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急诊手术风险评估工具研究的发展与实践选择：从传统评分到风险模型

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摘　要

急诊手术患者的围术期死亡率与并发症发生率显著高于非急诊手术，因此快速精准地风险评估对临床决策至关重要。本文系统综述了急诊手术常用的风险评估工具，将其分为风险评分系统和风险预测模型两大类，详述了美国麻醉医师协会分级系统(The American Society of Anesthesiologists classification system, ASA)、生理学和手术严重性评分(Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity, POSSUM)、急性生理与慢性健康评分(The Acute Physiology and Chronic Health Evaluation II, APACHE II)等13种常用工具的构成、临床应用价值及局限性，为临床合理选择工具及优化风险评估方案提供参考。

关键词

急诊手术，围术期管理，风险评估

Development and Practical Selection of Emergency Surgery Risk Assessment Tools: From Traditional Scores to Risk Models

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Abstract

Patients undergoing emergency surgery face significantly greater perioperative risks than those having non-emergency procedures. Therefore, rapid and accurate risk assessment is indispensable for guiding clinical decision-making. This review systematically examines common risk assessment tools for emergency surgery and classifies them into risk scoring systems and risk prediction models. We detail the constituent metrics, clinical applicability, and limitations of thirteen widely used tools, such as the American Society of Anesthesiologists (ASA) Classification System, the Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM), and the Acute Physiology and Chronic Health Evaluation II (APACHE II). This review aims to provide clinicians with practical insights for tool selection and the refinement of risk stratification in the perioperative management of emergency surgical patients.

Keywords

Emergency Surgery, Perioperative Management, Risk Assessment

1. 引言

急诊手术是全球医疗卫生领域的关键领域，其围术期死亡病例每年高达数百万例，已成为亟待重视的科学问题[1]。研究表明，急诊手术患者术后 30 天死亡率是非急诊手术患者的约 4.7 倍(12.50% vs 2.66%, $P < 0.0001$)，而其术后并发症发生率接近 50% [2]。急诊患者多具有病情危重、进展迅速、高龄、合并症多，且常伴随全身炎症反应与生理功能紊乱等特点[3] [4]。若能快速、准确地使用工具评估手术风险并进行精准危险分层，在此基础上开展个体化监测与干预治疗，对改善患者预后至关重要。目前可供临床使用的风险评估工具很多，但如何选择和使用尚无共识[5]。加拿大的一项研究指出标准化的急诊手术风险评估工具使用受限的主要原因是急诊场景下不易获取、使用繁琐耗时，以及对工具准确性的怀疑[6]。本文将对各类手术风险评估工具进行系统综述，旨在提高临床医生对患者风险识别的准确性，为临床治疗决策提供参考，进而改善患者预后。

2. 风险评估工具

风险评估工具分为风险评分和风险预测模型两类[7]。风险评分对独立危险因素赋予权重，权重的总和反映增加的风险。使用方便简单，但不能提供个体化的风险预测[8]。风险预测模型需输入患者的数据来估计个体风险概率，预测更加准确，但计算复杂、使用不便[8]。目前临床上使用较多的风险评估工具主要有以下几种。

2.1. 美国麻醉医师协会分级系统

该分级由美国麻醉医师协会(American Society of Anesthesiologists, ASA)提出，根据危及生命的程度分为 6 个等级，I 级表示正常健康状态，V 级表示濒临死亡，VI 级表示脑死亡，“E”级表示急诊手术。现发展为美国麻醉医师协会身体状况分级系统(ASA Physical Status, ASA-PS)，用以评估患者健康状态和

术前风险[9]。在急诊手术患者中，ASA ≥ III 级被证实是 30 天死亡率和发病率的有效预测因子[10]。ASA 的增加预示着发病率和死亡率的显著增加[11]。ASA 分级使用简单方便，且适于所有人群，在临床与科研中应用广泛[12]，但也因为纳入的评估要素有限，使得其难以对个体患者的手术风险做出精准预测[13]。此外，由于缺乏精确的定义，该分级具有较高的主观性[14]。

2.2. 生理学和手术严重性评分

生理学和手术严重性评分(Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity, POSSUM)包括 12 个生理学变量和 6 个手术变量，每个变量都根据递增的分数(1、2、4 和 8)进行分类，如果数据缺失，则分配分数 1 [15]。POSSUM 在多项研究中被证实对死亡率的预测存在高估[16]-[21]，尤其是对低风险患者死亡率的高估可高达 6 倍[19]。在此基础上发展出的朴次茅斯-POSSUM 评分(Portsmouth-POSSUM, P-POSSUM)有所改善，但仍倾向于高估低风险患者的死亡率[17] [18] [21]。在急诊手术中，两者都表现出良好的预测性能[16] [18]，且对死亡率预测准确性优于发病率[18]。由于纳入了术中的变量，该评分无法用于术前预测；部分变量比如对胸片的理解存在一定的主观性。其所需变量较多，计算过程复杂[20]，这可能限制其在紧急情景下的实用性。

2.3. 急性生理与慢性健康评分 II

急性生理与慢性健康评分 II(Acute Physiology and Chronic Health Evaluation II, APACHE II)是 12 个生理变量、年龄和慢性健康状态的组合，每个指标赋予不同的权重，最终得分为三部分评分的总和。适于评估成人重症监护室(Intensive Care Unit, ICU)患者的疾病严重程度[22]。在一个关于急诊手术风险评估工具的系统评价中，APACHE II 在不同亚组中显示出较为一致的准确性[23]。但有报道称 APACHE II 低估了术后患者和创伤患者的死亡率[24]，无法预测多器官功能衰竭综合征患者的发展和死亡[25]。为弥补这些缺陷，开发了 APACHE III 评分系统，该评分系统更侧重于急性生理紊乱，在预测重症外科疾病患者的死亡率上准确性可能更高[26]。在已有的几项关于急诊手术患者风险预测的研究中，两者均表现出出色的预测能力，但优化后的 APACHE III 并没有表现出相对的优势[27]-[29]，其是否在特定患者群体中适用，还需要进一步的研究明确。

2.4. 手术风险量表

手术风险量表(Surgical Risk Scale, SRS)包括三部分：手术类型，ASA 分级和手术等级[30]。其优点在于没有复杂的计算，使用简单方便，可用于手术患者术前风险预测。在一个关于成人非心脏、非神经手术风险评估工具的系统评价中，P-POSSUM 和手术风险量表被认为是最有一致准确性的工具[20]。Córdoba 对西班牙老年急诊患者进行了前瞻性研究，发现 SRS 具有中等预测性能[31]。SRS 的局限性在于纳入了 ASA 分级，易受观察者主观影响[20]；手术等级评估基于对英国医疗系统的了解；最后，该评分在一个低死亡率人群中进行了验证[30]，在其他人群中的适用性尚不清楚[20]。SRS 应用的简单性使其在临床普遍使用，指导医疗决策[32]。

2.5. 手术风险评分

手术风险评分(Surgical Risk Score)包含 ASA 分级、年龄、手术严重程度分级和手术类型，无需使用术中数据，适合床边使用[33]。POSSUM 和 P-POSSUM 存在高估死亡率的可能性，预测最低值分别为 1.08% 和 0.2%；相比之下，手术风险评分预测死亡率更接近现实，最低为 0.07% [17]。因此，该评分可以纠正 POSSUM 对低风险患者的过度预测，同时保持对高风险患者预测的准确性[34]。在预测急诊手术患者术后 30 天死亡率时表现出较优的预测性能，比单纯使用 ASA 分级评估更准确[34]。和手术风险量表一样，

该评分也存在主观性[20]，但其计算简单、数据易获取，是目前临床应用广泛的风险评估工具之一[34]。

2.6. 手术预后风险工具

手术预后风险工具(Surgical Outcome Risk Tool, SORT)包含 6 个变量：ASA-PS 分级、手术类型、高危专科外科、手术严重程度分级、癌症和年龄超过 65 岁，可作为在线计算器或智能手机应用程序直接使用[35]。外科医生只需简单地输入 6 个术前变量数据，便可获得患者死亡率风险百分比[35]。SORT 具有易用性和表面效度(指一个评估工具在表面上看起来是否测量了它所要测量的内容) [35]。在前面提到的西班牙老年急诊患者研究中，SORT 同样具有中等预测性能，但是低估了死亡率[31]。Wong 等 2020 年的研究将临床医生的主观评估和 SORT 结合用以预测术后 30 天死亡率，发现其预测效果优于单独使用主观评估或 SORT；不过在这项研究中单独使用 SORT 时出现了高估死亡率的情况[36]。虽然 SORT 纳入了 ASA-PS 分级存在一定主观性[20]，但评估过程简单高效，在临床实践中可能更容易推广[35]。同时 ASA 分级作为一项评估要素，被整合于多个综合性风险评分工具之内，这也提示简单评分工具在复杂评估框架中可能具有其独特的定位与补充价值。

2.7. 急诊手术敏锐度评分

急诊手术敏锐度评分(Emergency Surgery Acuity Score, ESAS)是一个范围从 0~29 的分数，包括 3 个人口统计学变量、10 个合并症和 9 个实验室变量，专门用于预测急诊手术围术期死亡率和发病率。不良结局的风险随着分数的增加相应增加[37] [38]。后更名为急诊手术评分(The Emergency Surgery Score, ESS)。外部验证研究发现，ESAS/ESS 在预测急诊术后死亡率和并发症发生率方面表现优异[39]-[41]，在不同专业的急诊手术中，如普通外科、妇科，也具有良好的适应性[39] [42]。其局限性在于所需变量数较多且存在明显的数据缺失问题[39]，Naar 和 ALSowaeigh 等人发现，数据库中变量缺失的急诊手术患者比例超过 70% [42] [43]。尽管似乎缺少一个或多个数据对其预测的准确性影响不大[42] [43]，但是对于急诊手术，更少变量的评分系统可能会更加有效[39]。

2.8. 急诊手术生理敏锐度评分

急诊手术生理敏锐度评分(Physiological Emergency Surgery Acuity Score, PESAS)是 ESAS 的生理简化版，评分范围在 0 到 15 分之间，仅包含 10 个实验室变量，均为术前容易获得和客观测量的生理指标，适合床边快速评估或是在病人无法提供病史的情况下使用。围术期死亡风险随着分数的增加而升高[4]。一项多中心回顾性验证研究显示，这两种评分工具对急诊手术患者术后死亡率的预测性能均良好，其 c 统计量均高于传统的察尔森合并症指数(Charlson Comorbidity Index, CCI)与 APACHEII [40]。这也从侧面表明，术前生理紊乱是急诊手术患者死亡的重要预测因素，独立于年龄和合并症等[4]。PESAS 主要用途在于利用客观数据评估患者疾病的急性生理紊乱程度，可与其他评分系统和风险预测模型结合使用[44]。该评分能否预测术后并发症风险有待进一步研究[4]。

2.9. 察尔森合并症指数

察尔森合并症指数(Charlson Comorbidity Index, CCI)包含 19 个医学合并症，得分范围 0~37 分，得分越高死亡风险越大合并症越严重。由于仅需基于病历或患者自述，计算方式简单迅速[45]。研究证明了 CCI 在预测各种人群长期死亡率方面的有效性[45]。在 CCI 的基础上又开发了年龄合并症指数(Age-adjusted Charlson Comorbidity Index, CACI)，40 岁以上每 10 岁增加 1 分。CACI 较 CCI 更能预测长期死亡率，最常用于肿瘤患者[46]。在预测急诊手术患者术后 30 天死亡率的研究中，CACI 亦表现出很强的预测能力，AUC 为 0.90 (95% CI: 0.84~0.95) [47]。由于其缺乏对急性生理紊乱及手术特异性因素的考量，

在急诊环境中的单独应用可能受限[40]。但多项研究显示和其他临床评估工具结合可以显著提高预测准确性[45] [48]。

2.10. 外科阿普加评分

外科阿普加评分(Surgical Apgar Score, SAS)是借鉴新生儿 Apgar 评分设计的 10 分制评估体系，分值越高，患者预后越好，其评分维度包含术中最低心率、最低平均动脉压与估计失血量[49]。该评分对普通外科术后 30 天死亡率预测效能中至高度，对并发症发生率呈中度预测，但在骨科人群中应用效果不佳[50]。急诊手术中，SAS 降低与术后不良结局升高显著相关，但其区分能力有限，不宜单独作为风险预测工具[51] [52]。

现有研究多从纳入手术时长、血氧饱和度等参数对 SAS 进行改良[53] [54]，Ju Houqiong 等亦针对微创手术调整了失血量阈值[55]，或与其他风险评分联合应用以提升评估全面性[56] [57]。SAS 可实时采集、即刻反馈，但仅能术中应用，无法术前预判；术中一过性血流动力学波动易造成评分偏差，失血量受术者技术与估算误差影响较大[58]，且适用术式存在局限，临床应用价值仍需进一步研究明确[50]。

2.11. 生物化学和血液学结果模型

生物化学和血液学结果模型(Biochemistry and Haematology Outcome Model, BHOM)系 POSSUM 评分体系基础上优化发展而来，该模型剔除了 POSSUM 中胸片、心电图等主观性较强的评估指标，精简纳入变量，最终纳入 5 项生化与血液学检测指标、年龄、性别、手术严重程度评分、入院方式及出院时死亡率等参数构建模型[59]。不同版本的 BHOM 在变量权重分配与算法设计上存在差异，但均采用准确客观、易于获取的临床数据。BHOM 在内部验证中展现出良好的预测效能。外部验证方面，Faisal 等研究证实，BHOM 在预测急诊患者院内死亡事件时具备良好的区分度，但校准度欠佳[60]；另有研究表明，BHOM 可较为准确地预测急诊手术患者术后 30 天死亡率[34]。该模型依托临床常规采集、记录的数据，可通过计算机程序自动运算，能够早期识别高危患者，尤其适用于急诊患者的围术期风险评估[60]。

2.12. 美国外科医生学会国家外科质量改进计划手术风险计算器

美国外科医生学会国家外科质量改进计划(American College of Surgeons National Surgical Quality Improvement Program, ACS-NSQIP)手术风险计算器包括 21 个术前变量和当前手术术语(Current Procedure Terminology, CPT)代码，用以预测术后 30 天死亡率和发病率，在死亡率方面表现优异[61] [62]，同时提供多种术后并发症(包括静脉血栓栓塞、肺炎和肾衰竭)的风险估计值[63]。有学者认为 ACS-NSQIP 手术风险计算器没有考虑到特定手术的风险因素[64]，但有研究发现，它和特定手术风险计算器预测结果相似，对不同的外科手术预测性能良好[61]。对于急诊手术，患者具有明显的异质性，术前对手术病理可能未知，通用风险评估工具优于特定风险评估工具[23]。由于患者可能存在其他额外危险因素，该工具允许外科医生根据经验在一定范围内增加术后风险[61]。ACS-NSQIP 手术风险计算器比较急诊手术和择期手术预后准确性的队列研究中，急诊手术的风险被相对低估[65]。在印度的一项回顾性研究中发现在预测接受急诊剖腹探查术的成年患者的死亡率和术后并发症方面，ACS-NSQIP 手术风险计算器略逊色于 APACHEII 评分[66]。

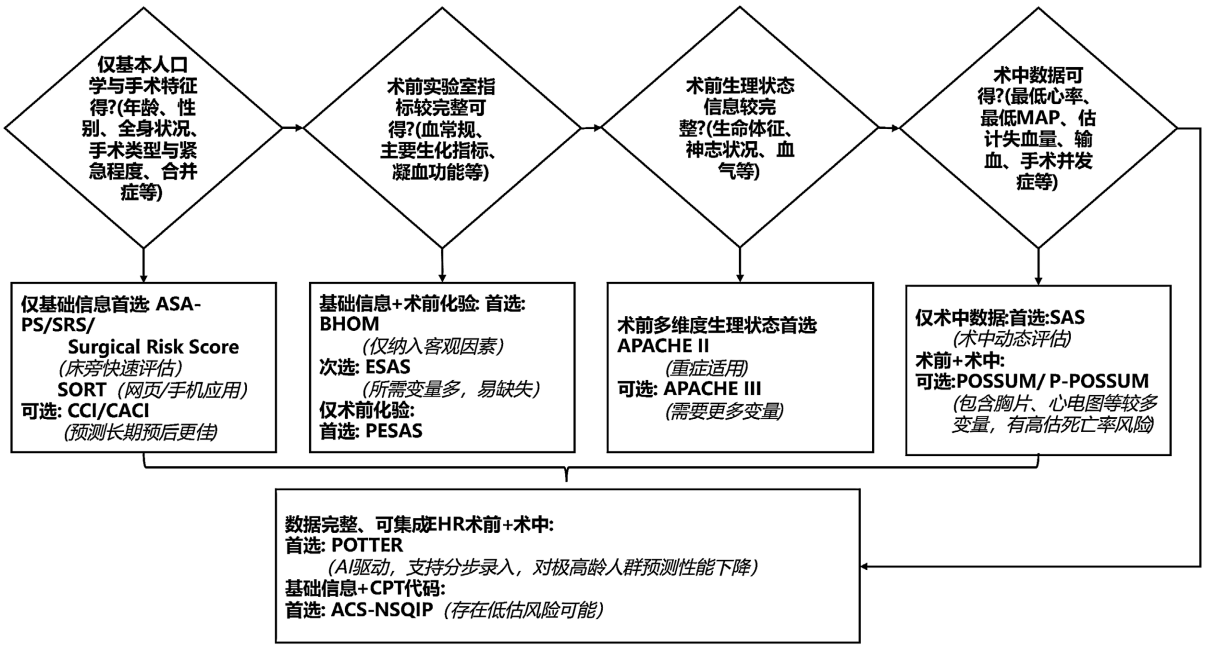
2.13. 人工智能驱动的急诊手术风险预测最优树计算器

人工智能驱动的急诊手术风险预测最优树计算器(Artificial Intelligence-Based Predictive Optimal Trees in Emergency Surgery Risk Calculator, POTTER)是一款易用型临床工具，通过分步式指标录入，可预测患者术后 30 天死亡率、总体发病率及 18 种术后并发症风险[67]。该工具基于循证依据与机器学习算法构建，具备预测精准、界面友好、可集成电子健康档案(Electronic Health Record, EHR)、临床可操作性强等

优势[67]。多项研究证实，POTTER 在急诊手术患者术后不良结局预测中效能突出[68]-[70]，可显著提高临床医师的预测准确性[70]，研究报道，POTTER 兼具准确性与实用性的急诊手术风险计算器，综合表现优于现有传统评估工具[67]。但其对 85 岁以上极高龄人群的预测性能有所降低[71]，并且预测效果受数据质量影响较大，变量与结局的因果关系尚未阐明，可干预靶点仍需深入探索[67]。

3. 挑战与展望

数十年来，急诊手术风险评估工具的开发与应用取得显著进展，从传统的 ASA 分级、POSSUM 等线性评分系统，逐步演进至 BHOM 等简化优化模型，再到 AI 驱动的 POTTER 计算器，工具的预测精准度、临床易用性与智能化水平持续提升[67]。本文系统梳理了 13 类主流工具：ASA 分级、SRS 等以“简便快捷”适配急诊场景的即时需求，BHOM 或 ESAS 仅使用客观实验室指标，减少主观偏差，SAS 仅包含术中参数适用于术中即时反馈，APACHE II、ESAS/ESS 等以“多维度覆盖”提升预测全面性，而 POTTER 则凭借机器学习优势，在捕捉变量复杂非线性关系、个体化风险预测方面展现出独特价值[67] [68]。基于此，我们尝试构建了一个选择建议流程图(见图 1)，希望能为临床医生选择合适的风险评估工具提供一定的参考，见图 1。然而，现有的每一种风险评估工具均有其局限性，仍需进一步完善和更新。未来急诊手术风险评估工具可能会更着力于优化模型、强化验证，推动风险评估精准智能全程化。



注：ASA-PS = 美国麻醉医师协会身体状况分级；SRS = 手术风险量表；SORT = 外科预后风险工具；CCI = 察尔森合并症指数；CACI = 年龄调整察尔森合并症指数；BHOM = 生物化学和血液学结果模型；ESAS = 急诊手术敏锐度评分；PESAS = 急诊手术生理敏锐度评分；APACHE II/III = 急性生理与慢性健康评分 II/III；SAS = 外科阿普加评分；POSSUM = 生理学和手术严重性评分；P-POSSUM = 朴次茅斯-POSSUM 评分；POTTER = 人工智能驱动的急诊手术风险预测最优树计算器；ACS-NSQIP = 美国外科医生学会国家外科质量改进计划；CPT = 当前手术术语。

Figure 1. Recommended flowchart for the selection of risk assessment tools in emergency surgery
图 1. 急诊手术风险评估工具选用建议流程图

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