

MRI 胎盘灌注与胎儿生长受限并发妊娠期高血压疾病相关性临床研究*

张鑫¹, 孔旭晨¹, 殷茵², 周欣^{2**}

[1. 南京医科大学第一临床医学院, 南京 210029;

2. 南京医科大学第一附属医院(江苏省人民医院产科), 南京 210029]

【摘要】 目的:探讨胎儿生长受限(FGR)孕妇胎盘灌注相关参数与妊娠期高血压疾病(HDP)的相关性。**方法:**选取2018年1月1日~2022年12月31日在南京医科大学第一附属医院产科超声诊断为FGR,随后行胎盘磁共振成像(MRI)检查的孕妇157例,依据有无HDP、分娩后是否确诊为FGR将其分为4组,其中FGR合并HDP者39例(A组),HDP无FGR者12例(B组),FGR无HDP者56例(C组),无HDP无FGR者50例(D组)。采用1.5T MR扫描仪进行体素内不相干运动(IVIM),测定胎盘灌注相关参数,包括胎盘面积(S)、标准弥散系数(D)、灌注扩散系数(D*)及灌注分数(f)。**结果:**(1)母儿结局:A组的分娩孕周小于B、C和D组[35.43(33.43~37)周 vs 39.14(35.43~40.54)周、37.22(36.61~38.54)、39.07(38.29~39.86)周],C组的分娩孕周小于D组,差异均有统计学意义(P 均 <0.05)。A组的剖宫产率(92.3%)、新生儿转NICU率(76.9%)均高于其它各组,D组的剖宫产率(46.0%)、新生儿转NICU率(4.0%)均低于其它各组,差异均有统计学意义(P 均 <0.05)。A组的新生儿体质量小于B、C和D组[(1760.00±496.92)g vs (2700.00±824.62)g、(2219.46±380.46)g、(2891.00±276.03)g],C组的新生儿出生体重小于B组及D组,差异有统计学意义(P 均 <0.05)。(2)胎盘灌注相关参数:A组的胎盘面积小于B、C和D组[(172.61±44.63)cm² vs (214.19±36.68)cm²、(202.73±39.82)cm²、(211.06±28.70)cm²],差异均有统计学意义(P 均 <0.05);C组的D值高于A组[(1.63±0.21)×10⁻³ vs (1.50±0.17)×10⁻³],差异均有统计学意义(P 均 <0.05);各组的D*值比较,差异均无统计学意义(P 均 >0.05);A组的f值低于B组和D组[(25.37±5.21)% vs (32.87±5.93)%、(34.38±5.17)%],C组的f值低于D组,差异均有统计学意义(P 均 <0.05)。(3)f值异常组的HDP(40.3%)、FGR(84.4%)、FGR合并HDP(36.4%)、早产发生率(45.5%)、剖宫产率(77.9%)、新生儿窒息率(13.0%)、新生儿转NICU率(51.9%)亦显著高于f值正常组,差异均有统计学意义(P 均 <0.05)。**结论:**MRI胎盘灌注相关参数中的胎盘面积、灌注分数在FGR合并HDP时呈减低状态,其中灌注分数降低常伴随着母儿不良结局的发生,因此针对f值减低的孕妇需加强母胎监测,以期改善母儿结局。

【关键词】 胎盘MRI;灌注分数;胎儿生长受限;妊娠期高血压疾病

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Clinical study of MRI placental perfusion in fetal growth restriction complicated by hypertensive disorders of pregnancy. Zhang Xin¹, Kong Xuchen¹, Yin Yin², et al. 1. The First Clinical School of Ningjing Medical University, Nanjing 210029; 2. The First Affiliated Hospital with Nanjing Medical University (Department of Obstetrics, Jiangsu Provincial People's Hospital), Nanjing 210029

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** 通信作者 Email:zhouxin101@sina.com

【Abstract】 Objective: A retrospective analysis was performed to analyze the correlation between placental perfusion related parameters and hypertensive disorders of pregnancy (HDP) in pregnant women with fetal growth restriction (FGR). **Methods:** A total of 157 pregnant women diagnosed with FGR by obstetric ultrasound in the First Affiliated Hospital of Nanjing Medical University from January 1, 2018 to December 31, 2022, and subsequently underwent placental magnetic resonance imaging (MRI) were selected, 39 cases FGR complicated by HDP, 12 cases without FGR, 56 cases without HDP, and 50 cases without HDP and FGR in group D. A 1.5T MR scanner was used to perform intravoxel incoherent motion (IVIM), and placental perfusion related parameters, including placental area (S), true dispersion coefficient (D), fast diffusion coefficient (D*) and perfusion fraction (f), were measured by a 1.5T MR scanner. **Results:** (1) Maternal and neonatal outcomes: In the FGR, group A, the delivery gestational age was less than that of the other groups [35.43 (33.43 ~ 37) weeks vs 39.14 (35.43 ~ 40.54) weeks, 37.22 (36.61 ~ 38.54) weeks, 39.07 (38.29 ~ 39.86) weeks], while in the C group, the delivery gestational age was less than that of the D group, the differences were statistically significant ($P < 0.05$). The caesarean section rate (92.3%) and neonatal transfer rate to NICU (76.9%) in the A group were higher than those in the other groups, while the caesarean section rate (46.0%) and neonatal transfer rate to NICU (4.0%) in the D group were lower than those in the other groups, the differences were statistically significant ($P < 0.05$). The body mass of the newborns in Group A was smaller than those in the other groups [(1760.00 ± 496.92) g vs (2700.00 ± 824.62) g, (2219.46 ± 380.46) g, (2891.00 ± 276.03) g], and the body mass of newborns in Group C was smaller than those in Group B and Group D, the differences were statistically significant ($P < 0.05$). (2) Placental perfusion-related parameters; the area of the placenta in Group A was smaller than that in the other groups (172.61 ± 44.63) cm² vs (214.19 ± 36.68) cm², (202.73 ± 39.82) cm², (211.06 ± 28.70) cm², the differences were statistically significant ($P < 0.05$). The D value in Group C was higher than that in Group A [(1.63 ± 0.21) × 10⁻³ vs (1.50 ± 0.17) × 10⁻³], the differences were statistically significant ($P < 0.05$). There was no statistically significant difference in the D* value among the groups ($P > 0.05$). The f value in Group A was lower than that in Groups B and D [(25.37 ± 5.21)% vs (32.87 ± 5.93)%、(34.38 ± 5.17)%], the f value in Group C was lower than that in Group D, the differences were statistically significant ($P < 0.05$). (3) The incidence of HDP (40.3%), FGR (84.4%), HDP with FGR (36.4%), and preterm delivery (45.5%) was higher in the group with abnormal f values than those in the group with normal f values, and the rates of cesarean section (77.9%), neonatal asphyxia (13.0%), and transfer to NICU (51.9%) were also significantly higher in the former group, the differences were statistically significant ($P < 0.05$) in all cases. **Conclusions:** The placental area and perfusion fraction in the parameters related to placental perfusion in MRI decreased when fetal growth restriction was complicated by hypertensive diseases during pregnancy, and the decrease in perfusion fraction was often accompanied by adverse maternal and infant outcomes.

【Key words】 Placental MRI; Fractional perfusion; Fetal growth restriction; Hypertensive disorders of pregnancy

胎儿生长受限 (fetal growth restriction, FGR) 是指受母体、胎儿、胎盘等病理因素影响所致的胎儿生长未达到其应有的遗传潜能, 我国的发病率约为 6.39%^[1], 据报道 70% 左右的早发型 FGR 以及 10% 左右的晚发型 FGR 与妊娠期高血压疾病 (hypertensive disorders of pregnancy, HDP) 有关^[1-2]。HDP 包括妊娠期高血压、子痫前期、子痫以及慢性高血压并发子痫前期^[3], 在我国的发病率约为 9.4% ~ 10.4%^[4], 是导致孕产妇死亡的第二大重要原因^[5], 在发达国家中亦占孕产妇死亡的 16%^[6]。既往研究认为, HDP 的发生与血管内皮功能受损、子宫螺旋动脉重塑障碍以及滋养层细胞侵袭异常有关^[7-9], 其中螺旋动脉重塑障碍导致胎盘缺血和灌

注异常, 与胎儿生长受限 (fetal growth restriction, FGR) 发生密切相关^[10-11]。既往针对胎盘因素所致 FGR 常采用多普勒超声检测相关参数, 如脐动脉血流通舒张末期搏动指数大于各孕周第 95 百分位数或舒张末期血流缺失提示胎儿宫内缺氧^[12-13], 大脑中动脉通过 PI 值或 S/D 下降提示胎儿缺氧^[14], 静脉导管 a 波反向提示胎儿可能处于酸中毒或濒死状态, 三者均是通过反映胎儿在宫内是否缺氧间接反映胎盘功能^[15-16]。磁共振成像 (magnetic resonance imaging, MRI) 是一种无创检查技术, 采用体素内不相干运动检测, 通过高分辨率和立体图像观察胎盘位置、分布面积以及周围结构的关系评估, 检测胎盘面积 (S)、使用 fire · voxel 软件测量获得灌

注分数(f)、灌注扩散系数(D^*)及标准扩散系数(D),其中 D 值是指水分子单位时间内随机运动的范围,反映了胎盘的组织密度; D^* 值是指灌注弥散系数,反映了胎盘毛细血管的微循环灌注; f 值是指体素内微循环灌注相关的扩散占总体扩散效应的百分率,反映了胎盘的微循环灌注^[17-18]。既往研究表明,FGR与MRI胎盘灌注参数异常密切相关^[19-20],但针对与胎盘功能异常密切相关的HDP及其并发FGR者的MRI胎盘灌注未行深入研究。本研究回顾分析了FGR合并HDP者的胎盘灌注相关参数。

1 资料与方法

1.1 研究对象 选取2018年1月1日至2022年12月31日于南京医科大学第一附属医院产科门诊系统产检,因胎儿超声诊断为FGR予行胎盘MRI检查后,在医院分娩的孕妇共157例。依据有无HDP、分娩后确诊是否为FGR将其分为4组,其中FGR合并HDP者39例(A组),HDP无FGR者12例(B组),FGR无HDP者56例(C组),无HDP无FGR者50例(D组)。纳入标准:超声诊断FGR。排除标准:(1)母体因素:孕妇合并自身免疫性疾病、妊娠期糖尿病、严重肝肾功能异常者;(2)胎儿因素:羊水穿刺、无创或唐氏筛查异常、系统超声提示结构异常;(3)胎盘异常:前置胎盘伴胎盘植入者、脐带附着异常或数目异常。

1.2 诊断标准 超声诊断FGR标准:胎儿超声测量的胎儿体质量或腹围小于相应孕周的第10百分位^[21]。FGR:新生儿出生体质量小于相应孕周出生体质量的第10百分位^[21-22]。HDP:是指妊娠与高血压并存的一组疾病,包括妊娠期高血压、子痫前期、子痫以及慢性高血压并发子痫前期。妊娠期高血压:妊娠20周后出现血压升高[收缩压 ≥ 140 mmHg和(或)舒张压 ≥ 90 mmHg]^[23]。新生儿窒息是指在分娩过程中由于各种原因导致新生儿出生后不能建立自主呼吸,一般1min或5min Apgar评分 ≤ 7 分^[23]。早产是指孕28周至孕36⁺6周的分娩^[24]。

1.3 MRI检查方法 采用西门子1.5TMR扫描仪,12通道表面体线圈和2个嵌入式脊柱线圈进行扫描,使用FireVoxel软件及采用双指数模型 $[S(b) = S_0 \cdot [(1-f) \cdot \exp(-b \cdot D) + f \cdot \exp(-b \cdot (D+D^*))]$ 处理基于多 b 值扩散加权图像的体素内不相干运动(intravoxel incoherent motion,IVIM)。其中 $S(b)$ 是指信号强度, S_0 为 $b=0$ s/mm²时的信号强度。通过使用所有 b 值对双指数模型进行逐体素拟合,生成 f 、 D 和 D^* 值参数。

1.4 观察指标 (1)一般资料:孕妇年龄、孕次、产次、超声诊断FGR孕周、MRI检查孕周;(2)妊娠结局:分娩孕周、分娩方式、新生儿体质量、新生儿性别、新生儿窒息、新生儿转NICU;(3)胎盘MRI灌注参数:胎盘面积(S 值)、 D 值、 D^* 值及 f 值;(4)根据Molly Malmberg团队^[25]以及我院放射科MRI^[24-25]测量,胎盘灌注相关参数的 f 值取28%为截断值, $\geq 28\%$ 为 f 值正常组, $< 28\%$ 为 f 值异常组。比较两组孕妇的收缩压、舒张压、HDP发生率、FGR发生率、FGR合并HDP发生率、分娩孕周、早产发生率、剖宫产率、新生儿体质量、新生儿窒息率以及新生儿转NICU率。

1.5 统计学处理 采用SPSS23统计学软件,定量资料采用Kolmogorov-Smirnov检验对其进行正态性检验,符合正态分布的定量资料采用($\bar{x} \pm s$)表示,采用单因素ANOVA检验进行方差齐性检验,符合方差齐性的定量资料组间比较采用单因素方差分析或 t 检验,组间采用Bonferroni检验进行多重比较;方差不齐的定量资料采用Kruskal-Wallis检验;不符合正态分布的定量资料采用中位数和四分位数 $[M(P_{25}, P_{75})]$ 表示,组间比较采用Kruskal-Wallis检验或Mann-Whitney U 检验;定性资料采用 $[n(\%)]$ 表示,组间比较采用卡方检验。 $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 孕妇基本资料比较 孕妇的年龄、产次、超声诊断FGR孕周以及MRI检查孕周比较,差异均无统计学意义(P 均 > 0.05),孕妇的孕次组间进行多重比较,差异无统计学意义($P > 0.05$),见表1。

表1 四组孕妇基本资料比较

指标	A组($n=39$)	B组($n=12$)	C组($n=56$)	D组($n=50$)	F/χ^2	P
年龄(岁)	30.95 \pm 4.15	27.92 \pm 3.15	29.82 \pm 3.03	29.86 \pm 3.99	2.2349	0.0864
孕次	2(1~3)	1(1~1.75)	1(1~1)	1(1~2)	8.031	0.0454
产次	1(1~2)	1(1~1)	1(1~1.25)	1(1~1)	4.8869	0.1803
超声诊断FGR孕周(周)	32.71(29.71~35.00)	34.57(32.18~34.97)	33.43(31.78~36.14)	34.14(31.07~35.75)	2.9215	0.4039
MRI检查孕周(周)	33.00(30.43~35.86)	34.64(32.54~35.18)	33.86(32.18~36.43)	34.71(31.79~36.07)	2.4837	0.4782

多重比较孕次: $P_{1-2}=0.098$;A组 vs B组, $P_{1-4}=0.419$;A组 vs D组

2.2 妊娠结局比较 A组的分娩孕周小于其它3组,C组的分娩孕周小于D组($P < 0.05$);A组的剖宫产率(92.3%)、新生儿转NICU率(76.9%)均高于其它各组,D组的剖宫产率、新生儿转NICU率低于其它各组,差异均有统计学意义(P 均 < 0.05);A组的新生儿体质量低于其它各组,而D组的新生儿体重大于A组和C组,差异均有统计学意义(P 均 < 0.05);4组间的新生儿窒息发生率以及新生儿性别

比较,差异均无统计学意义(P 均 > 0.05),见表2。

2.3 孕妇MRI胎盘灌注相关参数比较 A组的胎盘面积小于其它3组($P < 0.05$),B、C、D组的胎盘面积无统计学差异($P > 0.05$);C组的 D 值高于A组($P < 0.05$),其它组间 D 值无统计学差异($P > 0.05$);四组的 D^* 值无统计学差异($P > 0.05$);A组的 f 值低于B组和D组,C组的 f 值小于D组,差异有统计学意义($P < 0.05$),见表3。

表 2 四组孕妇的妊娠结局比较

指标	A 组(n=39)	B 组(n=12)	C 组(n=56)	D 组(n=50)	F/χ ²	P
分娩孕周(周)	35.43(33.43~37.00)	39.14(35.43~40.54)	37.22(36.61~38.54)	39.07(38.29~39.86)	63.1926	<0.0001
分娩方式						
剖宫产	36(92.3)	7(58.3)	37(66.1)	23(46.0)	21.127	<0.0001
顺产	3(7.7)	5(41.7)	19(33.9)	27(54.0)		
新生儿体重(g)	1760.00±496.92	2700.00±824.62	2219.46±380.46	2891.00±276.03	70.0638	<0.0001
新生儿窒息	7(17.9)	1(8.3)	4(7.1)	1(2.0)	7.492	0.0578
新生儿性别						
男	9(23.1)	6(50.0)	26(46.4)	21(42.0)	6.212	0.1018
女	30(76.9)	6(50.0)	30(53.6)	29(58.0)		
新生儿转 NICU	30(76.9)	3(25.0)	25(44.6)	2(4.0)	51.406	<0.0001

多重比较分娩孕周: P₁₋₂=0.0149, P₁₋₃=0.0002, P₁₋₄<0.0001, P₃₋₄<0.0001; 多重比较新生儿体重: P₁₋₂=0.0024, P₁₋₃<0.0001, P₁₋₄<0.0001, P₂₋₃=0.0261, P₃₋₄<0.0001; P₁₋₂: A 组 vs B 组; P₁₋₃: A 组 vs C 组; P₁₋₄: A 组 vs D 组; P₂₋₃: B 组 vs C 组; P₃₋₄: C 组 vs D 组

表 3 四组孕妇胎盘灌注相关参数的比较

参数	A 组(n=39)	B 组(n=12)	C 组(n=56)	D 组(n=50)	F/χ ²	P
S(cm ²)	172.61±44.63	214.19±36.68	202.73±39.82	211.06±28.70	8.8823	<0.0001
D(×10 ⁻³)	1.50±0.17	1.52±0.21	1.63±0.21	1.53±0.15	4.8507	0.003
D*(×10 ⁻³)	140.43±26.65	160.12±26.69	154.67±45.59	144.00±30.17	6.3711	0.0949
f(%)	25.37±5.21	32.87±5.93	26.71±6.54	34.38±5.17	24.2908	<0.0001

多重比较 S: P₁₋₂=0.0058, P₁₋₃=0.0011, P₁₋₄<0.0001; 多重比较 D: P₁₋₃=0.0169; 多重比较 f: P₁₋₂=0.0007, P₁₋₄<0.0001, P₂₋₃=0.0054, P₃₋₄<0.0001; P₁₋₂: A 组 vs B 组; P₁₋₃: A 组 vs C 组; P₁₋₄: A 组 vs D 组; P₂₋₃: B 组 vs C 组; P₃₋₄: C 组 vs D 组

2.4 胎盘 f 值正常组与异常组的比较 f 值异常组的收缩压(131.81±19.96)mmHg、舒张压(83.71±14.50)mmHg 均高于 f 值正常组, 差异均有统计学意义(P 均<0.05); 24h 尿蛋白定量组间无差异(P>0.05); f 值异常组的 HDP(40.3%)、FGR(84.4%) 以及 FGR 合并 HDP(36.4%) 发生率、剖宫产率(77.9%)、新生儿窒息率(13.0%) 以及新生儿转 NICU 率(51.9%) 均高于灌注分数正常组, 差异均有统计学意义(P 均<0.05); f 值异常组的分娩孕周小于 f 值正常组, 其中 f 值异常组<32 周分娩的发生率(9.0%) 高于 f 值正常组, 早产率(45.5%) 高于 f 值正常组, 差异均有统计学意义(P 均<0.05); f 值异常组的新生儿体重平均为(2135.45±653.24)g, 低于 f 值正常组, 差异有统计学意义(P<0.05), 见表 4。

表 4 灌注分数正常组与异常组基本资料、妊娠结局的比较 [x̄±s, n(%)]

指标	f<28% (n=77)	f≥28% (n=80)	F/χ ²	P
收缩压(mmHg)	131.81±19.96	125.28±19.66	2.065	0.041
舒张压(mmHg)	83.71±14.50	78.74±12.62	2.297	0.023
24h 尿蛋白定量(mg/L)	2901.30±3584.44	1732.48±2898.54	1.22932	0.219
HDP	31(40.3)	20(25.0)	4.993	0.025
FGR	65(84.4)	30(37.5)	53.681	<0.0001
FGR 合并 HDP	28(36.4)	11(13.8)	10.747	0.001
分娩孕周(周)	36.63±2.63	38.11±2.12	3.8904	<0.0001
<32	7(9.0)	1(1.3)	15.686	0.0013
32~<37	28(36.4)	13(16.3)		
37~<39	25(32.5)	35(43.8)		
≥39	17(22.1)	31(38.8)		
早产	35(45.5)	14(17.5)	17.093	<0.0001
分娩方式			10.16	0.0014
剖宫产	60(77.9)	43(53.8)		
顺产	17(22.1)	37(46.2)		
新生儿体重(g)	2135.45±653.24	2568.13±465.69	21.7346	<0.0001
新生儿窒息	10(13.0)	3(3.8)	4.408	0.0358
新生儿转 NICU	40(51.9)	20(25.0)	12.067	0.0005

3 讨论

3.1 FGR 合并 HDP 与妊娠结局的相关性 本研究提示, FGR 合并 HDP 孕妇的分娩孕周明显早于单纯 FGR 孕妇、单纯高血压孕妇及正常孕妇。考虑 FGR 合并 HDP 孕妇终止妊娠孕周提前的原因: (1) 与母体高血压疾病有关, 因 HDP 常合并多脏器功能损害, 积极治疗无效时, 终止妊娠是唯一有效的治疗措施。据报道, 与 HDP 相关的早产率约为 15%^[26]。(2) 与 FGR 有关, 本研究中单纯 FGR 孕妇的平均分娩孕周为[37.22(36.61~38.54)]周, 早于正常孕妇[39.07(38.29~39.86)]周, 差异亦较明显。FGR 合并 HDP 时, 母体因素可能加重了 FGR 的胎儿窘迫等不良预后的发生, 导致终止妊娠孕周提前, 并与新生儿平均体重降低有关。而 FGR 合并 HDP 时常因母体高血压疾病不能耐受分娩过程^[27], 另一方面 FGR 易导致胎儿窘迫^[28], 最终常以剖宫产术终止妊娠。本研究显示, FGR 合并 HDP 孕妇的剖宫产率为 92.3%, 显著高于单纯 HDP 孕妇(58.3%) 及单纯 FGR 孕妇(66.1%), 与 Cluver 等研究结果一致, 其 FGR 合并 HDP 组孕妇的剖宫产率可达 66.3%, 高于未并发 FGR 孕妇^[29]。新生儿转 NICU 率在 FGR 合并 HDP 组显著增加, 考虑可能与该组分娩孕周提前、新生儿体重减低等因素有关。

3.2 胎盘 MRI 灌注参数与 FGR 合并 HDP 的相关性 本研究提示, FGR 合并 HDP 孕妇的胎盘面积平均为(172.61±44.63)cm², 显著低于单纯 HDP 孕妇、单纯 FGR 孕妇及正常孕妇。FGR 合并 HDP 胎盘面积减小可能与 HDP 相关病理机制有关。HDP 时孕妇多有血管内皮损伤, 可使血管腔变窄^[30]、螺旋动脉

重塑障碍进而导致子宫-胎盘血管阻力增加^[31]、滋养层侵袭异常影响子宫血管扩张降低母体的胎盘血供,严重影响胎盘发育,使得胎盘绒毛数量减少,从而导致胎盘面积明显减小,与 FGR 发生密切相关。本研究中单纯 FGR 并未显示胎盘面积减小,这表明 FGR 的病因多样化,其中单纯 FGR 可能与母体的营养因素或者遗传等因素更相关^[32],因此与其他两组并未显示差异变化。

D 值指水分子单位时间内随机运动的范围,D 值的大小与组织细胞密度有关。临床上多用于肝纤维化分级^[33-34]。本研究显示,FGR 合并 HDP 孕妇与单纯 FGR 孕妇相比,胎盘的 D 值明显减低,如前所述考虑 FGR 合并 HDP 时不仅表现胎盘面积减小,同时 HDP 亦可发生血管重塑障碍、管壁增厚、血管壁纤维素样坏死、绒毛大片梗死钙化^[35]等多种原因导致的胎盘组织密度增加,细胞外间隙变小,单位时间内水分子的弥散范围减小。D*,即灌注弥散系数,主要反映毛细血管的微循环灌注,临床上常用于脑部胶质瘤的良恶性评价,高级别胶质瘤的 D* 值显著高于低级别胶质瘤^[36-37]。本研究中 4 组的 D* 值无统计学差异。Liu 等^[38]研究发现,17 例 FGR 及 28 例正常妊娠孕妇胎盘的 D* 值无差异,与本研究结果一致。D* 值的局限性在于无法显示 FGR 与非 FGR 胎盘微灌注的区别。目前最新研究表明,弥散衍生血管密度(diffusion-derived vessel density,DDVD)可用于反映胎盘组织内部的微灌注程度,尤其是在早发型 PE 并发 FGR 中^[18],但本研究未做相关深入研究。

f 值是体素内微循环灌注相关的扩散占总体扩散效应的百分率,与毛细血管血容量有关,而毛细血管血容量一般与毛细血管数量以及毛细血管管径有关。本研究提示,FGR 合并 HDP 孕妇胎盘的 f 值平均为(25.37±5.21)%,明显减低。FGR 合并 HDP 孕妇 f 值的降低可能与 HDP 时子宫螺旋动脉重塑异常使得血管壁平滑肌肥大、血管壁纤维素样坏死、血管粥样化、血管附壁血栓导致血管管径减小、血容量减少有关^[38],同时血管内皮功能损伤导致前列环素分泌减少,血栓素分泌增加,导致胎盘血管痉挛,使得血容量进一步减少^[39-40]。HDP 未并发 FGR 孕妇胎盘的 f 值无显著降低,考虑 HDP 未波及胎盘损害,因此并未影响胎儿正常生长。本研究提示,单纯 FGR 孕妇胎盘的 f 值低于正常孕妇,可能与胎盘发育早期绒毛及毛细血管面积的损伤有关,绒毛毛细血管数量的减少,可导致胎盘灌注异常,与 FGR 发生密切相关。Andescavage 等^[41]对 101 例正常孕妇和 36 例 FGR 孕妇进行 MRI 检查后分析胎盘灌注参数,发现

FGR 孕妇胎盘灌注的 f 值降低。Sohlberg 等^[42]在 35 例孕妇中,FGR 的胎盘灌注分数 f 明显小于正常妊娠(21% vs 32%),与本研究结果一致。

3.3 f 值与妊娠结局的关系 本研究提示,f 值异常组的收缩压、舒张压及 HDP 发生率均显著高于正常组(40.3% vs 25.0%),两组间 24h 尿蛋白定量无显著差异,考虑 f 值减低与肾脏功能损害可能并无明显相关性。f 值异常孕妇的 FGR 合并 HDP 发生率为 36.4%、FGR 发生率为 84.4%,均高于 f 值正常组孕妇,f 值异常组的早产率、新生儿窒息率以及新生儿转 NICU 率明显增加。f 值反映了胎盘灌注的状态,f 值异常与母体高血压疾病以及 FGR 发生有关,同时与母儿不良预后密切相关。

综上所述,FGR 合并 HDP 时,胎盘灌注相关参数中胎盘面积减小、弥散系数降低、灌注分数减小。其中胎盘灌注分数的减低常与母体高血压疾病和 FGR 相伴发生,并与剖宫产、早产、新生儿窒息、新生儿转 NICU 等不良结局密切相关。因此,针对 HDP 及并发 FGR 的孕妇,除了通过多普勒超声测量胎儿重要血管频谱的变化监测胎儿宫内状态,亦可增加胎盘 MRI 检查直接提供反映胎盘功能的相关参数,尤其应关注 f 值的变化,有助于为临床加强母胎管理,减少不良妊娠结局提供依据。

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第一作者简介: 张鑫 (1998-), 女, 南京医科大学第一临床医学院妇产科专业型研究生。主要研究方向: 妊娠期高血压疾病并发胎儿生长受限。