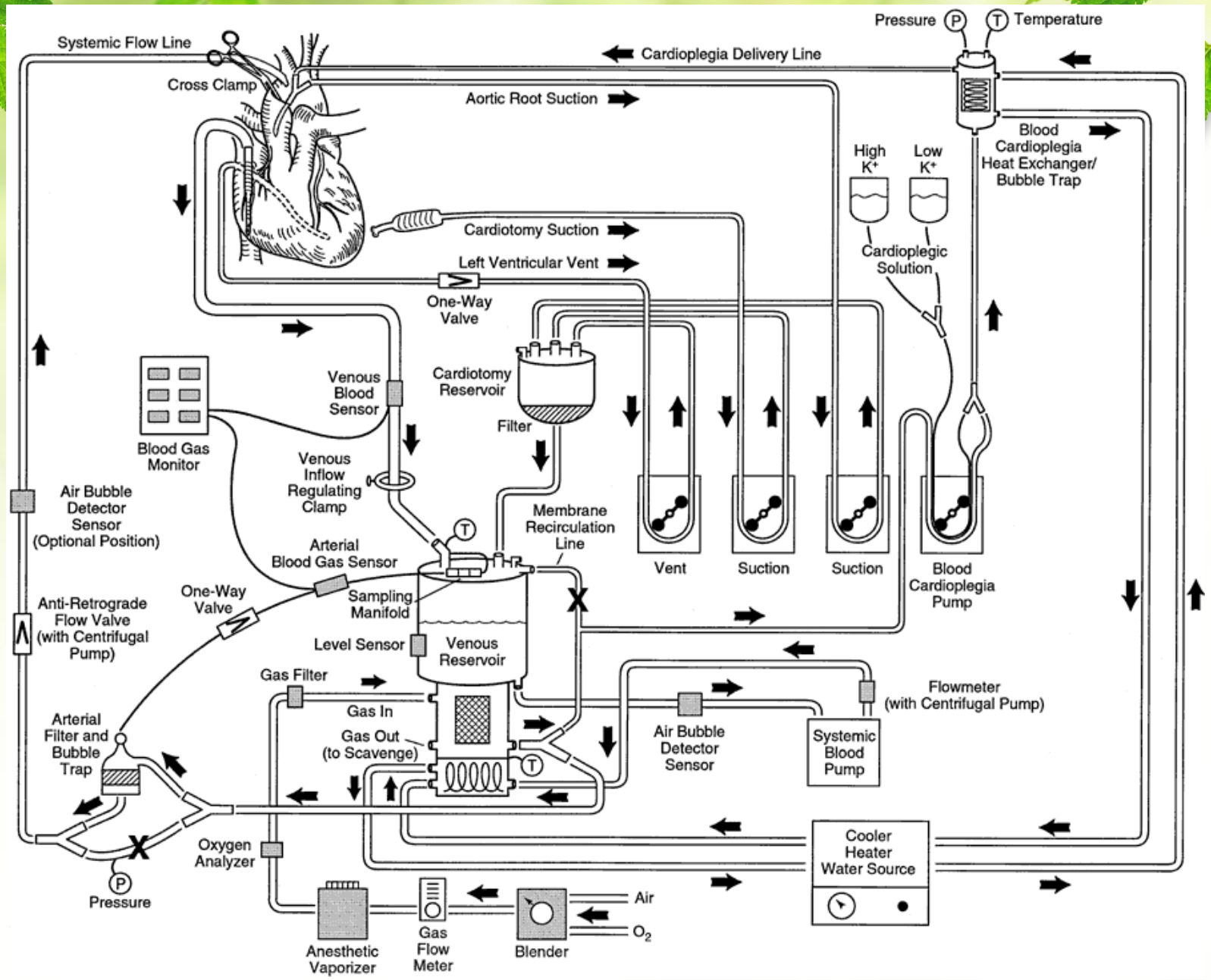
心血管外科术中体外循环平衡超滤

管玉龙



血液滤过技术的兴起

- 常规超滤、改良超滤

  快速滤除多余的水分，提高Hct

  患者体内的水分

  预充液（180-270-350-500-1000-1500）

  心脏停搏液

  调节胶体渗透压

- 平衡超滤

  调节体内内环境

  滤除部分炎性介质及酸性代谢产物

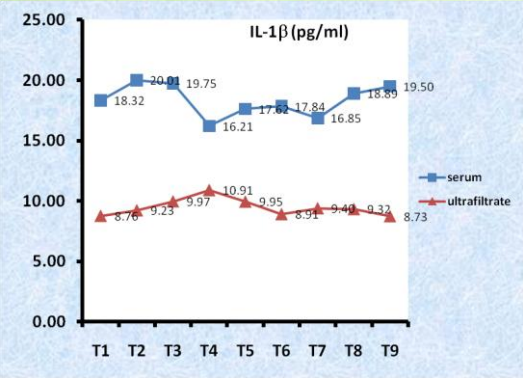
  调节晶体渗透压

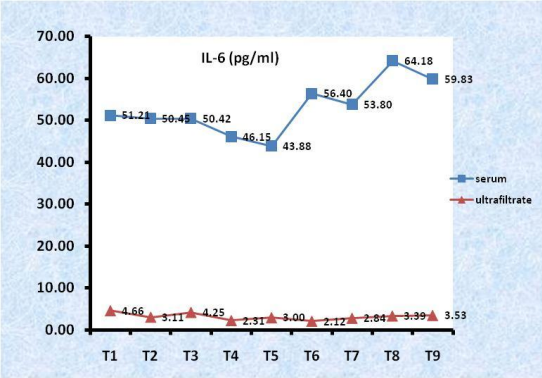
平衡超滤有助于滤除部分炎性介质

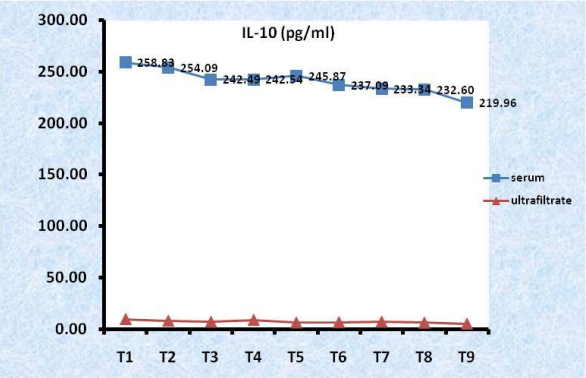
	Limit Of detection	T1(before hemofiltration + rewarming) Median Min/25%/75%/Max			T2 (After hemofiltration + rewarming) Median Min/25%/75%/Max			T3 (24h After operation) Median Min/25%/75%/Max		
	n	ZBUF (n= 10)	Control (n = 10)	P	ZBUF (n= 10)	Control (n = 10)	P	ZBUF (n= 10)	Control (n = 9)	P
C3a (mg/ml)	0.03	3.1 1.2/2.7/4.1/6.4	3.0 1/2.1/3.2/12.8	N.S. (0.34)	2.8 1/2.2/3.5/4.5	4.2 1.8/3.3/5.4/8.8	0.021	0.5 0.2/0.3/0.8/1.5	0.4 0.3/0.3/0.5/5.6	N.S. (0.76)
TNF (pg/ml)	1	2 0/1/3/6	1 0/0/3/29	*	1.2 0/1/2/26	4 0/2/18/49	0.045	2 0.5/1/10/72	8 4/7/31/421	0.028
IL-1β (pg/ml)	1	0 0/0/1/4	0 0/0/0/3	*	0 0/0/1/8	0 0/0/0/8	*	0 0/0/1/4	31 1/11/33/45	0.000 3
IL-6 (pg/ml)	2	10 0/1/15/185	4 0/3/40/202	N.S. (0.70)	30 3.5/13/72/30	46 10/30/67/210	N.S. (0.54)	30 4.5/14/50/210	302 0/13/476/210	0.019
Il-8 (pg/ml)	0.5	0.8 0/0/1/16	2 0/0/4/44	*	1 0/0/5/22	12 0/2/33/238	*	0 0/0/2/5	15 0/6/40/236	*

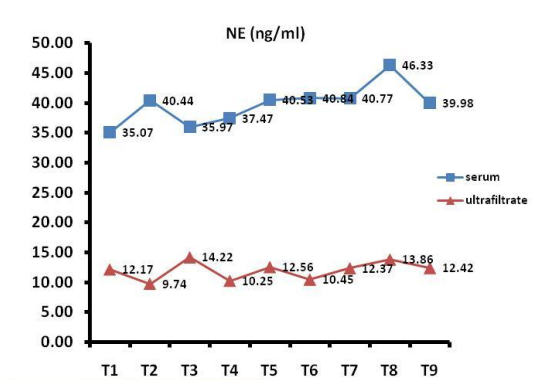
Journois D, Israel-Biet D, Pouard P, et al. High-volume, zero-balanced hemofiltration to reduce delayed inflammatory response to cardiopulmonary bypass in children. Anesthesiology. 1996 Nov;85(5):965-76.

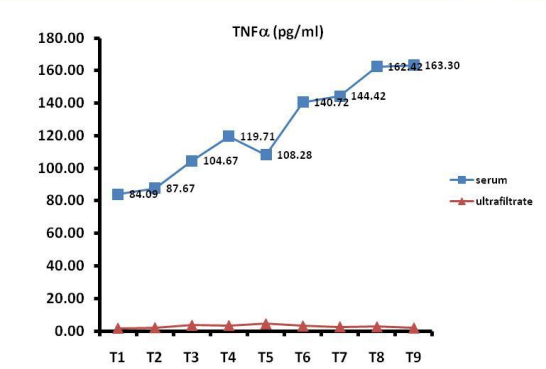
滤液中可以检测到炎性介质的存在











Guan Y, Wan C, Wang S, et al. Balanced ultrafiltration: inflammatory mediator removal capacity. Artif Organs. 2012 Oct;36(10):894-900.

滤除炎性介质（简单先心）

		BUF 组	NBUF 组	*P 值*
IL-1	超滤前血浆浓度(ng/L)	10.73±3.29	12.61±3.15	0.056
	超滤后血浆浓度(ng/L)	15.78±5.22	17.63±5.27	0.274
	滤液浓度(ng/L)	11.42±5.99	9.42±5.84	0.281
	滤液中含量(μg)	13.51±7.16	4.18±3.09	**0.000***
IL-6	超滤前血浆浓度(ng/L)	5.26±2.41	5.74±2.09	0.492
	超滤后血浆浓度(ng/L)	9.33±1.70	10.34±1.62	0.063
	滤液浓度(ng/L)	4.79±1.74	4.16±1.96	0.286
	滤液中含量(μg)	5.68±2.83	1.77±1.00	**0.000***
IL-10	超滤前血浆浓度(ng/L)	3.24±2.70	3.13±1.71	0.870
	超滤后血浆浓度(ng/L)	87.58±78.19	153.09±101.16	**0.026***
	滤液浓度(ng/L)	2.89±2.49	2.54±2.38	0.648
	滤液中含量(μg)	3.30±2.96	1.02±0.92	**0.000***

TNF-α	超滤前血浆浓度(μg/L)	118.36±114.01	110.01±68.93	0.777
	超滤后血浆浓度(μg/L)	349.73±136.54	482.34±121.74	**0.003***
	滤液浓度(μg/L)	86.83±62.49	72.09±58.71	0.436
	滤液中含量（mg）	100.87±77.87	29.48±23.29	**0.000***
NE	超滤前血浆浓度(ng/L)	2.88±1.76	4.03±2.46	0.071
	超滤后血浆浓度(ng/L)	20.42±17.57	27.02±14.04	0.205
	滤液浓度(ng/L)	3.12±3.38	2.12±2.29	0.259
	滤液中含量(μg)	3.36±2.54	0.92±1.05	**0.000***

ZBUF有助于术后肺功能

Table 6. Comparison of RIs at Different Perioperative Time Points Between the 2 Groups

	PZM Group (n = 32)	CM Group (n = 33)	p Value
T1	0.72 ± 0.17	0.65 ± 0.13	0.78
T4	0.78 ± 0.59	1.23 ± 0.48	0.009
T5	1.10 ± 0.13	1.52 ± 0.16	0.006
T6	0.85 ± 0.14	0.94 ± 0.17	0.59

NOTE. Mean ± SD.
Abbreviation: RI, respiratory index.

Time points: after the induction of anesthesia (T1), 5minutes after aortic clamping(T2),5minutes after removal of aortic clamping (T3), 5 minutes after MUF cessation (T4),1 hour after ICU admission (T5), and prior to extubation(T6).

Zhou G, Feng Z, Xiong H, et al. A combined ultrafiltration strategy during pediatric cardiac surgery: a prospective, randomized, controlled study with clinical outcomes. J Cardiothorac Vasc Anesth. 2013 Oct;27(5):897-902.

后的呼吸机辅助时间。分别在转流前(T1)、转流结束后20 min(T2)、术后2 h(T3)、术后6 h (T4)、术后12 h (T5) 测定动脉血氧分压(PaO_2)、二氧化

表 2 3 组患儿肺功能指标对比

Table 2 Comparison of pulmonary function indice among the 3 groups

指标	组别	T1	T2	T3	T4	T5
氧合指数	Z 组	337.8±96.3	207.8±63.9*	243.8±84.1*	257.2±90.4*	268.5±72.3*
	M 组	351.2±87.5	215.9±71.5*	239.5±80.4*	269.7±86.6*	275.4±81.4*
	Z+M 组	340.4±95.8	221.5±75.4*	287.6±91.5*†	304.8±95.1*†	306.9±93.1*†
气道阻力 / [$cmH_2O/(L·S)$]	Z 组	0.37±0.11	0.46±0.12*	0.51±0.14*	0.57±0.16*	0.49±0.14*
	M 组	0.35±0.13	0.45±0.13*	0.53±0.17*	0.58±0.14*	0.52±0.17*
	Z+M 组	0.36±0.12	0.42±0.15*	0.47±0.13*†	0.49±0.13*†	0.43±0.15*†
肺静态顺应性 / (mL/cmH_2O)	Z 组	5.75±0.82	5.21±0.79*	4.54±0.63*	4.19±0.71*	4.62±0.72*
	M 组	5.69±0.93	5.27±0.91*	4.47±0.77*	4.31±0.68*	4.58±0.61*
	Z+M 组	5.66±0.87	5.36±0.95*	5.01±0.69*†	4.88±0.76*†	5.22±0.75*†
肺泡 - 动脉氧分压差 /mmHg	Z 组	238.1±71.1	316.2±78.4*	378.7±85.6*	428.5±82.4*	398.5±82.4*
	M 组	225.3±67.4	329.3±92.1*	361.6±90.2*	416.1±88.3*	377.5±81.2*
	Z+M 组	241.8±73.6	306.8±85.7*	336.4±85.4*†	371.5±85.7*†	315.6±78.4*†

与 T1 比较，*$P<0.05$；与 Z 组和 M 组比较，†$P<0.05$

胡萍，姜志斌，许蓼梅，何争鸣，孙兰英，段炼. 零平衡超滤和改良超滤联合应用对婴幼儿心脏手术后肺功能的影响. 中南大学学报(医学版), 2014 Jul;39(7):698-702.

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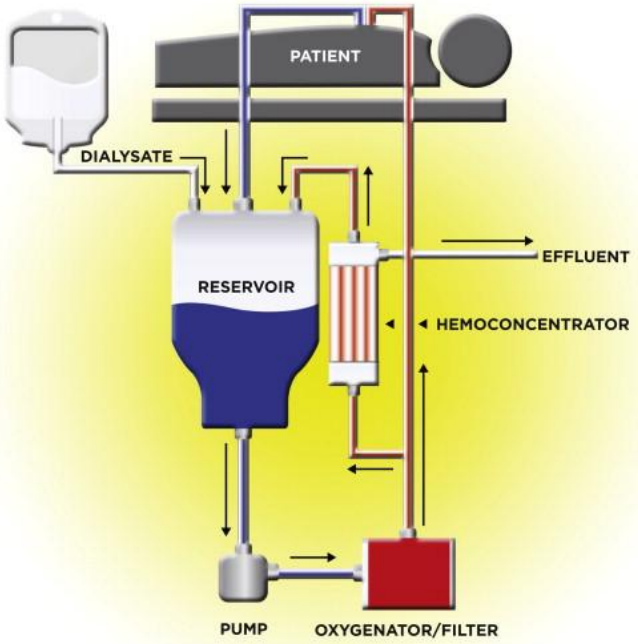
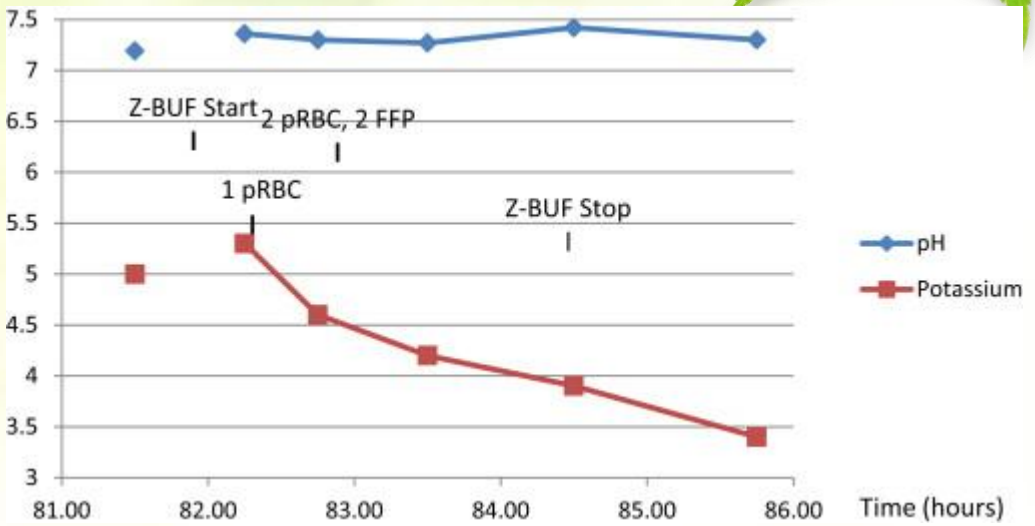
ZBUF用于肾功能低下患者心脏手术

- 平衡超滤可以显著降低术前即存在肾功能低下患者心脏手术后胸腔感染及不良终点事件（包括死亡、中风、心梗发生）
- 降低此类患者尿液中中性粒细胞明胶酶相关脂质运载蛋白（**NGAL)**肌酐比值、尿素、肌酐、肾小球滤过率等肾脏损伤指标的上升

Matata BM, Scawn N, Morgan M, et al. A Single-Center Randomized Trial of Intraoperative Zero-Balanced Ultrafiltration During Cardiopulmonary Bypass for Patients With Impaired Kidney Function Undergoing Cardiac Surgery. J Cardiothorac Vasc Anesth. 2015 Feb 20. pii: S1053-0770(15)00122-6.

ZBUF用于透析支持的肾功能低下患者心脏手术





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2. Takahashi Y, Nagamine Y, Fujimoto K, et al. [Continuous hemodiafiltration during graft repair for a ruptured thoracoabdominal aortic aneurysm was useful in a patient with chronic renal failure]. Masui. 2014 Oct;63(10):1149-52.
3. Tagaya M, Matsuda M, Yakehiro M, et al. Prospects for using a hemoconcentrator as an alternative hemodialysis method in cardiopulmonary bypass surgeries. Perfusion. 2014 Mar;29(2):117-23.
4. Lee LW, Gabbott S. High-volume ultrafiltration with extracellular fluid replacement for the management of dialysis patients during cardiopulmonary bypass. J Cardiothorac Vasc Anesth. 2002 Feb;16(1):70-2.

ZBUF可用于高钾的处理

Ishi K, Koga Y, Onitsuka T, et al. [Ultrafiltration for hyperkalemia during cardiopulmonary bypass]. Kyobu Geka. 1986 Oct;39(10):771-4.

替代液

名称	液体分布	渗透压（mOsm/L)	pH	Na^+ (mmol/L)	Cl^-	K^+	Mg^{2+}	Ca^{2+}	葡萄糖（g/L)	缓冲系
0.9%氯化钠	细胞外液	310(等渗）	5	154	154	0	0	0	0	无
乳酸林格	细胞外液	275（等渗）	6.5	130	109	4	0	3	0	乳酸盐
勃脉力A (Baxters, Deerfield, IL)	细胞外液	294（等渗）	7.4	140	98	5	3	0	0	醋酸盐，葡萄糖酸盐
Normosol™-R（Hospira, Lake Forest,IL）	细胞外液	295（等渗）	5.5-7	140	98	5	3	0	0	醋酸盐，葡萄糖酸盐
复方氯化钠/林格氏液	细胞外液	305（等渗）	4.5-7.5	145	154	4	0	2	0	

1. Martin DP, Gomez D, Tobias JD, et al. Severe hyperkalemia during cardiopulmonary bypass: etiology and effective therapy. World J Pediatr Congenit Heart Surg. 2013;4(2):197-200.
2. Heath M, Barbeito A, Welsby I, et al. Using Zero-Balance Ultrafiltration With Dialysate as a Replacement Solution for Toxin and Eptifibatide Removal on a Dialysis-Dependent Patient During Cardiopulmonary Bypass. J Cardiothorac Vasc Anesth. 2014 Dec 8. pii: S1053-0770(14)00607-7.
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- 平衡超滤有利于灌注师精确管理内环境的稳定、纠正离子失衡、一定程度降低炎性介质的上升幅度，有利于肺功能的恢复

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