·论著·

血清vWF、MCP-1、GDF-15联合检测对凶险性前置胎盘患者产后出血的预测价值

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摘要 **目的** 探讨血清血管性血友病因子（vWF）、单核细胞趋化蛋白-1（MCP-1）、生长分化因子-15（GDF-15）联合检测对凶险性前置胎盘（PPP）患者产后出血的预测价值。**方法** 选取我院2021年1月至2024年1月收治的PPP患者112例（研究组），将其分为产后出血组和非产后出血组，并选取同期胎盘位置正常孕妇112例（对照组），用ELISA检测血清vWF、MCP-1、GDF-15水平。**结果** 研究组血清vWF、MCP-1、GDF-15水平显著高于对照组（$P < 0.05$）。产后出血组PPP患者血清vWF、MCP-1、GDF-15水平显著高于非产后出血组PPP患者（$P < 0.05$）。logistic回归分析发现，vWF、MCP-1、GDF-15为PPP产后出血的影响因素（$P < 0.05$）。血清vWF、MCP-1、GDF-15三者联合检测预测PPP产后出血优于单独检测（$P < 0.05$）。**结论** 血清vWF、MCP-1、GDF-15联合检测对PPP产后出血有一定的预测价值。

关键词 血管性血友病因子；单核细胞趋化蛋白-1；生长分化因子-15；凶险性前置胎盘；产后出血；预测
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Predictive value of combined detection of serum vWF, MCP-1, and GDF-15 for postpartum hemorrhage in patients with pernicious placenta previa

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Abstract **Objective** To investigate the predictive value of the combined detection of serum von Willebrand factor (vWF), monocyte chemotactic protein-1 (MCP-1), and growth differentiation factor-15 (GDF-15) for postpartum hemorrhage in patients with pernicious placenta previa (PPP). **Methods** One hundred and twelve patients with PPP admitted to our hospital between January 2021 and January 2024 were selected as the study group. They were further divided into a postpartum hemorrhage group and a non-postpartum hemorrhage group and 112 pregnant women with normal placental position during the same period were selected as the control group. ELISA was used to detect serum vWF, MCP-1, and GDF-15 levels. **Results** Serum vWF, MCP-1, and GDF-15 levels were significantly higher in the study group than in the control group ($P < 0.05$). Serum vWF, MCP-1, and GDF-15 levels were significantly higher in the postpartum hemorrhage group than in the non-postpartum hemorrhage group ($P < 0.05$). Logistic regression analysis identified vWF, MCP-1, and GDF-15 levels as factors influencing postpartum hemorrhage for women with PPP ($P < 0.05$). The combination of serum vWF, MCP-1, and GDF-15 predicted postpartum hemorrhage in women with PPP better than either factor alone ($P < 0.05$). **Conclusion** Combined detection of serum vWF, MCP-1, and GDF-15 levels has predictive value for postpartum hemorrhage in women with PPP.

Keywords von Willebrand factor; monocyte chemotactic protein-1; growth differentiation factor-15; pernicious placenta previa; postpartum hemorrhage; prediction

凶险性前置胎盘（pernicious placenta previa，PPP）是剖宫产术后再次妊娠时发生的一种较严重的并发症，主要原因是再次妊娠时胎盘植入到原剖宫产切口部位，引起产后出血、子宫穿孔、感染等，从而增加母体子宫切除等风险[1-2]。根据胎盘植入深度，PPP可分为不同类型，其妊娠结局也不同，其中植入型和穿透型PPP发生产后出血的概率较高[3]。早期判断PPP患者产后出血的可能性，有助于临床治疗并降低患者的死亡风险，因此，寻找与PPP患者产后出血有关的标志物对改善患者预后尤为重要。

血管性血友病因子（von Willebrand factor，vWF）主要由血管内皮细胞分泌，其表达水平与血栓形成前状态有关，水平升高时可促进血小板聚集在血管损伤部位，影响血栓形成[4]。单核细胞趋化蛋白-1

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（monocyte chemoattractant protein-1，MCP-1）作为趋化因子家族一员，参与炎症疾病以及单核细胞浸润等，还能导致凝血功能障碍[5]。生长分化因子-15（growth differentiation factor-15，GDF-15）作为前体蛋白，可参与机体炎症、组织损伤等，还是与出血有关的指标[6]。目前关于血清vWF、MCP-1、GDF-15在PPP患者产后出血中的研究鲜有报道，因此，本研究探讨了血清vWF、MCP-1、GDF-15检测对PPP患者产后出血的预测价值。

1　材料与方法

1.1　临床资料

选取2021年1月至2024年1月我院收治的PPP患者112例作为研究组。纳入标准：符合PPP诊断标准[7]；经超声及病理检查确诊；单胎妊娠；行剖宫产分娩；资料完整；家属签署知情同意书。排除标准：免疫系统疾病；重要脏器功能障碍；重度贫血；既往有子宫肌瘤剥除术史；入院前服用影响血流动力学的药物。另选取同期同孕周及胎盘位置正常的孕妇112例作为对照组。本研究获得我院伦理委员会批准（伦理批号2022YX088）。

1.2　方法

1.2.1　血清vWF、MCP-1、GDF-15水平检测：采集研究对象空腹静脉血5 mL，分离血清后取上清液，按照ELISA试剂盒（购自武汉菲恩生物科技有限公司）说明书检测血清vWF、MCP-1、GDF-15水平。使用酶标仪检测吸光度值，绘制标准品的标准曲线，计算血清浓度。

1.2.2　产后出血评估[8]：在胎儿娩出后24 h内出血量≥1 000 mL定义为产后出血。根据是否发生产后出血，将研究组PPP患者再分为产后出血组（n = 47）和非产后出血组（n = 65）。

1.3　统计学分析

采用SPSS 25.0软件进行统计学分析。符合正态分布的计量资料以$\bar{x} \pm s$表示，采用t检验比较。计数资料以率（%）表示，采用χ^2检验比较。采用多因素logistic回归分析PPP患者产后出血的影响因素。绘制受试者操作特征（receiver operating characteristic curve，ROC）曲线，分析血清vWF、MCP-1、GDF-15联合检测对PPP产后出血的预测价值。P < 0.05为差异有统计学意义。

2　结果

2.1　研究组和对照组血清vWF、MCP-1、GDF-15水平及一般资料的比较

研究组血清vWF、MCP-1、GDF-15水平显著高于对照组，差异有统计学意义（P < 0.05）。其他一般资料比较无统计学差异（P > 0.05），具有可比性。见表1。

2.2　产后出血组和非产后出血组血清vWF、MCP-1、GDF-15水平及一般资料的比较

产后出血组血清vWF、MCP-1、GDF-15水平较非产后出血组显著增加，差异有统计学意义（P < 0.05）。其他一般资料比较，差异无统计学意义（P > 0.05）。见表2。

2.3　PPP患者产后出血的影响因素分析

以PPP患者产后是否出血作为因变量（是=1，否=0），以单因素分析有统计学差异的指标为自变量（vWF、MCP-1、GDF-15均为实测值，进行多因素logistic回归分析。结果显示，vWF、MCP-1、GDF-15为影响PPP患者产后出血的危险因素（P < 0.05）。见表3。

2.4　血清vWF、MCP-1、GDF-15联合检测对PPP患者产后出血的预测价值

将血清vWF、MCP-1、GDF-15作为检验变量，PPP产后出血情况作为状态变量，进行并联，根据ROC曲线得知，血清vWF、MCP-1、GDF-15预测PPP产后出血的曲线下面积（area under curve，AUC）为0.736、0.884、0.804，三者联合检测预测PPP产后出血的AUC为0.967，三者联合检测优于各自单独检测的预测价值（Z = 2.542、Z = 2.563、Z = 2.624，均P < 0.05），见图1、表4。

3　讨论

目前关于PPP的发病机制尚未明确，多认为可能由于基底蜕膜发育不良等造成胎盘植入异常，胎盘绒毛侵入肌层及邻近组织[9]。PPP是导致产后出血的主要原因，而临床上近50%围产期死亡是由产后出血所致[10]。研究[11]发现，胎盘植入后，其绒毛会侵入子宫肌层，造成胎儿娩出后胎盘不能与子宫壁分离，植入深度越深，孕产妇发生产后出血的风险越高。因此，寻找可预测PPP患者产后出血的指标以便进行治疗，可有效降低产后出血的发生率。

表1　研究组和对照组血清vWF、MCP-1、GDF-15水平及一般资料的比较

Tab.1　Comparison of serum vWF，MCP-1，and GDF-15 levels and general information between study and control groups

Item	Control group (n = 112)	Research group (n = 112)	t/χ^2	P
Age (year)	32.20 ± 4.51	32.11 ± 4.55	0.149	0.882
Week of pregnancy (week)	36.71 ± 1.05	36.83 ± 1.07	1.553	0.122
Frequency of pregnancies (times)	3.04 ± 0.42	3.06 ± 0.45	0.344	0.731
Frequency of births (times)	2.20 ± 0.40	2.21 ± 0.39	0.189	0.850
Frequency of previous Caesarean sections (times)	1.48 ± 0.33	1.46 ± 0.31	0.467	0.641
Time since last birth (month)	19.33 ± 3.12	19.30 ± 3.15	0.072	0.943
Smoking history [n (%)]	17 (15.18)	19 (16.96)	0.132	0.716
Drinking history [n (%)]	12 (10.71)	15 (13.39)	0.379	0.538
Assisted reproduction [n (%)]			0.154	0.695
Yes	16 (14.29)	14 (12.50)		
No	96 (85.71)	98 (87.50)		
Obese [n (%)]			0.653	0.419
Yes	16 (14.29)	12 (10.71)		
No	96 (85.71)	100 (89.29)		
Pregnancy-related complication [n (%)]				
Hypertension in pregnancy	15 (13.39)	17 (15.18)	0.146	0.703
Gestational diabetes	18 (16.07)	20 (17.86)	0.646	0.422
Anemic	23 (20.54)	25 (22.32)	0.106	0.745
Hypothyroidism	12 (10.71)	14 (12.50)	0.174	0.677
vWF (μg/L)	89.64 ± 10.24	117.68 ± 16.46	15.308	<0.001
MCP-1 (mg/mL)	1.01 ± 0.20	2.36 ± 0.34	36.219	<0.001
GDF-15 (pg/mL)	3 865.59 ± 720.68	4 394.47 ± 837.72	5.065	<0.001

vWF, von Willebrand factor; MCP-1, monocyte chemoattractant protein-1; GDF-15, growth differentiation factor-15.

表2　产后出血组和非产后出血组血清vWF、MCP-1、GDF-15水平及一般资料的比较

Tab.2　Comparison of serum vWF，MCP-1，and GDF-15 levels and general information between the postpartum hemorrhage group and the non-postpartum hemorrhage group

Item	Non-postpartum hemorrhage group (n = 65)	Postpartum hemorrhage group (n = 47)	t/χ^2	P
Age (year)	32.14 ± 4.52	32.08 ± 4.60	0.069	0.945
Week of pregnancy (week)	36.78 ± 1.05	36.91 ± 1.10	0.084	0.933
Frequency of pregnancies (times)	3.04 ± 0.41	3.08 ± 0.50	0.464	0.643
Frequency of births (times)	2.19 ± 0.36	2.23 ± 0.43	0.535	0.594
Frequency of previous Caesarean sections (times)	1.43 ± 0.28	1.51 ± 0.35	1.343	0.182
Time since last birth (month)	19.16 ± 3.12	19.49 ± 3.20	0.543	0.586
Smoking history [n (%)]	10 (15.38)	9 (19.15)	0.274	0.600
Drinking history [n (%)]	7 (10.77)	8 (17.02)	0.919	0.338
Assisted reproduction [n (%)]			1.514	0.219
Yes	6 (9.23)	8 (17.02)		
No	59 (90.77)	39 (82.98)		
Obese [n (%)]			1.479	0.224
Yes	5 (7.69)	7 (14.89)		
No	60 (92.31)	40 (85.11)		
Complications of pregnancy [n (%)]				
Premature rupture of the membranes of the foetus	14 (21.54)	9 (19.15)	0.095	0.757
Abruption of the placenta	19 (29.23)	14 (29.79)	0.004	0.949

（续表）

Item	Non-postpartum hemorrhage group (n = 65)	Postpartum hemorrhage group (n = 47)	t/χ^2	P
Excessive amniotic fluid	16 (24.62)	11 (23.40)	0.022	0.882
Pregnancy-related complications [n (%)]				
Hypertension in pregnancy	9 (13.85)	8 (17.02)	0.214	0.644
Gestational diabetes	10 (15.38)	10 (21.28)	0.646	0.422
Anemic	12 (18.46)	13 (27.66)	1.331	0.249
Hypothyroidism	8 (12.31)	6 (12.77)	0.005	0.942
Depth of placental implantation [n (%)]				
Agglutinative	24 (36.92)	12 (25.53)	1.623	0.203
Implantable	22 (33.85)	16 (34.04)	0.000	0.983
Penetrating	19 (29.23)	19 (40.43)	1.525	0.217
vWF (μg/L)	102.53 ± 13.65	138.64 ± 20.34	11.242	<0.001
MCP-1 (mg/mL)	1.26 ± 0.28	3.89 ± 0.42	39.754	<0.001
GDF-15 (pg/mL)	4 126.37 ± 824.31	4 765.24 ± 856.27	3.983	<0.001

表3　PPP患者产后出血的影响因素分析

Tab.3　Analysis of factors influencing postpartum hemorrhage in patients with PPP

Item	β	SE	Wald	P	OR	95%CI
vWF	1.240	0.369	11.299	<0.001	3.457	1.677–7.125
MCP-1	1.275	0.245	27.086	<0.001	3.579	2.214–5.785
GDF-15	1.436	0.356	16.266	<0.001	4.203	2.092–8.445

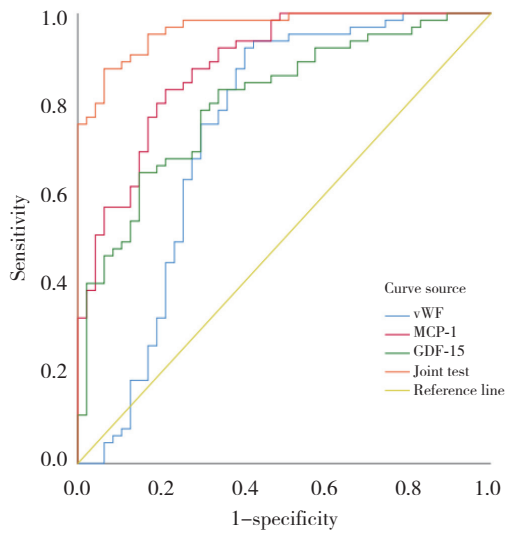


图1　血清vWF、MCP-1、GDF-15联合检测对PPP患者产后出血的预测价值

Fig.1　Predictive value of combined serum vWF, MCP-1 and GDF-15 detection for postpartum hemorrhage in patients with PPP

vWF作为多聚体糖蛋白，主要由血管内皮及巨核细胞合成释放，当内皮细胞发生损伤时，会被大量释放入血，从而促进血小板黏附和聚集，诱导血栓形成[12]。vWF还可破坏血管内皮细胞机能，提高血小板和凝血因子活性，增加血栓形成的风险[13]。作为影响血栓形成和止血过程的蛋白质，vWF水平能反映血小板活化情况[14]。有研究[15]发现，在女性妊娠期和产后出血时，监测vWF水平的变化可有效降低产后出血风险。

MCP-1作为CC趋化家族的成员，可结合血液中的单核细胞，造成超氧阴离子和溶酶体酶释放，并促进单核细胞转化为巨噬细胞，且激活的单核细胞与内皮细胞黏附后侵入血管内膜，造成大量炎性细胞因子释放，从而促进血管斑块形成[16]。MCP-1还可调节巨噬细胞的吞噬功能、促进细胞凋亡，参与机体炎症反应[17]。MCP-1有较强的趋化活性，能抑制机体血液循环，破坏人体细胞组织，并加剧免疫功能损伤[18]。研究[19]发现，患者发生产后出血时，血清MCP-1水平明显升高。

表4　血清vWF、MCP-1、GDF-15联合检测预测PPP患者产后出血的价值

Tab.4　The value of combined serum vWF，MCP-1，and GDF-15 testing to predict postpartum hemorrhage in patients with PPP

Item	AUC	95%*CI*	Sensitivity (%)	Specificity (%)	Cut-off value
vWF	0.736	0.630–0.842	76.16	78.34	123.254 μg/L
MCP-1	0.884	0.822–0.945	81.35	77.12	3.124 mg/mL
GDF-15	0.804	0.724–0.885	83.38	75.34	4 568.598 pg/mL
Joint test	0.967	0.940–0.994	95.46	73.52	–

GDF-15作为一种应激诱导的细胞因子，在组织损伤等刺激下，水平明显上调[20]。GDF-15还与炎症及巨噬细胞活化有关，冠状动脉粥样硬化性心脏病患者因心脏压力负荷增加，缺氧缺血条件下可促使p53活化并引诱释放GDF-15[21]。血浆GDF-15水平升高与冠状动脉疾病患者出血结局风险增加有关，可能成为评估出血结局的标志物[22]。血清GDF-15水平升高与心房颤动患者抗凝治疗出血风险增加呈正比，可作为预测其出血的标志物[23]。血清GDF-15是冠状动脉粥样硬化性心脏病患者经皮冠状动脉介入治疗后发生出血风险的有效预测指标[22]。

本研究结果发现，研究组血清vWF、MCP-1、GDF-15水平较对照组显著升高，产后出血组PPP患者血清vWF、MCP-1、GDF-15水平显著高于非产后出血组，说明其可能参与PPP患者产后出血的发生。多因素logistic回归分析显示，vWF、MCP-1、GDF-15是影响PPP患者产后出血的危险因素，提示检测其水平变化可有效评估患者产后出血的风险。本研究还发现，血清vWF、MCP-1、GDF-15三者联合检测对PPP患者产后出血的预测价值优于单独检测，表明三者联合检测可提高对PPP患者产后出血的预测价值，为临床医师及时诊治PPP提供参考。

综上所述，PPP患者血清vWF、MCP-1、GDF-15水平均显著升高，且与PPP患者产后出血有关，三者联合检测可提高对PPP患者产后出血的预测价值。

参考文献：

[1] 王阳，赵岩. 初次妊娠患者发生前置胎盘的影响因素分析[J]. 中国医科大学学报，2021，50(5)：449-452. DOI：10.12007/j.issn.0258-4646.2021.05.013.

[2] WANG N，SHI DD，LI N，et al. Clinical value of serum VEGF and sFlt-1 in pernicious placenta previa[J]. Ann Med，2021，53(1)：2041-2049. DOI：10.1080/07853890.2021.1999492.

[3] 陈永露，刘照然，李心怡，等. 基于MRI征象预测凶险性前置胎盘患者子宫切除风险[J]. 中国医学影像学杂志，2022，30(8)：821-825，827. DOI：10.3969/j.issn.1005-5185.2022.08.014.

[4] MICHELS A，DWYER CN，MEWBURN J，et al. Von Willebrand factor is a critical mediator of deep vein thrombosis in a mouse model of diet-induced obesity[J]. Arterioscler Thromb Vasc Biol，2020，40(12)：2860-2874. DOI：10.1161/ATVBAHA.120.314690.

[5] KAPUSTIN RV，CHEPANOV SV，BABAKOV VN，et al. Maternal serum leptin，adiponectin，resistin and monocyte chemoattractant protein-1 levels in different types of diabetes mellitus[J]. Eur J Obstet Gynecol Reprod Biol，2020，254：284-291. DOI：10.1016/j.ejogrb.2020.09.050.

[6] PENCE BD. Growth differentiation factor-15 in immunity and aging[J]. Front Aging，2022，3：837575. DOI：10.3389/fragi.2022.837575.

[7] 中华医学会妇产科学分会产科学组. 前置胎盘的临床诊断与处理指南[J]. 中华妇产科杂志，2013，48(2)：148-150. DOI：10.3760/cma.j.issn.0529-567x.2013.02.016.

[8] 谢幸，孔北华，段涛. 妇产科学[M]. 9版. 北京：人民卫生出版社，2018：153-155.

[9] 周露. 凶险性前置胎盘患者血浆hPL mRNA表达水平及其对并发产后大出血的预测价值[J]. 现代医学，2022，50(3)：348-353. DOI：10.3969/j.issn.1671-7562.2022.03.015.

[10] DU LL，FENG L，BI SL，et al. Probability of severe postpartum hemorrhage in repeat Cesarean deliveries：a multicenter retrospective study in China[J]. Sci Rep，2021，11(1)：8434. DOI：10.1038/s41598-021-87830-7.

[11] MA YS，YOU Y，JIANG XQ，et al. Use of nitroglycerin for parallel transverse uterine cesarean section in patients with pernicious placenta previa and placenta accrete and predicted difficult airway：a case report and review of literature[J]. Medicine，2020，99(5)：e18943. DOI：10.1097/MD.0000000000018943.

[12] 史瑞，温静，吴雯，等. 急性白血病患者化疗前后血清vWF，TM，FDP水平变化及其与预后的相关性[J]. 海南医学，2022，33(23)：3064-3067. DOI：10.3969/j.issn.1003-6350.2022.23.020.

[13] RAJPAL S，AHLUWALIA J，KUMAR N，et al. Elevated von Willebrand factor antigen levels are an independent risk factor for venous thromboembolism：first report from North India[J]. Indian J Hematol Blood Transfus，2019，35(3)：489-495. DOI：10.1007/s12288-019-01092-y.

[14] YANG JX，WU ZW，LONG Q，et al. Insights into immunothrombosis：the interplay among neutrophil extracellular trap，von Willebrand factor，and ADAMTS13[J]. Front Immunol，2020，11：610696. DOI：10.3389/fimmu.2020.610696.

[15] O'BRIEN SH，STANEK JR，KAUR D，et al. Laboratory monitoring during pregnancy and post-partum hemorrhage in women with von Willebrand disease[J]. J Thromb Haemost，2020，18(3)：604-608. DOI：10.1111/jth.14696.

[16] JIN ZN，LI Y，CHEN WB，et al. Correlation of HMGB1，PON-1，MCP-1，and periodontal *P. gingivalis* with amniotic fluid fecal dye[J].

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brain injury and its long-term impact for brain plasticity and function [J]. Pharmacol Res, 2024, 208: 107389. DOI: 10.1016/j.phrs.2024.107389.
[4] FESHARAKI-ZADEH A. Oxidative stress in traumatic brain injury [J]. Int J Mol Sci, 2022, 23 (21): 13000. DOI: 10.3390/ijms232113000.
[5] GARCIA-RENDUELES MER, VARELA L, HORVATH TL. Ghrelin [J]. Trends Endocrinol Metab, 2024, 35 (11): 1021-1022. DOI: 10.1016/j.tem.2024.07.002.
[6] MINGARDI J, MEANTI R, PAOLI C, et al. Ghrelin, neuroinflammation, oxidative stress, and mood disorders: what are the connections? [J]. Curr Neuropharmacol, 2025, 23 (2): 172-186. DOI: 10.2174/1570159X22999240722095039.
[7] GROSS JD, ZHOU Y, BARAK LS, et al. Ghrelin receptor signaling in health and disease: a biased view [J]. Trends Endocrinol Metab, 2023, 34 (2): 106-118. DOI: 10.1016/j.tem.2022.12.001.
[8] ERGUL ERKEC O, ACIKGOZ E, HUYUT Z, et al. Ghrelin ameliorates neuronal damage, oxidative stress, inflammatory parameters, and GFAP expression in traumatic brain injury [J]. Brain Inj, 2024, 38 (7): 514-523. DOI: 10.1080/02699052.2024.2324012.
[9] FESHARAKI-ZADEH A, DATTA D. An overview of preclinical models of traumatic brain injury (TBI): relevance to pathophysiological mechanisms [J]. Front Cell Neurosci, 2024, 18: 1371213. DOI: 10.3389/fncel.2024.1371213.
[10] ZHANG X, ZENG ZH, LIU YN, et al. Emerging relevance of ghrelin in programmed cell death and its application in diseases [J]. Int J Mol Sci, 2023, 24 (24): 17254. DOI: 10.3390/ijms242417254.
[11] LIPSKY RH, WITKIN JM, SHAFIQUE H, et al. Traumatic brain injury: molecular biomarkers, genetics, secondary consequences, and medical management [J]. Front Neurosci, 2024, 18: 1446076. DOI: 10.3389/fnins.2024.1446076.
[12] ORR TJ, LESHA E, KRAMER AH, et al. Traumatic brain injury: a comprehensive review of biomechanics and molecular pathophysiology [J]. World Neurosurg, 2024, 185: 74-88. DOI: 10.1016/j.wneu.2024.01.084.
[13] DEAN T, MENDIOLA AS, YAN ZQ, et al. Fibrin promotes oxidative stress and neuronal loss in traumatic brain injury via innate immune activation [J]. J Neuroinflammation, 2024, 21 (1): 94. DOI: 10.1186/s12974-024-03092-w.
[14] FU J, DU MR, WU BY, et al. CircRNA Itm2b induces oxidative stress via the interaction with Sirt1-Nox4 to aggravate sleep disturbances after traumatic brain injury [J]. Cell Biosci, 2025, 15 (1): 21. DOI: 10.1186/s13578-025-01353-6.
[15] LATINO D, VENDITTI M, FALVO S, et al. Steroidogenesis upregulation through mitochondria-associated endoplasmic reticulum membranes and mitochondrial dynamics in rat testes: the role of D-aspartate [J]. Cells, 2024, 13 (6): 523. DOI: 10.3390/cells13060523.
[16] SALMAN M, TABASSUM H, PARVEZ S. Tannic acid provides neuroprotective effects against traumatic brain injury through the PGC-1α/Nrf2/HO-1 pathway [J]. Mol Neurobiol, 2020, 57 (6): 2870-2885. DOI: 10.1007/s12035-020-01924-3.
[17] KIM M, KIM J, MOON S, et al. Korean red ginseng improves astrocytic mitochondrial function by upregulating HO-1-mediated AMPKα-PGC-1α-ERRα circuit after traumatic brain injury [J]. Int J Mol Sci, 2021, 22 (23): 13081. DOI: 10.3390/ijms222313081.

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J Healthc Eng, 2022, 2022: 3143102. DOI: 10.1155/2022/3143102.
[17] 张元秋, 曾萍, 周彦生, 等. 血MCP-1、PCT、免疫球蛋白在甲状腺癌患者术后感染并发症预测中的价值分析 [J]. 实用癌症杂志, 2021, 36 (7): 1181-1185. DOI: 10.3969/j.issn.1001-5930.2021.07.035.
[18] SALAH SM, MEISENHEIMER JD, RAO R, et al. MCP-1 promotes detrimental cardiac physiology, pulmonary edema, and death in the cpk model of polycystic kidney disease [J]. Am J Physiol Renal Physiol, 2019, 317 (2): F343-F360. DOI: 10.1152/ajprenal.00240.2018.
[19] GALLO DM, ROMERO R, BOSCO M, et al. Maternal plasma cytokines and the subsequent risk of uterine atony and postpartum hemorrhage [J]. J Perinat Med, 2022, 51 (2): 219-232. DOI: 10.1515/jpm-2022-0211.
[20] LARISSI K, POLITOU M, MARGELI A, et al. The growth differentiation factor-15 (GDF-15) levels are increased in patients with compound heterozygous sickle cell and beta-thalassemia (HbS/βthal), correlate with markers of hemolysis, iron burden, coagulation, endothelial dysfunction and pulmonary hypertension [J]. Blood Cells Mol Dis, 2019, 77: 137-141. DOI: 10.1016/j.bcmd.2019.04.011.
[21] YU PJ, GUO J, LI JJ, et al. lncRNA-H19 in fibroblasts promotes wound healing in diabetes [J]. Diabetes, 2022, 71 (7): 1562-1578. DOI: 10.2337/db21-0724.
[22] WANG JL, ZHANG T, XU F, et al. GDF-15 at admission predicts cardiovascular death, heart failure, and bleeding outcomes in patients with CAD [J]. ESC Heart Fail, 2023, 10 (5): 3123-3132. DOI: 10.1002/ehf2.14484.
[23] XIE SH, LU LP, LIU LW. Growth differentiation factor-15 and the risk of cardiovascular diseases and all-cause mortality: a meta-analysis of prospective studies [J]. Clin Cardiol, 2019, 42 (5): 513-523. DOI: 10.1002/clc.23159.

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