ICU

如何避免CRRT引起的血压波动？

北京协和医院　重症医学科
王郝

RRT开始指征（1B）

生化指标适应症	临床适应症
顽固性高钾血症>6.5mmol/L	尿量<0.3 ml/kg/h 持续24h或者无尿12h
血尿素氮>27mmol/L	AKI伴有多器官功能衰竭
难以纠正的代谢性酸中毒PH<7.15	难以纠正的容量负荷过重
难以纠正的电解质紊乱:低钠血症、高钠血症或高钙血症	累及终末器官：心包炎，脑病，神经病变，肌病和尿毒症出血
肿瘤溶解综合症伴有的高尿酸血症和高磷酸盐血症	需要输注血制品和静脉营养
尿素循环障碍和有机酸尿症导致的高氨血症和甲基丙二酸血症	重度中毒或药物过量
	严重的低体温或高体温

The NEW ENGLAND JOURNAL of MEDICINE

Intensity of Renal Support in Critically Ill Patients with Acute Kidney Injury

The VA/NIH Acute Renal Failure

This article (10.1056/NEJMoa0802639) was published at www.nejm.org on May 20, 2008.

N Engl J Med 2008;359.

ATN 试验设计

ICU

SOFA CV		Management Strategy	
		“Conventional”	Intensive
0-2	IHD (target Kt/V: 1.2-1.4/tx)	3x/week	6x/week
3-4	CVVHDF	20 mL/kg/hr	35 mL/kg/hr

ICU

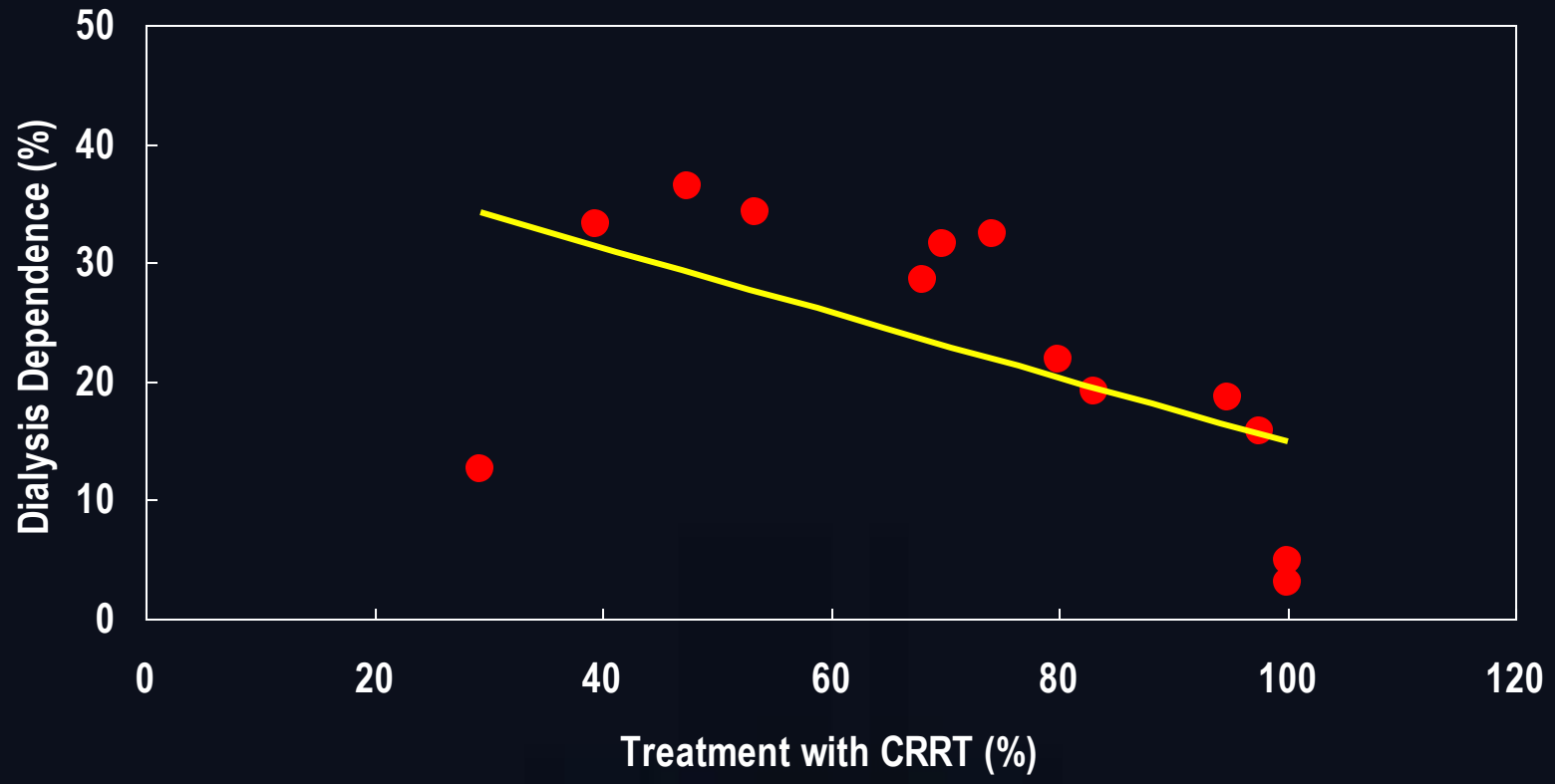
Cochrane Database Syst Rev 2007: CD003773.

- Hemodynamic instability: RR 0.48; 0.10-2.28; n = 205)
- Hypotension: (RR 0.92; 95% CI 0.72-1.16; n = 514).
- Mean arterial pressure at the end of the treatment: CRRT vs IHD (mean deviation 5.35; 95% CI 1.41-9.29; n = 112)
- Number of patients requiring escalation of vasopressors: CRRT vs IHD (RR 0.49; 95% CI 0.27-0.87; n = 149)

RRT-CRRT vs. IDH

肾功能恢复

ICU



Uchino S. Choice of therapy and renal recovery. Crit Care Med 2008; 36[Suppl]: S238-S242.

ICU

Table 22. Theoretical advantages and disadvantages of CRRT, IHD, SLED, and PD

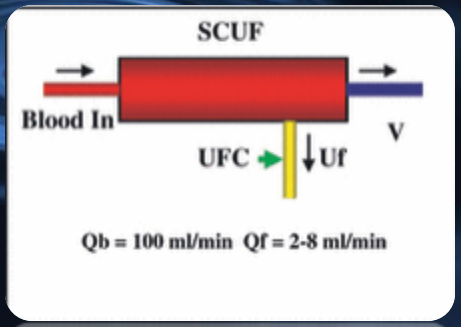
Modality	Potential setting in AKI	Advantages	Disadvantages
IHD	Hemodynamically stable	Rapid removal of toxins and low-molecular-weight substances Allows for "down time" for diagnostic and therapeutic procedures Reduced exposure to anticoagulation Lower costs than CRRT	Hypotension with rapid fluid removal Dialysis disequilibrium with risk of cerebral edema Technically more complex and demanding
CRRT	Hemodynamically unstable Patients at risk of increased intracranial pressure	Continuous removal of toxins Hemodynamic stability Easy control of fluid balance No treatment-induced increase of intracranial pressure User-friendly machines	Slower clearance of toxins Need for prolonged anticoagulation Patient immobilization Hypothermia Increased costs

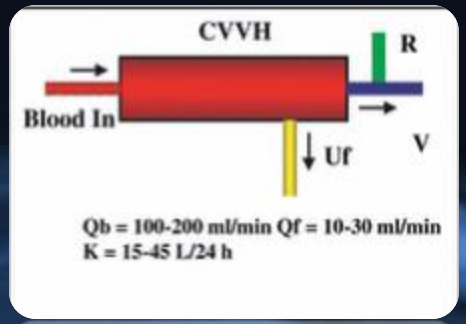
ICU

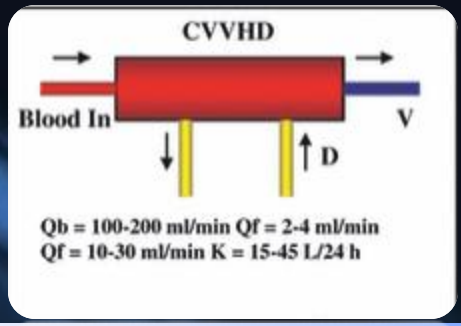
SLED	Hemodynamically unstable	Slower volume and solute removal Hemodynamic stability Allows for “down time” for diagnostic and therapeutic procedures Reduced exposure to anticoagulation	Slower clearance of toxins Technically more complex and demanding
PD	Hemodynamically unstable Coagulopathy Difficult access Patients at risk of increased intracranial pressure Under-resourced region	Technically simple Hemodynamic stability No anticoagulation No need for vascular access Lower cost Gradual removal of toxins	Poor clearance in hypercatabolic patients Protein loss No control of rate of fluid removal Risk of peritonitis Hyperglycemia Requires intact peritoneal cavity Impairs diaphragmatic movement, potential for respiratory problems

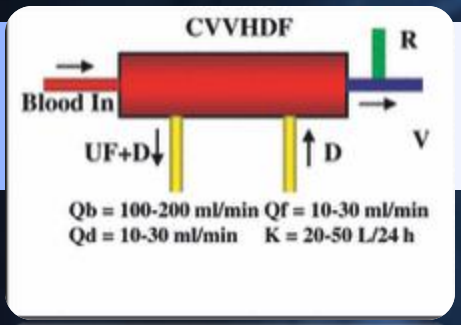
RRT

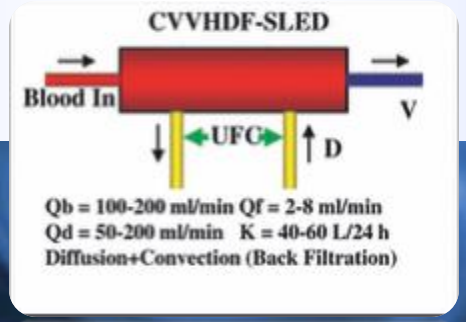
ICU

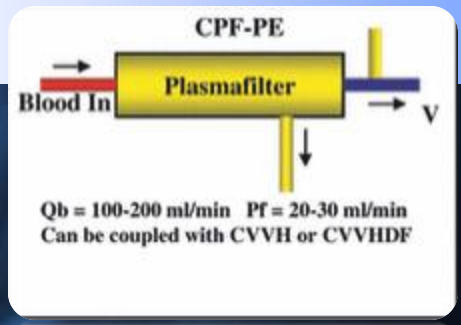

SCUF
Blood In
V
UFC
Uf
Qb = 100 ml/min Qf = 2-8 ml/min

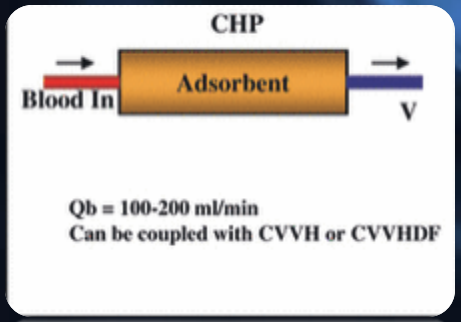

CVVH
R
Blood In
V
Uf
Qb = 100-200 ml/min Qf = 10-30 ml/min
K = 15-45 L/24 h

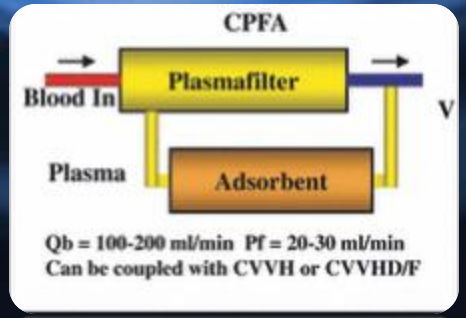

CVVHD
Blood In
V
D
Qb = 100-200 ml/min Qf = 2-4 ml/min
Qf = 10-30 ml/min K = 15-45 L/24 h

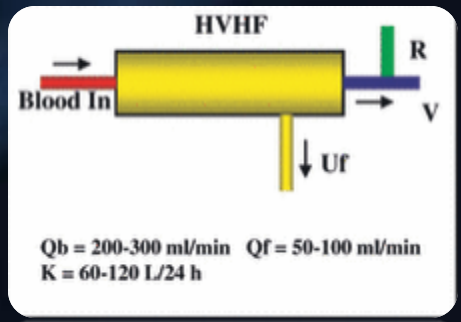

CVVHDF
R
Blood In
V
UF+D
D
Qb = 100-200 ml/min Qf = 10-30 ml/min
Qd = 10-30 ml/min K = 20-50 L/24 h


CVVHDF-SLED
Blood In
V
UFC
D
Qb = 100-200 ml/min Qf = 2-8 ml/min
Qd = 50-200 ml/min K = 40-60 L/24 h
Diffusion+Convection (Back Filtration)


CPF-PE
Blood In
Plasmafilter
V
Qb = 100-200 ml/min Pf = 20-30 ml/min
Can be coupled with CVVH or CVVHDF


CHP
Blood In
Adsorbent
V
Qb = 100-200 ml/min
Can be coupled with CVVH or CVVHDF


CPFA
Blood In
Plasmafilter
V
Plasma
Adsorbent
Qb = 100-200 ml/min Pf = 20-30 ml/min
Can be coupled with CVVH or CVVHD/F


HVHF
Blood In
R
V
Uf
Qb = 200-300 ml/min Qf = 50-100 ml/min
K = 60-120 L/24 h

The Lancet 2006 CRRT vs IHD

ICU

	Intermittent haemodialysis (n=184)	Continuous venovenous haemofiltration (n=175)	p value
Hypotension[*]	72 (39%)	**61 (35%)**	0·47
Bleeding event[‡]	13 (7%)	12 (7%)	0·89
Thrombocytopenia	22 (12%)	31 (18%)	0·12
Hypoglycaemia	12 (7%)	7 (4%)	0·42
Hypophosphataemia	13 (7%)	14 (8%)	0·71
Hypothermia	10 (5%)	31 (17%)	0·0005
Arrhythmia	18 (10%)	9 (5%)	0·15
Catheter infection	2 (1%)	3 (2%)	0·95

BEST kidney

Intensive care medicine. *(2007)*

ICU

Hypotension	**188/1000 (18.8%)**
Bleeding	33/997 (3.3%)
Indwelling vascular catheter sites	13/997 (1.3%)
Intra-abdominal	3/997 (0.3%)
Gastrointestinal	3/997 (0.3%)
Nostril	3/997 (0.3%)
Sternal wound	3/997 (0.3%)
Others [a]	8/997 (0.8%)
Arrhythmia	43/1000 (4.3%)
Atrial fibrillation	24/1000 (2.4%)
Supraventricular tachycardia	7/1000 (0.7%)
Cardiac arrest	4/1000 (0.4%)
Bradycardia	3/1000 (0.3%)
Ventricular tachycardia	3/1000 (0.3%)
Atrial flutter	1/1000 (0.1%)
Ventricular fibrillation	1/1000 (0.1%)

- 23个国家，54中心
- 1000例CRRT

- 预防建议：
- 先扩容
- 预先提高血管活性药物剂量
- 监测血流动力学

ICU

- 体外循环管路约占150-200ml
- 起始阶段容量迅速丢失可能是影响血压的原因

Complications of continuous renal replacement therapy in critically ill children: a prospective observational evaluation study

Maria J Santiago[1], Jesús López-Herce[1], Javier Urbano[1], María José Solana[1], Jimena del Castillo[1], Yolanda Ballestero[1], Marta Botrán[1] and Jose María Bellón[2]

Critical Care 2009, 13:R184

- 174 children treated with CRRT
- 13 (7.4%) presented problems of venous catheterization
  - more common in children under 12 months of age and in those weighing less than 10 kg
- Hypotension on connection to CRRT was detected in **53 patients (30.4%).**
- Clinically significant hemorrhage occurred in 18 patients (10.3%);

Table 2 *(Continued)*

Risk factors of hypotension during connection of CRRT in children					
Dose of adrenaline		> 0.6 μg/kg/min		> 0.6 μg/kg/min	
	12	35.3	32	29.4	0.513
Filter surface		<0.3 m²		>0.3 m²	
	21	33.3	32	24.4	0.586
Extracorporeal circuit volume/weight of patient		> 5 ml/kg		< 5 ml/kg	
	36	32.1	10	22.2	0.217
Mortalilty		Yes		No	
	24	38.7	29	26.4	0.095

ALT = alanine transferase; CRRT = continuous renal replacement therapy; MAP = mean arterial pressure; PELOD = pediatric logistic organ dysfunction; PIM = pediatric index of mortality; PRIMS = pediatric risk of mortality; SD = standard deviation.

	Hypotension		No hypotension		*P*
	Mean	SD	Mean	SD	
Age (months)	53.4	67.5	50.0	61.4	0.694
Weight (kg)	18.1	19.8	16.9	17.3	0.910
PRISM score	16.8	15.5	21.6	25.8	0.650
PIM score	10.1	13.4	10.9	16.8	0.874
PELOD score	25.7	30.2	20.7	22.7	0.294
Number of failed organs	3.2	1.2	2.8	1.1	0.139
Lactic acid (mmol/L)	3.2	3.3	3.0	3.8	0.357
Arterial pH	7.32	0.12	7.31	0.10	0.341
MAP (mmHg)	58.2	14.8	62.9	20.2	0.124
Dose of adrenaline (μg/kg/min)	0.4	0.5	0.57	1.3	0.734
Dose of dopamine (μg/kg/min)	9.1	6.6	9.0	6.6	0.932
Initial creatinine (mg/dL)	1.4	1.1	1.5	1.3	0.491
Initial urea (mg/dL)	79.2	61.4	86.2	59.6	0.236
ALT (UI/L)	523.5	1261.7	71.0	112.5	0.212
Billirubine (mg/dL)	1.8	1.6	1.8	2.4	0.667
Extracorporeal circuit volume/weight of patient (ml/kg)	8.6	4.6	8.8	5.3	0.982

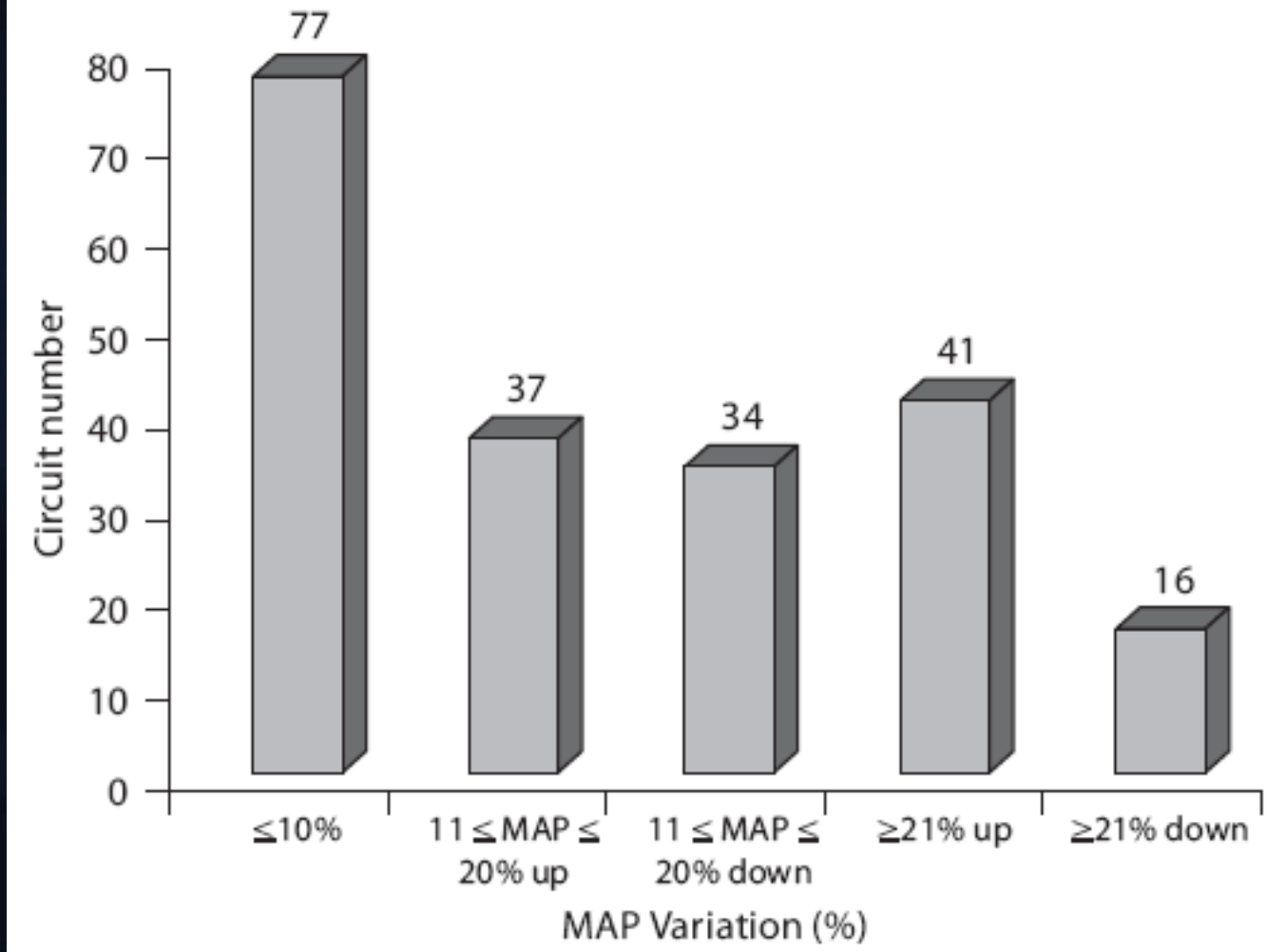
Circuit Start during Continuous Renal Replacement Therapy in Vasopressor-Dependent Patients: The Impact of a Slow Blood Flow Protocol

Blood Purif 2011;32:1–6

- 目标200ml/min
- 54例患者，205例管路
- 50ml/min起步
- 同时连接动静脉端口
- 慢20-50ml/min为一档，5-10min调整间隔
- 25%出现血压下降，7.8%在起始阶段

Circuit Start during Continuous Renal Replacement Therapy in Vasopressor-Dependent Patients: The Impact of a Slow Blood Flow Protocol

Blood Purif 2011;32:1–6



Circuit Start during Continuous Renal Replacement Therapy in Vasopressor-Dependent Patients: The Impact of a Slow Blood Flow Protocol

Blood Purif 2011;32:1–6

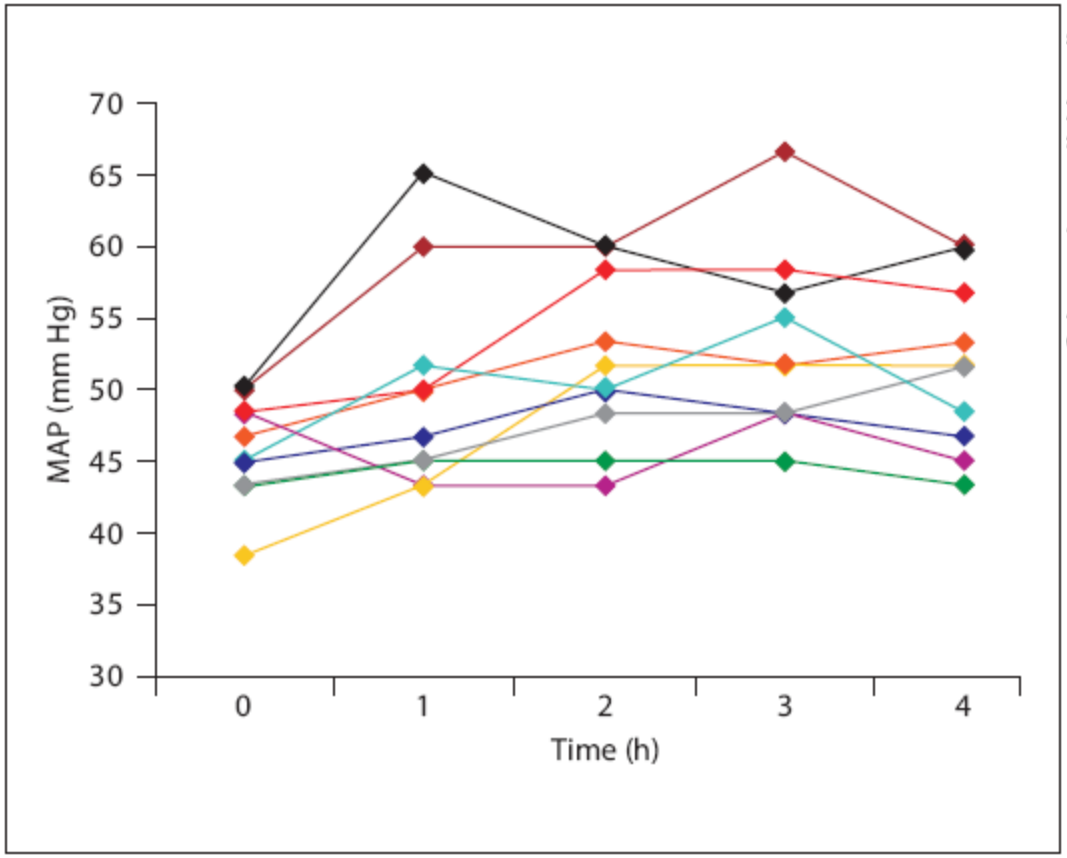


Fig. 2. Variation in MAP in patients with MAP ≤50 mm Hg at CRRT circuit start.

更慢起泵CRRT无差别

ICU

- 目标200ml/min
- 21例常规，20例慢速
- 常规：50ml/min为一档，1-4min调整间隔
- 慢速：20-50ml/min为一档，3-10min调整间隔
- 两组均无低血压或高血压出现

Blood Purif 2012;33:52–58

更慢起泵CRRT无差别

ICU

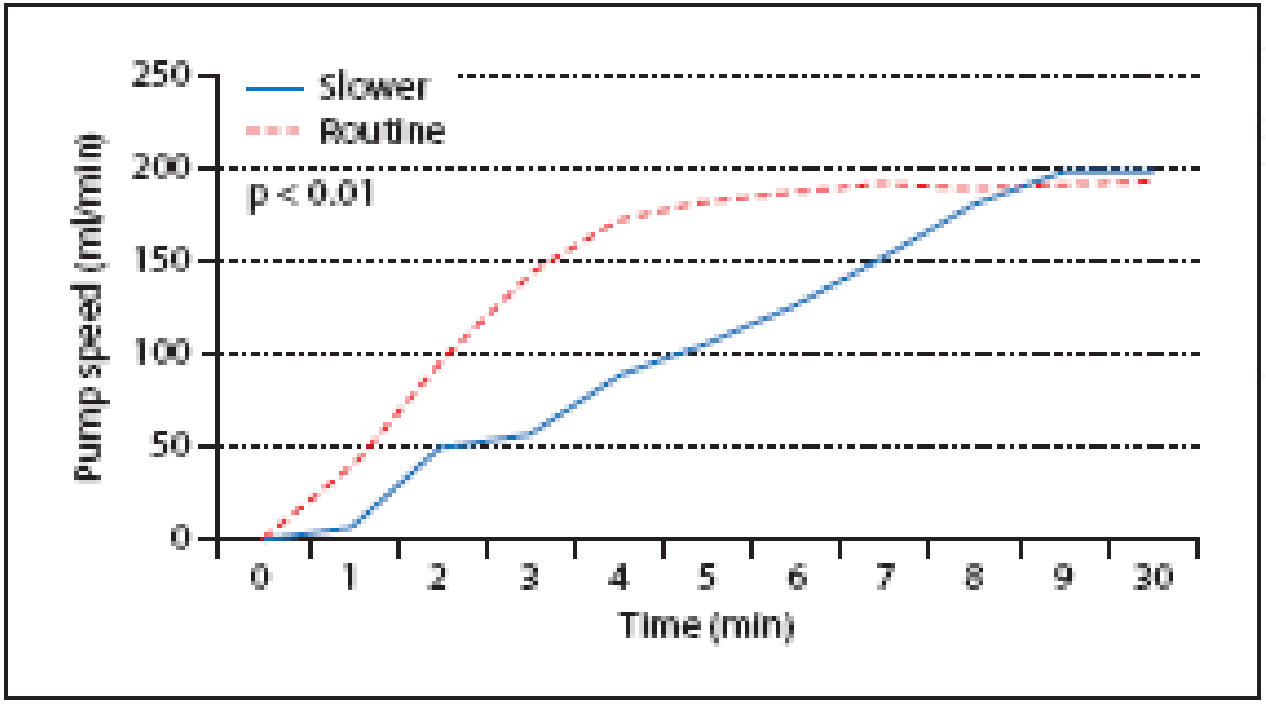
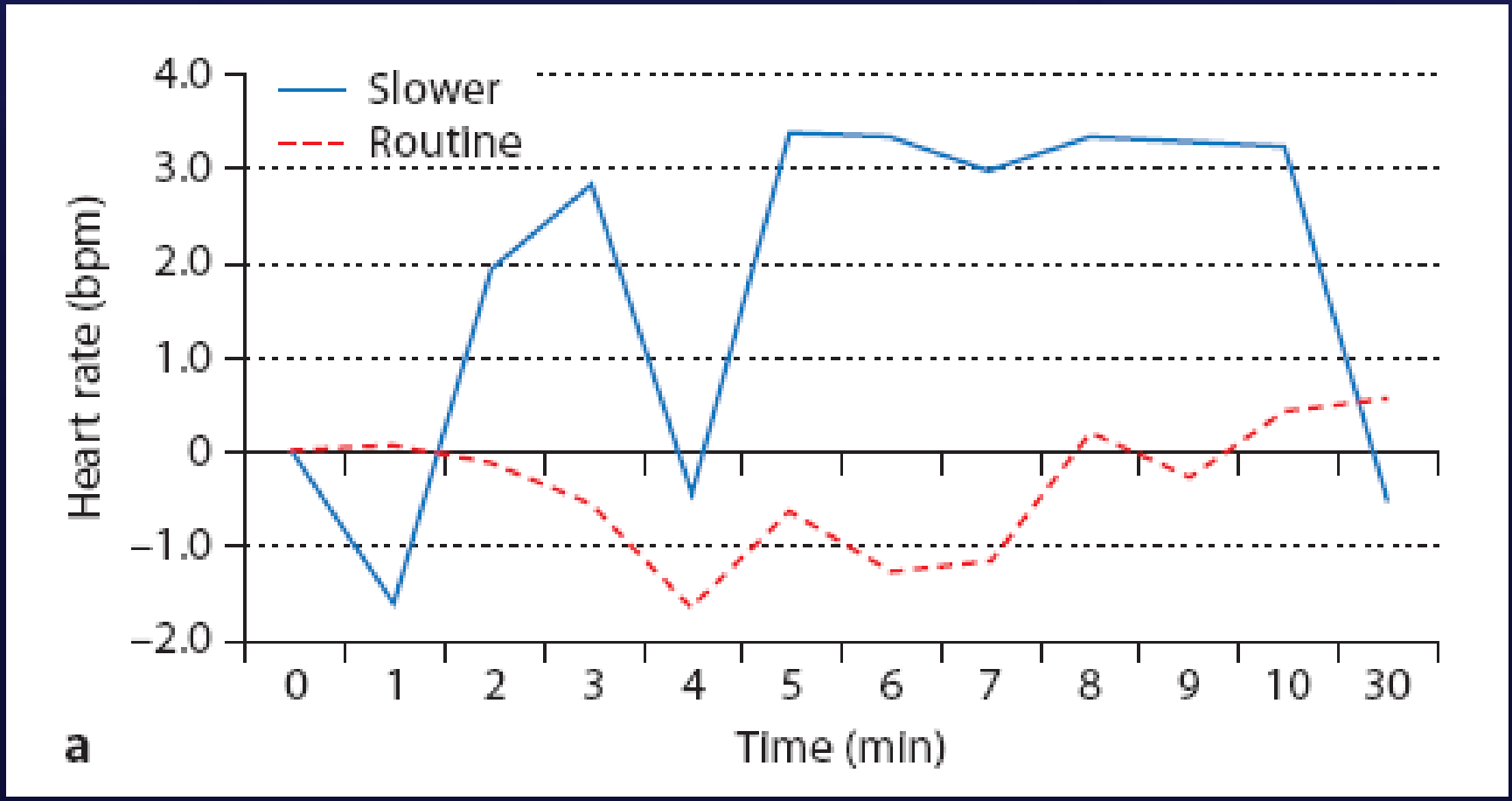


Fig. 1. Time-related changes in pump speed between 'routine-protocol' and 'slower' CRRT start in adult patients with AKI.

Blood Purif 2012;33:52–58

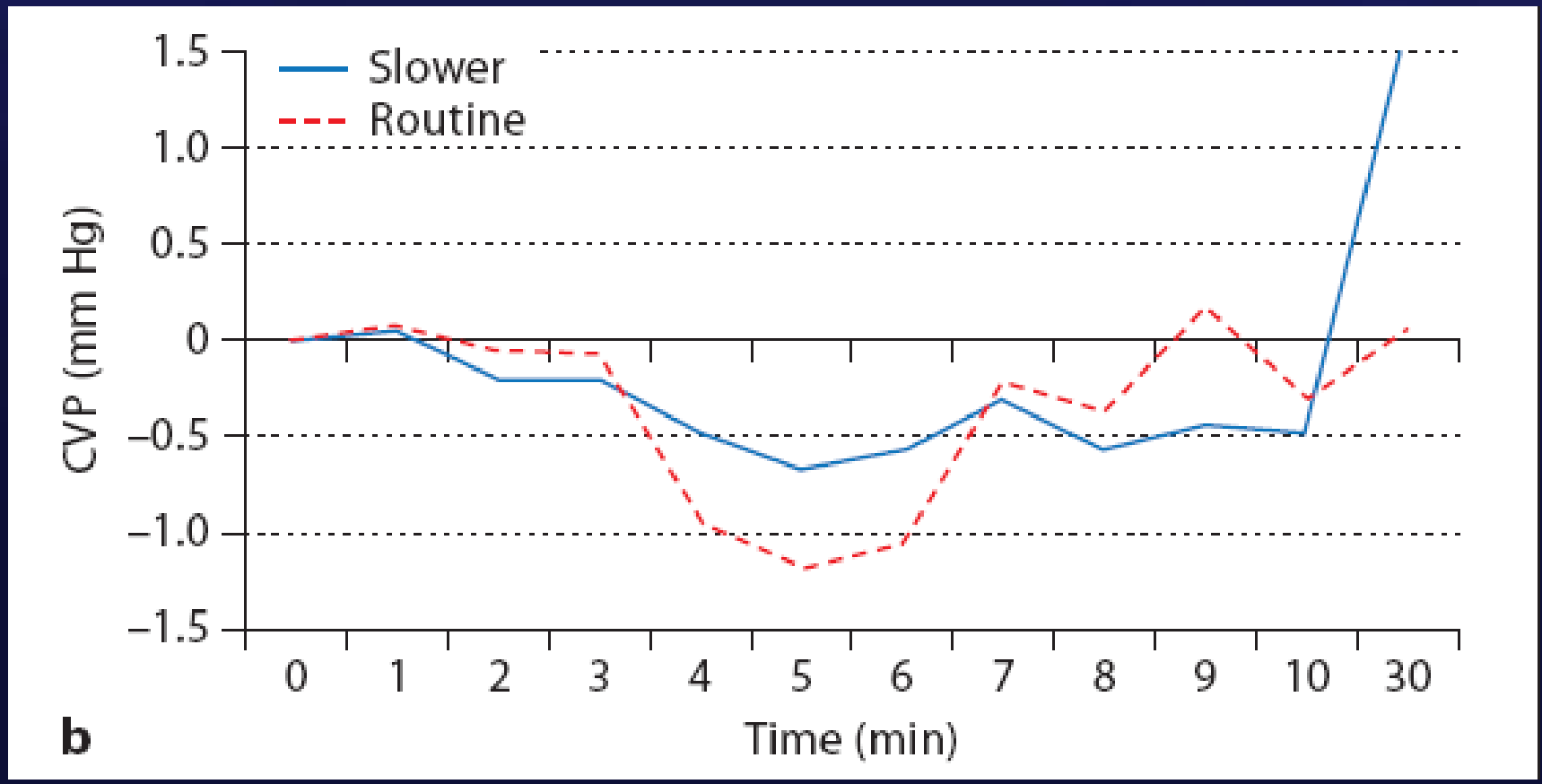
更慢起泵CRRT无差别

ICU



Blood Purif 2012;33:52–58

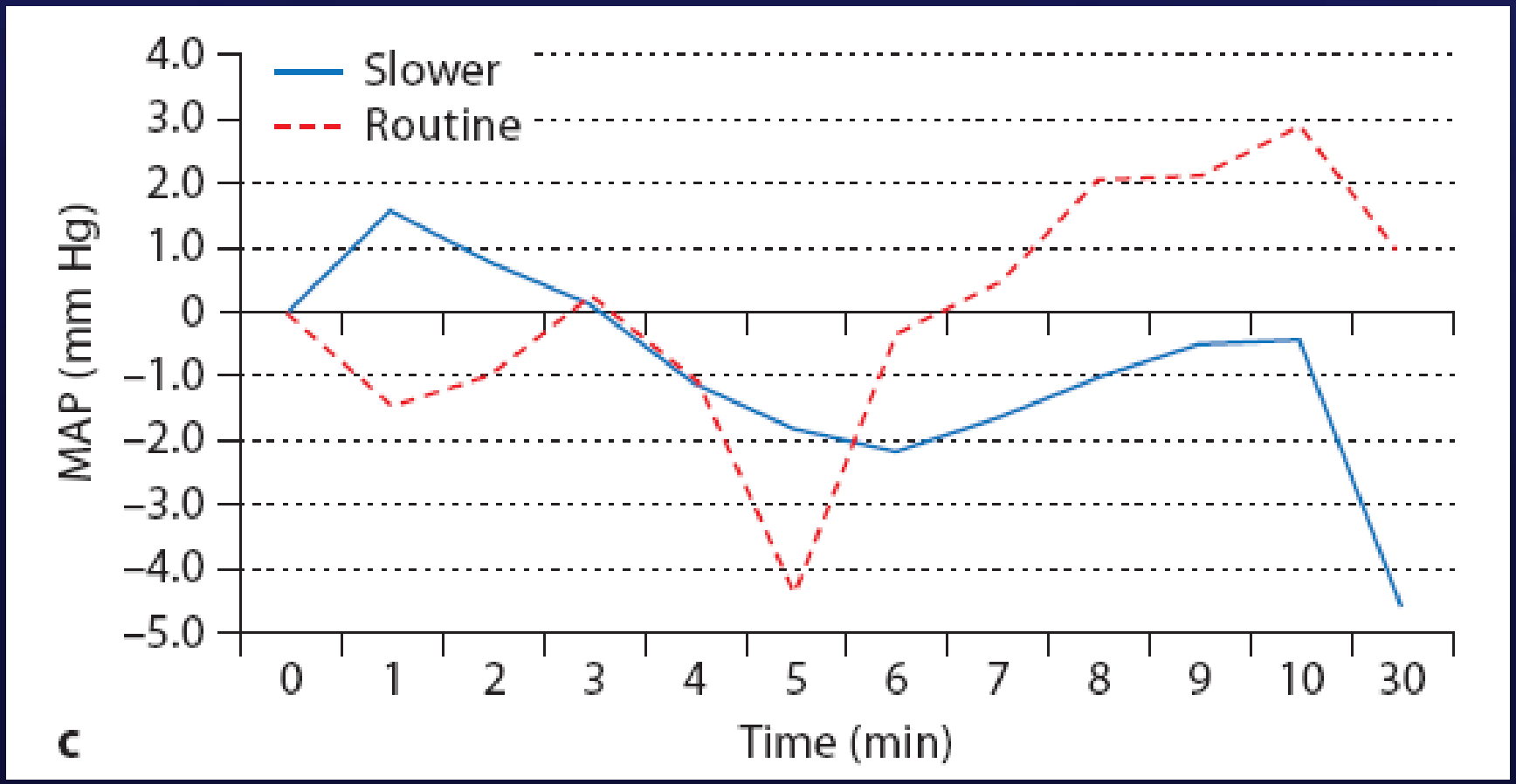
更慢起泵CRRT无差别



Blood Purif 2012;33:52–58

更慢起泵CRRT无差别

ICU



Blood Purif 2012;33:52–58

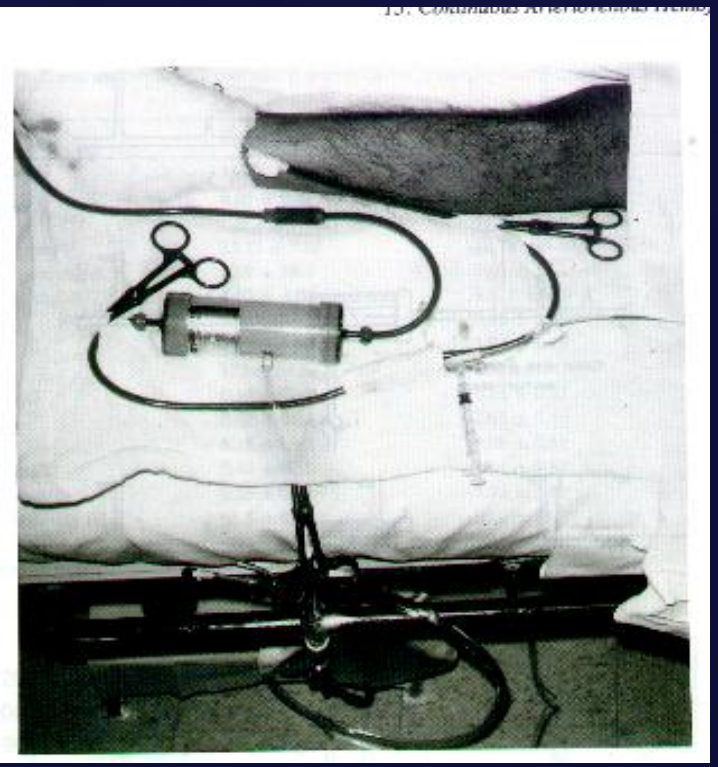
ICU

液体平衡影响血压吗？

容量管理

ICU

- 多数血压波动发生在CRRT过程中，与容量管理不当有关



容量管理

ICU

- CRRT与自主尿量的区别
- 寻找并维持最佳前负荷
- 功能性血流动力学监测

Blood Purif 2012;33:52–58

平衡管理
——CRRT系统脱水量

ICU

- 要有准确测量出入量的方法
- 持续记录、计算平衡值
- 调整脱水和置换液量的方法

ICU

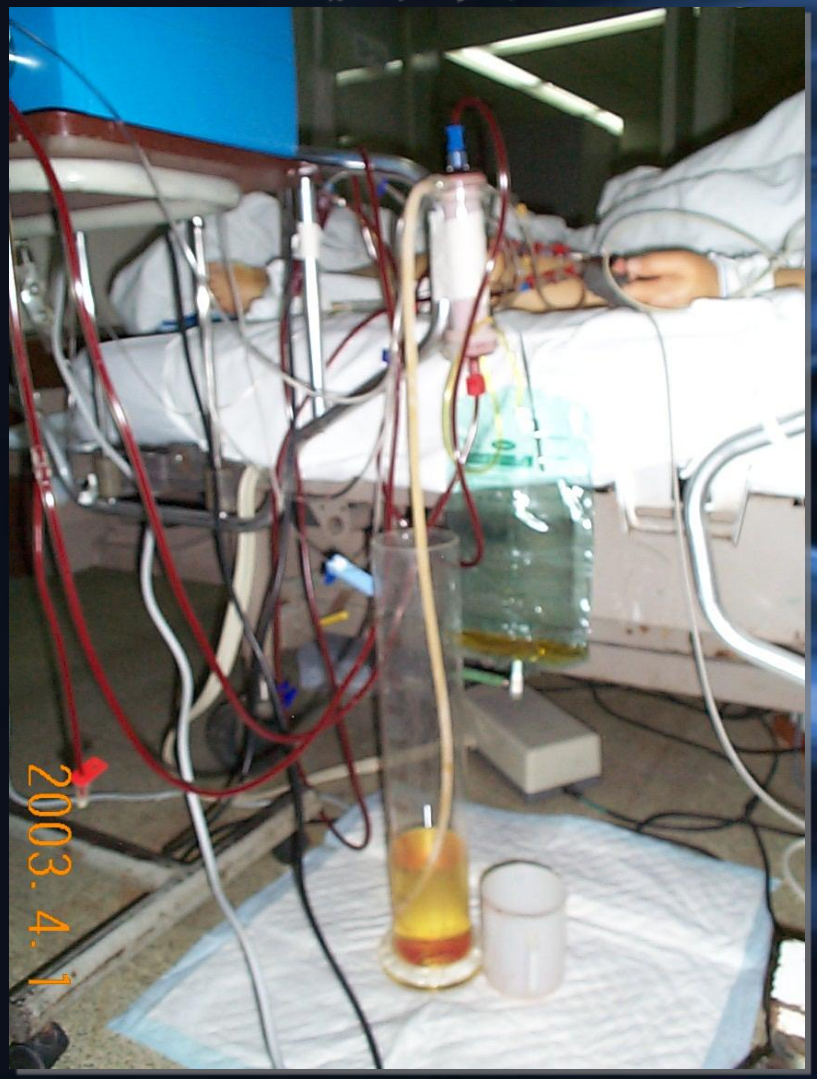
平衡管理——半自动

ICU

平衡管理——量筒

ICU

平衡管理——量筒，婴儿秤



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平衡管理——计算方法

- 一小时平衡计算
- 入量=3170ml
  - TPN 50ml+EN20ml+药物100ml+置换液2000ml+透析液1000ml
- 出量=3470ml
  - 大便100ml+尿量10ml+腹腔引流20ml+伤口渗血40ml+滤出液3300ml
- CRRT平衡=滤出液-置换液-透析液=超滤量=负300ml
- 总平衡=负300ml

ICU

平衡管理——血滤机

ICU

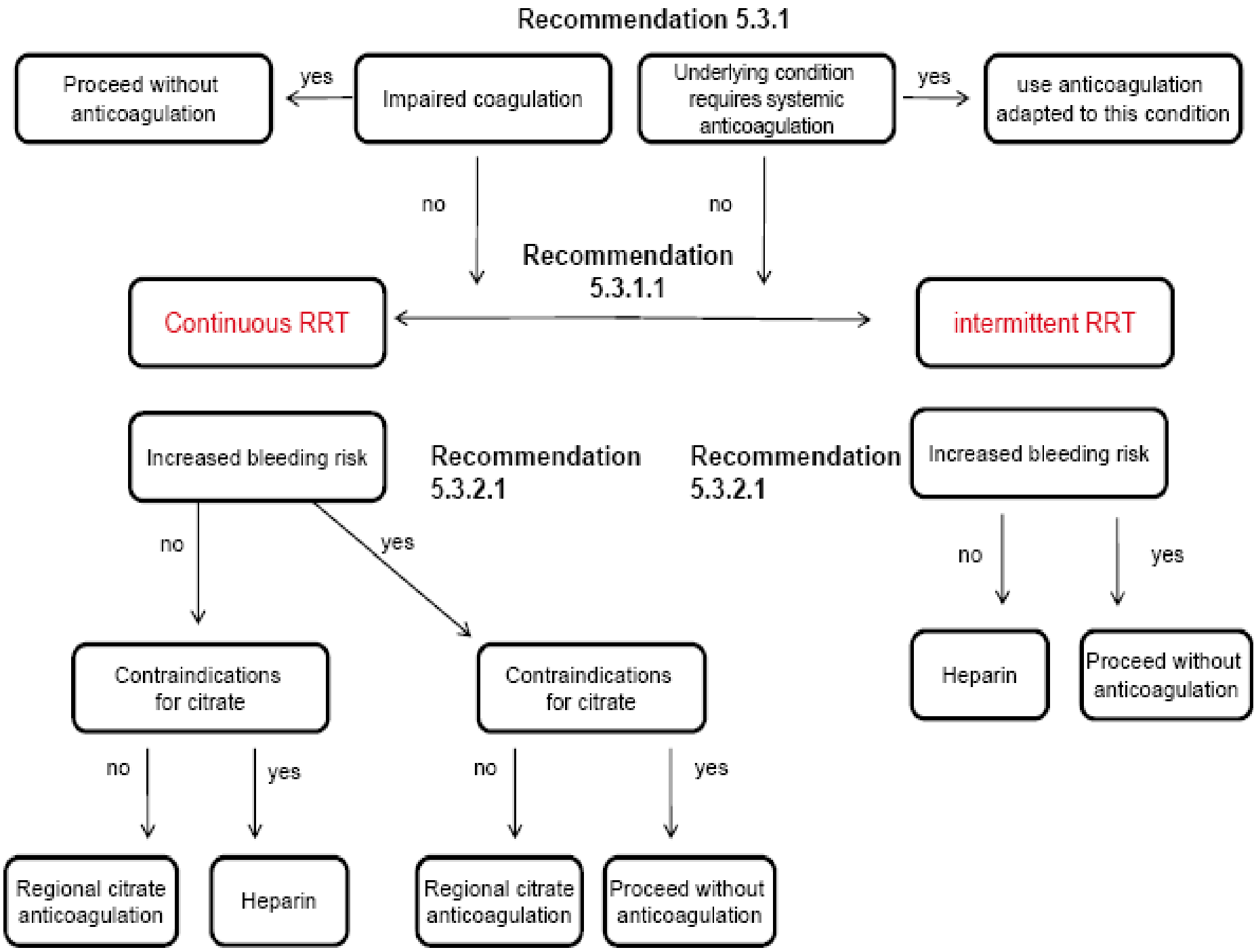
平衡管理——血滤机

- 多泵系统，精确控制流速
- 血流速度、置换液速度、滤出液速度
- 称量系统校准
- 自动计算，自动调节
- 提供实时记录及总结

ICU

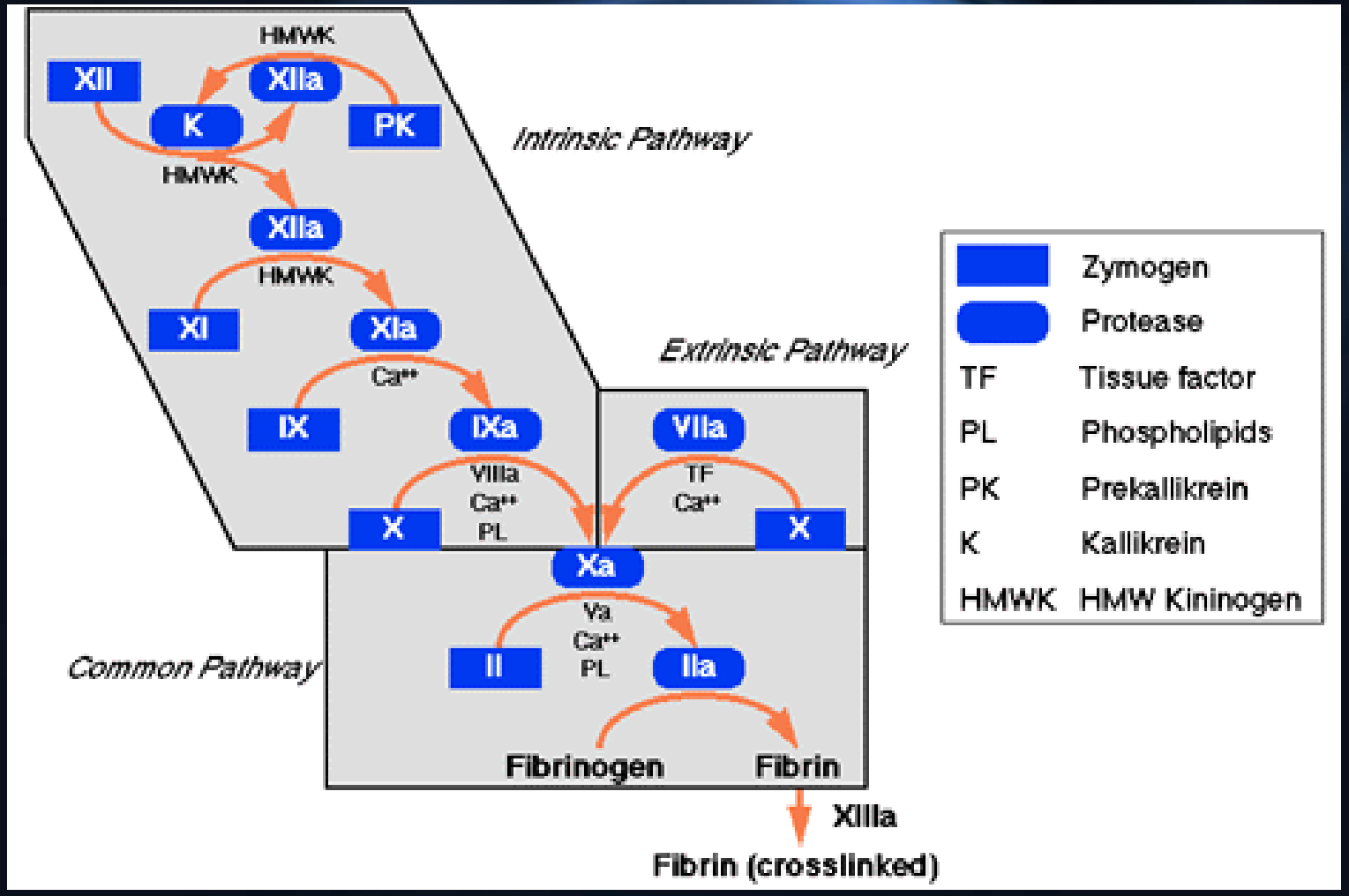
抗凝会影响血压吗？

- 抗凝过度，导致出血


Recommendation 5.3.1
Proceed without anticoagulation
yes
Impaired coagulation
Underlying condition requires systemic anticoagulation
yes
use anticoagulation adapted to this condition
no
no
Recommendation 5.3.1.1
Continuous RRT
intermittent RRT
Increased bleeding risk
Recommendation 5.3.2.1
Recommendation 5.3.2.1
Increased bleeding risk
no
yes
no
yes
Contraindications for citrate
Contraindications for citrate
Heparin
Proceed without anticoagulation
no
yes
no
yes
Regional citrate anticoagulation
Heparin
Regional citrate anticoagulation
Proceed without anticoagulation

ICU

枸橼酸抗凝的原理



枸橼酸抗凝导致休克的原理

ICU

- 枸橼酸本身无毒性
- 如枸橼酸过量，导致离子钙显著下降
- 导致心肌收缩力下降
- 导致血管张力力下降
- **导致血压下降**

ICU

置换液会影响血压吗？

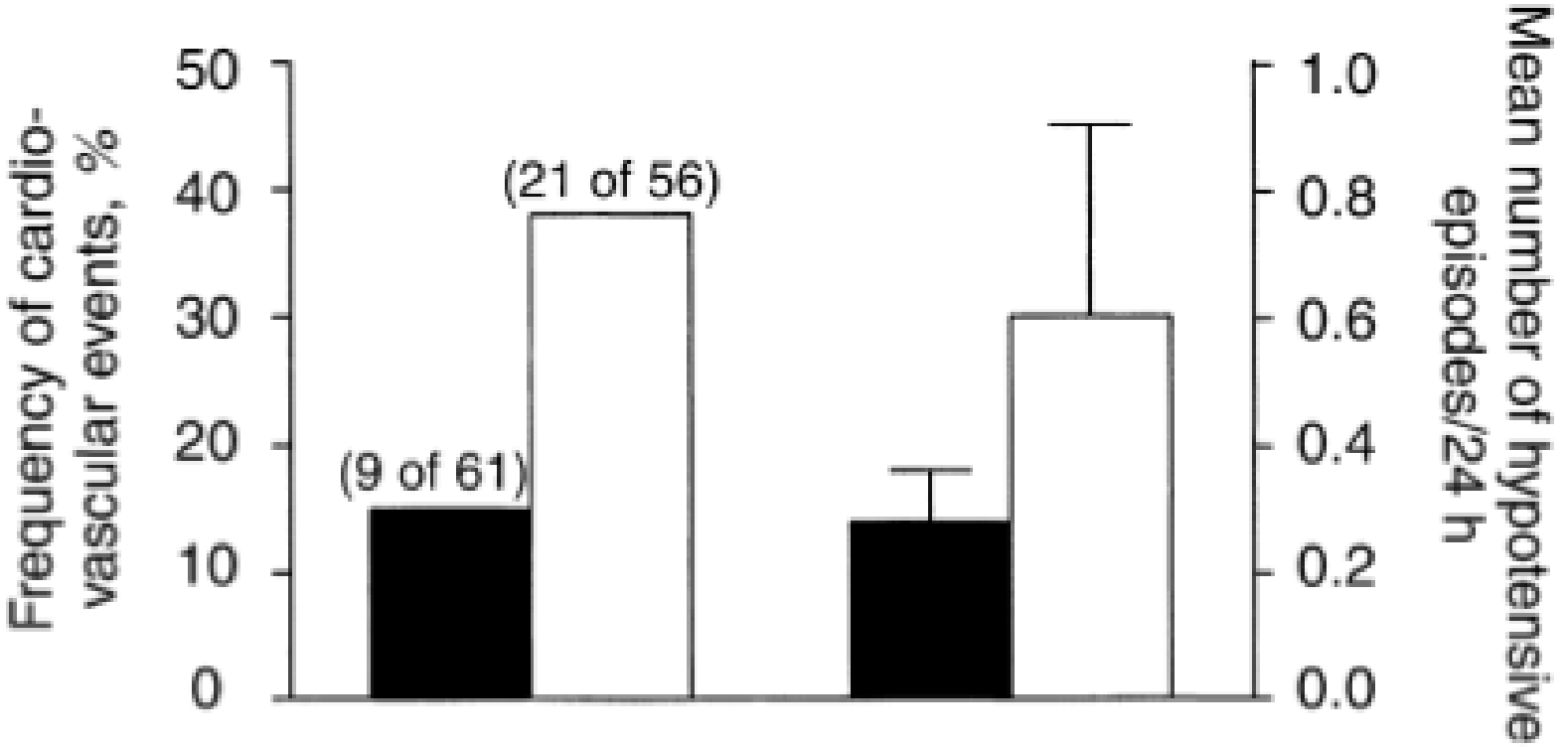


Fig. 1. Frequency of cardiovascular events and mean number of hypotensive episodes per 24 hours before the end of the study in patients with acute renal failure treated with bicarbonate-buffered (■; RF-bic; $N = 61$) and lactate-buffered (□; RF-lac; $N = 56$) replacement fluids during continuous venovenous hemofiltration (CVVH).

KI 2000 58: 1751

CHAPTER 5.7: BUFFER SOLUTIONS FOR RRT IN PATIENTS WITH AKI

5.7.1: We suggest using bicarbonate碳酸氢盐, rather than lactate乳酸盐, as a buffer in dialysate and replacement fluid for RRT in patients with AKI. (*2C*)

5.7.2: We recommend using bicarbonate, rather than lactate, as a buffer in dialysate and replacement fluid for RRT in patients with AKI and circulatory shock. (*1B*)

ICU

滤器会影响血压吗？

AN-69 膜导致CRRT低血压

ICU

- 2个儿科患者，体重小于10kg
- 全血预冲CRRT管路
- 开始后出现严重低血压
- AN-69膜 pH敏感 sensitive.
- 库血过酸，激活缓激肽，诱导低血压
- 盐水、蛋白预冲，无论**pH**值，均不会出现

American Journal of Kidney Diseases
Volume 38, Issue 1 , Pages 173-178, July 2001.

结论-如何避免CRRT血压波动？

ICU

- 开始前的血流动力学监测
- 对高危病人提前扩容或增加药物剂量
- 较慢的起始速度可能有益
- 进行中严密连续的容量评估

Blood Purif 2012;33:52–58

ICU

Thank You for Your Attention!