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有创机械通气患者撤机结局预测指标的研究进展

赵　辉，陈雪梅*

重庆医科大学附属第一医院重症医学科，重庆

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摘　要

有创机械通气技术的发展使得危重患者救治率大大提升，但呼吸支持的最终目的是使患者撤离呼吸机并实现自主呼吸。因此，撤机前的准确评估尤为重要。目前已经报道的撤机前评估指标如浅快呼吸指数、最大吸气压力、呼吸功等，均存在一定的局限性，近年来一些新的预测指标逐渐被报道。本文就目前国内外预测危重患者撤机结局的最新指标进行综述，结果显示尚无公认的最优预测指标，联合多种指标的人工智能辅助决策有望为临床提供帮助，以提高危重患者撤机的成功率。

关键词

呼吸机撤机，撤机结局，预测指标

Research Progress on Predictive Indictors of Weaning Outcomes in Patients with Invasive Mechanical Ventilation

Hui Zhao, Xuemei Chen*

Department of Critical Care Medicine, The First Affiliated Hospital of Chongqing Medical University, Chongqing

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Abstract

The development of invasive mechanical ventilation technology has greatly improved the treatment rate of critically ill patients, but the ultimate goal of respiratory support is to enable critically ill patients to successfully evacuate the artificial airway and achieve autonomous breathing.

*通讯作者。

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Therefore, accurate evaluation before withdrawal is particularly important. At present, it is reported that some evaluation indicators such as rapid breathing index, maximum inspiratory pressure, respiratory work, etc., all of them have certain limitations. In recent years, some new predictive indictors were gradually reported. In this paper, we reviewed recent studies about indicators in predicting the outcome of weaning from mechanical ventilation in critically ill patients both home and abroad, found that there is no recognized optimal predictor. The AI-assisted decision making combined with multiple indicators is expected to provide help for accurate assessment before weaning from invasive mechanical ventilation, thus improving weaning outcome.

Keywords

Weaning from Mechanical Ventilation, Weaning Outcome, Predictive Indicators

1. 引言

有创机械通气是临床用来纠正各种呼吸衰竭的重要手段，当其应用指征去除，患者能够维持自主呼吸时，应尽快让患者脱离机械通气。然而通过自主呼吸试验(Spontaneous Breathing Trial, SBT)后撤机的患者中，仍有 15%~20%撤机失败[1]。因此，在撤机前应用相关预测指标指导撤机无疑具有重要临床价值。以往的研究中，包括 B 型利钠肽(B-Type Natriuretic Peptide, BNP)、如浅快呼吸指数(Rapid Shallow Breathing Index, RSBI)、最大吸气压力(Maximal Inspiratory Pressure, MIP)等对于撤机结局具有一定的预测价值[2] [3]，但由于其预测效能等问题，最新的机械通气指南并未给出最佳推荐。本文就目前有创机械通气患者撤机结局预测指标的最新研究进展进行综述。

2. 经典的撤机预测指标

BNP 是心功能障碍的敏感和特异性血清标志物，研究发现[4] SBT 期间 BNP 增幅超过 20%可以预测撤机失败。最新荟萃分析[5]也显示，SBT 前后 BNP 的相对变化可以判断撤机结局。但由于心肾功能的影响、测量方法、阈值等问题，其有效性仍不清楚。RSBI 反映呼吸肌的做功能力。最新的荟萃分析[6]显示其预测能力欠佳，这与它本身只是呼吸参数不能反映患者状态相关，因此，最好与其他指标联合使用。MIP 反映患者呼吸肌的功能。研究发现[7]，通过膈肌电刺激训练治疗促进成功撤机的患者，其 MIP 明显增加。但由于患者自身因素及测量方法等影响，尚无公认的临界值。WOB 反映患者的吸气肌负荷，可通过特殊的胃管测量计算，其仍存在争议。最新的研究[8]发现 WOB 预测拔管失败的曲线下面积达 0.85，说明其有较好的效能。然而，WOB 的阈值、测量方法等尚未统一。P0.1 同时反映呼吸驱动和吸气肌功能。P0.1 > 6 cmH_2O 时撤机失败风险增加。最新荟萃分析[9]显示其预测撤机失败的敏感性和特异性分别为 86%、58%。但由于管路长度、测量方法等干扰，准确性仍不清楚。握力预测撤机结局饱受争议，关于能否预测拔管，既往的研究结论截然相反；德国的最新研究[10]发现握力改善对撤机成功率并没有影响，需要更多研究去验证。

3. 较新的撤机拔管指标

3.1. 呼吸驱动

呼吸驱动直接影响到撤机能否成功，临床常用膈肌电活动(Electrical Activity of the Diaphragm, EAdi)

来评估。研究[11]表明 EAdi 比 MIP 能更好地预测拔管结局。张等[12]发现，EAdi 增幅越大的患者越容易拔管。但 EAdi 信号需要安置胃管，并受到食管、心脏等的干扰，目前临床未常规开展。

3.2. 膈肌功能评估

膈肌功能良好是撤机成功的关键。超声可以较好地反映其功能，膈肌位移(Diaphragmatic Excursion, DE)和膈肌增厚分数(Diaphragmatic Thickening Fraction, DTF)通过反映膈肌收缩来预测撤机结局。荟萃分析表明[13]，DE > 1 cm，DTF > 29%的患者拔管成功率更高。但 DE 和 DTF 受到肋间隙、体位等影响，其可信度存疑。斑点跟踪超声可以测量膈肌的横向及纵向应变，比二维超声更优。研究发现[14]，膈肌纵向应变在预测撤机结局方面有较高的价值。虽然膈肌超声具有无创、便捷、易重复等优势，但其较高的技术要求、截断值、测量时间点等问题，都使其应用受到一定的限制。

3.3. 气道通畅性

3.3.1. 气囊漏气试验(The Cuff Leak Test, CLT)

CLT 评估拔管后气道的通畅性。荟萃分析显示[15]，CLT 可以较好的预测拔管后气道梗阻。但 CLT 尚无公认的测试方法与标准，且增加了呼吸机相关性肺炎(Ventilation Associated Pneumonia, VAP)的感染风险[16]。有学者提出通过测量 cuff 上方压力来判断气道梗阻的方法[17]，它不影响呼吸力学，也降低了感染风险，但其测量困难，受气管导管管径、延伸管长度等影响，准确性并不清楚。

3.3.2. 超声测量喉气柱宽度差(Air Column Width Differences, ACWD)

喉气柱宽度是指声带水平处空气声影的宽度，ACWD 是气囊充放气前后的气柱宽度之差，ACWD 大于 1.6 mm 的患者拔管成功率更高。最新的荟萃分析显示[18]，ACWD 预测拔管后喘鸣的预测效能良好。但包括导管管径、气道分泌物等都会影响其测量，有效性仍待进一步的研究。

3.4. 咳嗽评估

咳嗽峰流速(Cough Peak Flow, CPF)值越大的患者咳嗽能力越强，但其预测撤机结局的准确性仍不清楚。段等[19]的荟萃分析显示，CPF 在预测拔管结局方面优于咳嗽评分，主动比被动 CPF 有更好的预测能力。但 CPF 的操作方法及截断值等并无共识，操作性并不高。Norisue 等[20]发现患者咳嗽时的膈肌移动度降低拔管失败风险增加。此外，ONEill 等[21]证明导管气囊压力变化可用于咳嗽评估。但这些都为单中心研究，需进一步验证。

3.5. 心脏功能评估

由于心肺交互作用，撤机过程常诱发急性心力衰竭导致难以撤机。床旁经胸超声心动图通过检测二尖瓣血流频谱反映左心室舒张功能等。最新文献荟萃显示[22]，左室舒张不全程度越重撤机失败风险越高。然而，现阶段此类研究不多，缺乏足够的证据来证明其有效性。

3.6. 综合评分与人工智能撤机模型

撤机是个复杂的问题，单一指标不能反映患者整体情况而预测能力欠佳[23]。提出的多参数评分如呼吸综合指数、呼吸驱动指数、综合脱机指标等，其预测效能依然不佳，Burns 撤机计划以及更新版本均加强了患者的评估，使其预测准确性提高。最新的 ExPres 评分[24]，纳入了肌力、机械通气天数等因素，预测效能进一步提高。但其目前这些评分临床应用价值有限。随着人工智能在医疗领域的发展，通过大数据和机器学习建立的撤机预测模型[25] [26]，显示出较高的预测效能；廖等[27]用临床数据构建的人工智能仪表板，动态评估患者的撤机时机，明显缩短了患者机械通气时间。考虑到撤机的动态性，有学者

[26]用时间序列呼吸机衍生参数来预测拔管结局，其成功率达 94%。未来需要更多的前瞻性研究去证实人工智能模型在撤机决策中的有效性。

4. 展望

综上所述，机械通气患者的撤机对临床医生来说仍是一个挑战，目前各种预测指标和评分并没有达到理想的预测期望。其局限性主要与纳入的研究人群、使用的临界值和测量方法有关，虽然预测指标可用于同质人群，但其准确性在异质性人群中可能不会太理想。撤机的决定和时机往往依赖于临床医生的个人经验，需要综合考虑生命体征、实验室数据、影像学和呼吸参数等来决定是否撤机，这不可避免的存在误判风险。但随着人工智能的发展，联合多个预测指标的人工智能模型的开发可以帮助医生在撤机过程中做出更精确、更科学的决策，相信这会成为未来的研究重点。

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