)	0 (0)	<0.001
Dysfunction	6 (21.4)	1 (5.8)	1 (11.1)	0.02
VJR vs. VJL, p value				
Functional catheters	0.36	0.55	0.83	
Complications				
Thrombosis	0.76	0.99		
Infection	0.26			
Dysfunction	0.27	0.99		

SVC, superior vena cava; CAJ, cavoatrial junction; VJR, right internal jugular vein; VJL, left internal jugular vein.

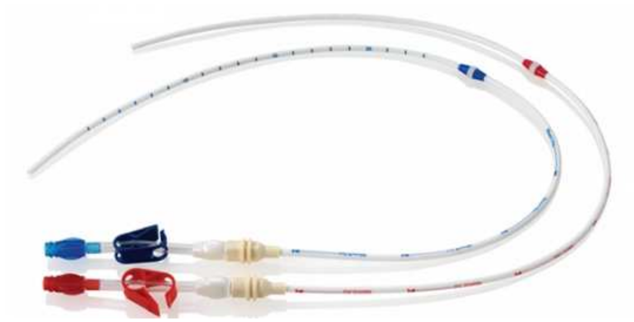


Les dimensions idéales sont donc

- Le plus gros calibre interne possible

- Suffisamment long pour atteindre l’OD, mais pas plus
  - Il faut donc être vigilent à la différence qui existe entre la longueur totale et la longueur cuff-to-tipLa tunnelisation rétrograde permet un meilleur positionnement dans l’OD, mais les extrémités externes sont plus longues… Parmi les cathéters à tunnelisation rétrograde, certains sont mieux conçus que d’autres avec des branches plus courtes…

L’extrémité distale

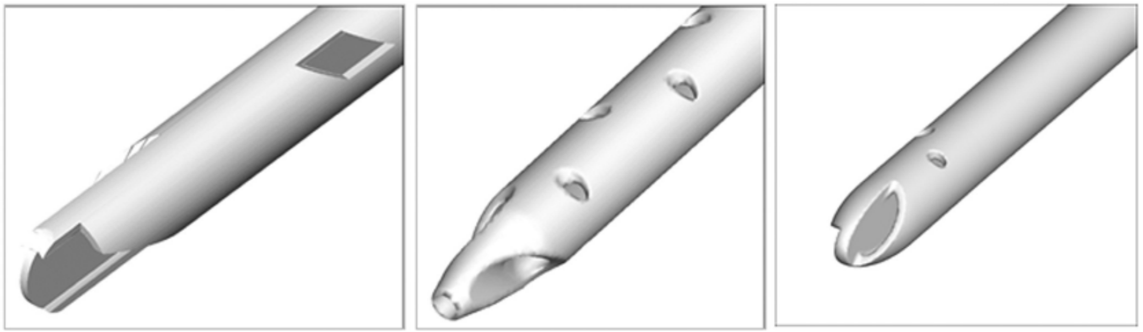


Step-tip

Split-tip

Split-tip, self-centering

Symetric-tip



A systematic review and meta-analysis of the comparison of performance among step-tip, split-tip, and symmetrical-tip hemodialysis catheters

Xiao-Chun Ling, MD,[a] Hsi-Peng Lu, PhD,[b] El-Wui Loh, PhD,[c,d] Yen-Kuang Lin, PhD,[e,f] Yi-Shiuan Li, MS,[a] Cheng-Hsin Lin, MD,[g,h] Yu-Chen Ko, MD,[h] Mei-Yi Wu, MD,[c,i,j] Yuh-Feng Lin, MD,[i,k] *and* Ka-Wai Tam, MD, PhD,[c,d,g,l,m,n] *Taipei and New Taipei City, Taiwan*

Table I. Characteristics of the included randomized controlled trials

Study (year)	Inclusion criteria	Study period	No. of patients (% male)	Age, years, mean ± SD median (range)	Intervention	RIJ vein insertion, %
Hwang et al[12] (2012)	Patients aged ≥18 years, expected duration of HD >2 weeks	2 months	Sym: 47 (48.3) ST: 50 (48.7)	Sym: 53 ± 15 ST: 57 ± 18	Sym: Palindrome ST: N/A	Sym: 100 ST: 100
Keeling et al[13] (2007)	ESRD patients referred for catheter insertion	26 months	SP: 101 (65) ST: 103 (53)	SP: 57 (18-91) ST: 64 (24-95)	SP: Ash Split ST: Permcath	SP: 67 ST: 71
Mankus et al[14] (1998)	Patients with chronic HD catheters	6 months	SP: 10 ST: 22 Dual: 17	N/A	SP: Ash Split ST: Mahurkar Dual: Tesio	N/A
O'Dwyer et al[15] (2005)	Inpatients referred for the insertion of tunneled HD catheters	12 months	SP: 33 (72.7) ST: 36 (50)	SP: 67.6 (15.9-89.0) ST: 63.4 (21.4-88.9)	SP: Ash Split ST: PermCath	N/A
Richard et al[16] (2001)	Expected duration of HD >2 weeks	6 months	SP: 38 ST: 39 Dual: 36	Overall 49 (22-98)	SP: Ash Split ST: OptiFlow Dual: Tesio	SP: 79 ST: 74 Dual: 83
Trerotola et al[17] (1999)	Use of the HD catheters > 6 weeks	6 months	SP:12 (0) ST: 12 (33.3)	SP: 52 ST: 54	SP: Ash Split ST: Hickman	SP: 100 ST: 100
Trerotola et al[18] (2002)	Patients referred for the insertion of tunneled HD catheters	6 months	SP: 64 (57.8) ST: 68 (67.6)	SP: 53.3 ± 14.3 ST: 56.2 ± 12.9	SP: Ash Split ST: OptiFlow	SP: 100 ST: 100
Van Der Meersch et al[6] (2014)	Patients aged ≥18 years, required a tunneled cuffed catheter	135.2 days (mean)	Sym: 151 (53.0) ST: 151 (56.9)	Sym: 69.2 ± 16.2 ST: 70.4 ±13.1	Sym: Palindrome ST: HemoStar	Sym: 100 ST: 100

ESRD, End-stage renal disease; *HD*, hemodialysis; *N/A*, not applicable; *RIJ*, right internal jugular; *SP*, split-tip catheter; *ST*, staggered-tip catheter; *Sym*, symmetrical.

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Check for updates

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	Step			Advanced				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
5.1.1 Step vs Split								
Keeling 2007	248	22	103	259	22	101	14.0%	-11.00 [-17.04, -4.96]
Mankus 1998	379	38.9	22	295	40.1	10	10.4%	84.00 [54.30, 113.70]
Odwyer 2005	261.9	66.7	36	270.8	50	33	10.7%	-8.90 [-36.57, 18.77]
Richard 2001	294	54.6	39	290	39.7	38	11.9%	4.00 [-17.28, 25.28]
Trerotola 1999	434	66	53	436	50	53	11.8%	-2.00 [-24.29, 20.29]
Trerotola 2002	359	13	8	422	12	8	13.4%	-63.00 [-75.26, -50.74]
Subtotal (95% CI)			**261**			**243**	**72.2%**	**-1.21 [-31.12, 28.69]**
Heterogeneity: Tau² = 1280.30; Chi² = 107.78, df = 5 (P < 0.00001); I² = 95%								
Test for overall effect: Z = 0.08 (P = 0.94)								
5.1.2 Step vs Symmetrical								
Hwang 2012	338	23	50	333	15	47	13.9%	5.00 [-2.68, 12.68]
Van der Meersch 2014	303.8	32.3	151	333.1	24.2	151	14.0%	-29.30 [-35.74, -22.86]
Subtotal (95% CI)			**201**			**198**	**27.8%**	**-12.22 [-45.83, 21.40]**
Heterogeneity: Tau² = 575.17; Chi² = 44.98, df = 1 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 0.71 (P = 0.48)								
Total (95% CI)			**462**			**441**	**100.0%**	**-5.37 [-23.75, 13.02]**
Heterogeneity: Tau² = 618.98; Chi² = 152.77, df = 7 (P < 0.00001); I² = 95%								
Test for overall effect: Z = 0.57 (P = 0.57)								
Test for subgroup differences: Chi² = 0.23, df = 1 (P = 0.63), I² = 0%								

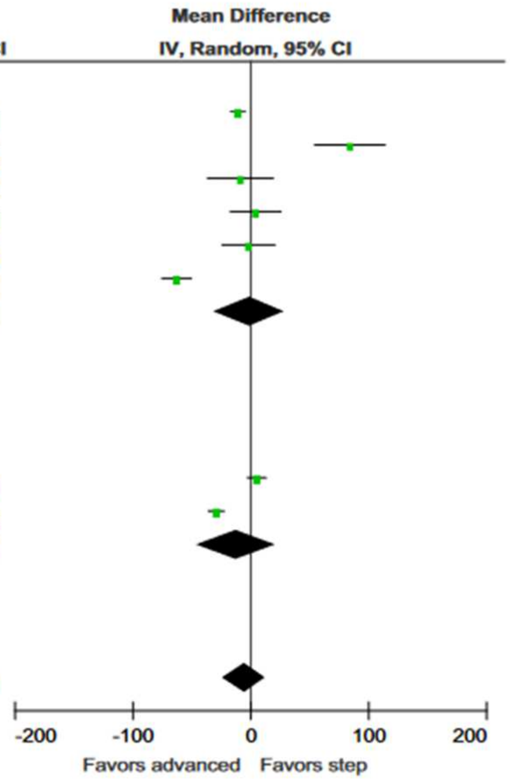

Fig 4. Forest plot of comparison, step vs advanced. Outcome: delivered blood flow. *CI*, Confidence interval; *IV*, inverse variance; *SD*, standard deviation.

A systematic review and meta-analysis of the comparison of performance among step-tip, split-tip, and symmetrical-tip hemodialysis catheters

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	Step			Split				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Trerotola 1999	5.6	1.4	12	1.3	1.3	12	84.9%	4.30 [3.22, 5.38]
Trerotola 2002	8.8	11.5	68	2.7	6.3	64	15.1%	6.10 [2.96, 9.24]
Total (95% CI)			80			76	100.0%	4.57 [3.31, 5.84]

Heterogeneity: Tau² = 0.19; Chi² = 1.13, df = 1 (P = 0.29); I² = 11%

Test for overall effect: Z = 7.09 (P < 0.00001)

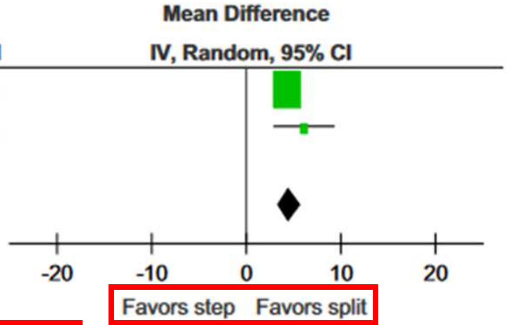

Fig 5. Forest plot of comparison, step vs split. Outcome: blood recirculation rate. *CI*, Confidence interval; *IV*, inverse variance; *SD*, standard deviation.

Comparative effectiveness and safety among different tip-design hemodialysis long-term catheters: A meta-analysis

Yunfeng Li [1,*], Zhenwei Shi [1], Yunyun Zhao[2], Zhengli Tan[3,*], Hongxia Guo[1], and Zhaoxuan Lu[1]

Table 1. Characteristics of included trials.

Author/year	Study design	Inclusion criteria	Follow time	Patients	Age/years/mean ± SD/median (range)	Male (%)	Diabetic (%)	Catheter band	RIJ vein insertion (%)	History insertion (%)	Cumulative catheter days (n)
Mankus et al.[12]	PC	Patients with chronic HD catheters	6 months	SP: 10/ST: 22	NA	NA	NA	SP: Ash Split/ST: Mahurkar	NA	NA	NA
Trerotola et al.[13]	RCT	Use of the HD catheters >6 weeks	42 days	SP:12/ST: 12	SP: 52/ST: 54	SP: 0/ST: 33.3	NA	SP: Ash Split/ST: Hickman	SP: 100/ST: 100	NA	SP: 462/ST: 336
Richard HM et al.[14]	RCT	Expected duration of HD > 2 weeks	6 months	SP: 38/ST: 39	Overall 49 (22–98)	NA	NA	SP: Ash Split/ST: OptiFlow	SP: 79/ST: 74	NA	SP: 5187/ST: 2800
Trerotola et al.[15]	RCT	ESRD patients referred for catheter insertion	6 months	SP: 64/ST: 68	SP: 53.3 ± 14.3/ST: 56.2 ± 12.9	SP: 57.8/ST: 67.6	NA	SP: Ash-split/ST: OptiFlow	SP: 100/ST: 100	NA	SP: 7267/ST: 6686
O'Dwyer et al.[16]	RCT	ESRD patients referred for catheter insertion	12 months	SP: 33/ST: 36	SP: 67.6 (15.9–89.0)/ST: 63.4 (21.4–88.9)	SP: 72.7/ST: 50	2.9	SP: Ash-split/ST: PermCath	NA	33.3	SP: 3686/ST: 5083
Keeling et al.[17]	RC	ESRD patients referred for catheter insertion	42 months	SP: 101/ST: 103	SP: 57 (18–91)/ST: 64 (24–95)	SP: 65/ST: 53	NA	SP: Ash-split/ST: PermCath	SP: 67/ST: 71	NA	SP: 24,816/ST: 24,596
Fry et al.[18]	PC	patients with ESRD	5 years	SP: 308/ST: 109	62.6	61%	26	SP: Split-Cath, Hemosplit/ST: PermCath	64%	53%	NA
Kakkos et al.[23]	RC	ESRD patients referred for catheter insertion	12 months	SP: 100/SYM: 100	SP: 58.5 (50–78)/SYM: 56 (49–65)	SYM: 49/SP: 45	SYM: 44/SP: 56	SP: Hemosplit/SYM: Palindrome	SP: 50/SYM: 68	SYM: 32/SP: 51	SYM: 9765/SP: 11,173
Moossavi et al.[27]	RC	patients with ESRD	NA	SP: 102/SYM: 14/ST: 10	64 (23–90)	39%	NA	NA	50%	NA	NA
Hwang et al.[20]	RCT	Patients aged ⩾18 years, expected duration of HD > 2 weeks	2 months	SYM: 47/ST: 50	SYM: 53 ± 15/ST: 57 ± 18	SYM: 48.3/ST: 48.7	SYM: 42.9/ST: 55.0	SYM: Palindrome/ST: NA	Sym: 100/ST: 100	SYM: 20 ± 40/ST: 30 ± 60	SYM: 2820/ST: 3000
Kakkos et al.[24]	PC	patients with ESRD	12 months	SYM: 132/SP: 144	SP: 58.5 ± 17/SYM: 58.9 ± 13	SYM: 47/SP: 56	NA	SP: Equistream/SYM: Sapphire	SP: 62/SYM: 62	SYM: 70/SP: 60	NA
Balamuthusamy[25]	RC	patients with ESRD	3 months	SYM: 20/SP: 38	SYM: 64.2 ± 13.5/SP: 62.6 ± 15.8	SYM: 65.5 SP: 52.6	SYM: 55.2/SP: 70	NA	SYM: 84.2/SP: 81.4	SYM: 21.1/SP: 30	SYM: 3420/SP: 1800
Van Der Meersch et al.[10]	RCT	ESRD patients referred for catheter insertion, aged ⩾18 years	3 years	SYM: 151/ST: 151	SYM: 69.2 ± 16.2/ST: 70.4 ± 13.1	SYM: 53.0/ST: 56.9	SYM: 36.4/ST: 33.8	SYM: Palindrome/ST: HemoStar	Sym: 100/ST: 100	SYM: 21.9/ST: 19.9	SYM: 20,522/ST: 20,605
Li et al.[21]	RC	ESRD patients referred for catheter insertion	12 months	SYM: 49/ST: 43	SYM: 71 ± 16/ST: 65 ± 14	SYM: 71.4/ST: 67.4	NA	SYM: Palindrome/ST: PermCath	Sym: 100/ST: 100	NA	NA
Clark et al.[26]	RC	ESRD patients referred for catheter insertion	158 days	SYM: 33/SP: 46	SYM: 64 ± 12/SP: 60 ± 13	SYM: 48.5/SP: 37.0	SYM: 64/SP: 61	SYM: VectorFlow/SP: Ash-split	SYM: 70/SP: 80	SYM: 9/SP: 15	SYM: 1758/SP: 1859
Ye et al.[22]	RC	Patients with ESRD	2 years	SYM: 118/ST: 166	SYM: 67.4 ± 15.2/ST: 67.8 ± 13.1	SYM: 48.0/ST: 71.0	SYM: 61/ST: 32	SYM: Palindrome/ST: PermCath	Sym: 91/ST: 88	NA	SYM:33,874/ST: 45,342
Petridis et al.[19]	PC	ESRD patients for at least 4 weeks, aged ⩾18 years	24 months	SP: 93/ST: 92	SP: 66 ± 13/ST: 67 ± 14	SP: 57.0/ST: 58.7	SP: 29/ST: 26	SP: Hemosplit/ST: HemoStar	SP: 56/ST: 52	SP: 19/ST: 18	SP: 34,317/ST: 35,328

PC: prospective cohort trial; RCT: randomized controlled trial; RC: retrospective cohort trial; SP: split-tip design; ST: step-tip design; SYM: symmetry-tip design;
a Data are expressed as mean or mean ± standard deviation.

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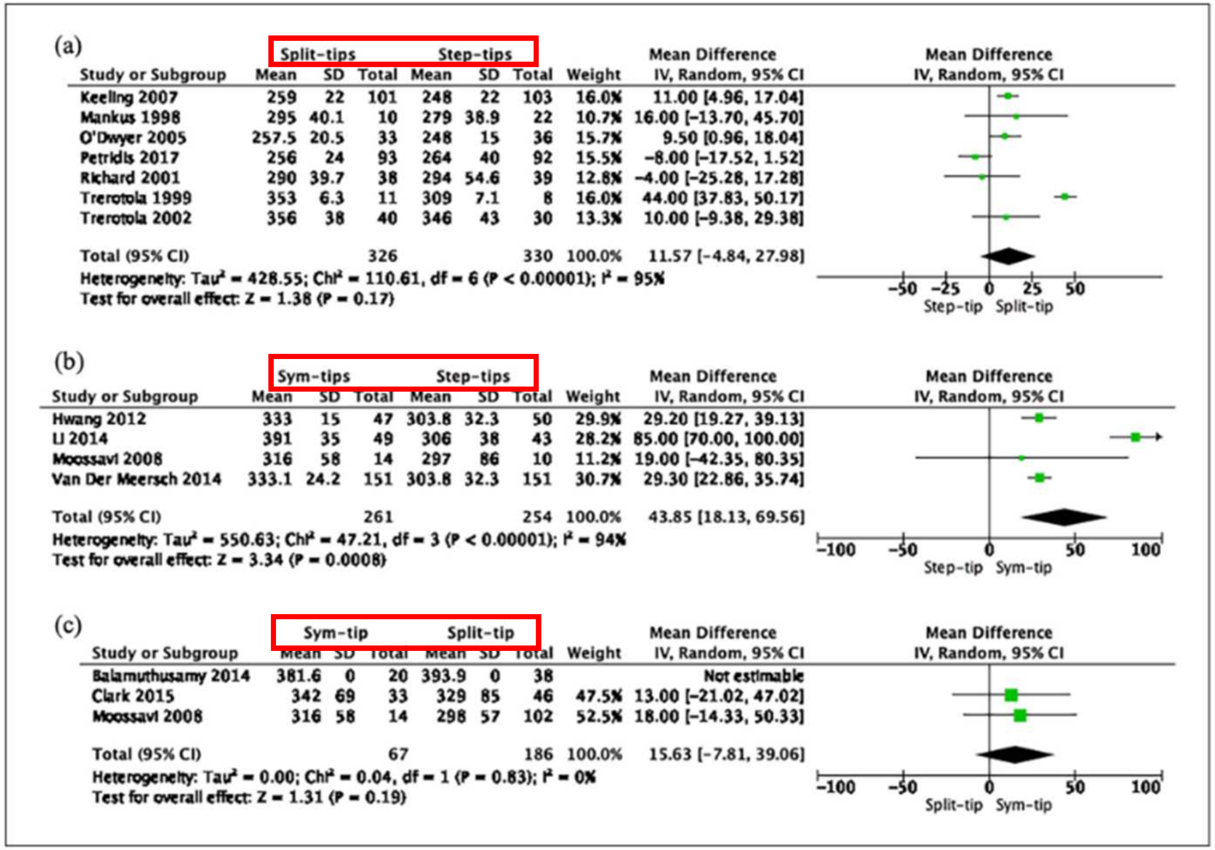
Comparative effectiveness and safety among different tip-design hemodialysis long-term catheters: A meta-analysis

Yunfeng Li [1,*], Zhenwei Shi [1], Yunyun Zhao[2], Zhengli Tan[3,*], Hongxia Guo[1], and Zhaoxuan Lu[1]

Débit sanguin moyen pendant toute la vie du cathéter



(a)

Study or Subgroup	Split-tips Mean	SD	Total	Step-tips Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Keeling 2007	259	22	101	248	22	103	16.0%	11.00 [4.96, 17.04]
Mankus 1998	295	40.1	10	279	38.9	22	10.7%	16.00 [−13.70, 45.70]
O'Dwyer 2005	257.5	20.5	33	248	15	36	15.7%	9.50 [0.96, 18.04]
Petridis 2017	256	24	93	264	40	92	15.5%	−8.00 [−17.52, 1.52]
Richard 2001	290	39.7	38	294	54.6	39	12.8%	−4.00 [−25.28, 17.28]
Trerotola 1999	353	6.3	11	309	7.1	8	16.0%	44.00 [37.83, 50.17]
Trerotola 2002	356	38	40	346	43	30	13.3%	10.00 [−9.38, 29.38]
Total (95% CI)			326			330	100.0%	11.57 [−4.84, 27.98]

Heterogeneity: Tau² = 428.55; Chi² = 110.61, df = 6 (P < 0.00001); I² = 95%
Test for overall effect: Z = 1.38 (P = 0.17)

(b)

Study or Subgroup	Sym-tips Mean	SD	Total	Step-tips Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hwang 2012	333	15	47	303.8	32.3	50	29.9%	29.20 [19.27, 39.13]
Li 2014	391	35	49	306	38	43	28.2%	85.00 [70.00, 100.00]
Moossavi 2008	316	58	14	297	86	10	11.2%	19.00 [−42.35, 80.35]
Van Der Meersch 2014	333.1	24.2	151	303.8	32.3	151	30.7%	29.30 [22.86, 35.74]
Total (95% CI)			261			254	100.0%	43.85 [18.13, 69.56]

Heterogeneity: Tau² = 550.63; Chi² = 47.21, df = 3 (P < 0.00001); I² = 94%
Test for overall effect: Z = 3.34 (P = 0.0008)

(c)

Study or Subgroup	Sym-tip Mean	SD	Total	Split-tip Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Balamuthusamy 2014	381.6	0	20	393.9	0	38		Not estimable
Clark 2015	342	69	33	329	85	46	47.5%	13.00 [−21.02, 47.02]
Moossavi 2008	316	58	14	298	57	102	52.5%	18.00 [−14.33, 50.33]
Total (95% CI)			67			186	100.0%	15.63 [−7.81, 39.06]

Heterogeneity: Tau² = 0.00; Chi² = 0.04, df = 1 (P = 0.83); I² = 0%
Test for overall effect: Z = 1.31 (P = 0.19)

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Hemodialysis Catheter Tip Design: Observations on Fluid Flow and Recirculation

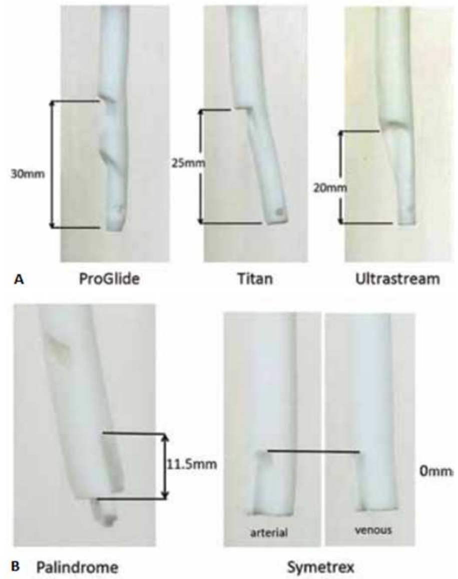
Thomas M. Vesely and Adrian Ravenscroft

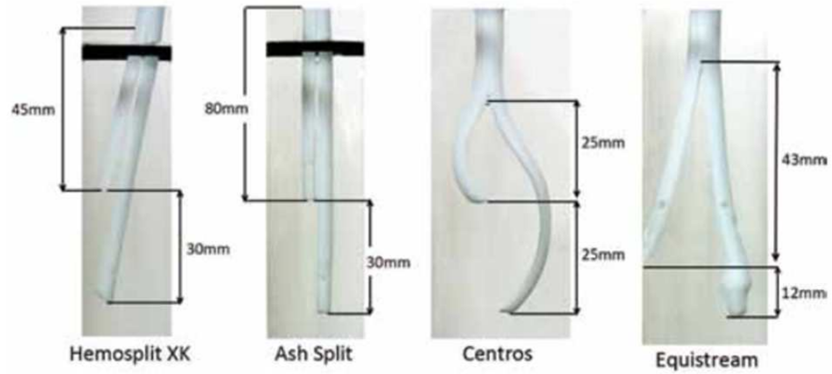
TABLE I - Design features of the nine tested hemodialysis catheters

Name	Size	Length	Tip design	A/V offset	Sideholes	Split length
ProGlide™	14.5	19 cm	Step	30 mm	Yes	
Titan™	15.5	24 cm	Step	25 mm	Yes	
Ultrastream™	15.5	28 cm	Step	20 mm	Yes	
Ash Split®	14	28 cm	Split	30 mm	Yes	80 mm
Centros®	15	24 cm	Split	25 mm	No	25 mm
Hemosplit® XK	16	23 cm	Split	30 mm	Yes	45 mm
Equistream®	16	27 cm	Split	12 mm	Yes	43 mm
Palindrome™	14.5	19 cm	Symmetrical	11.5 mm	Yes	
Symetrex	15.5	33 cm	Symmetrical	None	No	

TABLE II - Description of side holes in the nine tested hemodialysis catheters

Name	Arterial side holes	Venous side holes
ProGlide™	No	Two 1.25 mm holes
Titan™	No	Two 1.25 mm holes
Ultrastream™	No	Two 1.0 mm holes
Split Cath®	Three pairs of 1.25 mm side holes + one 1.25 mm × 2.75 mm oval	Two pairs of 1.0 mm holes
Centros®	No	No
Symetrex	No	No
Hemosplit® XK	Four 1.0 mm holes	No
Equistream®	One 2 mm × 4 mm oval hole + three 1.25 mm holes	No
Palindrome™	Yes	One 1.65 mm trapezoidal hole





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Hemodialysis Catheter Tip Design: Observations on Fluid Flow and Recirculation

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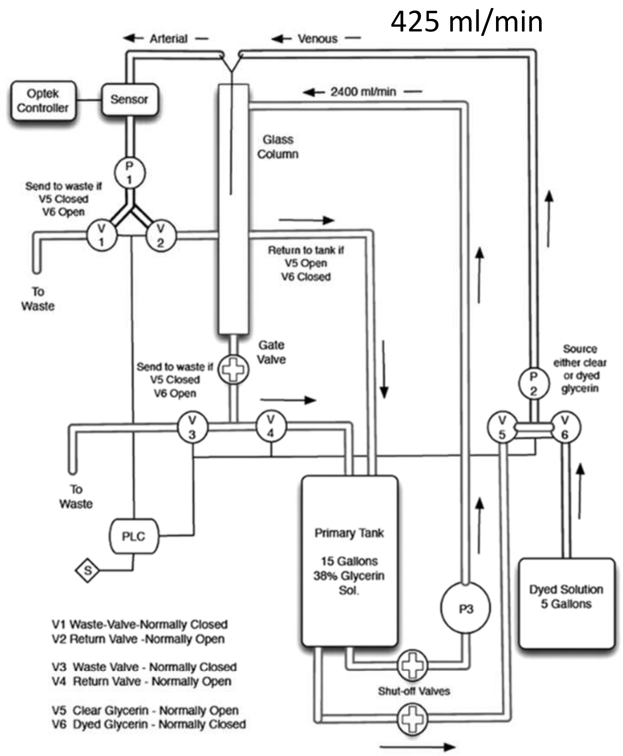
425 ml/min



En voies normales, aucun n'a de recirculation significative

TABLE III - Percent recirculation with reverse blood lines

Viscosity	Centros®	Ash Split®	ProGlide™	Ultrastream™	Titan™	Palindrome™	Equistream®	Hemosplit®	Symetrex
1.0 cP	20.4	29.7	7.3	15.8	20.5	0.0	0.0	28.2	0.0
2.3 cP	22.3	39.2	16.4	8.7	9.4	0.0	0.0	33.5	0.0

B Palindrome

Equistream

Symetrex

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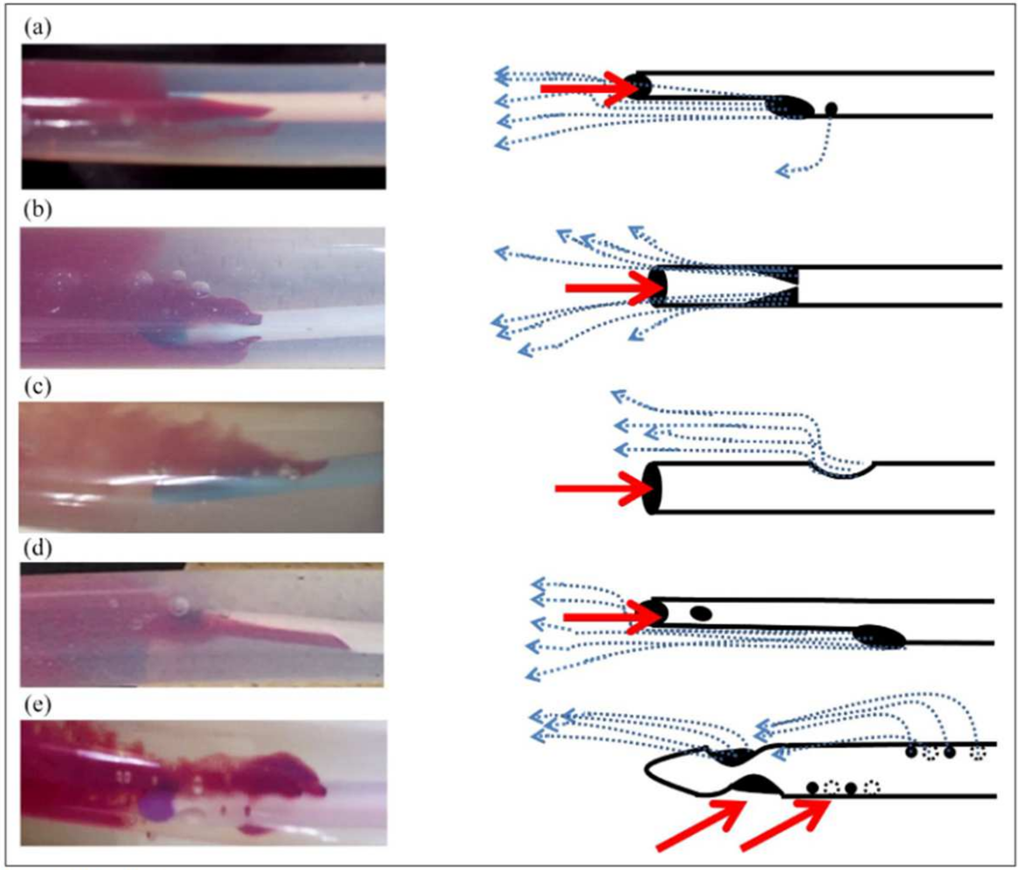
Volume 17, Issue 1, January/February 2016, Pages 29-39

Original research article

Effects of the tip structure of temporary indwelling catheters on blood recirculation at various blood flow rates and diameters of the mock blood vessel



En voies inversées, la recirculation diminue avec :

- Des larges trous latéraux
- L’augmentation de la distance entre les orifices A et V
- L’architecture symétrique
- L’augmentation du débit de la pompe à sang
- Le diamètre du vaisseaux et la vitesse circulatoire dans le vaisseau

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Thromboses

A systematic review and meta-analysis of the comparison of performance among step-tip, split-tip, and symmetrical-tip hemodialysis catheters

Check for updates

Xiao-Chun Ling, MD,[a] Hsi-Peng Lu, PhD,[b] El-Wui Loh, PhD,[c,d] Yen-Kuang Lin, PhD,[e,f] Yi-Shiuan Li, MS,[a] Cheng-Hsin Lin, MD,[g,h] Yu-Chen Ko, MD,[h] Mei-Yi Wu, MD,[c,i,j] Yuh-Feng Lin, MD,[i,k] and Ka-Wai Tam, MD, PhD,[c,d,g,l,m,n] *Taipei and New Taipei City, Taiwan*

Study or Subgroup	Step Events	Step Total	Advanced Events	Advanced Total	Weight	Risk Ratio M-H, Random, 95% CI
8.1.1 Step vs Split						
Keeling 2007	15	142	5	127	31.1%	2.68 [1.00, 7.17]
Trerotola 2002	8	68	7	64	32.2%	1.08 [0.41, 2.80]
Subtotal (95% CI)		210		191	63.3%	1.69 [0.69, 4.15]
Total events	23		12			
Heterogeneity: Tau² = 0.18; Chi² = 1.72, df = 1 (P = 0.19); I² = 42%						
Test for overall effect: Z = 1.14 (P = 0.26)						
8.1.2 Step vs Symmetrical						
Van der Meersch 2014	9	151	11	151	36.7%	0.82 [0.35, 1.92]
Subtotal (95% CI)		151		151	36.7%	0.82 [0.35, 1.92]
Total events	9		11			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.46 (P = 0.64)						
Total (95% CI)		361		342	100.0%	1.29 [0.64, 2.59]
Total events	32		23			
Heterogeneity: Tau² = 0.16; Chi² = 3.38, df = 2 (P = 0.18); I² = 41%						
Test for overall effect: Z = 0.72 (P = 0.47)						
Test for subgroup differences: Chi² = 1.31, df = 1 (P = 0.25), I² = 23.5%						

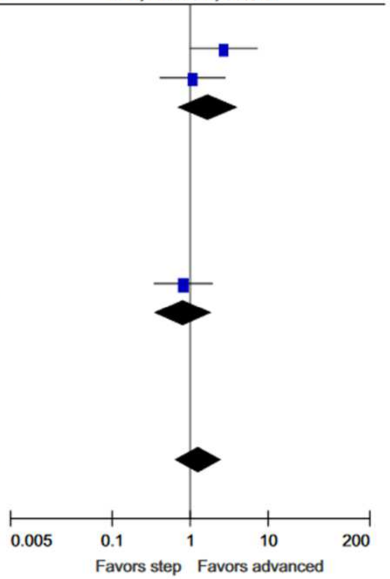

Fig 7. Forest plot of comparison, step vs advanced. Outcome: incidence of thrombosis. *CI*, Confidence interval; *M-H*, Mantel-Haenszel.

Journal of Vascular Surgery
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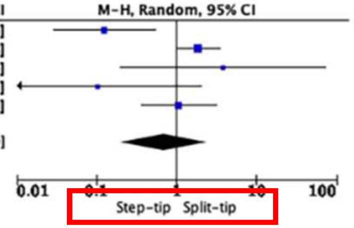
Comparative effectiveness and safety among different tip-design hemodialysis long-term catheters: A meta-analysis

Yunfeng Li [1,*], Zhenwei Shi [1], Yunyun Zhao[2], Zhengli Tan[3,*], Hongxia Guo[1], and Zhaoxuan Lu[1]

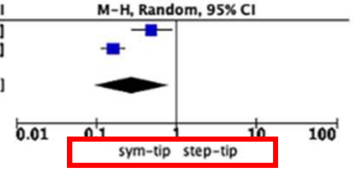
(a)

Study or Subgroup	Split-tip Events	Split-tip Total	Step-tip Events	Step-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Keeling 2007	2	24816	16	24596	22.1%	0.12 [0.03, 0.54]
Petridis 2017	27	34317	15	35328	29.6%	1.85 [0.99, 3.48]
Richard 2001	3	5187	0	2800	11.3%	3.78 [0.20, 73.14]
Trerotola 1999	0	462	3	336	11.3%	0.10 [0.01, 2.01]
Trerotola 2002	7	7267	6	6686	25.7%	1.07 [0.36, 3.19]
Total (95% CI)		72049		69746	100.0%	0.69 [0.20, 2.40]
Total events	39		40			
Heterogeneity: Tau² = 1.25; Chi² = 14.83, df = 4 (P = 0.005); I² = 73%						
Test for overall effect: Z = 0.58 (P = 0.56)						



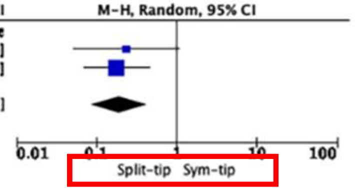
(b)

Study or Subgroup	sym-tip Events	sym-tip Total	step-tip Events	step-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Van Der Meersch 2014	17	20522	35	20605	47.6%	0.49 [0.27, 0.87]
Ye 2015	38	33874	311	45342	52.4%	0.16 [0.12, 0.23]
Total (95% CI)		54396		65947	100.0%	0.28 [0.09, 0.81]
Total events	55		346			
Heterogeneity: Tau² = 0.55; Chi² = 10.44, df = 1 (P = 0.001); I² = 90%						
Test for overall effect: Z = 2.34 (P = 0.02)						



(c)

Study or Subgroup	Sym-tip Events	Sym-tip Total	Split-tip Events	Split-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Balamuthusamy 2014	0	3420	0	1800		Not estimable
Clark 2015	2	1758	9	1859	27.5%	0.23 [0.05, 1.09]
Kakkos 2008	5	9765	32	11173	72.5%	0.18 [0.07, 0.46]
Total (95% CI)		14943		14832	100.0%	0.19 [0.09, 0.43]
Total events	7		41			
Heterogeneity: Tau² = 0.00; Chi² = 0.09, df = 1 (P = 0.77); I² = 0%						
Test for overall effect: Z = 4.02 (P < 0.0001)						



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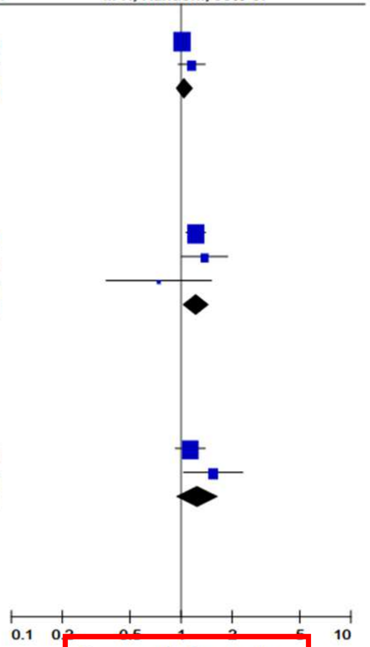
A systematic review and meta-analysis of the comparison of performance among step-tip, split-tip, and symmetrical-tip hemodialysis catheters

Check for updates

Xiao-Chun Ling, MD,[a] Hsi-Peng Lu, PhD,[b] El-Wui Loh, PhD,[c,d] Yen-Kuang Lin, PhD,[e,f] Yi-Shiuan Li, MS,[a] Cheng-Hsin Lin, MD,[g,h] Yu-Chen Ko, MD,[h] Mei-Yi Wu, MD,[c,i,j] Yuh-Feng Lin, MD,[i,k] *and* Ka-Wai Tam, MD, PhD,[c,d,g,l,m,n] *Taipei and New Taipei City, Taiwan*

Perméabilité primaire ?

Study or Subgroup	Step Events	Step Total	Split Events	Split Total	Weight	Risk Ratio M-H, Random, 95% CI
6.1.1 1 month						
Keeling 2007	128	142	113	127	69.3%	1.01 [0.93, 1.10]
Odwyer 2005	34	36	27	33	30.7%	1.15 [0.96, 1.38]
Subtotal (95% CI)		**178**		**160**	**100.0%**	**1.05 [0.94, 1.19]**
Total events	162		140			
Heterogeneity: Tau² = 0.00; Chi² = 1.69, df = 1 (P = 0.19); I² = 41%						
Test for overall effect: Z = 0.88 (P = 0.38)						
6.1.2 6 months						
Keeling 2007	123	142	90	127	68.3%	1.22 [1.07, 1.39]
Odwyer 2005	30	36	20	33	25.6%	1.38 [1.01, 1.88]
Trerotola 2002	11	68	14	64	6.1%	0.74 [0.36, 1.51]
Subtotal (95% CI)		**246**		**224**	**100.0%**	**1.22 [1.02, 1.46]**
Total events	164		124			
Heterogeneity: Tau² = 0.01; Chi² = 2.66, df = 2 (P = 0.26); I² = 25%						
Test for overall effect: Z = 2.16 (P = 0.03)						
6.1.3 12 months						
Keeling 2007	90	142	71	127	66.1%	1.13 [0.93, 1.38]
Odwyer 2005	27	36	16	33	33.9%	1.55 [1.04, 2.31]
Subtotal (95% CI)		**178**		**160**	**100.0%**	**1.26 [0.94, 1.68]**
Total events	117		87			
Heterogeneity: Tau² = 0.02; Chi² = 1.87, df = 1 (P = 0.17); I² = 46%						
Test for overall effect: Z = 1.57 (P = 0.12)						



Test for subgroup differences: Chi² = 2.51, df = 2 (P = 0.28), I² = 20.4%

Fig 3. Forest plot of comparison, step vs split. Outcome: incidence of functioning catheters at 1 month, 6 months, and 12 months. *CI,* Confidence interval; *M-H,* Mantel-Haenszel.

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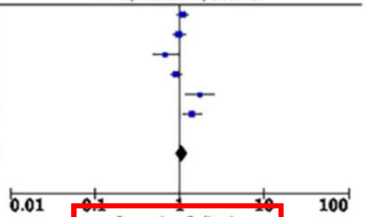
Comparative effectiveness and safety among different tip-design hemodialysis long-term catheters: A meta-analysis

Yunfeng Li[1,*], Zhenwei Shi[1], Yunyun Zhao[2], Zhengli Tan[3,*], Hongxia Guo[1], and Zhaoxuan Lu[1]

Perméabilité secondaire M6

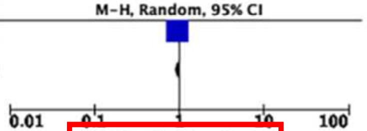
(a)

Study or Subgroup	Split-tip Events	Split-tip Total	Step-tip Events	Step-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Fry 2008	226	308	73	109	20.3%	1.10 [0.94, 1.27]
Keeling 2007	71	101	73	103	19.2%	0.99 [0.83, 1.18]
O'Dwyer 2005	19	33	30	36	13.4%	0.69 [0.50, 0.96]
Petridis 2017	58	75	64	76	20.0%	0.92 [0.79, 1.07]
Richard 2001	29	38	17	39	11.1%	1.75 [1.18, 2.61]
Trerotola 2002	49	64	37	68	16.0%	1.41 [1.09, 1.82]
Total (95% CI)		619		431	100.0%	1.07 [0.89, 1.29]
Total events	452		294			
Heterogeneity: Tau² = 0.04; Chi² = 21.59, df = 5 (P = 0.0006); I² = 77%						
Test for overall effect: Z = 0.72 (P = 0.47)						



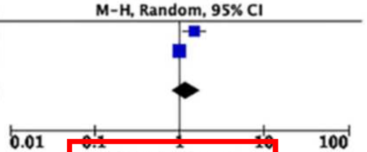
(b)

Study or Subgroup	Sym-tip Events	Sym-tip Total	Step-tip Events	Step-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Van Der Meersch 2014	135	151	140	151	100.0%	0.96 [0.90, 1.04]
Total (95% CI)		151		151	100.0%	0.96 [0.90, 1.04]
Total events	135		140			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.01 (P = 0.31)						



(c)

Study or Subgroup	Sym-tip Events	Sym-tip Total	Split-tip Events	Split-tip Total	Weight	Risk Ratio M-H, Random, 95% CI
Kakkos 2008	10	11	23	38	42.9%	1.50 [1.09, 2.06]
Kakkos 2013	107	132	116	144	57.1%	1.01 [0.90, 1.13]
Total (95% CI)		143		182	100.0%	1.19 [0.81, 1.76]
Total events	117		139			
Heterogeneity: Tau² = 0.07; Chi² = 5.41, df = 1 (P = 0.02); I² = 82%						
Test for overall effect: Z = 0.90 (P = 0.37)						



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Comparative effectiveness and safety among different tip-design hemodialysis long-term catheters: A meta-analysis

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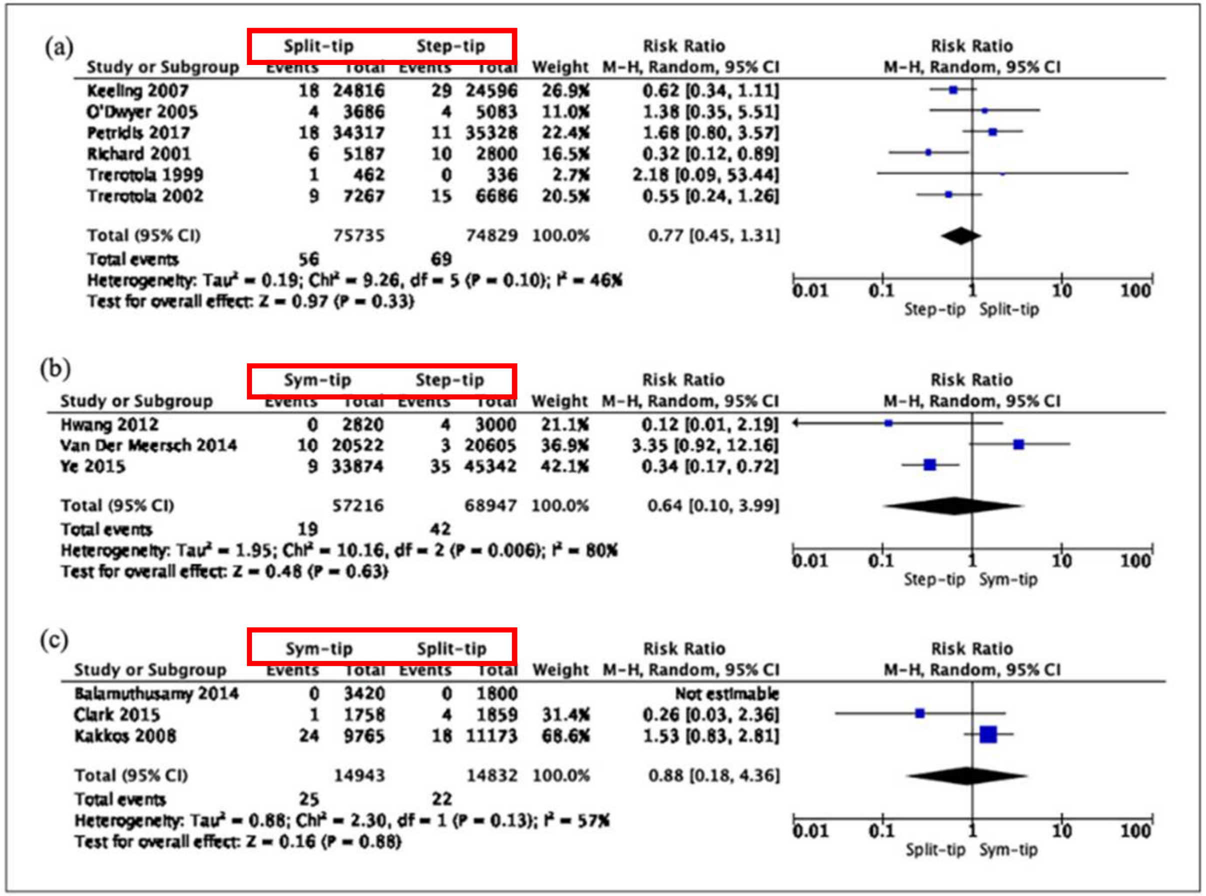
Infections liées au cathéter



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Take Home Messages

- Un bon cathéter est gros et le moins long possible (mais doit permettre une extrémité distale dans l'OD)
- Il semble que les cathéters en polyuréthane (ou ses dérivés) soient mieux que ceux en silicone sur le plan de la biocompatibilité
- Pas d'argument très convainquant pour utiliser des cathéters avec un traitement de surface. L'héparine pourrait réduire les infections.
- L'extrémité distale symétrique apporte un avantage en terme de débit, de thrombose et de recirculation, notamment lors de l'inversion des voies