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综述

急性呼吸窘迫综合征机械通气策略的新进展

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［摘　要］ 急性呼吸窘迫综合征(ARDS)机械通气的目标是保证足够的氧合和最小的呼吸机相关肺损伤。无创机械通气应慎用于 ARDS。小潮气量通气的肺保护性通气策略能降低 ARDS 死亡率,以驱动压为导向设置潮气量更合理。建议根据静态压力-容积曲线采用低位转折点法来确定理想的呼气末正压(PEEP),不支持常规使用高水平 PEEP。俯卧位通气、高频振荡通气和体外膜氧合技术可用于拯救重症 ARDS。机械通气中保持 ARDS 患者自主呼吸很重要,可采用双相气道正压通气、压力支持通气和神经电活动辅助通气等辅助通气模式。不推荐补充外源性肺泡表面活性物质、吸入一氧化氮或支气管扩张剂、气道压力释放通气和部分液体通气。 ［中国当代儿科杂志,2013,15(6):496-500］

［关　键　词］ 急性呼吸窘迫综合征;机械通气

Mechanical ventilation in acute respiratory distress syndrome

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Abstract: The goal of mechanically ventilating patients with acute respiratory distress syndrome (ARDS) is to ensure adequate oxygenation and minimal ventilator-associated lung injury. Non-invasive ventilation should be cautiously used in patients with ARDS. Protective ARDS mechanical ventilation strategies with low tidal volumes can reduce mortality. Driving pressure is the most reasonable parameter to optimize tidal volume. Available evidence does not support the routine use of higher positive end expiratory pressure (PEEP) in patients with ARDS. The optimal level of PEEP may be titrated by the inflection point obtained from static pressure-volume curve. Promising therapies include prone position ventilation, high frequency oscillatory ventilation and extracorporeal membrane oxygenation as salvage treatment. While mechanically ventilating, it is also important for ARDS patients to maintain spontaneous breathing via assisted ventilation mode such as bilevel positive airway pressure, pressure support ventilation and neurally adjusted ventilation assist. Exogenous surfactant, inhaled nitric oxide, bronchodilators, airway pressure release ventilation and partial liquid ventilation are not recommended therapies. [**Chin J Contemp Pediatr, 2013, 15(6):496-500**]

Key words: Acute respiratory distress syndrome; Mechanical ventilation

机械通气是纠正急性呼吸窘迫综合征(acute respiratory distress syndrome,ARDS)低氧血症最有效的手段,其目标是保证足够的氧合和最小的呼吸机相关肺损伤。近年来,虽然机械通气治疗明显降低了 ARDS 的死亡率,但是重症 ARDS 的死亡率仍高达 40%~50 %[1]。随着大量随机对照研究的涌现,ARDS 机械通气理念更趋科学化。本文将结合最新循证医学证据,就 ARDS 机械通气策略进行综述。

1 无创机械通气

Zhan 等[2]研究显示,无创机械通气(non-invasive ventilation, NIV)能显著降低气管插管率,降低住院死亡率;在血液动力学稳定时,NIV 可作为轻/中度 ARDS 首选的呼吸治疗措施。然而 Meta 分析表明,NIV 治疗成人 ARDS 的失败率约为 50%,尚不能证实 NIV 对 ARDS 死亡率和气管插管率有显著影响[3]。目前尚缺乏设计良好、有对照的应用 NIV 治疗儿童急性低氧性呼吸衰竭的研究,不能证实 NIV 可作为治疗儿童 ARDS 的常规方法[4]。因此,NIV 应慎用于 ARDS。急性肺损伤/急性呼吸窘迫综合征诊断与治疗指南(2006)指出[5],预计病情能够短期缓解的早期 ARDS 可考虑 NIV,合并免疫力低下的 ARDS 早期可首先试用 NIV;一旦 NIV 治疗失败,应及时改为有创机械通气。

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2 常规有创机械通气

2.1 以驱动压为导向的小潮气量设置

大潮气量(10～15 mL/kg)通气易引起肺泡过度膨胀、反复萎陷和复张,产生弥漫性肺泡损伤,诱导炎症因子释放到血循环,引起多器官功能衰竭[6]。然而,小潮气量通气可降低 ARDS 患者血浆炎性细胞因子[7]。ARDS 协作网研究显示[8],小潮气量(6 mL/kg 理想体重)可降低 ARDS 患者的死亡率和平均上机天数。Meta 分析表明,小潮气量通气可显著降低 ARDS 死亡率[9-10]。因此,国内外指南推荐小潮气量通气为基础的肺保护性通气策略[1,5]。在保证氧合的同时,允许动脉血二氧化碳分压(arterial carbon dioxide pressure, $PaCO_2$)在一定范围内缓慢升高,保持动脉血 pH > 7.2 和 $PaCO_2$ < 9.33 kPa,即允许性高碳酸血症[11]。小潮气量通气也适用于儿童 ARDS[12],可显著降低儿童 ARDS 气胸的发生率和死亡率[13]。

但是,6 mL/kg 理想体重的潮气量并不适用于所有 ARDS[14]。部分重症 ARDS 患者,即使采用 6 mL/kg的潮气量通气,气道平台压仍在 30 cm H_2O 以上,控制气道平台压在 30 cm H_2O 以内才能防止肺泡过度膨胀和呼吸机相关肺损伤[14]。气道平台压减去呼气末正压(positive end expiratory pressure, PEEP)即为驱动压,驱动压是产生潮气量的压力。有研究显示,控制驱动压比平台压更重要,驱动压大于 16 cm H_2O 甚至比低于 6mL/kg 的潮气量或平台压在 30 cm H_2O 产生呼吸机相关肺损伤的风险更大,结合驱动压设置潮气量更合理[15]。

2.2 实施肺复张策略

肺复张即采用高水平气道压力并维持短暂时间,促进萎陷肺泡复张,减少肺内分流,改善氧合,缩短呼吸机使用时间和改善肺外脏器功能[16]。儿童 ARDS 患者应用肺复张策略(恒压通气、吸气压 30～40 cm H_2O,持续时间为 15～20 s)后 6 h,吸入氧浓度(fraction of inspiration O_2, FiO_2)可降低 6.1%[17]。因此,肺复张策略是改善 ARDS 肺内分流的重要手段[18]。

目前采用何种肺复张方法以达到和维持肺泡复张以及采用多高的 PEEP 水平尚有争议[19]。有研究显示,肺复张虽然可以短暂改善氧合,但是不能降低死亡率,并可增加气胸发生率[20]。肺复张的安全性也无定论。Fan 等[21]发现,肺复张可引起 ARDS 患者出现短暂的低血压(12%)及低氧血症(8%)。因此,目前不推荐常规应用肺复张策略,仅用于威胁生命的难治性低氧血症,还要密切关注正常通气肺泡是否出现过度膨胀、甚至气压伤。

2.3 理想 PEEP 水平的设置

PEEP 是改善 ARDS 氧合最有效的参数。2000 年 Meta 分析表明,ARDS 患者的预后随 PEEP 水平升高而改善,高水平 PEEP 能使萎陷肺泡重新扩张,增加功能残气量和肺顺应性,改善氧合与肺内分流。然而,随后的 3 个随机对照研究显示,小潮气量通气联合高水平 PEEP 不能降低 ARDS 死亡率和呼吸机相关肺损伤发生率[22-24]。近 3 年 Meta 分析表明,高水平 PEEP 不能降低 ARDS 患者死亡率和改善预后[25-27]。

设置 PEEP 水平应强调个体化,要综合考虑 ARDS 的病程、肺损伤严重程度、塌陷肺泡的可复张性。Guerin 等[28]认为,高水平 PEEP 对于重度 ARDS 和高度可复张 ARDS 患者是有好处的,但对于轻度 ARDS 或急性肺损伤(acute lung injury, ALI)患者,应慎重使用高水平 PEEP。设置 PEEP 的方法很多,如 FiO_2/PEEP 递增法、低位转折点法和最大顺应性法等。Amato 等[29]和 Villar 等[30]研究显示,在小潮气量通气时,以静态压力－容积曲线低位转折点压力＋2 cm H_2O 来确定 PEEP 水平能遏制肺部炎症介质的释放,降低 ARDS 的死亡率。多中心随机对照研究显示,用 FiO_2/PEEP 递增法设置 PEEP 治疗 ARDS 的住院死亡率为 56%,而低位转折点法设置 PEEP 治疗 ARDS 的住院死亡率为 34%[31]。因此,建议根据静态压力－容积曲线采用低位转折点法来确定最佳 PEEP,若氧合不佳,可参考 FiO_2 逐步上调 PEEP,每次 2 cm H_2O,最高可调至 16～20 cm H_2O。

2.4 俯卧位通气

将患者置于俯卧位进行机械通气,可促进背区塌陷肺泡复张,减少肺内分流,促进肺内血流和气体的再分布,从而改善肺内通气/血流比值。儿童急性肺损伤和脓毒症调查协作网报道[32],俯卧位通气虽能显著改善 ALI 儿童的氧合,但对脱离呼吸机天数、死亡率、肺损伤恢复时间、无肺外器官衰竭天数和认知功能损害等无显著改善。Taccone 等[33]研究显示,采用 28 d 俯卧位通气,不能改善中/重度 ARDS 患者预后。Meta 分析表明,俯卧位通气可以降低严重 ARDS 患者的死亡率[34-35]。因此,俯卧位通气仅可作为短期的抢救措施用于常规机械通气治疗无效的重症 ARDS。目前 ICU 中仅有 10% 左右患者采用俯卧位通气,对于何时开始和怎样操作俯卧位通气尚有争议,并需要注意预防婴儿猝死综合征、气道阻塞、低血压、呕吐和意外拔管等并发症[36]。

3 新的机械通气模式

3.1 高频震荡通气

高频震荡通气(high frequency oscillatory ventilation,HFOV)以高频活塞泵运动将少量气体(20% ~ 80%解剖无效腔量)送入和抽出气道。与常规机械通气相比,HFOV 具有更小潮气量和空气层流,以较高的平均气道压用于复张塌陷的肺泡[37]。Meta 分析表明,HFOV 能减少成人 ARDS 的死亡率,降低顽固性低氧血症、低血压、气压伤和高碳酸血症发生率[38]。目前建议重症 ARDS 成人患者应早期使用 HFOV[39],常用指征有:在 $FiO_2 > 70\%$ 且 PEEP > 14 cm H_2O条件下,氧合难于维持,SaO_2 仍 $< 85\%$;在潮气量 > 6 mL/kg 且气道平台压 > 30 cm H_2O 条件下,pH 值仍 < 7.25。HFOV 的并发症有气压伤、低血压、黏液嵌塞、坏死性气管支气管炎和肺不张等。

3.2 体外膜氧合技术和体外 CO_2 清除技术

体外膜氧合技术(extracorporeal membrane oxygenation, ECMO)最核心的部分是膜肺和血泵,主要有静脉 - 动脉 ECMO 和静脉 - 静脉 ECMO,能保证氧合和 CO_2 清除,为损伤肺的修复赢得时间。体外生命支持组织报道 1990 ~ 2010 年共 44824 例患者接受 ECMO 治疗,其中 ARDS 儿童存活率为 54%[40]。2009 年常规通气支持与 ECMO 治疗成人重型呼吸衰竭的多中心研究显示[41],ARDS 早期接受 ECMO 治疗 6 个月生存率为 63%,而传统机械通气组存活率仅 47%,对于严重 ARDS 接受高浓度氧吸入或较高压力支持治疗超过 7 d 的患者,ECMO 的疗效明显下降。在 2009 年甲型 H1N1 流感病毒大流行期间,用 ECMO 治疗的严重 ARDS 成人和儿童存活率都在 70% 以上,ECMO 能改善严重 ARDS 住院死亡率和远期预后[42-44]。然而,Meta 分析表明,ECMO 不能改善成人 ARDS 的预后,只能作为重症 ARDS 的辅助支持手段[45]。应把握 ECMO 的适应证及治疗时机,考虑患者自身条件、原发病的可逆程度、机械通气时间和当地医疗条件[46]。

体外 CO_2 清除技术能有效清除 CO_2,而非改善氧合。该技术能减少肺损伤和改善 ARDS 预后[47]。Terragni 等[14]认为,当 ARDS 患者气道平台压在 28 ~ 30 cm H_2O 时,按每公斤体重 1 mL 降低潮气量直到气道平台压在 25 ~ 28 cm H_2O,同时为保证清除 CO_2 和缓冲 pH,可以增加呼吸频率到 40 次/min 以及 20 mEq/h输注碳酸氢钠,如经过上述治疗后,pH 仍小于 7.25,即应立即启动体外 CO_2 清除技术,以有效处理小潮气量通气产生的呼吸性酸中毒[14]。

3.3 部分液体通气

部分液体通气即在常规机械通气的基础上经气管向肺内注入相当于功能残气量的全氟碳化合物,以消除肺泡气液界面。有研究显示,部分液体通气对 ARDS 死亡率和机械通气时间无改善,不推荐用于 ARDS,仅作为严重 ARDS 常规机械通气无效时的一种选择[48]。

4 正压机械通气时保留自主呼吸

在机械通气过程中,保留自主呼吸有助于改善氧合、血流动力学和肺外器官灌注[49],减少呼吸机相关肺损伤[50],阻止呼吸机相关膈肌功能障碍和增加撤机成功率[5]。在机械通气治疗 ARDS 时,应注意发挥自主呼吸的优势[51],以改善机械通气效果。

4.1 双相气道正压通气

双相气道正压通气(bilevel positive airway pressure,BiPAP)是一种时间切换、压力控制的机械通气模式,可以为患者提供两种不同的吸气和呼气压力水平。BiPAP 不仅可以增加通气量,改善换气功能;同时还能避免过高压力造成的气压伤,减轻心血管的负担,改善患者的氧合和通气[52]。王晓芝等[53]研究显示,肺复张策略联合 BiPAP 比单纯小潮气量容量控制/辅助通气具有改善氧合迅速、肺顺应性增加明显、带机时间短、血液动力学稳定及所用镇静药物少等优点。因此,建议尽早采用 BiPAP 治疗 ARDS。

4.2 气道压力释放通气

采用气道压力释放通气时,患者可在持续气道正压通气的高压水平上自由呼吸,气道内压力可间断短暂地释放至低压水平[54]。研究表明,气道压力释放通气对 ARDS 患者在降低气道峰压及平均压、提高氧合、改善血流动力学和胃肠灌注、减少镇静和麻醉药使用等方面产生广泛有利影响;而且,自主呼吸对重力依赖区塌陷肺组织的重新开放发挥重要作用[55-56]。但多中心随机对照研究显示,气道压力释放通气的实际价值非常有限,尚不能证明其优于常规机械通气[57]。

4.3 压力支持通气

压力支持通气(pressure support ventilation, PSV)需要患者的自主呼吸触发,触发后患者每次吸气时呼吸机给予一定的压力,呼吸频率取决于患者,潮气量的大小取决于压力支持的大小和患者的呼吸力量。PSV 可保证 ARDS 时非均质的肺内各区带的气道压不会超过预定吸气压,从而减少呼吸机相关

肺损伤。早期研究提示,ARDS 患者应尽早使用 PSV 联合 PEEP,以减轻呼吸肌营养不良和缩短呼吸机时间[58]。但是,随着 PSV 支持水平增加,潮气量明显增加,吸/呼气转换时间明显延迟,触发延迟时间显著延长,人机难于同步。因此,近年来 PSV 改善 ARDS 的观点受到了挑战[59]。

4.4 神经电活动辅助通气

如果机械通气依赖吸气触发以及吸/呼气转换的流量或压力信号,常导致人机不同步。在 ARDS 患者中,人机不同步尤为突出。在呼吸周期中,膈肌电活动信号的改变明显早于气道压力或流速变化。神经电活动辅助通气(neurally adjust ventilation, NAVA)通过监测膈肌电活动,根据自身吸气驱动,成比例地持续辅助通气。吴晓燕等[60]研究显示,NAVA 能明显改善有创及无创机械通气人机同步性,减轻呼吸肌负载,自动调节通气支持水平,具有一定的肺保护作用。林竹等[61]研究显示,与压力支持通气相比,NAVA 通气支持时间、通气支持水平与自身呼吸形式更加匹配,更能改善人机同步性。目前 NAVA 的研究和应用还处于起步阶段。如何设置合理的 NAVA 既能减轻患者呼吸肌负荷,还能保证通气效果? 如何正确定位膈肌电极导管,防止打嗝、呕吐、体位改变等意外事件对导管位置的影响? 如果膈肌电活动长时间停止,如何启动后备的安全通气模式? 还需要大量的临床研究来探索 NAVA。

5 与机械通气相关的治疗措施

5.1 补充外源性的肺泡表面活性物质

ARDS 患者多伴有肺泡表面活性物质(pulmonary surfactant, PS)减少或功能缺失,易引起肺泡塌陷。PS 能降低肺泡表面张力,减轻肺部炎症反应,阻止氧自由基的氧化损伤。2005 年 Willson 等[62]对 153 例 1 周到 21 岁的 ALI/ARDS 患者采用 2 次经气管滴入 80 mL/m^2 小牛 PS,结果显示小牛 PS 可显著增加氧合和降低死亡率。但是,Meta 分析表明,外源性 PS 仅能改善给药后 24 h 内的氧合,并不能改善 ARDS 死亡率和给药 120 h 以后的氧合,并有较高的副作用发生率[63]。此外,也未解决 PS 的最佳用药剂量、给药时间和间隔问题[64],因此,PS 还不宜作为 ARDS 的常规治疗手段。

5.2 吸入一氧化氮

吸入一氧化氮(nitric oxide, NO)可选择性扩张肺血管,显著降低肺动脉压,减少肺内分流,同时具有抗炎特性。Meta 分析表明,吸入 NO 仅能一过性提高开始 24 h 的氧合,不能降低死亡率、机械通气时间和住院日,反而可能增加肾功能不全的风险[65]。因此,吸入 NO 不宜作为常规治疗手段,仅用于一般治疗无效的严重低氧血症。一般吸入浓度从 5 ppm 开始,视情况逐渐增加,最大不宜超过 40 ppm。治疗前要先测定患者对 NO 反应性(PaO_2/FiO_2 增高 >20% 为有反应)。吸入 NO 的禁忌证是高铁血红蛋白清除障碍、出血倾向、颅内出血和严重左心衰竭。

5.3 其他

有研究显示,吸入 β2 受体激动剂或前列环素不能降低 ARDS 死亡率,不推荐将其用于 ARDS[66-67]。

6 展望

随着对 ARDS 病理生理和呼吸力学的深入研究,将不断推出新的 ARDS 机械通气模式,如变异性通气[68]。随着新的监测技术,如电阻抗断层成像技术[69]、食管气囊导管估测跨肺压[70]和肺超声[71],用于指导肺复张和 PEEP 的选择,肺保护性通气将更易于个体化,ARDS 预后将得到改善。

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