

• 临床经验 •

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体外膜肺氧合在心脏移植围术期的支持策略

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[摘要]:目的 回顾性分析总结体外膜肺氧合(ECMO)在心脏移植围术期的支持策略。方法 自2008年9月至2014年7月武汉协和医院共行150例原位心脏移植术,其中1例为心肝联合移植。在围术期因严重心肺衰竭使用ECMO辅助11例,其中1例患者在等待供心期间急性左心衰行ECMO过渡后行心脏移植,4例边缘供心移植术中低心排中转ECMO辅助,5例心脏移植术后右心衰行ECMO辅助,1例移植术后左心衰行ECMO辅助。ECMO辅助主要采用静脉-动脉(VA)模式,温度维持在36~37℃,流量维持在2.5~3.5 L/min,全血激活凝固时间维持在160~180 s,转流过程中血流动力学和呼吸参数平稳。结果 11例心脏移植围术期ECMO辅助后8例脱机,脱机率72.7%。ECMO辅助时间15~1532 h,平均315 h。ECMO期间患者血流动力学明显改善,正性肌力药物用量减少。ECMO期间1例出现插管远端肢体缺血,经远端血管插管供血后缓解。此外,出血2例,溶血1例,肾功能衰竭2例,经积极对应治疗后6例ECMO辅助患者痊愈出院。结论 ECMO能对心脏移植围术期的心肺功能衰竭提供强有力的支持治疗,并且提高“边缘供心”的使用成功率,扩大了供心来源。

[关键词]: 体外膜肺氧合; 心脏移植; 围术期心力衰竭

The strategy of extracorporeal membrane oxygenation support in the peri-operative period of heart transplantation

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[Abstract]: **Objective** To summarize and analyze the clinical effect and experience of extracorporeal membrane oxygenation (ECMO) support in the peri-operative period of heart transplant patients in Wuhan Union Hospital. **Methods** From September 2008 to May 2014, 150 orthotopic heart transplantations were performed in Wuhan Union Hospital, including one case with simultaneous heart-liver transplantation. Eleven patients with severe ventricular failure in the peri-operative period of heart transplant received ECMO support. One patient received ECMO support because of acute left heart failure during waiting for donor heart; four patients of marginal donor heart transplantation received ECMO support during operation because of low cardiac output after cardiopulmonary bypass; five patients because of right heart failure and one patient because of left heart failure after transplantation received ECMO support. ECMO was established in these patients by cannulation of VA model. Temperature was maintained between 36~37℃, active clotting time (ACT) was maintained between 160~180 seconds, mean blood flow was 2.5~3.5 L/min during ECMO assistant period. The hemodynamic and respiratory parameters were maintained stabilization. **Results** ECMO was weaned off successfully in eight of eleven patients (72.7%). The ECMO time was 15~1532 h and mean time was 315 h. The hemodynamic parameters of eleven patients were improved during ECMO and the dose of vasoactive drugs was decreased. One patient occurred catheter-associated ischemia in distal limb, and was treated by using the distal vascular intubation. In addition, there were hemorrhage in two patients, hemolysis in one patient and renal failure in two patients. All these six patients recovered after treatment and discharged successfully. **Conclusion** ECMO is an important extracorporeal method of life support for heart transplant patients with severe perioperative heart failure, and it can extend the use of marginal donor hearts, which is very important because of the shortage of donor hearts resource today.

[Key words]: Extracorporeal membrane oxygenation; Heart transplantation; Preoperative heart failure

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心脏移植是终末期心脏病的唯一有效治疗手段。但因供体受体比例严重失调,供心短缺及“边缘供心”应用日益增加,许多终末期心脏病患者需要辅

助循环才能平稳度过心脏移植围术期。体外膜肺氧合(extracorporeal membrane oxygenation, ECMO)作为一种心肺辅助措施,能提供较长时间的持续有效的呼吸循环支持,且能同时进行心肺支持,目前已成为心脏移植术围术期心肺衰竭最常用的机械辅助手段之一^[1-2]。自 2008 年 9 月到 2014 年 7 月武汉协和医院共行 150 例原位心脏移植术,其中 1 例为心肝联合移植,围术期应用 ECMO 辅助治疗 11 例,8 例成功脱机。现将心脏移植围术期使用 ECMO 支持的经验做一总结汇报。

1 资料与方法

1.1 一般资料 本组 150 例原位心脏移植术,其中 1 例为心肝联合移植。男 122 例,女 28 例,平均年龄(42.6 ± 22.5)岁,平均体重(62.73 ± 12.29) kg。有 56 例移植了边缘供心(22 例供受体体重比 <0.8 , 31 例心肌缺血时间 >6 h, 25 例 ABO 血型不匹配,数据有交叉)。心脏移植围术期共 11 例患者因心力衰竭行 ECMO 辅助,均为扩张型心肌病,纽约心脏协会(NYHA)心功能Ⅲ级 3 例、Ⅳ级 8 例,在应用 ECMO 支持治疗以前均有难以控制的严重心衰;心胸比率 $0.65 \sim 0.80$;心脏超声心动图检查提示左心室射血分数 $0.15 \sim 0.44$ (0.28 ± 0.13)。

1.2 ECMO 的建立及管理 ECMO 灌注系统由离心泵(Maquet)、肝素涂抹膜式氧合器(Maquet)、股动静脉插管、肝素涂层管路和变温水箱等组成。均采用外周股动静脉(VA)插管方式。ECMO 期间血流量初始维持在 $2.5 \sim 3.5$ L/min,转中根据患者病情不同阶段调整,静脉血氧饱和度(SvO_2)维持在 0.70 以上,吹入膜肺的氧浓度在 40%~70%,吹入气流量根据血流量和血气结果进行调整,静脉引流负压维持在 30 mm Hg 以内^[3-7]。应用变温水箱将体温维持在 $36 \sim 37$ °C。ECMO 期间常规监测患者血常规、胶渗压、血浆游离血红蛋白、血生化和动脉血气等指标。当辅助期间血流动力学平稳,内环境稳定,超声心动图证实心脏具有足够的射血功能、心肺功能逐渐恢复并有一定的储备功能,呼吸机参数达到指标,血气分析满意时,可考虑撤离 ECMO。撤离时逐渐降低流量,适当延长 ACT,观察数小时,如生命体征平稳,可终止 ECMO^[8-13]。

2 结果

11 例心脏移植围术期 ECMO 辅助患者中 8 例成功脱机,脱机率 72.7%。ECMO 辅助时间 $15 \sim 1532$ h,平均 315 h。ECMO 期间患者血流动力学

明显改善,正性肌力药物用量减少。有 1 例原位心脏移植术后 2 年既往移植心脏衰竭,在移植术前,常规药物无法支持循环,联合应用主动脉内球囊反搏(intra-aortic balloon pump, IABP)+ECMO+血液透析辅助下等待供心,ECMO 辅助 15 h 后再次心脏移植成功;有 4 例边缘供心因移植术中低心排不能脱离体外循环而中转 ECMO 辅助;术后 1 例因为急性排异导致左心衰在 ECMO 辅助下成功调整药物浓度后痊愈出院;术后 5 例因为严重右心衰常规药物治疗无效而使用 ECMO 辅助后脱离危险。1 例出现插管远端肢体缺血,经远端血管插管供血后缓解。出血 2 例,溶血 1 例,肾功能衰竭 2 例,这 6 例患者经治疗后痊愈出院。

3 讨论

心脏移植目前已成为终末期心脏疾病的有效治疗手段,但由于供体短缺严重,约 1/3 的患者在等待供体期间因心衰死亡。近年来研究发现机械辅助可以帮助受体度过移植术围术期的“心衰危险期”而备受关注。ECMO 作为一种心肺辅助措施,能提供较长时间持续有效的呼吸循环支持,且能同时进行心肺支持,目前已成为心脏移植术围术期心肺衰竭最常用的机械辅助手段之一。本组 1 例心功能衰竭患者在等待供心期间发生急性心源性休克,在常规药物治疗无效时,及时进行有效的 ECMO 支持治疗,成功等到供心,行心脏移植术,效果良好,痊愈出院。另有 2 例脑死亡供体在 ECMO 支持下成功实现器官捐献,供心几乎无热缺血时间,移植受体后心脏功能良好并痊愈出院。提示 ECMO 还可以在供心摘取前辅助供体,从源头上加强供体器官保护,值得推广应用。

近年来随着“边缘供心”使用比例逐年增多,心肌缺血再灌注损伤也日益加重,移植术中低心排及体外循环无法脱机现象也明显增加,在常规药物治疗无效时,术中可以由体外循环直接中转 ECMO,经过内环境调整和心肌训练后,心肺功能逐渐康复好转。本组有 5 例边缘供心因移植术中低心排不能脱机而中转 ECMO 辅助后顺利康复,提示对于边缘供心,特别是缺血时间长者,及时直接从体外循环中过渡到 ECMO,这样才能增加围术期救治成功率。

此外,由于受体长期左心衰竭,肺动脉高压,肺小动脉阻力增加,加上“边缘供心”质量欠佳、缺血时间长等不利因素,常导致右室收缩舒张障碍,因此,心脏移植术后右心衰比左心衰更常见^[14-15]。ECMO 通过肺血管解痉挛,降低肺动脉高压训练右

室心肌,改善右心和肺功能,降低心脏前后负荷,在减少正性肌力药物使用的同时,使心肺得以充分休息,为心肺可逆性病变的恢复提供宝贵机会。ECMO 具有能在床旁插管、迅速建立、心功能恢复后可在床旁拔管、改善全身氧合、相比于心室辅助装置费用较低、使用方便等优点^[16-17]。本组 4 例肺动脉高压心脏移植术后右心衰导致循环不稳定用 ECMO 近两周的辅助代替常规治疗,锻炼右心室获得成功,均痊愈出院。对于心脏移植术后左心衰或(和)右心衰并存者,可以及时联合应用 IABP 和 ECMO 以及左心引流,成功辅助左右心室,增强心肺功能和提高抢救成功率。本组结果显示,在心脏移植整个围术期都要尽量争取在重要器官出现损害前及时尽早开始 ECMO 辅助才能提高救治成功率,此观点与韩杰等^[18]报道一致。

正确掌握适应证、找准介入时机、避免并发症,是提高 ECMO 抢救成功率的关键。本院的心脏移植围术期 ECMO 支持策略主要有以下几点:①因心脏移植特殊性,首选 VA 或 VVA 模式。②启动 ECMO 支持时机至关重要;对缺血时间超长(>8 h)的边缘供心,停机时考虑直接 ECMO 辅助,安全度过心肌水肿期。③对于移植术后左心衰竭,可联合 IABP 来改善重要脏器(尤其脑及冠脉)的灌注效果。两者撤离时要先撤 ECMO。④移植术后因肺高压出现右心衰时,ECMO 辅助时间延长,在肺血管解痉同时训练右室。⑤围术期合并多器官功能的病例,要及时介入肾脏透析,人工肝支持等,以提高 ECMO 成功率。

在 ECMO 运行管理期间,要特别注意以下问题^[19-20]:①为减少出血风险,应在 ECMO 运行前进行留置鼻空肠管、留置深静脉等操作;并根据出血情况及全血激活凝固时间(ACT)调整肝素剂量。在较高流量辅助时维持 ACT 于 160~180 s;②尽早使用胃肠动力药物和小肠喂养,避免脂肪乳剂对氧合器使用寿命的影响;膜式氧合器出现血浆渗漏时要及时更换氧合器。③加强血糖控制,力争维持患者机体内环境正常(血气、生化及凝血指标要保持在预定范围);④在任何可能的情况下,ECMO 患者的脂肪乳输注应选择单独的静脉通路。⑤ ECMO 推荐使用时间<30 d,运转 14 d 后增加并发症的风险,长时间 ECMO 支持治疗,易发生出血、栓塞、肝肾功能不全、感染、卒中、机械故障等各种并发症,要及时预防和针对性处理。

总之,ECMO 作为一种重要的体外生命支持形式,对于心脏移植围术期心肺功能衰竭具有确切的

疗效。ECMO 可作为终末期心衰患者向心脏移植过渡的纽带,有效扩大边缘供心的使用比例,避免重要生命器官功能衰竭,有效降低危重症心脏移植患者围术期死亡率,具有较好的临床推广应用价值。

参考文献:

- [1] Ayad O, Dietrich A, Mihalov L. Extracorporeal membrane oxygenation [J]. Emerg Med Clin North Am, 2008, 264(4): 953-959.
- [2] Schuerer DJ, Kolovos NS, Boyd KV, et al. Extracorporeal membrane oxygenation: current clinical practice, coding, and reimbursement [J]. Chest, 2008, 134(1): 179-184.
- [3] Pecha S, Yildirim Y, Reichenspurner H, et al. Successful extracorporeal membrane oxygenation weaning after cardiac resynchronization therapy device implantation in a patient with end-stage heart failure [J]. Interact Cardiovasc Thorac Surg, 2012, 15(5): 922-923.
- [4] Tsuneyoshi H, Rao V. The role of extracorporeal membrane oxygenation (ECMO) therapy in acute heart failure [J]. Int Anesthesiol Clin, 2012, 50(3): 114-122.
- [5] Dahdouh Z, Roule V, Sabatier R, et al. Extra-corporeal life support, transradial thrombus aspiration and stenting, percutaneous blade and balloon atrioseptostomy, all as a bridge to heart transplantation to save one life [J]. Cardiovasc Revasc Med, 2012, 13(4): 241-245.
- [6] Bermudez CA, Rocha RV, Toyoda Y, et al. Extracorporeal membrane oxygenation for advanced refractory shock in acute and chronic cardiomyopathy [J]. Ann Thorac Surg, 2011, 92(6): 2125-2131.
- [7] Pitsis AA, Visouli AN. Mechanical assistance of the circulation during cardiogenic shock [J]. Curr Opin Crit Care, 2011, 17(5): 425-438.
- [8] Wang S, Lv S, Guan Y, et al. Cardiopulmonary bypass techniques and clinical outcomes in Beijing Fuwai Hospital: a brief clinical review [J]. ASAIO J, 2011, 57(5): 414-420.
- [9] Mihaljevic T, Jarrett CM, Gonzalez-Stawinski G, et al. Mechanical circulatory support after heart transplantation [J]. Eur J Cardiothorac Surg, 2012, 41(1): 200-206.
- [10] Belohlávek J, Rohn V, Tosovsky J, et al. A review of a newly established ECMO program in a university affiliated cardiac center [J]. J Cardiovasc Surg (Torino), 2011, 52(3): 445-451.
- [11] Mah D, Singh TP, Thiagarajan RR, et al. Incidence and risk factors for mortality in infants awaiting heart transplantation in the USA [J]. J Heart Lung Transplant, 2009, 28(12): 1292-1298.
- [12] Chung JC, Tsai PR, Chou NK, et al. Extracorporeal membrane oxygenation bridge to adult heart transplantation [J]. Clin Transplant, 2010, 24(3): 375-380.
- [13] Khan MS, Mery CM, Zafar F, et al. Is mechanically bridging patients with a failing cardiac graft to retransplantation an effective therapy [J]? J Heart Lung Transplant, 2012, 31(11): 1192-1198.
- [14] D'Alessandro C, Aubert S, Golmard JL, et al. Extra-corporeal

- membrane oxygenation temporary support for early graft failure after cardiac transplantation [J]. *Eur J Cardiothorac Surg*, 2010, 37(2): 343-349.
- [15] Beiras-Fernandez A, Deutsch MA, Kainzinger S, *et al*. Extracorporeal membrane oxygenation in 108 patients with low cardiac output - a single-center experience [J]. *Int J Artif Organs*, 2011, 34(4): 365-373.
- [16] Gurbanov E, Meng X, Cui Y, *et al*. Evaluation ECMO in adult cardiac transplantation: can outcomes of marginal donor hearts be improved [J]? *J Cardiovasc Surg (Torino)*, 2011, 52(3): 419-427.
- [17] Listijono DR, Watson A, Pye R, *et al*. Usefulness of extracorporeal membrane oxygenation for early cardiac allograft dysfunction [J]. *J Heart Lung Transplant*, 2011, 30(7): 783-789.
- [18] 韩杰, 孟旭, 贾一新, 等. ECMO 在临床心脏移植领域的应用 [J]. *中华胸心血管外科杂志*, 2009, 25(2): 112-114.
- [19] Madershahian N, Nagib R, Wippermann J, *et al*. A simple technique of distal limb perfusion during prolonged femoro-femoral cannulation [J]. *J Card Surg*, 2006, 21(2): 168-169.
- [20] Oliver WC. Anticoagulation and Coagulation Management for ECMO [J]. *Semin Cardiothorac Vasc Anesth*, 2009, 13(3): 154-175.

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(上接第 230 页)

- [11] Sugita T, Watarida S, Katsuyama K, *et al*. Effect of a human urinary protease inhibitor (Ulinastatin) on respiratory function in pediatric patients undergoing cardiopulmonary bypass [J]. *J Cardiovasc Surg (Torino)*, 2002, 43(4): 437-440.
- [12] Yu XY, Fan LL. Effects of different doses of ulinastatin on inflammatory response and pulmonary function after cardiopulmonary bypass [J]. *Zhongguo Wei Zhong Bing Ji Jiu Yi Xue*, 2009, 21(11): 664-667.
- [13] Levy JH, Tanaka KA. Inflammatory response to cardiopulmonary bypass [J]. *Ann Thorac Surg*, 2003, 75(2): S715-720.
- [14] Apostolakis E, Filos KS, Koletsis E, *et al*. Lung dysfunction following cardiopulmonary bypass [J]. *J Card Surg*, 2010, 25(1): 47-55.
- [15] Nakanishi K, Takeda S, Sakamoto A, *et al*. Effects of ulinastatin treatment on the cardiopulmonary bypass-induced hemodynamic instability and pulmonary dysfunction [J]. *Crit Care Med*, 2006, 34(5): 1351-1357.
- [16] Jiang YF, Wang WW, Ye WL, *et al*. Effects of alprostadil and ulinastatin on inflammatory response and lung injury after cardiopulmonary bypass in pediatric patients with congenital heart diseases [J]. *Zhonghua Yi Xue Za Zhi*, 2008, 88(41): 2893-2897.
- [17] Miura M, Sugiura T, Aimi Y, *et al*. Effects of ulinastatin on PMNL and vascular endothelial injury in patients undergoing open heart surgery with CPB [J]. *Masui*, 1998, 47(1): 29-35.
- [18] Hiyama A, Takeda J, Kotake Y, *et al*. A human urinary protease inhibitor (ulinastatin) inhibits neutrophil extracellular release of elastase during cardiopulmonary bypass [J]. *J Cardiothorac Vasc Anesth*, 1997, 11(5): 580-584.
- [19] Hachenberg T, Tenling A, Nystrom SO, *et al*. Ventilation-perfusion inequality in patients undergoing cardiac surgery [J]. *Anesthesiology*, 1994, 80(3): 509-519.
- [20] Morgan GE, Mikhail MS, Murray MJ. Clinical anesthesiology [M]. 4th ed. New York: Lange Medical Books/McGraw Hill, Medical Pub. Division, 2006.
- [21] Kondili E, Xirouchaki N, Vaporidi K, *et al*. Short-term cardiorespiratory effects of proportional assist and pressure-support ventilation in patients with acute lung injury/acute respiratory distress syndrome [J]. *Anesthesiology*, 2006, 105(4): 703-708.
- [22] Liu CW, Hu W, Lu J. Protective effect of ulinastatin against lung injury in patients undergoing cardiopulmonary bypass [J]. *Zhongguo Wei Zhong Bing Ji Jiu Yi Xue*, 2008, 20(4): 244.
- [23] Chan EY, Bridge PD, Dundas I, *et al*. Repeatability of airway resistance measurements made using the interrupter technique [J]. *Thorax*, 2003, 58(4): 344-347.

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