

DOI: 10.16781/j.CN31-2187/R.20211016

· 论 著 ·

复方果糖电解质注射液在骨创伤患者中的疗效观察

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[摘要] **目的** 探讨复方果糖电解质注射液在骨创伤患者中的临床疗效和应用价值。**方法** 纳入2020年1月至2021年6月在海军军医大学(第二军医大学)第二附属医院行骨创伤切开复位内固定术的患者80例, 随机分为对照组和试验组, 每组40例。对照组患者术后采用常规补液方案(5%葡萄糖氯化钠注射液与5%葡萄糖注射液各1 000 mL/d静脉滴注, 其中5%葡萄糖注射液中添加1.5 g氯化钾和1 g葡萄糖酸钙), 试验组患者术后给予复方果糖电解质注射液2 000 mL/d静脉滴注, 疗程均为5 d。观察两组患者的血糖、肝肾功能、电解质水平、血液流变学和凝血功能、手术与术后相关指标及伤口愈合情况。**结果** 术后所有患者生命体征平稳。对照组术后第1、2、5天给药后即刻及给药后2 h血糖水平均高于试验组($P < 0.01$), 对照组的血糖水平波动较大。试验组患者术后1、5 d全血比高切黏度、全血比低切黏度、血浆比黏度均低于对照组($P < 0.05$), 凝血酶原时间均高于对照组($P < 0.05$), 但两组患者的肝肾功能、电解质水平、手术时间、术中出血量、术后引流量、拆线天数差异均无统计学意义($P > 0.05$)。**结论** 复方果糖电解质注射液可安全、有效地应用于骨创伤患者的术后补液治疗, 对患者的血糖、肝功能和电解质水平等影响均较小, 同时可以降低血液黏滞度, 降低血栓风险。

[关键词] 复方果糖电解质注射液; 骨创伤; 血糖; 电解质; 血液流变学**[中图分类号]** R 683 **[文献标志码]** A **[文章编号]** 2097-1338(2022)07-0772-06

Compound fructose electrolyte injection in patients with bone trauma: efficacy observation

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[Abstract] **Objective** To explore the clinical efficacy and application value of compound fructose electrolyte injection in patients with bone trauma. **Methods** A total of 80 patients who underwent open reduction and internal fixation of bone trauma in The Second Affiliated Hospital of Naval Medical University (Second Military Medical University) from Jan. 2020 to Jun. 2021 were enrolled and randomly divided into control group ($n=40$) and experimental group ($n=40$). The patients in the control group were treated with routine fluid resuscitation scheme (intravenous drip of 5% glucose and sodium chloride injection 1 000 mL/d and 5% glucose injection 1 000 mL/d, 1.5 g potassium chloride and 1 g calcium gluconate were added into the 5% glucose injection) after operation, and the patients in the experimental group were treated with intravenous drip of compound fructose electrolyte injection 2 000 mL/d after operation, both for 5 d. Blood glucose, liver and kidney function, electrolyte level, hemorheology and coagulation function, operative and postoperative related indexes, and wound healing were observed in the 2 groups. **Results** The postoperative vital signs of all patients were stable. The levels of blood glucose immediately and 2 h after administration on the 1st, 2nd, and 5th day after operation in the control group were

[收稿日期] 2021-10-09 **[接受日期]** 2022-04-18**[基金项目]** 全军医学科技青年培训计划应用基础研究项目(21QNY041), 海军军医大学(第二军医大学)第一附属医院“深蓝123”军事医学研究专项探索培育项目(2020SLZ007)。Supported by Application Basic Research Plan of Youth Training Project of Military Medical Science and Technology Program (21QNY041) and “Deep Blue 123” Military Medical Research Project of The First Affiliated Hospital of Naval Medical University (Second Military Medical University) (2020SLZ007).**[作者简介]** 李雨虹, 住院医师. E-mail: liyuhongd163@163.com; 杨素霞. E-mail: yangsuxia20210102@163.com

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significantly higher and with larger fluctuation range than those in the experimental group (all $P < 0.01$). The whole blood specific high shear viscosity, whole blood specific low shear viscosity, plasma specific viscosity in the experimental group were significantly lower than those in the control group 1 and 5 d after operation (all $P < 0.05$), and prothrombin time was significantly higher than that in the control group (both $P < 0.05$). There were no significant differences in liver or kidney function, electrolyte level, operation time, intraoperative blood loss, postoperative drainage, or suture removal days between the 2 groups (all $P > 0.05$). **Conclusion** Compound fructose electrolyte injection is safe and effective for postoperative rehydration in bone trauma patients, with less interference on blood glucose, liver and kidney function, and electrolyte level. Meanwhile, it can reduce blood viscosity and decrease the risk of thrombosis.

[**Key words**] compound fructose electrolyte injection; bone trauma; blood glucose; electrolyte; hemorheology

[Acad J Naval Med Univ, 2022, 43(7): 772-777]

骨创伤是目前临床上常见的一种骨外科疾病。近年来随着交通和建筑意外事故发生率的升高,多发性损伤和高能量损伤明显增多^[1-2]。骨创伤可引起机体发生一系列生理、病理应激反应,这些反应相互影响和制约,诱发高能量消耗、高代谢率、高凝状态、电解质异常、代谢性酸中毒等内环境紊乱^[3]。战场条件恶劣,大量战伤性骨创伤的作战人员早期可因严重出血抢救不及时而死亡^[4],对于这类患者,不仅要积极进行手术治疗,围手术期的补液也至关重要。合理的补液方案有助于患者术后扩容、快速恢复,避免“死亡三角”(低体温、酸中毒、凝血功能异常)出现,降低创伤患者的病死率^[5]。海军军医大学(第二军医大学)第二附属医院于2003年研发了一种复方果糖电解质注射液,截至目前已安全应用于临床18年,其成分配比合理,护理操作简便,可有效防止血糖、电解质的剧烈波动。本研究旨在分析该复方果糖电解质注射液在骨创伤患者中的应用效果,进一步探讨其对骨创伤患者血糖、肝肾功能、电解质水平、血液流变学指标和凝血功能、手术与术后相关指标和伤口愈合的影响,以及对未来战场的应用价值。

1 资料和方法

1.1 研究对象 本研究为单中心、前瞻性随机对照研究。选择2020年1月至2021年6月在海军军医大学(第二军医大学)第二附属医院行骨创伤切开复位内固定术的患者100例。纳入标准:(1)年龄 >18 周岁;(2)患者受伤至住院前未进行药物处理,经过检查符合骨创伤诊断标准;(3)行骨创伤切开复位内固定术的患者;(4)既往否认糖尿病病史且入院空腹血糖 <6.9 mmol/L;(5)愿意参与本研究治疗。排除标准:(1)对果糖过敏且不耐受者或有高尿酸血症、痛风等不符合采用复

方果糖电解质注射液治疗的患者;(2)合并重要脏器功能障碍的患者;(3)伴有其他恶性肿瘤的患者。将入组患者随机分为对照组和试验组,所有患者均对本研究内容了解且自愿签署参与研究知情同意书。本研究通过海军军医大学(第二军医大学)第一附属医院临床研究伦理委员会审批。

1.2 给药方法 (1)对照组患者术后给予5%葡萄糖氯化钠注射液与5%葡萄糖注射液各1 000 mL/d静脉滴注。其中5%葡萄糖注射液中添加1.5 g氯化钾和1 g葡萄糖酸钙,输液时间约6 h,疗程5 d。

(2)试验组患者术后给予复方果糖电解质注射液2 000 mL/d静脉滴注。复方果糖电解质注射液每袋500 mL,由海军军医大学(第二军医大学)第二附属医院提供(总制字2016G506006),输液时间约6 h,疗程5 d。用药前禁食4 h,用药后2 h内禁食;试验期间禁用其他药物。

1.3 观察指标 (1)血糖值:术前空腹,术后第1、2、5天每次用药前及用药后即刻和用药后2 h,以及停药后1 d测指血糖。(2)血液黏滞度及凝血指标:术前及术后1、5 d早晨空腹采集肘正中静脉血,检测血细胞比容、血液黏滞度及凝血功能。

(3)肝肾功能及电解质指标:术前及术后1 d早晨空腹采集肘正中静脉血,检测肝肾功能及电解质水平。(4)手术与术后相关指标:手术时间、术中出血量、术后引流量。(5)伤口愈合天数及愈合情况。

1.4 不良反应 试验期间密切观察患者是否出现与治疗药物相关的不良反应,如是否出现电解质及酸碱平衡紊乱。

1.5 统计学处理 应用SPSS 23.0软件进行统计分析。呈正态分布的计量资料以 $\bar{x} \pm s$ 表示,两组间术前、术后资料的比较采用独立样本 t 检验,组内用药前、用药后资料的比较采用配对 t 检验;呈偏

态分布的计量资料以中位数（下四分位数，上四分位数）表示，两组间比较采用 Wilcoxon 秩和检验；计数资料以例数和百分数表示，两组间比较采用 χ^2 检验。检验水准（ α ）为 0.05。

2 结果

2.1 一般情况 根据纳入、排除标准，最终共 80 例患者入组，对照组和试验组各 40 例。对照组男 18 例、女 22 例；年龄为 28~50 岁，平均年龄为（40.95±7.06）岁；创面面积为 16~231 cm²，中位创面面积为 95.5（69.5，129.5）cm²；交通事

故伤 10 例，高空坠落伤 13 例，重物砸压伤 9 例，机械伤 8 例。试验组男 17 例、女 23 例；年龄为 26~52 岁，平均年龄为（40.93±7.62）岁；创面面积为 18~236 cm²，中位创面面积为 94.5（63.5，129.0）cm²；交通事故伤 12 例，高空坠落伤 11 例，重物砸压伤 10 例，机械伤 7 例。两组患者的性别、年龄、BMI、创面面积等基线资料差异均无统计学意义（ P 均>0.05，表 1）。且两组患者术后均尿量正常，生命体征平稳，均未出现严重的补液相关不良事件。

表 1 两组骨创伤患者基线资料比较

Tab 1 Comparison of baseline characteristics of bone trauma patients in 2 groups

Item	Control group	Experimental group	Statistic	P value
Gender, n (%)			$\chi^2=0.051$	0.822
Male	18 (45.0)	17 (42.5)		
Female	22 (55.0)	23 (57.5)		
Age/year, $\bar{x}\pm s$	40.95±7.06	40.93±7.62	$t=0.015$	0.988
Height/cm, $\bar{x}\pm s$	164.75±8.78	165.28±6.92	$t=-0.297$	0.767
Weight/kg, $\bar{x}\pm s$	60.36±6.82	61.02±7.81	$t=-0.401$	0.689
Body mass index/(kg·m ⁻²), $\bar{x}\pm s$	22.24±2.21	22.27±2.19	$t=0.056$	0.955
Wound area/cm ² , $M(Q_L, Q_U)$	95.5 (69.5, 129.5)	94.5 (63.5, 129.0)	$Z=-0.269$	0.788

Control group: The patients were treated with routine fluid resuscitation scheme (intravenous drip of 5% glucose and sodium chloride injection 1 000 mL+5% glucose injection 1 000 mL, 1.5 g potassium chloride and 1 g calcium gluconate were added into the 5% glucose injection) daily for 5 d after operation; Experimental group: The patients were treated with intravenous drip of compound fructose electrolyte injection (2 000 mL) daily for 5 d after operation. $M(Q_L, Q_U)$: Median (lower quartile, upper quartile).

2.2 血糖水平变化情况 两组患者术前空腹、术后给药前及停药后 1 d 的血糖水平差异均无统计学意义（ P 均>0.05）。术后第 1、2、5 天给药后

即刻及给药后 2 h 对照组血糖水平均高于试验组（ P 均<0.01），对照组的血糖水平波动较大。见表 2。

表 2 两组骨创伤患者的血糖水平变化情况

Tab 2 Changes of blood glucose levels of bone trauma patients in 2 groups

Item	Control group	Experimental group	t value	P value
Fasting blood glucose before operation	5.37±0.61	5.34±0.76	-0.162	0.872
1 st day after operation				
Before administration	5.12±0.48	5.14±0.60	0.143	0.886
Immediately after administration	8.28±2.52	6.27±0.90	-4.750	<0.001
2 h after administration	6.14±1.27	5.38±0.75	-3.257	0.002
2 nd day after operation				
Before administration	5.46±0.84	5.49±0.81	-0.204	0.839
Immediately after administration	8.67±2.59	6.86±0.98	-4.126	<0.001
2 h after administration	6.18±1.10	5.53±0.76	-3.044	0.003
5 th day after operation				
Before administration	5.37±0.62	5.24±0.53	-0.971	0.334
Immediately after administration	8.54±2.33	6.75±0.97	-4.488	<0.001
2 h after administration	6.36±0.86	5.59±0.97	-4.334	<0.001
1 st day after drug withdrawal	5.59±0.86	5.28±0.85	-1.614	0.111

Control group: The patients were treated with routine fluid resuscitation scheme (intravenous drip of 5% glucose and sodium chloride injection 1 000 mL+5% glucose injection 1 000 mL, 1.5 g potassium chloride and 1 g calcium gluconate were added into the 5% glucose injection) daily for 5 d after operation; Experimental group: The patients were treated with intravenous drip of compound fructose electrolyte solution (2 000 mL) daily for 5 d after operation.

2.3 血液黏滞度及凝血功能变化情况 相较于术前,术后两组共有68例患者血液黏滞度升高。两组术后1 d全血比高切黏度、全血比低切黏度、血浆比黏度均高于术前,凝血酶原时间均低于术前,

差异均有统计学意义(P 均 <0.05)。试验组术后1、5 d全血比高切黏度、全血比低切黏度、血浆比黏度均低于对照组,凝血酶原时间均高于对照组,差异均有统计学意义(P 均 <0.05)。见表3。

表3 两组骨创伤患者的血液黏滞度及凝血功能变化

Tab 3 Changes of blood viscosity and coagulation function of bone trauma patients in 2 groups

Item	Control group	Experimental group	t value	$n=40, \bar{x} \pm s$
				P value
HSV/(mPa·s)				
Before operation	4.77±0.73	4.66±0.76	-0.683	0.497
1 st day after operation	5.87±0.68*	5.38±0.80*	-2.955	0.004
5 th day after operation	4.87±0.72	4.48±0.60	-2.636	0.010
LSV/(mPa·s)				
Before operation	9.85±1.34	9.68±1.38	-0.537	0.593
1 st day after operation	11.80±1.90*	10.85±1.25*	-2.617	0.011
5 th day after operation	10.70±1.17	9.63±0.70	-4.961	<0.001
PSV/(mPa·s)				
Before operation	1.38±0.06	1.36±0.04	-1.828	0.071
1 st day after operation	1.58±0.09*	1.52±0.10*	-2.736	0.008
5 th day after operation	1.60±0.12	1.47±0.16	-3.972	<0.001
PT/s				
Before operation	12.84±0.91	12.67±1.03	0.794	0.429
1 st day after operation	11.67±0.84*	12.16±1.17*	2.167	0.034
5 th day after operation	11.79±0.92	12.28±1.04	2.246	0.028
Hematocrit/%				
Before operation	47.10±4.85	48.50±4.29	1.367	0.175
1 st day after operation	49.85±3.63	48.25±4.31	-1.796	0.076
5 th day after operation	47.75±2.70	48.90±3.35	1.691	0.095

Control group: The patients were treated with routine fluid resuscitation scheme (intravenous drip of 5% glucose and sodium chloride injection 1 000 mL + 5% glucose injection 1 000 mL, 1.5 g potassium chloride and 1 g calcium gluconate were added into the 5% glucose injection) daily for 5 d after operation; Experimental group: The patients were treated with intravenous drip of compound fructose electrolyte solution (2 000 mL) daily for 5 d after operation. * $P < 0.05$ vs the same group before operation. HSV: Whole blood specific high shear viscosity; LSV: Whole blood specific low shear viscosity; PSV: Plasma specific viscosity; PT: Prothrombin time.

2.4 肝肾功能、电解质水平变化情况 两组患者均未出现严重的电解质紊乱事件。两组患者各时间点的肝肾功能、电解质(Ca^{2+} 、 K^{+} 、 Na^{+} 、 Cl^{-})水平均相近,差异均无统计学意义(P 均 >0.05)。见表4。

2.5 手术与术后相关指标变化情况 对照组患者的手术时间、术中出血量、术后引流量分别为(129.43±20.74) min、(301.65±49.18) mL、(89.38±13.52) mL,试验组患者的上述指标分别为(122.78±19.65) min、(282.08±60.20) mL、

(95.45±18.88) mL,两组间差异均无统计学意义($P=0.145$ 、 0.115 、 0.102)。

2.6 伤口愈合情况 试验组患者伤口愈合良好,创面无红肿,无皮缘坏死,拆线天数为(10.73±2.05) d;对照组5例患者出现创面红肿,3例创面皮缘坏死,拆线天数为(11.05±2.36) d,两组间拆线天数差异无统计学意义($P=0.513$)。

2.7 安全性评价 临床观察表明,两组患者均未出现明显与用药有关的不良反应,两组用药对疾病的转归无不良影响,安全可靠。

表4 两组骨创伤患者的肝肾功能和电解质水平变化

Tab 4 Changes of liver and kidney function and electrolyte level of bone trauma patients in 2 groups

Item	Control group		Experimental group		<i>t</i> value	<i>P</i> value
	$\bar{x} \pm s$	Range	$\bar{x} \pm s$	Range		
<i>n</i> = 40						
AST/(U·L ⁻¹)						
Before operation	33.93 ± 5.46	18-50	32.43 ± 5.80	21-45	-1.191	0.237
1 st day after operation	34.35 ± 4.20	23-44	32.63 ± 4.29	24-42	-1.818	0.073
ALT/(U·L ⁻¹)						
Before operation	33.03 ± 4.81	21-43	31.08 ± 4.93	19-41	-1.794	0.077
1 st day after operation	33.28 ± 4.99	22-46	31.75 ± 4.23	22-43	-1.475	0.144
BUN/(mmol·L ⁻¹)						
Before operation	6.15 ± 1.03	3.8-8.2	5.80 ± 0.83	4.3-7.6	-1.675	0.098
1 st day after operation	7.17 ± 1.34	3.9-11.7	6.72 ± 1.19	5.1-10.3	-1.608	0.112
SCr/(μmol·L ⁻¹)						
Before operation	78.20 ± 11.18	52-107	75.58 ± 12.66	55-105	-0.983	0.329
1 st day after operation	85.93 ± 11.98	63-116	81.23 ± 12.10	59-109	-1.746	0.085
Ca ²⁺ /(mmol·L ⁻¹)						
Before operation	2.28 ± 0.11	2.11-2.63	2.26 ± 0.10	2.12-2.57	-0.889	0.376
1 st day after operation	2.32 ± 0.75	2.13-2.83	2.33 ± 0.16	2.11-2.75	0.403	0.688
K ⁺ /(mmol·L ⁻¹)						
Before operation	3.74 ± 0.39	2.8-4.5	3.68 ± 0.34	3.1-4.3	-0.710	0.480
1 st day after operation	3.52 ± 0.35	3.1-4.4	3.64 ± 0.33	3.2-4.2	1.631	0.107
Na ⁺ /(mmol·L ⁻¹)						
Before operation	140.25 ± 3.02	131-145	140.65 ± 2.28	137-146	0.668	0.506
1 st day after operation	138.93 ± 3.60	129-149	139.95 ± 2.61	135-148	1.458	0.149
Cl ⁻ /(mmol·L ⁻¹)						
Before operation	98.88 ± 3.71	91-106	99.10 ± 2.95	93-104	0.300	0.765
1 st day after operation	101.93 ± 3.75	95-110	101.53 ± 3.03	95-108	-0.525	0.601

Control group: The patients were treated with routine fluid resuscitation scheme (intravenous drip of 5% glucose and sodium chloride injection 1 000 mL + 5% glucose injection 1 000 mL, 1.5 g potassium chloride and 1 g calcium gluconate were added into the 5% glucose injection) daily for 5 d after operation; Experimental group: The patients were treated with intravenous drip of compound fructose electrolyte solution (2 000 mL) daily for 5 d after operation. AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; BUN: Blood urea nitrogen; SCr: Serum creatinine.

3 讨论

美军现代化作战经验丰富,其战伤救治革新技术、装备和科学研究等处于国际领先水平^[6]。美军《战术战伤救治指南》规定,出现休克体征的重伤员应立即予以液体复苏,复苏液体推荐优先使用新鲜全血,其次是血浆、红细胞和血小板(1:1:1)等血液制品,同时强调战(现)场的晶体补液治疗不可忽视^[7-8]。总之,快速止血、液体复苏、及时转运后送是提高严重战创伤伤员存活率的关键。

患者遭遇骨创伤并且接受手术后胰岛素释放受到抑制,同时机体肝糖原分解加剧、糖异生明显增加,导致血糖升高,血糖代谢紊乱影响了骨代谢平衡^[9]。创伤患者出现的持续高血糖状态还可以使患者体内晚期糖基化终末产物不断产生和积聚,高水平的晚期糖基化终末产物可以抑制成骨细胞的

增殖与分化,并诱导成骨细胞凋亡,病情严重者可发生高渗、酮症酸中毒等急性并发症^[10-11]。骨创伤和手术也会对患者造成一系列损伤,包括机械性损伤、热损伤、化学损伤等,导致患者凝血系统激活,而术后制动、高血糖状态等又进一步加重凝血功能紊乱^[12]。对于骨创伤患者,电解质紊乱尤其是钙磷代谢异常不利于骨折愈合,而血钾等异常甚至可能危及生命^[13]。因此骨创伤术后补液不仅需要提供能量,也需尽可能降低血糖、电解质水平波动幅度和血栓形成风险。

针对骨创伤患者术后机体代谢特点,本研究采用复方果糖电解质注射液进行补液。复方果糖电解质注射液利用果糖代替葡萄糖提供能量,更容易代谢且无需胰岛素参与,还能够避免血糖剧烈波动^[14],可以安全用于糖尿病患者的补液。本研究中,使用复方果糖电解质注射液的骨创伤患者血糖水平较对照组稳定,且用药后即刻与用药后2 h血

糖均低于对照组。复方果糖电解质注射液中添加了 Ca^{2+} ,有利于断骨愈合^[15];还添加适量的 Mg^{2+} , Mg^{2+} 不仅参与成骨细胞生长、调控糖代谢,而且可以干扰血小板黏附和凝血酶原生成时间,降低了血栓形成风险^[16]。本研究也观察到,试验组的术后血液黏滞度低于对照组,有利于预防血栓形成。另外,两组患者术后血 Ca^{2+} 、 K^{+} 、 Na^{+} 、 Cl^{-} 均维持在正常参考值范围内,说明复方果糖电解质注射液中各种电解质配比恰当,可有效避免患者发生电解质紊乱。

应用复方果糖电解质注射液进行补液操作的优势还包括简便易行、无需其他配药操作、降低医护工作量、避免出错概率。在战创伤救护中,由于战场医疗条件不足,一旦出现大批量伤员,常规静脉补液治疗难以实施或实施延迟,致使多发创伤或大出血伤员的病死率增加^[17]。现今液体复苏方案较多,多数需要频繁加药与调换液体顺序,因此不能完全满足战场液体复苏的需求。在临床中观察到,肾移植患者经常会出现术后多尿期,受者尿量可超过20 000 mL/d,如何进行补液以维持肾脏血流灌注及内环境的水、电解质和酸碱平衡是重中之重。通过前期的摸索与应用,复方果糖电解质注射液在海军军医大学(第二军医大学)器官移植科肾移植区已经安全应用6 000余例,并且在麻醉科术中补液、创伤骨科、胰胆外科、泌尿外科、脑外科、新型冠状病毒肺炎患者各期补液治疗中被广泛应用,至今未发现严重不良事件。复方果糖电解质注射液在自然灾害、战场环境下液体治疗也可能具有独特优势。

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[本文编辑] 杨亚红