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# Intracranial pressure and laboratory parameters in high- and low-risk pregnant women

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## ABSTRACT

**Background:** Pregnancy can trigger several pathological changes, thus representing a great challenge for gynecology and obstetrics. The objective is to evaluate high- and low-risk pregnant women through Intracranial pressure (ICP) and laboratory parameters.

**Methods:** Volunteers clinical and laboratory data were collected from medical records and ICP was monitored through noninvasive method.

**Results:** Statistically significant differences were observed between the group of high-risk and low-risk pregnant women for serum levels of alkaline phosphatase (ALP) and US-C-reactive protein (CRP) and a statistically positive association between blood pressure (BP) levels and plasma glucose. About 12.77% of the volunteers presented altered ICP. Higher BP values were encountered with the higher plasma glucose values. All ICP altered volunteers presented altered BP. ALP is among the most effective biochemical markers for assessing the risk of premature birth before 32 weeks of gestation.

**Conclusion:** We have observed important changes on BP, serum glucose, US-CRP, and ALP thus indicating higher risk of complications during pregnancy. Even more, some of the volunteers presented altered ICP what could indicate cerebral compliance changes.

**Keywords:** Alkaline phosphatase, C-reactive protein, Gestation, Intracranial pressure, Pregnant women

## INTRODUCTION

Pregnancy, despite being a physiological process, produces changes in the maternal organism that places it at the limit of the pathological. In some cases, this can result in gestational complications, which, in turn, are responsible for 4–8% of the total maternal deaths.[11,22,24]

According to the latest survey by the Ministry of Health, the number of maternal deaths over almost two decades has only increased. In 1996, there were 1520 maternal deaths, in 2006, there were 1623 deaths, and in 2013, the number of pregnant women who died reached 1686.[18] Data from the United Nations (UN) show that from 2000 to 2013 Brazil had the fourth worst position in the ranking of reduction of maternal deaths in the world, remaining alongside Madagascar and behind Guatemala, South Africa, and Iraq.[9]

Approximately 350,000 women die each year from pregnancy-related causes worldwide. Pregnancy-specific hypertensive disease (DHEG), hemorrhage, severe anemia and sepsis are among the most common causes of maternal deaths.[26] In cases not related to death, DHEG is one of the main complications of pregnancy, causing premature birth, delayed fetal growth, and placental abruption, in addition to leading to long-term health problems in pregnant women, such as chronic arterial hypertension, and renal and hepatic failure.[26,27]

Pregnancy is also marked by metabolic changes, including increased inflammatory factors, insulin resistance, oxidative stress, and dyslipidemia. The increase in these factors can result in preeclampsia, premature birth, delayed intrauterine growth, increased risk of low birth weight, and gestational diabetes mellitus.[2]

With regard to the increase in inflammatory factors, some biomarkers, such as C-reactive protein (CRP), detect the state of systemic inflammation in a nonspecific way. CRP is a well-established acute-phase reagent, whose levels increase in response to infectious and/or inflammatory exposures.[4,7]

CRP has been used as a nonspecific measure of inflammatory status in epidemiological studies of cardiovascular diseases and diabetes, where high CRP levels are associated with an increased risk of these diseases.[4,10,19] In pregnant women, high levels of CRP have been associated with adverse outcomes, such as premature birth, preeclampsia, birth of babies small for gestational age, and fetal growth restriction.[3,10,14,25] In addition to CRP, the measurement of alkaline phosphatase (FAL) also stands out, which is useful in monitoring the risk of premature birth, being able to assess pregnant women at risk quite reliably.[14]

Thus, the present study aimed to assess the contribution of conducting nonroutine laboratory analyzes in pregnant women in different situations (low and high risk) with the measurements of CRP and FAL, in addition to other laboratory evaluations together with the determination of blood pressure (BP) over the gestational trimesters in high- and low-risk pregnant women.

## MATERIALS AND METHODS

### Study design

This is a cross-sectional study carried out on pregnant women attended by the Municipal Health System, carried out from September 2014 to July 2015. Each pregnant woman participated only once in the research, being, therefore, different pregnant women each quarter.

The doctors accompanying them were asked to prescribe laboratory tests for hematological tests (complete blood count), biochemical tests (glucose, gamma-glutamyl transferase, alkaline phosphatase, transaminases, urea, and creatinine), and immunological tests (PCR-us). The results of these tests were made available for the monitoring of pregnant women who were able to undergo medical evaluation when necessary, in addition to being part of the research data. Data related to the health status and other information of the pregnant women were obtained through the analysis of the medical records of each one.

### Population data

In total, there were 94 pregnant women (73 considered high risk and 21 considered low risk). For the high-risk group, there were six pregnant women in the first trimester (1–3 months of pregnancy), 31 in the second trimester (4–6 months of pregnancy), and 36 in the third trimester (7–9 months of pregnancy). For the low-risk group, there were five pregnant women in the first trimester, eight in the second, and eight in the third.

The characterization of high-risk pregnancies occurred when pregnant women attended by primary health care in the public health system (usually health posts) were identified with some change and/or complication, and were then referred to a specialized center. In this center, after an evaluation by specialist doctors, if the risk was confirmed, the pregnant woman continued to be seen at that location, otherwise, she returned to the initial referral site. Thus, risk characterization was always carried out by two doctors, one from primary care and the other from specialized care.

All volunteers had their BP measured with the aid of a sphygmomanometer intracranial pressure (ICP) was monitored for about 5 min. The monitor used for noninvasive ICP monitoring was developed by Brain4care®, model BcMM-1500-R. Volunteers remained lying down during monitoring, the sensor was positioned on the right side of the head in all cases. The files containing the PIC wave data were stored on a computer and subsequently uploaded to the Brain4care Analytics platform of the same company, this system generated reports for each monitoring, showing an average of the P2/P1 ratio for each minute of monitoring. We have considered normal ICP when P2/P1 was smaller than 1.0. Slightly altered ICP was considered when $1.0 \geq P2/P1 < 1.1$ and elevated ICP was considered IF $P2/P1 \geq 1.1$.

### Inclusion criteria

Pregnant women of high and low risk, who decided to participate as volunteers in this study after being informed about the research objectives, were included in the study.

### Exclusion criteria

Nonpregnant women and pregnant women who did not accept to participate in the study were excluded from the study.

### Statistical analysis

Statistical calculations were performed using the GraphPad Prism® version 5 program, with 95% confidence levels. The volunteers' data were presented as a confidence interval for the mean, mean and standard deviation for continuous variables, and as number and percentages for categorical variables.

The results were also tested for normal distribution using the Kolmogorov–Smirnov test. The possible differences in the comparison of means between groups were investigated using one-way analysis of variance (ANOVA) followed by Tukey's posttest for continuous variables. In the correlations between laboratory tests and BP, Pearson's correlation test was used, identifying associations between themselves and with other continuous variables of the sample population. For the nominal variables, the Chi-square test with Yates correction was used. Through the Grubbs test, all results were tested to verify the presence of extreme values (or outliers) for their rejection and/or exclusion. In all tests, the level of significance considered was $P < 0.05$.

### Ethical standards

The research was approved by the Research Ethics Committee under Opinion No. 734,587, of July 31, 2014. This research was ended at 2016. The participating pregnant women were informed about the research objectives and agreed to participate in it as volunteers by signing the free and informed consent form.

## RESULTS

Ninety-four volunteer pregnant women met the inclusion criteria, being divided into two groups: high-risk pregnant women (73 volunteers) and low-risk pregnant women (21 volunteers).

The age range was 15–44 years and there was no statistical difference in age between the groups of pregnant women. This shows that the study population is homogeneous and that the differences found between the comparisons of these two groups are not due to age, but due to other factors. The age of the pregnant women was assessed for normality using the Kolmogorov–Smirnov test, and all or groups obtained $P > 0.1$, showing that there was a good distribution of the groups.

According to the analysis of medical records of high-risk pregnant women, there was a higher prevalence of cases of arterial hypertension in all gestational trimesters. In addition to hypertension, cases of obesity and smokers were seen in the second trimester and in the third trimester, the most common diseases were diabetes, obesity, and urinary tract infection, as shown in [Table 1].

**Table 1:** Incidence of injuries and complications in the groups studied.

| Characteristics | Low risk (*n*=21) | High risk 1st Tri (*n*=6) | High risk 2nd Tri (*n*=31) | High risk 3rd Tri (*n*=36) |
|---|---|---|---|---|
| Hypertensive | 0[a] | 3[a] | 9[b] | 11[b] |
| Obese | 0[a] | 2[a] | 7[a] | 7[a] |
| ITU | 0[a] | 0[a] | 2[a] | 8[a] |
| Diabetic | 0[a] | 1[a] | 3[a] | 8[a] |
| Smoker | 0[a] | 0[a] | 4[a] | 4[a] |
| Syphilis | 0[a] | 1[a] | 3[a] | 2[a] |
| Hypothyroidism | 0[a] | 1[a] | 3[a] | 2[a] |

Many patients in the high-risk group had more than 1 comorbidity. Chi-square with Yates correction showed a statistical difference only for hypertension between the groups, represented by the different superscript letters.

Analyzing arterial hypertension in the high-risk group, it was noted that the number of cases increased as the gestational trimesters progressed. Through the one-way ANOVA test followed by the Tukey test, a statistical difference was found when comparing the values of systolic BP in pregnant women in the first trimester, when comparing low-risk pregnant women (mean of 104 mmHg of systolic pressure) with those of high risk (mean of 130 mmHg of systolic pressure).

In this work, the association between BP and plasma glucose was analyzed and it was found that pregnant women who had higher BP values also had higher fasting glucose.

In the high-risk group, pregnant women with plasma glucose above 100 mg/dL (mean 116 mg/dL) had an average BP of 132/85 mmHg and pregnant women with plasma glucose below 99 mg/dL (mean 87 mg/dL) the mean BP was 113/71 mmHg. In the low-risk group, the mean BP was 94/63 mmHg (with an average glucose of 85 mg/dL). Pearson's correlation test showed a value of $P$ with a correlation coefficient of 0.6, 0.8, and 0.7 for the respective cases cited, thus showing that there was a tendency to increase glucose values in cases of higher BP.

[Table 2] shows the laboratory results of the pregnant women and shows significant differences between the low-risk group and the high-risk group for serum levels of FAL and CRP-us. For other biochemical parameters such as glucose, creatinine, urea, TGO, TGP, and GGT, there were no significant differences between the groups and neither during the gestational trimesters.

When examining the levels of CRP and FAL in the serum of high-risk pregnant women, it was found that CRP levels increased during pregnancy and the FAL decreased in the second trimester and increased again in the third trimester. For CRP-us in the group of high-risk pregnant women, the average was 6.63 mg/L, and in the low-risk group, 3.15 mg/L, and for FAL, the average was 149.06 mg/L and 136.73 mg/L, respectively.

The one-way ANOVA test with Tukey's posttest showed statistical differences in the hs-CRP values between the groups. This difference was found in the second and third trimesters (low-risk pregnant women compared to high-risk pregnant women), whereas in the first trimester, the comparison between low-risk and high-risk pregnant women was not significant, as well as not there was a statistical difference over the gestational trimesters.

Adopting the 7 mg/L limit to analyze in our study pregnant women at risk of premature birth,[15] it was found that 52% of pregnant women in the high-risk group exceeded this limit, while in the low-risk group, there were 14% of pregnant women. Through the Chi-square test with Yates correction, statistical differences were observed between the groups, represented by the different superscript letters [Table 3].

High concentrations of CRP-us (>3 mg/mL to assess cardiac risk) 15 were observed in 42.8% in the low-risk group of pregnant women and in 93.15% in the high-risk group with statistically significant differences through the test Chi-square with Yates correction, represented by the different superscript letters [Table 4].

In this research, a comparison was made between low-risk and high-risk pregnant women for the complete blood count. The hematological parameters are shown in [Table 5].

The volunteers' ICP was assessed, which was possible due the availability of noninvasive technology. Of the 94 pregnant women evaluated, we found an increase in ICP in five of them (P2/P1 > 1.1), being two from the low-risk group and three from the high-risk group. From seven of them, a ICP was slightly altered (1.0 ≥ PIC < 1.1). A greater number of cases of slightly altered ICP were observed in the second trimester in both groups. Thus, from the 94 pregnant women, 12 (12.77%) presented some kind of ICP change (supplementary material). The cases of pregnant women with high ICP revealed higher values of systolic BP than the cases of normal ICP and slightly altered/abnormal ICP [Table 6].

**Table 2:** Biochemical and immunological analyzes performed with pregnant women.

| Parameters | 1st quarter | | 2nd quarter | | 3rd quarter | |
|---|---|---|---|---|---|---|
| | Low risk (*n*=5) | High risk (*n*=6) | Low risk (*n*=8) | High risk (*n*=31) | Low risk (*n*=8) | High risk (*n*=36) |
| Glucose | 84.6$^{a}$±7.12 (79–97) | 91.83$^{a}$±7.38 (85–101) | 83.5$^{a}$±8.45 (73–98) | 91.10$^{a}$±13.48 (76–142) | 94.38$^{a}$±6.96 (78–97) | 87$^{a}$±14.80 (72–147) |
| Creatinine | 0.68$^{a}$±0.15 (0.43–0.81) | 0.67$^{a}$±0.02 (0.65–0.71) | 0.60$^{a}$±0.07 (0.52–0.75) | 0.63$^{a}$±0.10 (0.43–0.87) | 0.61$^{a}$±0.08 (0.45–0.72) | 0.62$^{a}$±0.07 (0.49–0.82) |
| ALP | 139$^{a}$±1.58 (137–14)1 | 153.8$^{a}$±20.44 (138–182) | 122.5$^{a}$±13.7 (103–140) | 144.5$^{b}$±17.99 (120–202) | 136$^{a}$±13.08 (120–162) | 155.9$^{b}$±17.6 (129–193) |
| GGT | 19.2$^{a}$±2.77 (16–23) | 16.5$^{a}$±3.27 (12–21) | 20.13$^{a}$±4.22 (15–28) | 20.03$^{a}$±4.22 (14–31) | 23.88$^{a}$±4.94 (18–31) | 20.75$^{a}$±4.86 (13–31) |
| LDH | 292$^{a}$±39.3 (258–356) | 257.8$^{a}$±42.16 (185–310) | 341.9$^{a}$±101.8 (173–472) | 267$^{a}$±84.42 (147–417) | 262$^{a}$±78.25 (192–380) | 318.7$^{a}$±90.1 (173–472) |
| Urea | 20.4$^{a}$±2.70 (16–23) | 16.33$^{a}$±1.24 (14–18) | 20.38$^{a}$±4.53 (12–27) | 16.48$^{a}$±3.52 (11–23) | 15.5$^{a}$±2.77 (12–21) | 19.08$^{a}$±4.68 (9–29) |
| GOT | 27.2$^{a}$±7.46 (20–39) | 22.63$^{a}$±7.24 (16–39) | 26.13$^{a}$±5.22 (18–34) | 19$^{a}$±3.16 (14–23) | 25.1$^{a}$±6.89 (10–39) | 21.86$^{a}$±6.77 (11–39) |
| GPT | 89$^{a}$±9.27 (81–101) | 91.83$^{a}$±7.38 (85–101) | 83.5$^{a}$±8.45 (73–98) | 90.71$^{a}$±13.69 (67–142) | 94.38$^{a}$±13.71 (81–123) | 87.89$^{a}$±15.22 (63–147) |
| us-PCR | 2.380$^{a}$±1.41 (0.50–4.10) | 4.20$^{a}$±2.22 (0.70–6.40) | 2.86$^{a}$±2.46 (0.70–8.20) | 6.53$^{c}$±2.34 (0.90–11.4) | 4.03$^{a}$±3.06 (0.60–9.20) | 7.28$^{b}$±2.70 (1.00–12.0) |

Values presented by mean±standard deviation and confidence interval. Lines with different superscript letters show significant statistical differences by the one-way ANOVA test, with Tukey's posttest for $P<0.05$.

**Table 3:** Assessment of the risk of premature birth using the CRP-us analysis.

| | Low risk | | | High risk | | |
|---|---|---|---|---|---|---|
| | 1st Tri (*n*=5) | 2nd Tri (*n*=8) | 3rd Tri (*n*=8) | 1st Tri (*n*=6) | 2nd Tri (*n*=31) | 3rd Tri (*n*=36) |
| N (CRP-us> 7 mg/L) | 0$^{a}$ | 1$^{a}$ | 2$^{a}$ | 0$^{a}$ | 15$^{b}$ | 23$^{b}$ |
| Intragroup percentage | 0 | 12.5 | 25 | 0 | 48.38 | 63.88 |
| Group average (%) | Low risk 14 | | | High risk 52 | | |

Chi-square test with Yates correction: statistical differences represented by the different superscript letters

**Table 4:** Evaluation of the risk of cardiac events by the analysis of CRP-us.

| | Low risk | | | High risk | | |
|---|---|---|---|---|---|---|
| | 1st Tri (*n*=5) | 2nd Tri (*n*=8) | 3rd Tri (*n*=8) | 1st Tri (*n*=6) | 2nd Tri (*n*=31) | 3rd Tri (*n*=36) |
| N (CRP-us>3 mg/ | 2[a] | 3[a] | 4[a] | 4[a] | 29[b] | 35[b] |
| Intragroup percentage | 44.0 | 37.5 | 50 | 66.66 | 93.54 | 97.22 |
| Group average (%) | Low risk 42.85 | | | High risk 93.15 | | |

Chi-square test with Yates correction: statistical differences represented by the different superscript letters.

**Table 5:** Hematological analyzes performed with pregnant women.

| Parameters | 1st quarter | | 2nd quarter | | 3rd quarter | |
|---|---|---|---|---|---|---|
| | Low risk (*n*=5) | High risk (*n*=6) | Low risk (*n*=8) | High risk (*n*=31) | Low risk (*n*=8) | High risk (*n*=36) |
| Red blood cells (M/μL) | 4.04[a]±0.4 | 4.54[a]±0.38 | 4.1[a]±0.42 | 4.18[a]±0.39 | 4.28[a]±0.28 | 4.20[a]±0.42 |
| Hemoglobin (g/dL) | 12.34[a]±0.93 | 13.51[a]±0.99 | 11.92[a]±0.85 | 12.54[a]±0.92 | 12.92[a]±0.85 | 12.61[a]±1.17 |
| Hematocrit (%) | 36.14[a]±2.61 | 39.95[a]±3.54 | 36.11[a]±2.17 | 37.83[a]±3.04 | 38.51[a]±2.68 | 37.70[a]±3.14 |
| VMC (fL) | 89.58[a]±3.22 | 87.96[a]±3.13 | 87.52[a]±7.04 | 88.59[a]±3.90 | 89.92[a]±3.3 | 89.65[a]±5.14 |
| HCM (pg) | 30.58[a]±1.59 | 29.76[a]±1.10 | 29.23[a]±2.61 | 29.68[a]±1.81 | 30.18[a]1.89 | 30.01[a]±2.34 |
| CHCM (g/dL) | 34.1[a]±0.92 | 33.83[a]±0.87 | 32.87[a]±1.39 | 33.19[a]±1.36 | 33.55[a]±1.21 | 33.09[a]±2.04 |
| Leukocytes (Cel/mL) | 9377.6[a]±1942 | 8498.33[a]±2570 | 9421.25[a]±2169.06 | 9925.41[a]±2226 | 8815[a]±2054.8 | 9938.88[a]±2444 |
| Lymphocytes (Cel/mL) | 25.4[a]±2.07 | 30.16[a]±6.88 | 24[a]±5.26 | 24.64[a]±5.77 | 26.87[a]±7.25 | 24.55[a]±7.57 |
| Monocytes (Cel/mL) | 4[a]±1.2 | 4.5[a]±1.37 | 4.87[a]±1.16 | 3.96[a]±1.37 | 4.25[a]±1.63 | 4.97[a]±1.68 |
| Neutrophils (Cel/mL) | 68.4[a]±3.36 | 62.83[a]±6.43 | 69.12[a]±4.83 | 69.8 [a]±7.33 | 66.37[a]±9.33 | 68.55[a]±8.11 |
| Platelets (103/mL) | 251[a]±410.24 | 243.16[a]±54.33 | 206.12[a]±494.75 | 256.83[a]±49.14 | 234.75[a]±505.48 | 219.75[a]±69.30 |

Values represented by mean and standard deviation. There were no statistical differences between the groups with one-way ANOVA and Tukey's posttest, represented with equal superscript letters.

**Table 6:** Clinical and laboratory parameters for pregnant grouped at normal ICP, slightly altered ICP, and elevated ICP

| Parameters | Normal ICP (*n*=82) | Slightly altered ICP (*n*=7) | Elevated ICP (*n*=5) |
|---|---|---|---|
| Systolic pressure | 112.68±17.64[a] | 101.42±15.73[a*] | 136±39.11[b*] |
| Diastolic pressure | 73.90±13.85[a] | 65.71±5.34[a] | 60±7.07[a] |
| GOT | 23.45±6.96[a] | 26.28±5.28[a] | 19.6±3.78[a] |
| GPT | 23.71±7.64[a] | 26.85±5.72[a] | 20.8±6.01[a] |
| GGT | 20.42±4.67[a] | 21.42±4.50[a] | 18±2.23[a] |
| ALP | 147.81±19.67[a] | 140.28±11.26[a] | 135±18.35[a] |
| Urea | 17.69±4.18[a] | 18.14±3.80[a] | 21.4±3.84[a] |
| Creatinine | 0.61±0.08[a] | 0.69±0.10[a] | 0.71±0.08[a] |
| Glucose | 89.25±13.33[a] | 84.85±6.93[a] | 80.2±9.85[a] |
| LDH | 291.29±86.68[a] | 285.57±82.09[a] | 340.6±107.70[a] |
| us-PCR | 6.58±2.39[a] | 4.78±2.36[a] | 5.82±3.33[a] |

Values presented by mean±standard deviation and confidence interval. Lines with different superscript letters show significant statistical differences by the one-way ANOVA test, with Tukey's posttest for $P<0.05$.

There was no difference at laboratory parameters when comparing normal ICP, slightly altered ICP and elevated ICP.

## DISCUSSION

When analyzing the BP of pregnant women, it was observed that it was higher in the first trimester of the high-risk group, with even statistical differences in relation to the low-risk group in that same quarter for systolic BP. This may be due to the fact that, as soon as a pregnant woman is diagnosed as hypertensive, a treatment to reverse this process is initiated. Thus, although the BP continues to rise, this increase does not occur so intensely, and thus, there are no statistical differences over the quarters or even when compared with the pregnant women in the low-risk group.

With regard to pregnant women who had higher BP and plasma glucose, the results of this study were in agreement

with another study, thus being more evidence that the higher the BP values, the higher the plasma glucose values. Some inflammatory markers establish a very direct relationship between this association, for example, situations such as overweight, high BP, and increasing age cause an increase in the amount of the inflammatory marker TNF-α, which, in turn, is related to problems in signaling of insulin.[15]

Elevated plasma glucose levels are also associated with an increased risk of hospitalization for acute myocardial infarction, coronary artery bypass, coronary angioplasty, stroke, and carotid endarterectomy.[20] As a result, women who develop some pathology during pregnancy need more caution because they are more vulnerable to the appearance of other pathologies. This particular attention guarantees an increase in the chances of a healthy development of the fetus and a reduction in risks for pregnant women.

High values of FAL and CRP-us were observed among high-risk pregnant women in the second and third trimesters, with statistically significant differences in relation to the low-risk group. According to the literature, pregnant women at risk of preterm delivery have significantly higher levels of CRP-us and FAL and both increased over the course of pregnancy.[14] Thus, the pregnant women evaluated in the present study who had higher values of CRP-us, had higher chances of having a premature birth, thus increasing even more the risk already existing in them, especially in high-risk women.

FAL is among the most effective biochemical markers for assessing the risk of premature birth before 32 weeks of gestation.[12] Elevated levels of FAL indicate an increase in the risk of uterus muscle contraction activity, especially when its value exceeds 300 u/l, and an excess of 2 times or more of the FAL reference value correlates positively with an increase in 2.9 times the relative risk of premature birth and low birth weight (below 2.500 g).[14]

The concentration of serum CRP is a good risk predictor for the development of atherosclerosis and coronary disease.[8] The mechanisms proposed for these associations suggest that during an inflammatory process, there is an increase in insulin resistance, a greater release of adhesion cells by the vascular endothelium, the liver synthesizes greater amounts of fibrinogen and the pro-coagulant effect of platelets becomes greater.[5] In this way, pregnant women with CRP values above the established, need more caution because they have higher risks of unfavorable cardiac events, this special attention, therefore, ends up minimizing the adverse occurrences regarding the cardiac risk parameters that can be controlled.

Different changes in hematological parameters are reported in the literature between pregnant and nonpregnant women, such as increased CMV, hematocrit, total leukocytes (mainly neutrophils), and reduction in the number of platelets.[9,13,16,17,21-24] Although these frequent changes were observed in pregnant women in our data, the comparison with nonpregnant women was not performed, being limited only to the comparison of low-risk pregnant women with high-risk pregnant women, to which there were no statistical differences between these two groups.

The dynamic process and the complexity of the necessary and anatomical changes that occur in the gestational cycle expired and specific in each period and the risk classification is a dynamic process of identifying patients that occur immediately, according to the risk potential, the injuries health, or degree of suffering.[6] As already reported in the literature, high blood pressure increases the amount of blood that reaches the brain and is responsible for increasing ICP. This increased ICP occurs with the loss of brain compliance, showing that the compensation mechanisms have been lost and an intracranial hypertension has been installed in these pregnant women.[1] Thus, pregnant women with high BP are likely to have a high ICP, which would increase their risks. In this perspective, the use of this equipment to assess ICP in pregnant women in a noninvasive way may imply an improvement in the monitoring of high-risk prenatal care.

The scarcity of qualitative and quantitative studies with a significant number of samples and with methodological rigor that compares and demonstrates the clinical and laboratory parameters in high- and low-risk pregnant women represents the limitations of this study. It is important to clarify that this study did not evaluate a control group of not pregnant woman what could be considered an important study limitation.

## CONCLUSION

It was found in this study that BP and glucose were positively associated so that pregnant women with higher BP levels are more likely to have higher blood glucose levels as well. During a high-risk pregnancy, laboratory parameters such as CRP and FAL are significantly higher, indicating that they may be more prone to the risk of having adverse cardiovascular diseases, premature birth, children with low birth weight, and abortion. In addition, changes in the ICP were observed in 12.77% of pregnant women, which indicates the importance of this monitoring in this population. Pregnant women who showed changes in ICP also showed changes in BP, which indicated that this is an important factor in the evolution of the loss of cerebral compliance in these women.

## COMPLIANCE WITH ETHICAL STANDARDS

### Ethical approval

The research was approved by the Research Ethics Committee under Opinion No. 734,587, of July 31, 2014.

### Animal experiments

This article does not have studies with human or animal participants carried out by any of the authors.

### Declaration of patient consent

Patient's consent not required as there are no patients in this study.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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