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# 高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查的相关性研究\*

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**摘要 目的:**探讨与研究高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查的相关性。**方法:**2018年2月到2020年1月在本医院进行建档分娩的高危孕妇108例作为研究对象,都给予彩色多普勒超声结合四维超声检查,记录影像学特征,判定胎儿缺氧发生情况并进行相关性分析。**结果:**在108例中,发生宫内缺氧28例(宫内缺氧组),发生率为25.9%;宫内缺氧组的大脑中动脉、脐动脉的阻力指数(RI)、搏动指数(PI)、收缩期峰值流速舒张期流速比值(S/D)均高于非宫内缺氧组( $P<0.05$ );宫内缺氧组的上腔静脉血流心室收缩期峰值流速(S波)、心房收缩期速度(A波)、心室舒张期峰值流速(D波)均高于非宫内缺氧组( $P<0.05$ );高危孕妇108例中,Spearsman分析显示大脑中动脉、脐动脉的RI、PI、S/D以及上腔静脉血流S、D、A均与宫内缺氧都存在相关性( $P<0.05$ );logistic多因素回归分析显示:大脑中动脉、脐动脉的S/D与上腔静脉血流S、A为导致胎儿缺氧的主要影响因素( $P<0.05$ )。**结论:**高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查特征具有相关性,彩色多普勒超声结合四维超声可作为检查胎儿缺氧的可行、简单无创、方便快捷的方式,具有极高的应用价值。

**关键词:**高危孕妇;胎儿缺氧;彩色多普勒;四维超声

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## Correlation Study of High-risk Pregnant Women with Fetal Hypoxia and Color Doppler Ultrasound Combined with Four-dimensional Ultrasound\*

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**ABSTRACT Objective:** To explore and study the correlation between high-risk pregnant women and fetal hypoxia and color Doppler ultrasound combined with four-dimensional ultrasound. **Methods:** February 2018 to January 2020, 108 cases of high-risk pregnant women who were filed deliveries in our hospital were selected. All the cases were all given color Doppler ultrasound combined with four-dimensional ultrasound, recorded the imaging characteristics and determined the occurrence of fetal hypoxia. And carried out correlation analysis. **Results:** There were 28 cases of intrauterine hypoxia occurred (intrauterine hypoxia group) in the 108 cases, the incidence were 25.9 %. The resistance index (RI), pulsation index (PI), the peak systolic flow velocity and the diastolic flow velocity ratio (S/D) of the middle cerebral artery and the umbilical artery in the intrauterine hypoxia group were higher than those of the non-intrauterine hypoxia group ( $P<0.05$ ). The superior vena cava blood flow ventricular systolic peak velocity (S wave), atrial systolic velocity (a wave) and ventricular diastolic peak flow velocity (D wave) in the intrauterine hypoxia group were higher than those in the non-intrauterine hypoxia group ( $P<0.05$ ). In the 108 high-risk pregnant women, Spearsman analysis showed that the RI, PI, S/D of the middle cerebral artery and umbilical artery, blood flow S, D, A of the superior vena cava were correlated with the intrauterine hypoxia ( $P<0.05$ ). The logistic multivariate regression analysis showed that the S/D of the middle cerebral artery and the umbilical artery and the blood flow of the superior vena cava S and A were the main influencing factors of fetal hypoxia ( $P<0.05$ ). **Conclusion:** Fetal hypoxia in high-risk pregnant women are correlated with the characteristics of color Doppler ultrasound combined with four-dimensional ultrasound. Color Doppler ultrasound combined with four-dimensional ultrasound can be feasible, simple, non-invasive, convenient and quick way to detect fetal hypoxia, and have very good application values.

**Key words:** High-risk pregnant women; Fetal hypoxia; Color Doppler; Four-dimensional ultrasound

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### 前言

随着我国二胎分娩制度的实施,当前高龄孕妇逐渐增多导

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致高危孕妇比例增加,其中胎儿宫内缺氧已成为产科较为常见的产后并发症<sup>[1,2]</sup>。胎儿宫内缺氧是导致胎儿宫内发育迟缓、围生期死亡、胎死宫内的主要原因之一,多数发生在孕妇妊娠晚期以及分娩过程中<sup>[3,4]</sup>。胎儿缺氧的具体发病机制尚不明确,但与脐带发育异常、胎儿心脏畸形、母体血液含氧量不足等有关,对胎儿宫内缺氧进行早期预测具有重要价值<sup>[5]</sup>。现代研究表明:胎儿宫内缺氧时,胎儿大脑中动脉(Middle cerebral artery, MCA)与脐动脉(Umbilical artery, UA)血流阻力指标会发生相应改变,为此通过检查血流阻力指标的实时动态变化,可有效预测胎儿母体情况<sup>[6,7]</sup>。另有学者报道发现,胎儿宫内窘迫的胎儿缺血缺氧性损伤程度与脐血流超声参数存在一定的关联性<sup>[8,9]</sup>。随着影像学技术的发展,四维超声得到了广泛应用,可对胎儿心脏多个切面进行动态、直观、全方位检查,更充分地显示胎儿心脏解剖立体结构,有利于胎儿安全性的检查<sup>[10,11]</sup>。彩色多普勒超声也可细化胎儿的动脉血管状况,对胎儿宫内状态和生长发育状况进行判定<sup>[12,13]</sup>。同时在产科诊断中,超声诊断已成为必不可少的检查的项目之一<sup>[14]</sup>。本文探讨与研究了高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查的相关性。

## 1 资料与方法

### 1.1 研究对象

2018年2月到2020年1月在本院进行建档分娩的高危孕妇108例作为研究对象。

纳入标准:孕妇年龄 $\geq 30$ 岁;单胎活妊娠;孕周32-38周;孕妇精神状态、身体状态正常;本院伦理委员会批准了此次研究;签署知情同意书。

排除标准:多胎妊娠孕妇;胎膜已破裂或早破的孕妇;图像显示不清晰者。

### 1.2 彩色多普勒超声结合四维超声检查方法

采用GE E8彩色多普勒超声仪,配有四维探头。所有患者均先进行彩色多普勒超声检查,设置频率为4-8 MHz,嘱咐孕

妇屏住呼吸,胎儿身体静止时,在二维模式下以标准切面显示胎儿心脏,以四腔心为采集初始平面获取胎儿容积信息,扫描时间10.0 s-12.5 s。采集角度 $25^{\circ}$ - $30^{\circ}$ 。发现大脑中动脉、脐动脉血流波形稳定且听到血流声后,冻结波段,测定与记录胎儿大脑中动脉、脐动脉的阻力指数(Resistance index, RI)、搏动指数(Pulsatility Index, PI)、收缩期峰值流速舒张期流速比值(S/D)。

在四维超声中,采用空间时间相关成像技术,获取孕妇最佳图像后,启动脱机分析软件,选取最佳图像以多切面成像模式和断层超声成像模式显示四腔心、左右室流出道、血管气管平面,测定胎儿上腔静脉血流频谱状况,包括心室收缩期峰值流速(S波)、心房收缩期速度(A波)、心室舒张期峰值流速(D波)等。由两位具有丰富经验的专业医师诊断超声图检查结果,并达成一致诊断意见。

### 1.3 胎儿缺氧判断标准

符合以下条件之一,可判断为胎儿缺氧:胎心率 $>160$ 次/min或 $<120$ 次/min;羊水检查II度污染;反复出现变异减速;新生儿Apgar评分 $\leq 7$ 分<sup>[15]</sup>。

### 1.4 统计方法

采用SPSS19.00进行分析,计量数据以 $(\bar{x} \pm s)$ 表示,对比为t检验,计数数据以(n/%)表示,对比为卡方 $\chi^2$ 检验,相关性分析采用Spearsman分析,影响因素分析采用logistic多因素回归分析,检验水准为 $\alpha=0.05$ 。

## 2 结果

### 2.1 胎儿缺氧发生情况

在高危孕妇108例中,发生宫内缺氧28例(宫内缺氧组),发生率为25.9%。

### 2.2 一般资料对比

宫内缺氧组的孕周、年龄、孕次、产次、收缩压、舒张压等与非宫内缺氧组对比差异无统计学意义( $P>0.05$ )。见表1。

表1 两组一般资料对比 $(\bar{x} \pm s)$

Table 1 Comparison of general data between the two groups $(\bar{x} \pm s)$

| Groups                         | n  | Gestational age (weeks) | Age (years)      | Number of pregnancies (times) | Yield (times)   | Systolic blood pressure (mmHg) | Diastolic blood pressure (mmHg) |
|--------------------------------|----|-------------------------|------------------|-------------------------------|-----------------|--------------------------------|---------------------------------|
| Intrauterine hypoxia group     | 28 | 36.21 $\pm$ 1.15        | 30.28 $\pm$ 1.73 | 2.39 $\pm$ 0.35               | 1.43 $\pm$ 0.25 | 124.87 $\pm$ 13.76             | 78.98 $\pm$ 6.79                |
| Non-intrauterine hypoxia group | 80 | 36.29 $\pm$ 1.58        | 30.33 $\pm$ 1.11 | 2.40 $\pm$ 0.26               | 1.44 $\pm$ 0.18 | 124.20 $\pm$ 14.68             | 79.00 $\pm$ 7.17                |
| t                              |    | 0.144                   | 0.098            | 0.034                         | 0.056           | 0.633                          | 0.065                           |
| P                              |    | 0.892                   | 0.924            | 0.978                         | 0.967           | 0.452                          | 0.945                           |

### 2.3 彩色多普勒超声指标对比

宫内缺氧组的大脑中动脉、脐动脉的RI、PI、S/D值都高于非宫内缺氧组( $P<0.05$ )。见表2。

### 2.4 四维超声指标对比

宫内缺氧组的上腔静脉血流S、D、A值都高于非宫内缺氧组( $P<0.05$ )。见表3。

### 2.5 相关性分析

在高危孕妇108例中,Spearsman分析显示大脑中动脉、脐动脉的RI、PI、S/D以及上腔静脉血流S、D、A均与宫内缺氧组存在相关性( $P<0.05$ )。见表4。

### 2.6 影响因素分析

在高危孕妇108例中,logistic多因素回归分析显示大脑中动脉、脐动脉的S/D与上腔静脉血流S、A为导致胎儿缺氧的主要因素( $P<0.05$ )。见表5。

表 2 两组彩色多普勒超声指标对比( $\bar{x} \pm s$ )

Table 2 Comparison of color Doppler ultrasound indexes between the two groups ( $\bar{x} \pm s$ )

| Groups                         | n  | Middle cerebral artery |            |            | Umbilical artery |            |            |
|--------------------------------|----|------------------------|------------|------------|------------------|------------|------------|
|                                |    | RI(cm/s)               | PI(cm/s)   | S/D        | RI(cm/s)         | PI(cm/s)   | S/D        |
| Intrauterine hypoxia group     | 28 | 0.78± 0.10             | 1.78± 0.11 | 4.57± 0.35 | 0.78± 0.13       | 1.34± 0.22 | 4.02± 0.34 |
| Non-intrauterine hypoxia group | 80 | 0.60± 0.09             | 1.54± 0.15 | 3.78± 0.42 | 0.65± 0.09       | 1.09± 0.18 | 3.54± 0.27 |
| t                              |    | 10.482                 | 8.988      | 14.294     | 7.873            | 9.884      | 10.753     |
| P                              |    | <0.001                 | <0.001     | <0.001     | <0.001           | <0.001     | <0.001     |

表 3 两组四维超声指标对比( $\text{cm/s}, \bar{x} \pm s$ )

Table 3 Comparison of 4-d ultrasonic indexes between the two groups ( $\text{cm/s}, \bar{x} \pm s$ )

| Groups                         | n  | S           | D           | A           |
|--------------------------------|----|-------------|-------------|-------------|
| Intrauterine hypoxia group     | 28 | 55.69± 3.48 | 30.58± 0.33 | 23.85± 1.66 |
| Non-intrauterine hypoxia group | 80 | 52.48± 4.19 | 28.98± 1.45 | 25.09± 2.27 |
| t                              |    | 9.852       | 8.482       | 9.113       |
| P                              |    | <0.001      | 0.007       | <0.001      |

表 4 高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查的相关性(n=108)

Table 4 Correlation between fetal hypoxia in high-risk pregnant women and color Doppler ultrasound combined with four-dimensional ultrasound (n=108)

| Items | Middle cerebral artery |       |       | Umbilical artery |       |        | S      | D     | A      |
|-------|------------------------|-------|-------|------------------|-------|--------|--------|-------|--------|
|       | RI                     | PI    | S/D   | RI               | PI    | S/D    |        |       |        |
| r     | 0.466                  | 0.511 | 0.567 | 0.484            | 0.533 | 0.724  | 0.672  | 0.496 | 0.699  |
| P     | 0.023                  | 0.010 | 0.004 | 0.018            | 0.007 | <0.001 | <0.001 | 0.016 | <0.001 |

表 5 影响高危孕妇胎儿缺氧发生的 logistic 多因素回归分析(n=108)

Table 5 Logistic multivariate regression analysis of fetal hypoxia in high-risk pregnant women (n=108)

| Items                      | $\beta$ | SE    | P     | OR    | 95%CI       |
|----------------------------|---------|-------|-------|-------|-------------|
| Middle cerebral artery S/D | 0.204   | 0.111 | 0.032 | 1.355 | 1.144-1.762 |
| Umbilical artery S/D       | 0.579   | 0.142 | 0.020 | 1.782 | 1.324-2.503 |
| S                          | 0.480   | 0.143 | 0.015 | 1.652 | 1.119-2.184 |
| A                          | 0.420   | 0.180 | 0.018 | 1.562 | 1.099-2.196 |

### 3 讨论

因各种因素的影响,高龄孕妇数量大幅度增多,高危孕妇也相应增多,同时也增加胎儿宫内缺氧的发生几率<sup>[15]</sup>。胎儿宫内缺氧是导致新生儿窒息的重要因素,即使存活的新生儿也会有部分出现智力发育欠缺等,因此早期预测宫内缺氧发生具有重要价值。缺氧胎儿不同程度出现伤残为 16.0 %左右,由围产期缺氧引起的占比为 30.0 %左右<sup>[16,17]</sup>。当前学者认为胎儿缺氧的原因较多,孕期感染、糖尿病、吸烟、妊娠期间接触电磁辐射、不当使用抗生素药物、近亲结婚等为重要病因<sup>[18]</sup>。

近几年,胎儿超声技术逐渐发展并得到了广泛应用,主要应用于胎儿的产前诊断与随访等<sup>[19]</sup>。特别是彩色多普勒超声技

术可实时显示血管内血流状况,胎儿血流动力学指标可直接反映胎盘、胎儿及脑循环血流动力学特征<sup>[20,21]</sup>。本研究显示:在 108 例高危孕妇中,发生宫内缺氧 28 例(宫内缺氧组),发生率为 25.9 %;宫内缺氧组的大脑中动脉、脐动脉的 RI、PI、S/D 值均高于非宫内缺氧组,表明高危孕妇胎儿缺氧多伴随有 RI、PI、S/D 值升高。这一结果与马超等人<sup>[22]</sup>以及 Tao J<sup>[23]</sup>等人的研究具有一致性,即宫内缺氧时,脐动脉指标出现异常的同时,胎儿大脑中动脉血流速度也随之产生变化,导致大脑中动脉 RI、PI、S/D 值升高。从机制上分析原因:RI、PI、S/D 可有效反映机体的血流阻力情况,其中 RI 可反映血管的阻力状态,PI 可反映血流速率变化,PI 值升高时,表明血流速率减缓;RI 值升高表明机体血管阻力增加;S/D 中的 D 代表舒张末期流速,可反映胎盘血管阻

力;S代表收缩期峰值流速,可反映血流量,S/D可反映出胎盘血供及外周阻力情况<sup>[24,25]</sup>。RI、PI、S/D升高表明孕妇机体血管阻力增加,致使胎盘血供不足,降低了血流速率,进而加重了胎儿缺血缺氧性损伤程度<sup>[26]</sup>。脐动脉是连接胎盘与胎儿的纽带,对胎儿的生长发育至关重要。与普通动脉血流相同,脐动脉也受心脏收缩力影响。当增大血管末端阻力,舒张期血流将会降低,并消失为负性血流;当阻力较小时,也会存在舒张期血流<sup>[27]</sup>。在正常妊娠期中,孕妇于妊娠后期绒毛间隙扩大,子宫胎盘床出现高速低阻力血液循环,致使局部血流量增多。胎儿宫内缺氧可促使血管腔变窄,阻碍胎儿与胎盘间的各项物质循环,减少脐动脉舒张末期血流量,从而升高脐动脉 RI、PI、S/D 值升高<sup>[28]</sup>。

胎儿缺氧仍是产前筛查中易漏诊的疾病。常规彩色多普勒超声虽在一定程度上能检出胎儿缺氧,但在诊断的重复性、可靠性还有一定的不足<sup>[29]</sup>。四维超声空间时间相关成像技术主要包括容积数据库采集和后期脱机分析,弥补彩色多普勒超声成像检查胎儿宫内缺氧的缺点,可动态四维超声成像,并将时间因素加入数据采集中,从而完整、直观、立体地分析诊断胎儿宫内缺氧<sup>[30]</sup>。四维超声还可进行图像重建,降低技术依赖性,具有操作时间短、简便易行等特点,进而降低漏诊率。胎儿上腔静脉是与胎儿右心连接的主要静脉,而静脉导管是胎儿时期特有的血管之一。本研究显示:宫内缺氧组的上腔静脉血流 S、D、A 值均高于非宫内缺氧组。这一结果与 Turan S 等人<sup>[31]</sup>具有一致性,即胎儿缺氧其上腔静脉血流 S、D、A 值均升高,四维超声可用于检测胎儿状况。进一步分析其原因可知,当胎儿出现宫内缺氧时,心功能首先受到影响,并表现为舒张功能的变化,而上腔静脉血流频谱的变化可较好的反应胎儿的右心室舒张功能。四维超声可准确反映胎儿右心舒张功能的变化情况,也为判断胎儿缺氧提供了基础<sup>[31]</sup>。

胎儿缺氧是妊娠期及分娩期内一种危重并发症,临床表现为胎动异常、胎心变化、羊水胎粪污染等。若不及时进行干预,将严重影响胎儿的生长发育,加重胎儿缺氧程度,严重情况下可导致胎儿病死<sup>[32]</sup>。本研究 Spearsman 分析显示:高危孕妇的大脑中动脉、脐动脉的 RI、PI、S/D 及上腔静脉血流 S、D、A 与宫内缺氧均存在相关性;logistic 多因素回归分析显示:大脑中动脉、脐动脉的 S/D 及上腔静脉血流 S、A 为导致胎儿缺氧的主要影响因素。这一结果与陈文显等人<sup>[33]</sup>以及 Cui H<sup>[34]</sup>等人的报道具有一致性。分析原因可知:彩色多普勒超声可明确胎盘循环阻力状况,有效掌握胎儿在孕妇体内供血、供养等状况。当阻力水平明显增加后,对孕妇胎盘供血造成负面影响,血流量会相应降低,造成胎儿缺氧。当胎儿出现缺氧后,其大脑中动脉与脐动脉出现扩张现象,从而造成血流量上升,使得 S/D 出现异常。特别是宫内长期低血氧环境会使分娩时宫缩增强,引发缺氧、缺血状况,对围产儿造成严重的负面影响。四维超声可提高产前胎儿缺氧诊断准确性,有效弥补彩色多普勒超声诊断不精确的缺点,具有较高的辅助诊断价值<sup>[33-35]</sup>。但本研究也存在一定的不足,本文是以正常中晚孕胎儿为主要研究对象,其样本数较少,未设置正常妊娠组,将在后续研究中进行探讨。

总之,高危孕妇胎儿缺氧与彩色多普勒超声结合四维超声检查特征具有相关性,彩色多普勒超声结合四维超声可作为检查胎儿缺氧的准确可行、简单无创、方便快捷的特点,具有极高

的临床应用价值。

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