

以充气背心为主体的新型双泵复苏术的血流动力学研究^①

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提 要 传统心肺复苏成功率不高的原因之一是冠脉有效灌注压(CPP)低,本文提出舒张期辅以增强型体外反搏(EECP)(外周泵)的充气背心(VEST)(中心泵)的新型复苏术(VDVEST-CPR)。以 IBM PC 386 为控制主机的多功能复苏装置,在 8 条犬心室颤动 30s 后随机地实施充气背心心肺复苏术(VEST-CPR)及 VDVEST-CPR,自身对照设计。实验结果,VDVEST-CPR 较 VEST-CPR 显著升高主动脉压和右房的舒张压($P < 0.01$)。主动脉舒张压升高程度较右房的舒张压大,故 CPP 仍有较大幅度升高($P < 0.01$),CPP 峰值($6.81 \pm 2.95 \text{ kPa}$ vs $4.07 \pm 3.05 \text{ kPa}$),CPP 平均值($5.76 \pm 2.62 \text{ kPa}$ vs $3.87 \pm 2.81 \text{ kPa}$)。主动脉收缩压平均值也显著性升高($10.62 \pm 4.23 \text{ kPa}$ vs $9.39 \pm 4.61 \text{ kPa}$, $P < 0.05$)。结果表明,VDVEST-CPR 既体现 VEST 特点,又发挥了 EECP 的长处。既有较高收缩压,又有一定舒张压,CPP 明显改善。

主题词 心肺复苏术/方法;反搏术/方法;血流动力学;狗

中图分类号 R 605.974;318.6

现代心肺复苏术的成功率只有 10%~15%,主要原因之一是血流动力学效果不佳,尤其是动脉舒张压低,冠脉有效灌注压(CPR)不足^[1],如何提高 CPP 是当前复苏领域的热点之一^[2]。基于胸泵学说的充气背心心肺复苏术(VEST-CPR)^[3],是目前产生主动脉收缩压最高的一种复苏方法,但舒张压报道不一^[4~6],其临床效果仍待继续研究^[7]。增强型体外反搏(EECP)以提高主动脉舒张压、改善心肌血供为目的而用于临床^[8]。为此,我们用 EECP 弥补 VEST-CPR 不足,提出一种放松期辅以 EECP(外周泵)的充气背心(VEST)(中心泵)新型复苏术(VDVEST-CPR)。用犬室颤模型,比较 VEST-CPR 与 VDVEST-CPR 两种复苏术的血流动力学效果。

1 材料与方 法

杂种犬 8 条,雌雄不拘,体重 $15.9 \pm 1.79 \text{ kg}$ 。戊巴比妥钠(30mg/kg)静脉麻醉,气管插管,自然呼吸。右颈外静脉二属支,分别插入 6F 双极起搏电极到右室和 5F 导管式压力传感器(SPC-450,Millar Co.)到右房。6F 导管式压力传感器(PC-460,Millar Co.)经右颈总动脉插入到升主动脉。四肢电极记录心电图。犬胸廓包扎气囊背心,大腿及臂部包扎反

搏气囊,犬仰卧固定。静脉注射肝素(0.5mg/kg)抗凝。

Gould 2800 8 导仪、IBM PC 386 及 AD 卡组成生理指标的监测及数据采集系统,记录心电图、升主动脉压、右房压、VEST 气囊压、气道压、呼吸流量及呼吸容量。以 IBM PC 386 为控制主机的多功能复苏装置,执行机构是:定容呼吸机(SC I 型,上海),VEST 及反搏系统。实验方案为:①VEST-CPR,充气背心按压频率为 80 次/min,气囊压 26~33kPa,按压放松比为 1:1。放松期 100%氧定容量通气,15ml/kg 潮气量,按压通气比为 5:1;②VDVEST-CPR,人工通气与胸部按压同 VEST-CPR,放松期辅以 EECP(下半身序贯加压),反搏气囊压 40kPa。实验方案参数在实验前设置,以参数文件存盘,实验中调用。

20V 交流电作用右室诱导犬室颤,动脉压下降成直线,立即静脉注射 1mg 肾上腺素,0.004mg/kg/min 静脉维持。30s 后开始复苏,随机化安排 VEST-CPR 及 VDVEST-CPR 的先后顺序,每种方法进行 1.5min,其后两种方法交替进行。血压曲线稳定后,记录 6~8 个心动周期,采样 20K 数据存盘。30min 后结束实验,作胸部病理检查。自编的复苏数

① 本课题为国家自然科学基金资助项目;

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据处理软件(Turbo C2.0)处理实验数据, CPP 为主动脉压与右房压之差。统计软件(华西医科大学)作配对 t 检验。

2 实验结果

VDVEST-CPR 与 VEST-CPR 比较, 主动脉收缩压峰值和均值都升高, 均值升高有显著性 ($P <$

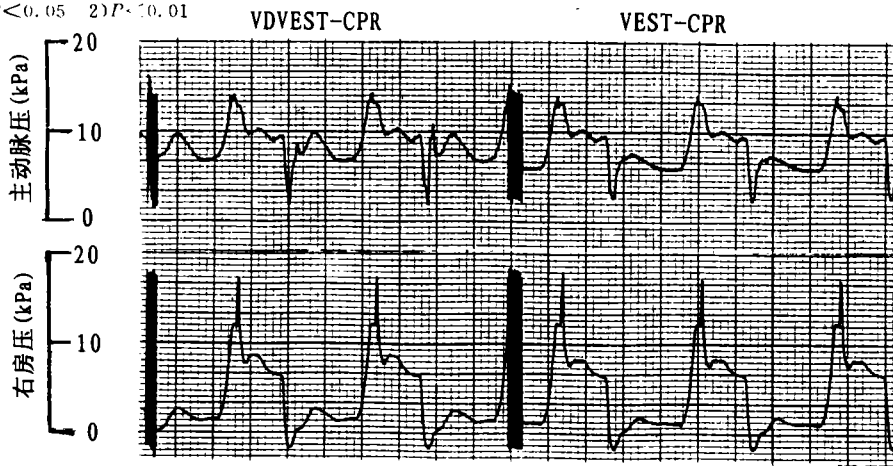
0.05)。主动脉和右房的舒张压峰值及均值也显著升高 ($P < 0.05$), 由于主动脉舒张压升高程度大于右房的舒张压, 舒张期 CPP 峰值及均值仍有较大幅度升高 ($P < 0.01$)。主动脉平均压及冠脉平均压都显著改善 ($P < 0.01$)。血流动力学结果见附表及附图。

大体病理检查, 未发现胸骨骨折, 4 条犬的双肺下叶有散在斑片状出血, 其中 2 条犬在实验后期咯血, 心包及心肌未见挫伤。

附表 VDVEST-CPR 与 VEST-CPR 的血流动力学比较 (kPa)

		收缩压峰值	收缩压均值	舒张压峰值	舒张压均值	血压平均值
主动脉	VEST-CPR	12.96±5.25	9.39±4.61	6.03±3.00	5.00±2.77	7.41±3.75
	VDVEST-CPR	14.37±3.88	10.62±4.23 ¹⁾	9.59±3.06 ²⁾	7.42±2.68 ²⁾	9.20±3.54 ²⁾
右心房	VEST-CPR	13.21±4.21	8.37±3.50	1.97±0.84	1.13±0.65	5.01±2.09
	VDVEST-CPR	13.97±3.17	8.58±3.05	2.78±1.25 ²⁾	1.65±0.70 ²⁾	5.33±1.83
CPP	VEST-CPR	-0.25±1.64	1.02±1.87	4.07±3.05	3.87±2.81	2.38±2.29
	VDVEST-CPR	0.38±1.84	2.03±1.73	6.81±2.95 ²⁾	5.76±2.62 ²⁾	3.86±2.04 ²⁾

1) $P < 0.05$ 2) $P < 0.01$



附图 VDVEST-CPR 与 VEST-CPR 的记录曲线

图左侧为 VDVEST-CPR, EECF 使舒张压及右房压升高, 但以舒张压升高程度较大。图右侧为 VEST-CPR

3 讨论

本实验的血流动力学结果显示, 辅以 EECF 的 VDVEST-CPR 较 VEST-CPR 显著升高主动脉收缩压平均值、舒张压和舒张期 CPP, 而 VEST-CPR 的舒张期 CPP 与国外文献报道一致^[3,4]。近年来业已证明冠脉流量及 CPP 与复苏成功率相关^[7,9,10]。猝死状态下, 冠脉流量自我调节消失, 冠脉血管的固有紧张性处于最低状态^[11], 冠脉流量主要取决于冠脉有效灌注压^[9,10]。由于复苏中冠脉流量监测难以

实施, 美国第 4 版心肺复苏指南(1992)建议用冠脉有效灌注压评估复苏效果及其预后^[7]。由此可见, VDVES-CPR 有效地增加动脉舒张压从而提高冠脉有效灌注压, 可望提高复苏成功率。

VDVEST-CPR 的血流动力学机制: “舒张期” EECF 加压于大腿及臀部, 使动脉血返流, 主动脉舒张压升高; 静脉回心血流增加, 进入肺循环的血流因而增加, 提高了左心的前负荷; “收缩期”胸部加压, 射血增多, 收缩压升高。然而本实验使用定容通气, 肺内正压使肺血管阻力增大, 大量回流的静脉血, 不能完全通过肺循环, 使右房压也升高, 但毕竟部分静

脉回流血入肺循环以及静脉顺应性大,右房压升高程度较主动脉舒张压小,以致 CPP 仍显著增加。

插入性腹部加压(IAC-CPR)^[12]在胸部按压的放松期对腹部按压,类似于 VDVEST-CPR 中的 EECP 作用,提高舒张压和右房压,由于腹部加压力有限(13~20kPa),舒张压升高的程度不大,对 CPP 的效果各家报道不一^[12,13]。EECP 对下肢及臂部加压(40kPa),使舒张压和 CPP 明显升高。故 VDVEST-CPR 的血液动力学效果理论上优于 IAC-CPR。

VEST 是对整个胸廓加压,VEST 气囊压在 26-33kPa 范围,据 VEST-CPR 文献报道,肺损伤少见^[4]。肺受到损伤,可能原因有:①由于复苏装置的定容通气控制欠佳,延续到后一个按压期的早期,已扩张的肺受到 VEST 高压而使肺泡破裂出血;② VDVEST-CPR 的 EECP 产生的静脉回流增加,而肺循环调动欠佳所致,有待今后进一步研究中改进。

VDVEST-CPR 使右房压升高及肺损伤,可能与肺循环调动不佳有关。我们拟以体外膈肌起搏(EDP)或负压 VEST 来调动肺循环,结合 EECP,期望解决目前存在的问题。

本文提出 EECP 与 VEST 结合的新型复苏术,产生了较高的主动脉收缩压,体现 VEST 特点,又升高了主动脉舒张压,发挥了 EECP 的长处,从而既有较高收缩压,又有一定舒张压,冠脉有效灌注压明显改善。

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(1995-06-14 收稿 1995-07-14 修回)

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AN ULTRASTRUCTURAL STUDY OF NEONATAL THYMUS

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The ultrastructure of eleven cases of human neonatal thymuses, including five cases of normal thymuses and six atrophic thymuses, had been studied by scanning and transmission electron microscope. The results showed that there were various forms of closely direct contact between epithelial cells (EC) and thymocytes and that the thymic nurse cells (TNC) were located in human neonatal thymic cortex. It had been found that there was disorder of basic structure and no distinct demarcation between the cortex and medulla in the severe atrophic thymuses. The physiologic significance of cellular microenvironments of normal thymus and the pathological significance of the structural changes of atrophic thymus were also discussed in this paper.

Subject headings thymus gland/ultrastructure; infant, newborn; atrophy

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"DOUBLE PUMP" CARDIOPULMONARY RESUSCITATION: THE HEMODYNAMIC STUDY OF THE INFLATIONAL VEST WITH ENHANCED EXTERNAL COUNTERPULSATION

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Because coronary perfusion pressure (CPP) is lower which relates to survival rate in CPR, a novel CPR named as VDVEST-CPR was developed that was inflational vest assisted with enhanced external counterpulsation (EECP) during deflation. Methods: After 30 seconds of ventricular fibrillation both VDVEST-CPR and VEST-CPR were executed in random order on each of 8 dogs and alternated in 90 seconds interval. The statistical analysis used by paired-*t* test. Results: Mean systolic pressure of aorta in VDVEST-CPR was higher than VEST-CPR (10.62 ± 4.23 kPa vs 9.39 ± 4.61 kPa, $P < 0.01$). The diastolic pressure of aorta (Pao) and right atrium (Pra) in VDVEST-CPR were significantly higher than in VEST-CPR ($P < 0.01$), but the increment of diastolic Pao was greater than that of diastolic Pra, so that CPP were improved significantly in VDVEST-CPR ($P < 0.01$). Maximum of CPP was increased 2.74 kPa and mean of CPP was risen 1.89 kPa. Conclusion: To compare with VEST-CPR, VDVEST-CPR possessed the character of VEST which produced higher systolic Pao and the superiority of EECP which increased diastolic Pao, and improved CPP.

Subject headings cardiopulmonary resuscitation/method; counterpulsation/method; hemodynamics; dogs