

论著·临床研究

早中期早产儿校正18月龄神经发育状况和影响因素

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[摘要] **目的**·了解出生胎龄≤34周的早中期早产儿在校正月龄18个月时的神经发育状况并分析其影响因素。**方法**·选取2013年1月—2020年4月在上海市儿童医院重症监护中心住院,并在出院后进行规律随访的早中期早产儿作为研究对象。收集早产儿及其父母的人口学特征和临床相关资料。根据校正月龄18个月时的格塞尔发育量表(Gesell Development Schedule, GDS)结果,将早产儿分为神经发育正常组和神经发育迟缓组。比较2组在早产儿基本人口学特征、出生情况、父母亲基本人口学特征和产检情况方面的差异,采用逐步Logistic回归探讨早产儿神经发育迟缓的影响因素。**结果**·共调查了929例早产儿,其中男童527例(56.7%)、女童402例(43.3%),平均胎龄为(31.06±2.23)周,极早早产儿138例(14.9%)。在校正月龄18个月时,发生神经发育迟缓共147例(15.8%),在粗动作能、细动作能、言语能、应物能和应人能的异常率分别为7.4%、9.7%、17.9%、14.2%和13.7%。对神经发育迟缓组和正常组的临床特征进行比较发现,性别、是否为极早早产儿、出生体质量、分娩方式和是否发生宫内窘迫在2组间的差异有统计学意义(均 $P<0.05$)。逐步Logistic回归分析的结果显示,男童($OR=1.60$, 95% CI 1.05~2.44, $P=0.028$)、剖宫产分娩($OR=1.67$, 95% CI 1.08~2.60, $P=0.022$)、极早早产儿($OR=2.20$, 95% CI 1.34~3.62, $P=0.002$)和发生宫内窘迫($OR=5.03$, 95% CI 2.11~11.99, $P=0.000$)是早中期早产儿神经发育迟缓的危险因素。**结论**·男童、极早早产儿、剖宫产分娩和发生宫内窘迫的早中期早产儿发生神经发育迟缓的可能性较高,应重点关注和加强这类早产儿的随访管理。

[关键词] 早产儿;神经发育;神经发育迟缓;危险因素;格塞尔发育量表

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Current status of neurodevelopmental outcomes and its influencing factors of early-to-moderate preterm infants at corrected age of 18 months

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[Abstract] **Objective**·To analyze the neurodevelopmental outcomes and risk factors of early-to-moderate preterm infants with gestational age≤34 weeks at corrected age of 18 months. **Methods**·The early-to-moderate preterm infants hospitalized in Neonatal Intensive Care Unit of Shanghai Children's Hospital from January 2013 to April 2020, and regularly followed up after discharge were included in this study. Demographic and clinically relevant data of preterm infants and their parents were collected. The infants were divided into the neurodevelopmental retardation group and the normal neurodevelopment group according to their Gesell Development Schedule (GDS) scores at corrected age of 18 months. The demographic characteristics of preterm infants, birth status, demographic characteristics of parents and prenatal examinations between the two groups were compared, and stepwise Logistic regression was used to explore the factors influencing neurodevelopmental outcomes in preterm infants. **Results**·A total of 929 preterm infants were included in the study, including 527 boys (56.7%) and 402 girls (43.3%), with a mean gestational age of (31.06±2.23) weeks and 138 (14.9%) extremely preterm infants. A total of 147 infants (15.8%) had neurodevelopmental retardation of early-to-moderate preterm infants at corrected age of 18 months, with abnormalities of 7.4%, 9.7%, 17.9%, 14.2% and 13.7% in

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gross motor, fine motor, language, adaptive behavior and personal-social behavior, respectively. A comparison of the clinical characteristics between the neurodevelopmental retardation group and the normal neurodevelopment group revealed statistically significant differences in terms of gender, whether the baby was an extremely preterm infant, birth weight, mode of delivery, and occurrence of intrauterine distress (all $P < 0.05$). Stepwise Logistic regression analysis showed that boys ($OR = 1.60$, 95%CI 1.05–2.44, $P = 0.028$), cesarean section ($OR = 1.67$, 95%CI 1.08–2.60, $P = 0.022$), extremely preterm infants ($OR = 2.20$, 95%CI 1.34–3.62, $P = 0.002$) and intrauterine distress ($OR = 5.03$, 95%CI 2.11–11.99, $P = 0.000$) were the risk factors for neurodevelopmental retardation.

Conclusion Boys, extremely preterm infants, cesarean section and intrauterine distress may increase the neurodevelopmental retardation risk of early-to-moderate preterm infants and improving follow-up management of these preterm infants should be focused on and enhanced.

[Key words] preterm infant; neurodevelopment; neurodevelopmental retardation; risk factor; Gesell Development Schedule

随着围产医学和新生儿重症技术的快速发展,我国早产儿存活率明显提高^[1]。然而,由于早产儿各器官系统发育不成熟,尤其是早中期早产儿(胎龄 ≤ 34 周)常需要长时间的住院治疗,极易发生各种并发症,远期神经发育障碍发生率较大,给家庭和社会带来沉重负担^[2-4]。国内外越来越多的学者提出,早产儿管理的重点不仅在于如何提高其生存率,更需要关注其出生后神经系统发育状况^[5]。0~3岁是神经发育的关键时期,也是大脑发育可塑性最强的时期,因此对出院后的早产儿还需密切随访,定期对其进行神经发育评估,尽早开展针对性的干预,最大程度改善早产儿神经发育结局^[6-7]。因此,了解早中期早产儿神经发育特点及神经发育迟缓的危险因素对早期实施干预具有重大意义。本研究通过开展回顾性队列研究,探讨早中期早产儿神经发育迟缓的现状及其影响因素,以期对孕期教育和早产儿早期干预、管理提供依据。

1 对象与方法

1.1 研究对象

基于上海市儿童医院的早产儿队列,纳入2013年1月—2020年4月在重症监护中心住院的早产儿。纳入标准:①出生胎龄 ≤ 34 周。②规律随访至校正月龄18个月。排除标准:临床随访资料不完整。

1.2 资料收集

本研究使用自行设计的一般情况调查表进行资料收集。内容包括早产儿父母情况(年龄、有无慢性病、吸烟饮酒情况、孕期并发症和其他孕期异常情况)、产检情况(产检次数和产检医院)、早产儿基本人口学资料(性别、出生胎龄、出生体质量、出生身长、分娩方式等)和出生情况(是否有呼吸衰竭、呼

吸暂停、肺炎、化脓性脑膜炎、高胆红素血症等)。其中早产儿信息从新生儿医疗记录系统中进行收集。

1.3 神经发育状况评估及分组

在早产儿校正月龄18个月时,采用格塞尔发育量表(Gesell Development Schedule, GDS)^[6]进行评估,包括粗动作能、细动作能、应物能、言语能和应人能5个能区。每个能区测试结果以发育商(development quotient, DQ)表示,当 $DQ \geq 86$ 分为发育正常, ≤ 85 分为发育异常。

根据GDS评估结果,当有2个及以上能区评定为异常时,则判断为GDS综合评价异常,即神经发育迟缓;1个及无能区异常则为神经发育正常^[8]。将研究对象按评估结果分别纳入神经发育迟缓组和神经发育正常组。

1.4 相关概念的界定

本研究采用世界卫生组织(WHO)制定的儿童生长发育标准(2006年版)^[9],将出生体质量 $< 1\,500\text{ g}$ 的新生儿定义为极低出生体质量儿,1 500~2 500 g为低出生体质量儿, $> 2\,500\text{ g}$ 为正常出生体质量儿。将胎龄 ≤ 28 周的早产儿定义为极早早产儿。

1.5 统计学分析

采用R 4.0.5软件和SPSS 22.0软件进行数据处理和统计分析。使用Shapiro-Wilk法进行正态性检验。正态分布的定量资料使用 $\bar{x} \pm s$ 描述,2组间比较采用独立样本 t 检验;非正态分布的定量资料使用 $M(Q_1, Q_3)$ 描述,2组间比较采用Mann-Whitney U 检验;定性资料使用频数和百分比描述,其中二分类和有序多分类变量组间比较采用 χ^2 检验或Fisher确切概率法,等级资料组间比较采用Mann-Whitney U 检验。对所

有影响因素进行单因素分析,将单因素分析中差异有统计学意义的影响因素纳入逐步 Logistic 回归,以有无神经发育迟缓为因变量,计算 *OR* 及 95%*CI*。通过 R 语言中 rms 包进行列线图 (nomogram) 可视化输出。 $P<0.05$ 表示差异具有统计学意义。

2 结果

2.1 早产儿基线资料

共纳入 929 例出生胎龄 ≤ 34 周的早产儿,其中男

童 527 例 (56.7%),女童 402 例 (43.3%),平均胎龄 (31.06 \pm 2.23) 周,极早早产儿 138 例 (14.9%)。出生体质量中位数 1.61 (1.32, 1.91) kg,出生身长中位数 42.0 (39.0, 44.8) cm。在校正月龄 18 个月时,神经发育迟缓 147 例 (15.8%),列为神经发育迟缓组;神经发育正常 782 例 (84.2%),列为神经发育正常组。对 2 组早产儿的临床特征进行比较 (表 1) 发现,性别、是否为极早早产儿、出生体质量、分娩方式和是否发生宫内窘迫的差异有统计学意义 (均 $P<0.05$)。

表 1 神经发育正常组和迟缓组早产儿临床指标比较

Tab 1 Comparison of clinical variables of preterm infants between the normal neurodevelopment group and the neurodevelopmental retardation group

Variable	Total (n=929)	Normal neurodevelopment group (n=782)	Neurodevelopmental retardation group (n=147)	t/z/ χ^2 value	P value
Gender/n(%)				8.023	0.005
Boy	527 (56.7)	428 (54.7)	99 (67.3)		
Girl	402 (43.3)	354 (45.3)	48 (32.7)		
Gestational age/week	31.06 \pm 2.23	31.10 \pm 2.18	30.81 \pm 2.46	1.211	0.140
Extremely preterm infant/n(%)	138 (14.9)	107 (13.7)	31 (21.1)	5.365	0.021
Birth weight/kg	1.61 (1.32, 1.91)	1.64 (1.35, 1.93)	1.50 (1.24, 1.80)	2.412	0.016
Birth weight/n(%)				3.518	0.172
Normal birth weight	40 (4.3)	33 (4.2)	7 (4.8)		
Low birth weight	439 (47.3)	381 (48.7)	58 (39.5)		
Extremely low birth weight	303 (32.6)	248 (31.7)	55 (37.4)		
Missing	147 (15.8)	120 (15.3)	27 (18.4)		
Body length/cm	42.0 (39.0, 44.8)	42.0 (39.0, 45.0)	42.0 (38.0, 44.0)	1.298	0.194
Delivery mode/n(%)				13.211	0.000
Vaginal delivery	709 (76.3)	614 (78.5)	95 (64.6)		
Cesarean delivery	220 (23.7)	168 (21.5)	52 (35.4)		
Intrauterine distress/n(%)	24 (2.6)	13 (1.7)	11 (7.5)	16.658	0.000
Respiratory failure of newborn/n(%)	237 (25.5)	191 (24.4)	46 (31.3)	3.071	0.080
Apnea of newborn/n(%)	83 (8.9)	70 (9.0)	13 (8.8)	0.002	0.966
Pneumonia of newborn/n(%)	308 (33.2)	260 (33.2)	48 (32.7)	0.020	0.888
Purulent meningitis of newborn/n(%)	40 (4.3)	35 (4.5)	5 (3.4)	0.347	0.556
Hyperbilirubinemia of newborn/n(%)	447 (48.1)	374 (47.8)	73 (49.7)	0.167	0.683

2.2 早产儿父母基本资料及孕期情况

本研究纳入的早产儿中,母亲平均生育年龄为 31.0 (28.0, 34.0) 岁,33 例 (3.6%) 早产儿的父亲有慢性病,43 例 (4.6%) 母亲有慢性病;48 例 (5.2%) 早产儿母亲妊娠期有妊娠高血压,95 例

(10.2%) 妊娠期有糖尿病,44 例 (4.7%) 妊娠期有甲状腺疾病,36 例 (3.9%) 妊娠期有贫血。对早产儿父母基本资料、产检情况进行组间比较发现,早产儿父母基本资料及产检情况的差异在 2 组间均无统计学意义 (表 2)。

表2 神经发育正常组和迟缓组早产儿父母临床指标比较

Tab 2 Comparison of clinical variables for parents of preterm infants between the normal neurodevelopment group and the neurodevelopmental retardation group

Variable	Total (n=929)	Normal neurodevelopment group (n=782)	Neurodevelopmental retardation group (n=147)	z/χ^2 value	P value
Maternal age/year	31.0 (28.0, 34.0)	31.0 (28.0, 34.0)	31.0 (28.0, 34.0)	0.161	0.872
Parental smoking ^① /n(%)	179 (19.3)	145 (18.5)	34 (23.1)	1.674	0.196
Maternal alcohol consumption/n(%)	4 (0.4)	4 (0.5)	0 (0)	0.755	0.855
Father's chronic illness/n(%)	33 (3.6)	25 (3.2)	8 (5.4)	1.821	0.177
Mother's chronic illness/n(%)	43 (4.6)	34 (4.3)	9 (6.1)	0.883	0.347
Gestational hypertension/n(%)	48 (5.2)	37 (4.7)	11 (7.5)	1.912	0.167
Gestational diabetes mellitus/n(%)	95 (10.2)	76 (9.7)	19 (12.9)	1.386	0.239
Thyroid disease during pregnancy/n(%)	44 (4.7)	33 (4.2)	11 (7.5)	2.920	0.087
Anemia during pregnancy/n(%)	36 (3.9)	27 (3.5)	9 (6.1)	2.368	0.124
Placenta previa/n(%)	15 (1.6)	14 (1.8)	1 (0.7)	0.388	0.533
Abruptio placentae/n(%)	9 (1.0)	9 (1.2)	0 (0)	0.719	0.396
Abnormal fetal position/n(%)	5 (0.5)	5 (0.6)	0 (0)	0.128	0.721
Number of prenatal tests \geq 8/n(%)	363 (39.1)	307 (39.3)	56 (38.1)	0.070	0.791
Tertiary hospital maternity examination/n(%)	401 (43.2)	331 (42.3)	70 (47.6)	1.412	0.235

Note: ^①In the past year.

2.3 早产儿神经发育状况

在校正月龄 18 个月时, 早产儿在粗动作能、细动作能、言语能、应物能和应人能的异常率分别为 7.4%、9.7%、17.9%、14.2% 和 13.7%。如表 3 所示, 神经发育迟缓组早产儿的粗动作能、细动作能、言语能、应物能和应人能均落后于神经发育正常组, 差异

有统计学意义 (均 $P<0.05$)。

2.4 早产儿神经发育迟缓危险因素分析

逐步 Logistic 回归发现, 男童、剖宫产分娩、极早早产儿和出现宫内窘迫的早产儿发生神经发育迟缓的风险更高 (表 4)。

表3 早产儿 GDS 各能区异常情况比较

Tab 3 Comparison of abnormality rates by GDS scores in preterm infants

Abnormality	Total (n=929)	Normal neurodevelopment group (n=782)	Neurodevelopmental retardation group (n=147)	χ^2 value	P value
Gross motor/n(%)	69 (7.4)	20 (2.6)	49 (33.3)	170.455	0.000
Fine motor/n(%)	90 (9.7)	19 (2.4)	71 (48.3)	297.568	0.000
Language/n(%)	166 (17.9)	80 (10.2)	86 (58.5)	196.481	0.000
Adaptive behavior/n(%)	132 (14.2)	33 (4.2)	99 (67.3)	404.518	0.000
Personal-social behavior/n(%)	127 (13.7)	31 (4.0)	96 (65.3)	394.527	0.000

表4 早产儿神经发育迟缓的逐步 Logistic 回归

Tab 4 Stepwise Logistic regression analysis of neurodevelopmental retardation in preterm infants

Variable	B	SE	P value	OR (95%CI)
Constant	-2.37	0.20	0.000	
Boys	0.47	0.21	0.028	1.60 (1.05—2.44)
Cesarean section	0.52	0.23	0.022	1.67 (1.08—2.60)
Extremely preterm infants	0.79	0.25	0.002	2.20 (1.34—3.62)
Intrauterine distress	1.62	0.44	0.000	5.03 (2.11—11.99)

2.5 列线图的建立与验证

基于逐步 Logistic 回归结果,将4个危险因素纳入列线图中,将每个危险因素的不同水平对应的分值

相加获得总评分,通过总评分即可定位早产儿在校正月龄18个月时发生神经发育迟缓的风险,即预测概率值(图1)。

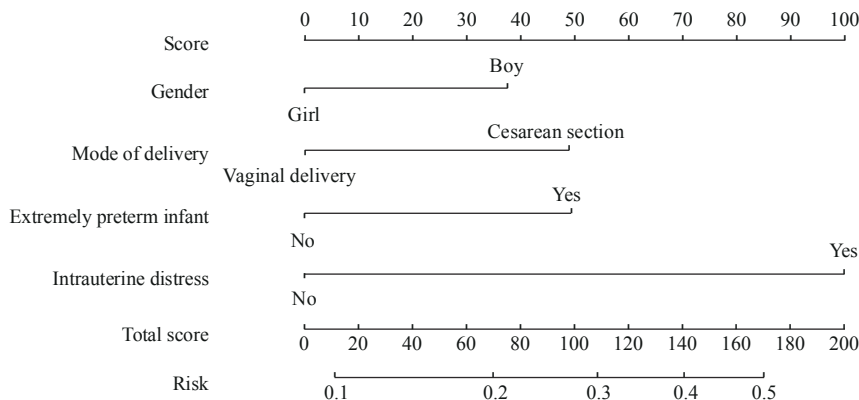


图1 早产儿在校正月龄18个月时发生神经发育迟缓概率的列线图

Fig 1 Nomogram for predicting neurodevelopment retardation in preterm infants at corrected age of 18 months

3 讨论

近年来,围产期重症监护技术发展迅速,大大提高了早产儿的存活率^[9]。早产是新生儿以及婴幼儿发生脑损伤的常见原因^[10]。早产儿大脑沟回数目少,其大脑质量低于足月儿,在发育过程中很容易受到伤害,神经发育常落后于足月儿^[11]。GDS是目前临床最常用的适用于0~6岁婴幼儿的发育评估量表,包括粗动作、精细动作、言语、应物和应人5个方面的诊断评估^[12-13]。本研究发现,在校正月龄18个月时,早中期早产儿神经发育迟缓的发生率为15.8%,粗动作能、细动作能、言语能、应物能和应人能的异常率分别为7.4%、9.7%、17.9%、14.2%和13.7%。进一步分析发现,男童、极早早产儿、剖宫产分娩和宫内窘迫可能是早中期早产儿神经发育迟缓的危险因素,新生儿呼吸暂停和新生儿化脓性脑膜炎在神经发育迟缓组和正常组间差异均无统计学意义。虽然既往研究^[14]发现,新生儿呼吸暂停和新生儿化脓性脑膜炎会对早产儿近期神经系统发育产生影响,但此次纳入的早产儿均在儿童保健科规律随访,由家长定期带其到医院进行体检,接受喂养与发育指导,进行体格检查、神经系统发育评估、疾病筛查与治疗,经过干预和自我修复后,在校正月龄18个月时,其对神经系统发育的影响可能会消失。

本研究发现,早中期早产儿在校正月龄18个月时,男童比女童更易出现神经发育迟缓。SANTOS

等^[15]开展系统综述提出,神经发育障碍的病因是由诸多因素组成的,其中性别是主要影响因素之一,男童神经发育迟缓的发生率普遍高于女童,这可能与遗传、激素、环境或炎症诱导等因素有关。神经影像学^[16-17]发现,女童大脑运动网络发育比男童快,参与社会认知的额叶皮层体积也比男童大,大脑结构的差异导致了不同性别早产儿神经发育水平的不同。BREACH等^[18]近期研究发现,性别差异是神经发育障碍的一个突出特点,男童在自闭症谱系障碍和注意缺陷障碍的发病率远高于女童,且免疫系统在影响神经发育方面起着关键作用。因此,临床医师需更加关注男童的神经发育状况,家长在日常生活情境中应注意培养早产儿各方面的能力,给予多种感官刺激和教育活动。

本研究还发现,极早早产儿发生神经发育迟缓的比例更高,是神经发育迟缓的危险因素。国内外研究者^[19-21]提出,极早早产儿和中晚期早产儿在智力发育和运动发育指数上均低于足月儿,胎龄越低的早产儿存在越高的神经发育迟缓风险。既往研究^[22-23]发现,极早早产儿是神经发育受损和脑功能异常的高危人群,出生胎龄越小,神经系统损害和发育迟缓的发生率越高,对学龄期儿童生活和学习也会产生严重影响。BELL等^[24]研究发现,极早早产儿2岁时神经发育迟缓的发生率仍较高,约为29.3%。系统综述^[25]发现,足月儿的神经认知能力高于早产儿,且持续到成年期;其中,极早早产儿神经认知能力最

低。因此,需整合新生儿科、神经外科、儿童保健科等各专业优势,使得极早早产儿在新生儿期尽早得到系统化、规范化和专业化的管理及综合干预,最大程度改善其神经发育结局和生活质量。

随着剖宫产技术越来越成熟,全世界剖宫产率从1990年约6%增加至2015年的21%,剖宫产的出现显著降低了产妇和新生儿死亡率^[26]。KUHLE等^[27]研究发现,剖宫产分娩的婴儿远期健康结局较差,其肥胖、哮喘、糖尿病和自闭症的发生率较高。本研究中23.7%的早产儿分娩方式为剖宫产,剖宫产分娩的早产儿在校正月龄18个月时神经发育迟缓比例显著高于顺产分娩。前瞻性队列研究^[28]发现,剖宫产会增加12月龄儿童粗大动作和精细动作2个能区发育迟缓的风险和24月龄儿童言语能发育迟缓的风险。Meta分析^[29]结果发现,与阴道分娩相比,剖宫产分娩与儿童神经发育迟缓、自闭症和注意缺陷多动障碍的发生风险相关。大量研究^[30-32]发现,脑-肠轴理论可能可以解释剖宫产对儿童神经发育的影响;相对于阴道分娩儿童,剖宫产分娩的儿童肠道菌群更容易发生改变,且较易引起潜在致病菌的定植,肠道菌群可通过脑-肠轴调节其大脑的发育和行为,这些可能可以解释早产儿出现远期神经发育不良预后。但目前关于剖宫产对儿童神经发育影响的机制仍存在争议,是需要行剖宫产的因素还是剖宫产本身对神经发育的影响需进一步研究论证。

胎儿宫内窘迫是指妊娠后期或临产过程中,因高危因素而出现的胎儿-母体间气体交换障碍并导致胎儿在宫内缺氧和酸中毒,也是造成新生儿围产期脑损伤及神经系统后遗症的重要原因^[33]。本研究共24例(2.6%)早产儿出现宫内窘迫,其发生神经发育迟缓的比例更高。既往研究^[34]发现,缺血缺氧状态下,机体炎症因子被激活并大量分泌,导致神经功能发生损害,从而影响神经系统的发育。LI等^[35]发现,宫内缺血缺氧引起神经系统紊乱,并产生兴奋性毒性影响大脑发育,导致新生儿神经发育异常的风险增加。李晓庆等^[36]研究发现,胎儿宫内窘迫将影响新生儿早期体格及神经系统发育,造成体格和神经发育迟缓。0~3岁是人体中枢神经系统代偿的黄金时期,积极的中枢神经刺激可促进婴幼儿脑结构的完善及发育^[37]。因此,应加强对孕妇孕期健康监测和对高危

因素的排查及干预,以提高早产儿神经心理发育水平,从而改善早产儿近远期预后。

本研究为单中心研究,仅纳入坚持规律随访的早中期早产儿,放弃治疗或未进行规律随访的早产儿未纳入研究,可能存在选择偏倚,样本代表性受到限制。由于本研究为回顾性分析,受限于可获得的有限的临床资料,仅针对早产儿及其父母的一般人口学资料、父母既往病史、产检情况、早产儿神经发育状况进行分析,存在部分危险因素未收集。未来需要开展前瞻性、多中心队列研究全面探索早产儿神经发育不良状况及影响因素。

综上所述,早中期早产儿有较差的神经发育结局,在认知、语言和应物等方面均受到影响。同时,男童、极早早产儿、剖宫产分娩和宫内窘迫可能是其神经发育迟缓的危险因素。因此,应对新生儿期和婴幼儿期早产儿神经发育给予更多的关注,加强早产儿早期管理和健康随访,特别是注重对男童、极早早产儿、剖宫产分娩早产儿、有宫内窘迫史早产儿神经发育系统的评估和监测,并通过健康宣教提高家长对早产儿日常照护和家庭干预的认知,最终达到改善其神经发育结局和提高生活质量的目的。

利益冲突声明/Conflict of Interests

所有作者声明不存在利益冲突。

All authors disclose no relevant conflict of interests.

伦理批准和知情同意/Ethics Approval and Patient Consent

本研究经上海市儿童医院伦理委员会(文件号:2020R105-F02)审核批准。受试对象的父母已经签署知情同意书。

This study was reviewed and approved by Ethics Committee of Shanghai Children's Hospital (No. 2020R105-F02). Consent letters have been signed by the research participants' parents.

作者贡献/Authors' Contributions

沈力负责数据分析和论文撰写。黄亨烨和于广军负责研究设计和论文修改。所有作者均阅读并同意最终稿件的提交。

SHEN Li performed the statistical analysis and drafted the manuscript. HUANG Hengye and YU Guangjun were responsible for the study design and revised the manuscript. All the authors have read the last version of paper and consented for submission.

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[本文编辑] 包 玲

学术快讯

上海交通大学基础医学院钟清/曹木青合作团队揭示中心体微丝网络动态控制和监察机制及其对细胞周期和纤毛的调控

2023年3月27日, 上海交通大学基础医学院病理生理学系钟清团队与曹木青团队合作在 *Nature Communications* 发表题为 *An actin filament branching surveillance system regulates cell cycle progression, cytokinesis and primary ciliogenesis* 的研究论文。该研究揭示了中心体蛋白 OFD1 (oral-facial-digital syndrome 1) 协同 Arp2/3 复合物调控中心体周围的微丝分支动态变化; 去除 OFD1 或破坏 OFD1-Arp2/3 复合体的相互作用, 激活 RB 通路并促使增殖的非转化细胞退出细胞分裂周期进入静息状态, 同时诱导细胞组装纤毛; 在原癌基因诱导的转化细胞和大部分肿瘤细胞中去除 OFD1, 细胞无法有效形成胞质分裂环, 而发生不可逆的细胞死亡。该研究揭示了 OFD1 调控微丝骨架网络分支动态性的方式和微丝网络的监察机制; 该机制的激活决定了正常细胞和肿瘤细胞不同的命运; 靶向该监察机制, 有望为肿瘤的治疗提供新策略。