·专家笔谈·

早产儿生发基质-脑室内出血的分型特点与管理策略

全文二维码

吴水华
中南大学湘雅医学院附属儿童医院(湖南省儿童医院)神经外科,长沙 410007
Email:292454021@qq.com

【摘要】 随着围产医学与新生儿重症监护技术的进步,早产儿及极低出生体重儿的存活率显著提升,但早产儿脑损伤仍然是影响患儿远期生存质量的重要因素。生发基质-脑室内出血(germinal matrix-intraventricular hemorrhage,GMH-IVH)及其继发的出血后脑室扩张和出血后脑积水,是导致患儿脑瘫、认知障碍及癫痫的主要原因。GMH-IVH 的临床诊疗涉及多学科协作,如何透过影像学分型洞察病理本质、利用量化指标把握外科干预时机以及制定个体化的引流方案是当前面临的核心问题。本文结合国内外最新循证医学证据,从神经外科视角剖析 GMH-IVH 的病理生理机制与分型内涵,构建基于经颅超声多参数量化的序贯评估体系;在治疗策略上,倡导依据病情演变实施从集束化监护、临时性脑脊液引流到永久性分流的"阶梯化"管理策略,为早产儿 GMH-IVH 的规范化诊疗提供参考。

【关键词】 早产; 生发基质-脑室内出血; 出血后脑积水; 显微外科手术; 脑室腹腔分流术; 神经发育结局; 脑室指数
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Classification characteristics and management strategies of germinal matrix-intraventricular hemorrhage in preterm infants

Wu Shuihua
Department of Neurosurgery, The Affiliated Children's Hospital of Xiangya School of Medicine, Central South University (Hunan Children's Hospital), Changsha 410007, China
Email: 292454021@qq.com

【Abstract】 With advances in perinatal medicine and neonatal intensive care technologies, the survival rates of extremely preterm infants and extremely low birth weight infants have increased significantly; however, brain injury in preterm infants remains a major constraint on long-term quality of survival. Germinal matrix-intraventricular hemorrhage (GMH-IVH) and its secondary complications, including posthemorrhagic ventricular dilatation (PHVD) and posthemorrhagic hydrocephalus (PHH), are the leading causes of cerebral palsy, cognitive impairment, and epilepsy in survivors. The clinical diagnosis and management of GMH-IVH require multidisciplinary collaboration. Key current challenges include elucidating the pathological essence through imaging-based classification, determining the optimal timing for surgical intervention using quantitative indicators, and formulating individualized drainage strategies. Integrating the latest domestic and international evidence-based medical data, this article provides an in-depth analysis from a neurosurgical perspective of the pathophysiological mechanisms and classification connotations of GMH-IVH, and constructs a sequential assessment system based on multiparametric quantitative transcranial ultrasonography. In terms of treatment strategies, a "stepwise" management approach is advocated according to disease progression, ranging from bundled monitoring and temporary cerebrospinal fluid drainage to permanent shunting, thereby providing a reference for the standardized diagnosis and treatment of GMH-IVH in preterm infants.

【Key words】 Preterm; Germinal Matrix-Intraventricular Hemorrhage; Posthemorrhagic Hydrocephalus; Microsurgery; Ventriculoperitoneal Shunt; Neurodevelopmental Outcome; Ventricular Index
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早产儿生发基质-脑室内出血(germinal matrix-intraventricular hemorrhage, GMH-IVH)是新生儿期最常见且最具破坏性的颅内出血类型。2025 年发布的最新专家共识指出,其防治工作已成为改善早产儿预后的关键环节[1]。流行病学数据显示,在极低出生体重儿中,GMH-IVH 的总体发生率约为 20%[2]。尽管随着产前糖皮质激素的规范应用和复苏技术的改进,轻度出血发生率有所下降,但重度出血(Ⅲ~Ⅳ级)发生率仍维持在 10% 左右[3]。低胎龄、感染及血流动力学波动仍是导致 IVH 发生与进展的核心危险因素[4-5]。GMH-IVH 不仅是患儿急性期的致死性疾病,更是远期神经发育障碍(neurodevelopmental impairment, NDI)的主要原因[6-7]。因此,神经外科医师需摒弃陈旧观念,早期介入,全程管理,以最大程度降低继发性脑损伤。

一、病理生理机制与分型特征的临床内涵

深入理解 GMH-IVH 的发病机制与分型内涵,是制定精准治疗策略的基石。

(一)解剖易损性与血流动力学机制

GMH-IVH 多发生于出生后 72 h 内,主要源于室管膜下生发基质(germinal matrix, GM)独特的解剖基础。GM 区域富含未分化神经胶质前体细胞,代谢旺盛且血供丰富。然而,该区域微血管网呈现显著的“不成熟性”:血管壁仅由单层内皮细胞构成,缺乏平滑肌及胶原纤维支持;基底膜层缺乏粘连蛋白,紧密连接松散[8]。这种“高流量、弱结构”的特点使其难以承受血流波动。加之早产儿脑血管自动调节功能发育不全,呈“压力被动性”特征,当遭遇窒息、呼吸窘迫、气胸或机械通气压力剧变时,全身血压波动直接传递至脑微循环,极易冲破脆弱的血管[9-10]。此外,缺血-再灌注损伤及宫内炎症亦通过破坏血管内皮成为诱发出血的重要机制[11-12]。

(二)继发性脑损伤的病理级联

出血并非病程终点,血液破入脑室后会启动复杂的病理级联反应[13]。首先是机械性梗阻,血凝块直接阻塞导水管或第四脑室出口;其次是炎症与毒性损伤,红细胞裂解产物(游离铁、血红蛋白)及凝血酶具有强神经毒性,诱发小胶质细胞激活并释放 TGF-β 等炎性因子。TGF-β 上调导致蛛网膜颗粒纤维化,引发交通性脑积水。更重要的是,积血产生的氧化应激直接攻击脑室旁少突胶质细胞前体,导致髓鞘化障碍和脑室周围白质软化(periventricular leukomalacia, PVL),构成早产儿脑病的病理核心[14-15]。

(三)分型特征与预后判读

临床广泛采用 Papile 分级及其改良版进行分型,但需透过影像明确其病理本质[16-17]。Ⅰ级与Ⅱ级预后相对良好;Ⅲ级提示脑脊液循环受阻,发生出血后脑积水(post-hemorrhagic hydrocephalus, PHH)的风险约为 40%[17]。脑室内积血急剧扩张压迫终末髓静脉,导致扇形区域静脉回流受阻、淤血梗死。这意味着脑白质结构已发生不可逆坏死,是预测脑性瘫痪(尤其是痉挛性偏瘫)的最强因子。

二、基于多参数量化的影像评估体系

由于早产儿颅骨可塑性强,早期的颅内高压体征(如前囟隆起)往往滞后[18]。建立以经颅超声(cranial ultrasonography, cUS)为核心的序贯量化监测体系,是捕捉干预时机的关键。

(一)经颅超声的量化监测

建议对胎龄 <32 周或出生体重 <1 500 g 的早产儿常规筛查,首次检查应在出生后 3~7 天,随后动态复查[18]。关键量化指标包括:

1. 脑室指数(ventricular index, VI):即 Levene 指数,是监测脑室扩张最敏感的指标。临床应将 VI 值标记在 Levene 生长曲线上动态观察其百分位变化。

2. 前角宽度(anterior horn width, AHW):AHW >6 mm 为轻度扩张, >10 mm 为重度扩张。AHW 与额叶白质受压程度呈正相关, >10 mm 常提示不可逆损伤风险激增[19]。

3. 额枕角比值(fronto-occipital horn ratio, FOHR):FOHR >0.55 通常提示需要外科处理[20]。

4. 丘脑-枕部距离(thalamo-occipital distance, TOD):枕角常是积血最先沉积部位,TOD 具有早期预警价值。

(二)多模态影像与功能监测

对于Ⅲ~Ⅳ级出血患儿,建议在纠正胎龄 36~40 周或手术前行 MRI 检查,利用 SWI 序列评估微出血灶,利用 DTI 序列评估白质纤维束完整性。此外,近红外光谱(near-infrared spectroscopy, NIRS)可实时监测局部脑组织氧饱和度,若观察到氧饱和度持续下降,可提示颅高压已致脑灌注受损,可作为影像学之外的功能性干预指征[21]。

三、阶梯化与全程化管理策略

GMH-IVH 的治疗目标在于控制颅内压、清除有害血液产物、减少继发性脑损伤,并尽可能推迟永久性分流。治疗应遵循“阶梯化、个体化”原则[22]。

(一)第一阶梯:早期支持与集束化护理

适用于Ⅰ~Ⅱ级 GMH-IVH 及稳定期患儿。核

心措施是集束化护理：保持头部中立位，避免颈静脉扭曲，采用“最小触碰”原则，维持血流动力学稳定。循证医学显示，乙酰唑胺等药物不能减少分流需求，反而增加并发症风险，故目前专家共识不推荐常规使用[1]。

（二）第二阶梯：进展性出血后脑室扩张（post-hemorrhagic ventricular dilatation，PHVD）的临时干预

当脑室进行性扩大时，需启动干预。关于干预阈值，ELVIS 研究对比了低阈值（VI > P97）和高阈值（VI > P97 +4 mm）策略，结果显示两组分流率无显著差异[23-24]。目前推荐采用“相对积极但审慎”的策略：当 VI 达到 P97 + 4 mm（action line），或 AHW > 10 mm，或出现临床症状时，应立即干预[19]。

1. 脑室储液囊（Ommaya reservoir）置入术：是治疗早产儿 PHVD 最常用方式。Ommaya 囊提供可控减压窗口，并能清除部分炎性脑脊液。15%～20% 的患儿经此治疗后脑脊液循环获得再通，避免了永久分流[25]。

2. 脑室－帽状腱膜下引流术（ventricular subgaleal drainage，VSG）：利用皮下淋巴系统吸收脑脊液，符合生理性持续引流。Meta 分析显示，VSG 在减少穿刺次数和降低颅内感染发生率方面优于 Ommaya 囊置入术，但两者的永久分流率无显著差异[26]。

3. 间歇性腰椎穿刺（intermittent lumbar puncture，L-P）：仅作为交通性脑积水早期的短期过渡措施，因反复腰椎穿刺增加感染及生理应激风险，不宜长期使用[22]。

（三）第三阶梯：脑室灌洗纤溶治疗（drainage，irrigation and fibrinolytic therapy，DRIFT）

DRIFT 技术通过注射纤溶药物（t-PA）并持续冲洗，旨在快速清除积血和炎性介质。RCT 研究及 10 年随访显示，DRIFT 组严重认知障碍发生率显著低于标准治疗组（31% 比 59%）[27-28]。但该技术存在继发性再出血风险（约 35%），目前仅建议在具备极高监护能力的中心经严格审批后谨慎开展，不推荐常规普及[29]。

（四）第四阶梯：永久性脑脊液分流

当患儿体重达标（ > 2.0kg）、脑脊液蛋白下降（ < 1.5 g/L），但撤除临时引流后仍出现颅内高压时，需行脑室－腹腔分流术（ventriculo-peritoneal shunt，VPS）。针对早产儿术后高颅内感染发生率问题，建议实施标准化抗感染流程，包括抗生素浸泡分流管、双层手套及“不接触技术”等[30]。

四、并发症管理与远期随访

GMH-IVH 的治疗具有长期性，术后需警惕分流相关并发症，VPS 术后第 1 年尤其前 6 个月是分流故障高发期，一旦怀疑感染，应果断拔管并行脑室外引流[31-32]。此外，神经发育结局是评价治疗效果的金标准。Ⅲ～Ⅳ级出血幸存者属高危人群，出院后应建立多学科随访档案，涵盖运动（GMs 评估）、语言及认知（Bayley-Ⅲ量表）评估，并尽早启动康复干预，利用大脑可塑性改善预后[7]。

五、总结与展望

早产儿 GMH-IVH 及 PHVD 的诊治是一项系统工程，“预防优于治疗，保护重于重建”是核心理念。未来，随着分子生物学标志物的发现、神经保护药物（如去铁胺）的研发及微创技术的革新，早产儿 GMH-IVH 预后有望进一步改善。当前，通过量化超声严格把关指征、利用 Ommaya 囊平稳渡过急性期、慎重选择永久性分流时机的阶梯化治疗策略，仍然是临床最有效的应对策略。

利益冲突　作者声明不存在利益冲突

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