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肾阻力指数在脓毒症所致急性肾损伤中的研究进展

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摘 要

脓毒症临床常见的危重病，发病率高，病死率高，严重威胁人们生命。其中，肾脏是脓毒症最常累及的器官之一，脓毒症所致急性肾伤(S-AKI)与患者不良预后相关，目前S-AKI的诊断主要依靠指南上的尿量和肌酐，但尿量和肌酐受多种因素的影响，确诊时间延迟且价值不高。随着超声技术的发展，床旁超声在严重肾脏疾病方面中的应用越来越广泛，基于多普勒的肾阻力指数(RRI)是肾脏检查中描述最多的测量值，具有无创、安全、可重复操作等优点，是S-AKI床旁诊断的重要工具。本文主要从RRI的定义、测量方法、影响因素及其早期诊断S-AKI的临床意义进行综述。

关键词

脓毒症，急性肾损伤，肾阻力指数

Research Progress of Renal Resistance Index in Acute Renal Injury Caused by Sepsis

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Abstract

Sepsis is a common critical illness with high morbidity and fatality rate, which seriously threatens

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people's lives. Among them, kidney is one of the most commonly involved organs of sepsis, acute renal injury (S-AKI) caused by sepsis is associated with poor prognosis of patients. Currently, the diagnosis of S-AKI mainly relies on urine volume and creatinine as shown in the guidelines, but urine volume and creatinine are affected by various factors, so the diagnosis time is delayed and the value is not high. With the development of ultrasound technology, bedside ultrasound has been applied more and more widely in severe kidney diseases. The renal resistance index (RRI) based on Doppler is the most described measurement value in kidney examination, which has the advantages of non-invasive, safe and repeatable operation, and is an important tool for S-AKI bedside diagnosis. This article mainly reviews the definition, measurement method, influencing factors of RRI and its clinical significance in early diagnosis of S-AKI.

Keywords

Sepsis, Acute Kidney Injury, Renal Resistance Index

1. 引言

脓毒症是宿主对感染反应失调，继而引起全身炎症反应及多器官功能衰竭的一组临床综合征[1]。改善全球肾脏病预后组织(Kidney Disease: Improving Global Outcomes, KDIGO)将急性肾损伤(acute kidney injury, AKI)定义为由各种原因引起的肾功能短时间内急剧下降，是脓毒症患者最常见的并发症之一[2]。有研究表明，脓毒症患者 AKI 的发病率高达 48%，且与不良预后密切相关，因此，早期发现脓毒症所致急性肾伤(sepsis-induced acute kidney injury, S-AKI)对患者的预后及治疗至关重要[3] [4] [5] [6]。基于多普勒的肾阻力指数(renal resistive index, RRI)作为床旁肾脏超声的一种检测方法，已成为早期预测 S-AKI 的重要方法。本文主要从 RRI 的定义、测量方法、影响因素及其早期诊断 S-AKI 的临床意义进行综述，探讨 RRI 在脓毒症患者发生 AKI 中的意义。

2. 血清肌酐和尿量的局限性

目前临床上对 AKI 的诊断仍以肌酐和尿量为主要指标[7]，但肌酐易受年龄、性别等因素影响，在肾小球滤过率明显下降时肌酐才会明显升高，而尿量易受药物、容量状态等多种因素影响，对 AKI 的诊断缺乏敏感性和特异性，存在明显的滞后性，不利于 AKI 的早期诊断[8] [9]。因此，迫切需要寻找一种更灵敏的方法早期预测 S-AKI。

3. RRI 的生理性相关因素

3.1. RRI 的定义及测量方法

RRI 即肾阻力指数，是将多普勒技术添加到灰色图像上利用肾内彩色多普勒波形测量，来无创评估肾血流动力学及肾血流灌注状态，从而评价肾功能。RRI 的测量通常使用 2~5 MHz 凸阵探头，嘱患者取仰卧位或侧卧位，从腹部后外侧获取肾脏长轴切面，在彩色多普勒超声引导下进行脉冲多普勒检查，一般选择肾叶间动脉或弓状动脉，出现 3~5 个连续且相似波形被认为是最佳频谱，获得收缩期峰值流速(peak systolic velocity, PSV)和舒张末期流速(end diastolic velocity, EDV)，并根据 RRI = (PSV − EDV)/PSV 公式

计算 RRI，测量 3 次后取其平均值。RRI 的正常值目前尚无统一标准，健康成人 RRI 值通常在 0.6~0.7 之间，其上限值是 0.7 [10] [11]。

3.2. RRI 的影响因素

3.2.1. 年龄与性别

正常人的 RRI 范围取决于年龄，呈年龄依赖性[12]。一项研究测量了 115 名新生儿至 16 岁健康儿童的 RRI，结果表明，RRI 在出生时最高，随着年龄的增长而下降，逐渐稳定到成人水平，且 72 月龄以上儿童的 RRI 与成人无显著差异[13]。成人 RRI 值 < 0.7 被认为是正常的，而老年人 RRI 因动脉僵硬等因素而较高。此外，在一项多中心研究中，正常成年女性比男性 RRI 值高，这可能是由于激素差异以及 RRI 具有遗传特征的事实[14]。

3.2.2. 脉压差和心率

心率可通过改变舒张期来影响 RRI，当心率增加时，心脏舒张期缩短，每搏输出量减少，脉压下降，RRI 降低。一项针对健康人群和高血压患者的研究证实了心率与 RRI 之间呈负相关(R = −0.14 and R = −0.15; P < 0.008) [14]。

3.2.3. 血管顺应性

血管顺应性是指在压力作用下使血管容积增大而不破裂的一种特性，是反映血管硬化程度与弹性的指标。多项动物实验观察到 RRI 与肾血管阻力之间存在相关性，当血管阻力增加时，RRI 随之升高[15] [16]。在过去许多研究中，RRI 和肾血管阻力被认为具有相同含义，但实际上两者存在一定的差异[17]。Bude Ro 等人[18]研究发现血管顺应性和血管阻力与 RRI 密切相关，当血管顺应性正常时，RRI 越能反映肾血管阻力的变化，两者呈正相关，而血管顺应性下降为零时，RRI 与血管阻力无关。

3.2.4. 动脉硬化程度

RRI 升高被认为是肾内动脉硬化的标志物，肾功能恶化与原发性高血压炎症状态相关的肾小管间质损伤相关，在人类中，高敏感性 C 反应蛋白(hs-CRP)血清水平与肾小管间质损伤的尿液标志物相关，在高血压患者中，hs-CRP 值与 RRI 直接相关[19]。

除以上影响因素外，还有超声探头的压力、呼吸、血压、平均动脉压、药理因素等也能影响 RRI 值。在使用 RRI 测量时需要考虑这些因素，以提高多普勒 RRI 分析的临床相关性。

4. RRI 早期诊断 S-AKI 的临床意义

脓毒症导致的 AKI 是重症 ICU 中常见的危及生命的并发症[20]，与患者的不良预后相关，包括慢性肾脏病、心血管事件和死亡风险增加，是预测患者死亡的独立危险因素[21]。我国一项纳入 3687 名 ICU 患者的研究显示，约 54.7%的患者患有 AKI，脓毒症是其最常见的病因(约 49.2%)，S-AKI 患者病情更严重，需要 ICU 更多的支持治疗[22]。Lerolle 等人[23]研究发现，在脓毒性休克患者中持续性 AKI 的 RRI 显著高于短暂性 AKI 患者(分别为 0.67 ± 0.09 和 0.74 ± 0.13；P < 0.01)，为早期识别肾脏危险程度提供方法，早期进行治疗干预，提高生存率[24]。在一项 99 例 ICU 患者的前瞻性观察性研究中，较高的 RRI 是危重患者入 ICU 一周内发生 AKI 的预测指标，可作为 AKI 发生的早期评价指标[25]。此外，有研究结果表明，RRI 是脓毒症休克患者发生 AKI 的独立危险因素[26]。运用 RRI 实时监测肾脏血流状况，及时准确预测脓毒症患者发生 AKI，从而改善患者预后。

5. 小结与展望

超声多普勒 RRI 具有无创、安全、可床旁操作等优点，尤其适用于动态观察肾脏血流动力学变化，

在肾功能改变早期就可以提供肾脏血流情况。RRI 是早期预测 S-AKI 的一个重要方法，具有广阔的应用前景，然而其影响因素众多，目前仍缺乏大样本多中心临床研究证实，且未制订统一标准指导 RRI 的应用，未来仍需要大规模前瞻性研究来确认其预测效果。

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