Original Article

Procalcitonin levels compared to CRP as a primary marker of chorioamnionitis in (PPROM)

Marzieh Ghasemi[1,2], Masoumeh Saghafi Behzadi[3], Narjes Noori[1*], Alireza Dashipour[4], Mehdi Jahantigh[5]

[1] Pregnancy Health Research Center Zahedan University of Medical Sciences, Zahedan, Iran.[2] Moloud Infertility Center, Ali ibn Abitaleb Hospital, Zahedan University of Medical Sciences, Zahedan, Iran. [3] Gynecologist, Department of Medicine, Zahedan University of Medical Sciences, Zahedan, Iran. [4] Department of Food Sciences and Nutrition, Cellular and Molecular Research Center and Department of Clinical Biochemistry, School of Medicine, Zahedan University of Medical Sciences, Zahedan, Iran. [5]Assistant Professor of Pathology· Department of Pathology, School of Medicine· Zahedan University of Medical Sciences, Zahedan, Iran.

Correspondence: Narjes Noori, Pregnancy Health Research Center, Zahedan University of Medical Sciences, Zahedan, Iran. Email: nnoori1400@gmail.com

ABSTRACT

Background and aim: serum levels of procalcitonin and of CRP in pregnant woman have been used as laboratory factors in the process of diagnosing placental sepsis. However, different and sometimes contradictory results have been obtained during the studies. In the case of preterm rupture of membranes, the study aims to compare the serum levels of procalcitonin and of CRP as a primary marker of chorioamnionitis in pregnant women. **Methods:** This investigation was a case - control study. Pregnant women with preterm rupture of membranes and PPROM in 2018, who referred to Ali Ibn Abitaleb Hospital, form a statistical population. The sample size was 110 people who were divided into two groups with equal proportions consisting of two samples (at baseline and with chorioamnionitis) and control group (which included women with healthy membranes). The data we used were collected through two methods such as interviews with patients as well as laboratory data. After importing the data into the computer, SPSS software and independent T-test and correlation were used to analyze. **Results:** In this study, the results from 110 people studied in relation to the diagnosis of chorioamnionitis showed that in the mother's serum procalcitonin test, the parameters such as sensitivity, specificity, positive predictive value and negative predictive value were 68.2%, 73.9%, 71.4% and 50%, respectively and in the procalcitonin test of the mother's serum before chorioamnionitis (at baseline), the sensitivity, specificity, positive predictive value and negative predictive value were 45.45%, 34.7%, 40% and 41.2%, respectively. Also, in the test for serum procalcitonin in pregnant women with normal membranes, the sensitivity, specificity, positive predictive value and negative predictive value were 36.4%, 43.4%, 38.9% and 41.6%, respectively. Also, according to results of Pearson correlation test in preterm rupture of membranes, a positive and significant relationship between maternal serum levels of procalcitonin and of maternal CRP was observed at baseline and before the end of pregnancy because of chorioamnionitis ($P < 0.01$). **Conclusion:** The results showed that in prediction of preterm rupture of membranes, the serum procalcitonin and CRP levels in the mother's blood, the chorioamnionitis was effective and in chorioamnionitis during preterm rupture of membranes, there is a positive and significant relationship between serum procalcitonin and CRP. In mothers present in the case group at baseline compared to mothers with normal membranes, high serum levels of procalcitonin and CRP are considered as inflammatory marker.

Keywords: Procalcitonin, CRP, chorioamnionitis, preterm rupture of membranes

Introduction

One of the most sensitive and important stages of women's lives, which is accompanied by changes in psychological (such as increased anxiety and depression) and physical needs (such as weight gain and cardiac output, etc.), is pregnancy [1]. Neonatal septicemia is the leading cause of newborn mortality worldwide [2]. In the first 28 days of life, neonatal septicemia, a clinical syndrome of systemic disease occurs with bacteriuria [1]. In 85% of newborns, less than 24 hours after birth, the initial sepsis is seen, this symptom occurs in 5% of cases within 24 to 48 hours and in a lower percentage of patients, between 48 hours and 6 days after the life initiation [2]. Infectious amniotic fluid or the

Access this article online	
Website: www.japer.in	**E-ISSN:** 2249-3379

How to cite this article: Marzieh Ghasemi, Masoumeh Saghafi Behzadi, Narjes Noori, Alireza Dashipour, Mehdi Jahantigh. Procalcitonin levels compared to CRP as a primary marker of chorioamnionitis in (PPROM). J Adv Pharm Edu Res 2020;10(S1):165-170.
Source of Support: Nil, Conflict of Interest: None declared.

birth canal are considered as the route of entry for bacteria that cause early infection during accouchement, resulting in high mortality [3]. When bacteria infect the chorion (outer membrane), the amnion (the fluid-filled sac within the uterus), and the fluid around the fetus (amniotic fluid), chorioamnionitis occurs. This condition, which occurs in about 2 to 4 percent of births, can mainly lead to preterm delivery or severe maternal and neonatal sepsis [4]. In 2 to 5.4% of all pregnancies, preterm rupture of the neonatal membranes (PPROM) is observed which is correlated with perinatal mortality [5]. The event is considered clinical chorioamnionitis or clinical amniotic infection, when there are symptoms of a particular disease [6]. Fetal inflammatory reaction syndrome (PCT) is a reaction that the fetus presents against sepsis. Cerebral palsy and other short-term and long-term neurological defects are among the complications of PCT [7-9]. As a result, one of the most important factors in reducing fetal and childish complications, is early and appropriate management of chorioamnionitis. Assessment of tumor necrosis factor (TNF), interleukins (IL-10, IL-6), white blood cells (WBC) and acute phase protein (CRP) are laboratory testing methods in PCT measurement [5, 10, 11]. According to various studies, the best markers for fetal inflammation include IL-6 and microbial concentrations within amniotic cavity [12]. To evaluate the sepsis and its primary causes, some of the cheaper and faster methods of diagnosing neonatal inflammation that are primarily used in neonatal intensive care include assessment of the presence of procalcionin and CRP, which are other markers of sepsis [13]. A evaluation of the relationship between CRP level and preterm delivery in the study of Tavassolian et al. showed that among women who underwent preterm delivery before 30 weeks of gestation, the mean CRP concentration increased compared to the other two groups ($p < 0.05$). Also, there was a significant difference in CRP concentration ($p < 0.05$) between women with preterm delivery before 30 weeks of gestation and women with childbirth after 37 weeks of pregnancy. The reason that the inflammatory marker of CRP can be effective in identifying mothers at risk for preterm delivery, is that there is a direct link between increased CRP concentration and preterm delivery [14]. During pregnancy, childbirth, and postpartum in the study by Pacolet et al. in 2011, procalcitonin levels were assessed. At 24-28 weeks (n = 7), 36-40 weeks (n = 60) during gestation, in accouchement (n = 59) and at 2-3 (n = 58) and 10 days (n = 53) postpartum, PCT levels were monitored sequentially. The results of this study showed that the mean levels of PCT at 28-24 weeks, 36-40 weeks, during accouchement, on 2-3 days and 10 days Postpartum were 0.043 µg / L (range 0.010- 0.080), 0.061 micrograms per liter (range 0.010-0.110), 0.068 micrograms per liter (range 0.010-0.170), 0.200 micrograms per liter (range 0.030-5.00) and 0.060 micrograms per liter (range 0.020-0.120), respectively. Three women showed a PCT levels of 0.25 micrograms per liter and 0.5 micrograms per liter and two women showed a level of more than 0.5 micrograms per liter on days 2-3 postpartum [14]. A gold standard in children with cancer and suspected sepsis, according to a blood culture comparison during a study carried out in 2017, was CRP and PCT in hemorrhagic infections. In order to eliminate bloody infections, the results of this study showed that PCT has a better serological marker than that of CRP [15]. The sensitivity, specificity, positive predictive value, and negative predictive value of CRP in another study of 276 pregnant women were 0.686, 0.958, 0.501, and 0.765, respectively, which were better than PCT. The area under the ROC curve, CRP= 0.869 and PCT= 0.787 for the 28-33 + 6 weeks pregnancy group based on groups analysis, was shown among different weeks of pregnancy. The PCT sensitivity and specificity were 0.830 and 0.950, respectively, which were significantly better than that of CRP [16]. The present study intends to compare the serum procalcitonin levels with serum CRP as a primary marker of chorioamnionitis in Premature preterm rupture of membranes in the mothers' serum with PPROM.

Materials and Methods

The type of present study is the case-control. All patients who referred with diagnose of the preterm rupture of the membranes before 37 weeks of pregnancy (premature PROM), composed the study population. Rupture of the membranes and gestational age of 25 to 34 weeks, and the minimum duration of rupture of the membranes within 24 hours, were the inclusion criteria in the study, a twain conception, congenital abnormalities of the fetus and diabetes mellitus, preeclampsia, vaginal hemorrhage and pregnancies under 25 weeks and over 34 weeks, any type of maternal officinal disease (hepatic, renal and infectious diseases) and the consumption of non-steroidal anti-inflammatory drugs (NSAIDs) were considered as the exclusion criteria. 110 persons composed the sample size. In this study, the sampling method was non-random and according to variables such as maternal age and gestational age, etc., the samples were divided into two groups of case and control. Two samples from the case group were analyzed at baseline and after chorioamnionitis. Group A1 as at baseline composed of 55 pregnant women with gestational age of 26-34 weeks, and group A2, women in the post-chorioamnionitis condition by referral to preterm rupture of the membranes (PPROM), were considered as case group. Group B, consisting of 55 women with normal fetal membranes present in the preterm group with gestational age of 26-28 weeks, who referred to the gynecology clinic for pregnancy control, was selected as the PPROM control group. The information form, laboratory results and clinical examinations of the project were approved by the Research Council and the Ethics Committee. This case- control by obtaining an introduction letter from Zahedan University of Medical Sciences, was conducted in the gynecology department of Ali Ibn Abitaleb Hospital in Zahedan in order to evaluate the serum level of procalcitonin compared with serum CRP as a primary marker of chorioamnionitis in preterm rupture of membranes. After the patients were informed of the plan and conscious consent was received from them, they included in the study. Methods such as sterile speculum installation and observation of outflow from the cervix, nitrazine test, or Fern test were used in this research to detect rupture of the membranes. Intravenous ampicillin at a dose of 2 g every 6 hours for 48 hours, followed by oral

amoxicillin 500 mg every 8 hours and azithromycin daily for up to one week was administered to treat the hospitalized patients. Pyrexia, increased maternal and fetal heart beating, uterine susceptibility and vaginal purulent secretions, and vaginal hemorrhage during hospitalization as symptoms of chorioamniotitis, were considered and when the fetal distress or placental preterm separation were added to the above symptoms, or the gestational age reached 34 full weeks, or obstetric contractions began, the pregnancy termination was done. Vaginal examination was not performed at all during the hospitalization period, except in cases where regular obstetric contractions have begun. Both case and control group were examined in this investigation. The evaluation of the first group (case group) consists of two stages. The first stage was considered by testing on women during chorioamnioititis occurrence and also before the onset of chorioamniomititis (at baseline) and the second stage as the condition after the onset of symptoms of chorioamniomititis (pyrexia, chills, increased CRP) and the second group consisted of pregnant women with a normal membrane (control group). Also, based on the relevant formulas, diagnostic evaluation indicators were performed. Ultimately, the data were collected and imported into SPSS statistical software version 24 and various statistical indices were used to compare these three groups.

Results

According to the results of Table 1, 43.6% (24 persons) in the control group and 56.4% (31 persons) in the case group, have at least twice the previous history of pregnancy and there was no significant difference in this regard between different groups (p> 0.608). history of twice abortion in 50.9% (28 persons) of the control group and history of once abortion 43.6% (24 persons) of the case group, was recorded as the highest number of abortions in each group and a significant difference in this regard between different groups was not observed (p> 0.152). Cesarean type of accouchement was observed in 30 persons (54.6%) from the control group and 31 persons (56%) from the case group and in the rest of persons, the accouchement was performed with normal type and there was no significant difference in type of pregnancy between different groups. The sex of most newborns was as follows: 31 male newborns (56%) were observed in the control group and 28 (50.9%) female newborns in the case group and no significant difference was reported between different groups in this regard. (P > 0.228)

Table 1. Demographic and Midwifery characteristics of the studied samples

demographic and midwifery characteristics	control group Number(%)	Case group (%) Number	P-value
number of pregnancies			
one	21 (38.2%)	21(38.2%)	
two	24 (43.6%)	31(56.4%)	0.608
three or more	10 (18.2%)	3(5.4%)	
history of abortion			
zero	11(20%)	16(29%)	0.152
one	16(29.1%)	24(43.6%)	
two or more	28(50.9%)	15(27.4%)	
accouchement type			
normal	25(45.4%)	24(49%)	0.960
caesarean	30(54.6%)	31(56%)	
newborn sex			
boy	31(56%)	27(49.1%)	0.228
girl	24(49%)	28(50.9%)	

In the procelsitonin test, maternal serum during chorioamnionitis diagnosis, the sensitivity, specificity, positive predictive value and negative predictive value were reported 68.2%, 73.9%, 71.4% and 50%, respectively, and in the conditions of pre-chorioamnionitis (at baseline) the sensitivity, specificity, positive predictive value, and negative predictive value were 45.45%, 34.7%, 40%, and 41.2%, respectively. Also, in relation to serum procalcitonin evaluation in pregnant women with normal membranes, the sensitivity, specificity, positive predictive value and negative predictive value were 36.4%, 43.4%, 38.9% and 41.6%, respectively (Table 2).

Table 2: Comparison of sensitivity, specificity, positive predictive value and negative predictive value related to maternal serum levels of procalcitonin at baseline, with chorioamnionitis and control group

Laboratory tests		sensitivity	specificity	positive predictive value	negative predictive value
Maternal serum procalcitonin levels in the case group	with chorioamnionitis	68.2	73.9	71.4	50
	at baseline	45.45	34.7	40	41.2
Maternal serum procalcitonin levels in the control group	Pregnant women with normal membranes	36.4	43.4	38.9	41.6

During the maternal serum levels of CRP testing related to chorioamnionitis diagnosis, the sensitivity, specificity, positive predictive value and negative predictive value were found to be 54.5%, 47.8%, 50% and 52.3%, respectively, and these parameters in pre- chorioamnionitis occurrence were reported to be 45.4%, 39.1%, 41.6%, and 45%, respectively. Also during the pregnant mothers' serum levels of CRP assessment who had normal membranes, the sensitivity, specificity, positive predictive value and negative predictive value were 40.9%, 34.8%, 37.5% and 38.9%, respectively (Table 3).

Table 3: Comparison of sensitivity, specificity, positive predictive value and negative predictive value related to maternal serum levels of CRP at baseline, with chorioamnionitis and control group

Laboratory tests	sensitivity	specificity	positive predictive value	negative predictive value

Maternal serum CRP levels in the case group	with chorioamnionitis at baseline	54.5	47.8	50	52.3
		45.4	39.1	41.6	45
Maternal serum CRP levels in the control group	Pregnant women with normal membranes	40.9	34.8	37.5	38.09

There was a positive and significant relationship between the increase in maternal serum levels of CRP at baseline and maternal serum levels of CRP pregnancy termination according to the results from Pearson correlation test, this led to chorioamnionitis. Also, a positive and significant relationship was observed between the increase in maternal serum levels of procalcitonin at the baseline and before pregnancy termination in mather with chorioamnionitis. A positive and significant relationship was reported in preterm rupture of membranes before the pregnancy termination with the maternal serum levels of CRP at the baseline and also before pregnancy termination due to chorioamniotitis ($P < 0.01$). That is, with increasing maternal serum levels of procalcitonin, serum CRP levels also increased (Table 4).

Table 4. The relationship between maternal serum levels of procalcitonin at baseline and before the pregnancy termination with the maternal serum levels of CRP at baseline and before the pregnancy termination due to chorioamniotitis in preterm rupture of membranes

	maternal serum levels of CRP at baseline	maternal serum levels of CRP in post-chorioamnionitis conditions	maternal serum levels of procalcitonin	maternal serum levels of procalcitonin in post-chorioamnionitis conditions
maternal serum levels of CRP at baseline	1	0.346** 0.010	0.393** 0.003	0.367** 0.006
maternal serum levels of CRP in post-chorioamnionitis conditions	0.346** 0.010	1	0.278** 0.040	0.391** 0.003
maternal serum levels of procalcitonin	0.393** 0.003	0.278** 0.040	1	0.367** 0.05
maternal serum levels of procalcitonin in post-chorioamnionitis conditions	0.367** 0.006	0.391** 0.003	0.367** 0.05	1

There was a significant relationship between maternal serum levels of CRP at baseline and serum levels of CRP in mothers' with normal membrane based on the results from Pearson correlation test, accordingly, it was reported that the levels of CRP in the maternal serum increased compared to the serum levels in mothers with normal membranes at baseline. Also, there was a positive and significant relationship between maternal serum levels of procalcitonin at baseline and of maternal serum with normal membranes. This means that the CRP levels of the maternal serum at baseline was higher than that in the maternal serum in the pre-conception conditions. (Table 5).

Table 5: Relationship between serum levels of procalcitonin and CRP at baseline in mothers with membrane rupture and mothers with normal membrane.

	maternal serum levels of CRP at baseline	maternal serum levels of CRP in post-chorioamnionitis conditions	maternal serum levels of procalcitonin	maternal serum levels of procalcitonin in post-chorioamnionitis conditions
maternal serum levels of CRP at baseline	1	0.305** 0.015	0.308** 0.022	0.390** 0.003
maternal serum levels of CRP in post-chorioamnionitis conditions	0.305** 0.015	1	0.796** 0.000	0.796** 0.000
maternal serum levels of procalcitonin	0.308** 0.022	0.796** 0.000	1	0.373** 0.005
maternal serum levels of procalcitonin in post-chorioamnionitis conditions	0.390** 0.003	0.316** 0.03	0.373** 0.005	1

Discussion

There was no significant statistical difference in terms of number of conceptions, history of abortion, accouchement type and newborn sex between the both control and case groups according to the results from the present study. Also, when testing for maternal serum levels of procalcitonin in relation to the diagnosis of chorioamnionitis, the sensitivity, specificity, positive predictive value and negative predictive value were 68.2%, 73.9%, 71.4% and 50%, respectively, and in the test performed in mothers in the situations prior to the onset of chorioamniotitis (at baseline), above parameters were reported to be 45.45%, 34.7%, 40%, and 41.2%, respectively. On the other hand, during the serum levels of procalcitonin testing in pregnant mothers with normal membranes, the sensitivity, specificity, positive predictive value and negative predictive value were obtained as 36.4%, 43.4%, 38.9% and 41.6%, respectively. According to a study by Torbe´in 2007, in both groups, preterm rupture and expected rupture, the plasma concentrations of procalcitonin increased, but why procalcitonin is more sensitive and specific in detecting preterm rupture of membranes, is due to an increase in its concentration in preterm rupture [17]. Based on the findings of Rewatkar et al.'s (2018) investigation, two factors with high diagnostic value in chorioamnionitis and preterm newborn sepsis, respectively, are serum levels pf CRP > 9.4 mg / L as well as procalcitonin [18]. In the present study, in the maternal serum levels of CRP testing related to chorioamnionitis diagnosis, the sensitivity, specificity, positive predictive value and negative predictive value were 54.5%, 47.8%, 50% and 52.3%, respectively, and in the maternal serum levels of CRP testing before occurrence of chorioamnionitis (at baseline), above parameters were 45.4%, 39.1%, 41.6% and 45%, respectively. Also, on serum levels of CRP assessment in

pregnant mothers with normal membranes, the sensitivity, specificity, positive predictive value and negative predictive value were 40.9%, 34.8%, 37.8% and 38.9%, respectively. Researchers involved in another study reported that in the case of neonatal sepsis in preterm rupture of membranes, a positive and significant relationship was observed between increased procalcitonin levels and CRP in the mother's blood. According to the other results of this study, in the process of neonatal sepsis prediction during preterm rupture of membranes, the predictive effect of serum procalcitonin is higher than that of serum CRP levels [19].

This study revealed that there was a positive and significant relationship between the increases in maternal serum levels of CRP at baseline and of that before the pregnancy termibation, chorioamnionitis occurred due to this correlation. Also, between maternal serums levels of procalcitonin at baseline and of that before termination of pregnancy related to chorioamnionitis, a positive and significant relationship was reported. On the other hand, it can be stated that there was a positive and significant relationship in maternal serum levels of CRP before pregnancy termination with of that before pregnancy termination related to chorioamniotitis in preterm rupture of membranes; The CRP levels also increased with increasing serum procalcitonin levels. There was also a significant relationship between maternal serum levels CRP levels at baseline and maternal serum levels of CRP with normal membranes, meaning that maternal serum levels of CRP were higher than that in mothers with normal membrane. It was also observed that there was a positive and significant relationship between maternal serum levels of procalcitonin at baseline and serum levels of procalcitonin in mothers with normal membranes, meaning that maternal serum levels of CRP were higher than that prior to pregnancy termination. In a investigatin on women with intra-amniotic inflammation in a study by Dulay et al. (2015), it was found that there was a positive and significant overlap and relationship between increasing serum levels of procalcitonin, CRP and IL-6; when prolactitonin levels increased, serum levels of CRP and IL-6 also increased [20]. The results from another study carried out in 2019 indicated that there was a significant incremental link between serum CRP levels and procalcitonin and WBC in chorioamnionitis and women with preterm rupture of membranes. Also, the results obtained by the researchers present in this study showed that the most predictive effect in chorioamnionitis occurred in women with preterm rupture of membranes among CRP, procalcitonin and WBC, was seen for CRP increase [21].

Conclusion

Based on the findings of this study, the predictive effect of serum procalcitonin levels and protein of acute reactive phase (CRP) in maternal blood is demonstrated in chorioamnionitis occurrence in Premature preterm rupture of membranes. In the occurrence of chorioamnionitis in preterm rupture of membranes, there is a positive and significant relationship between serum prolactinonin and CRP levels. Based on the results, inflammatory marker is shown when the serum levels of procalcitonin and CRP of maternal serum are higher than that of mothers with normal membranes at baseline in case group.

References

1. Rudigoz RC. How to manage term PROM?. Gynecol Obstet Fertil 2008; 36: 1244.
2. Karwan-Plonska A, Okninska A. [The condition of premature newborns of patients hospitalized due to premature rupture of fetal membranes (PROM). Gynecol Pol 2001; 72:1170-1176.
3. Zakariah AY, Alexander S. Immediate induction or expectant management in term PROM? Do not falter, do not wait. Gynecol Obstet Fertil 2008; 36: 1248-1250.
4. Kollef MH, Sherman G, Ward S, Fraser VJ. Inadequate antimicrobial treatment of infections: a risk factor for hospital mortality among critically ill patients. Chest 1999;115(2):462-74.
5. Naghavi M. Mortality in 18 Provinces in Islamic Republic of Iran, 2001. Iran, Tehran: Deputy of Health, Ministry of Health and Medical Education; 2003.
6. Ratanakorn W, Srijariya W, Chamnanvanakij S, Saengaroon P. Incidence of neonatal infection in newborn infants with a maternal history of premature rupture of membranes (PROM) for 18 hours or longer by using Phramcongkutklao Hospital Clinical Practice Guideline (CPG). J Med Assoc Thai 2005; 88: 973-978.
7. Casado-Flores J, Blanco-Quirós A, Asensio J, Arranz E, Garrote JA, Nieto M. Serum procalcitonin in children with suspected sepsis: a comparison with C-reactive protein and neutrophil count. Pediatr Crit Care Med. 2003;4(2):190-5.
8. Afrasiabian Sh ., MD1, Nouri H .,Medical Student2, Hajibagheri K., MD3, Ghaderi E., PhD4 , Abdollahi Sh.,MSc5, Mohsenpour B ., MD . Serum procalcitonin level as a biomarker for the differential diagnosis between infectious and non-infectious systemic inflammatory response syndrome: a prospective case–control study. Scientific Journal of Kurdistan University of Medical Sciences. 2018. 95(2):80-90.
9. Zhao D, Zhou J, Haraguchi G, Arai H, Mitaka C. Procalcitonin for the differential diagnosis of infectious and non-infectious systemic inflammatory response syndrome after cardiac surgery. J Intensive Care 2014; 3; 2: 35.
10. SungYeon C, JungHyun C. Biomarkers of sepsis. Infection and Chemotherapy. 2014;46(1):1-12.
11. Tupchong K, Koyfman A, Foran M. Sepsis, severe sepsis, and septic shock: A review of the literature. African Journal of Emergency Medicine. 2014.
12. Reinhart K, Bauer M, Riedemann NC, Hartog CS. New approaches to sepsis: molecular diagnostics and biomarkers. Clinical microbiology reviews. 2012;25(4):609-34.
13. Zegers Bas S J, Pauline L. H. Winkler–Seinstra, Cuno S. P. M. Uiterwaal, Tom V. P. M. de Jong, Jan L. L. Kimpen and Catharine C. E. de Jong–de Vos van Steenwijk; Urinary tract infections in children with spina bifida: an inventory of

41 European centers, Pediatric Nephrology 2008, 24 (4): 783-788.

14. Paccolat C1, Harbarth S, Courvoisier D, Irion O, de Tejada BM. Procalcitonin levels during pregnancy, delivery and postpartum. Journal of Perinatal Medicine, 11 Aug 2011, 39(6):679-683.
15. R Nath S, Jayapalan S, Nair H, Kusumakumary P, Prema NS, Priyakumari T, Rajamohanan K. Comparative diagnostic test evaluation of serum procalcitonin and C-reactive protein in suspected bloodstream infections in children with cancer. J Med Microbiol, 2017. 66(5):622-627.
16. Li K, Yu H, Wang X, Liu X. Predictive value of procalcitonin or c-reactive protein for subclinical intrauterine infection in patients with premature rupture of membranes (PROM). J Prenat Med, 2016. 10(3-4):23-28.
17. Torbe A. Maternal plasma procalcitonin concentrations in pregnancy complicated by preterm premature rupture of membranes. Mediators Inflamm. 2007;2007:35782.
18. Rewatkar M, Jain S, Jain M, Mohod K. C-reactive protein and white blood cell count as predictors of maternal and neonatal infections in prelabour rupture of membranes between 34 and 41 weeks of gestation. J Obstet Gynaecol. 2018;38(5):622-8.
19. Cetin O, Aydin ZD, Verit FF, Zebitay AG, Karaman E, Elasan S, et al. Is Maternal Blood Procalcitonin Level a Reliable Predictor for Early Onset Neonatal Sepsis in Preterm Premature Rupture of Membranes? Gynecol Obstet Invest. 2017;82(2):163-9.
20. Dulay AT, Buhimschi IA, Zhao G, Bahtiyar MO, Thung SF, Cackovic M, et al. Compartmentalization of acute phase reactants Interleukin-6, C-Reactive Protein and Procalcitonin as biomarkers of intra-amniotic infection and chorioamnionitis. Cytokine. 2015;76(2):236-43.
21. Asadi N, Faraji A, Keshavarzi A, Akbarzadeh-Jahromi M, Yoosefi S. Predictive value of procalcitonin, C-reactive protein, and white blood cells for chorioamnionitis among women with preterm premature rupture of membranes. Int J Gynaecol Obstet. 2019;147(1):83-8.