The Review Of
DIABETIC
STUDIES OPEN ACCESS

Correaltion Between C-Reactive Protein And Carcinoembryonic Antigen In Obese Adults From Cartavio-Ascope, Peru

Alvaro David Rodríguez-Salvatierra[1], Jorge Leyser Vidal-Fernandez[1], Cecilia Betzabet Bardales-Vásquez [2], Martha Karina Lezama-Escobedo[2], Enrique Aurelio Martin-Alva[2], Carmen Carolina Cumpa-Yupton[3], Katherine Marita Elizabeth Medina-Vásquez[3], Carlos Alberto León-Torres[4*]

[1] Faculty of Health Sciences, Universidad Privada Antenor Orrego, Av. América Sur 3145, Trujillo, Perú.
[2] Faculty of human medicine, Universidad Privada Antenor Orrego, Av. América Sur 3145, Trujillo, Perú.
[3] Faculty of environmental engineering, Universidad Privada del Norte. Calle 31-Urb. San Isidro, Trujillo, Perú
[4] Faculty of Biological Sciences, Universidad Nacional de Trujillo, Av. Juan Pablo II s/n. Trujillo, Perú.
** corresponding author: cleon@unitru.edu.pe*
ID ORCID de los autores
Alvaro David Rodríguez-Salvatierra: https://orcid.org/0000-0001-5358-1628
Jorge Leyser Vidal-Fernandez: https://orcid.org/0000-0003-0332-533X
Cecilia Betzabet Bardales-Vásquez: https://orcid.org/0000-0002-7811-3676
Martha Karina Lezama-Escobedo: https://orcid.org/0000-0001-7025-9032
Enrique Aurelio Martin-Alva: http://orcid.org/0000-0001-5341-8206
Carmen Carolina Cumpa-Yupton: http://orcid.org/0000-0002-3259-5040
Katherine Marita Elizabeth Medina-Vásquez: https://orcid.org/0000-0003-2550-9084
Carlos Alberto León-Torres: http://orcid.org/0000-0002-9808-186X

ABSTRACT

Objective: To estimate the correlation between C-reactive protein (CRP) and Carcinoembryonic Antigen (CEA) in obese adults in Cartavio, Ascope province, Peru, in 2024.

Material and Methods: This was a correlational, cross-sectional study. One hundred thirty-seven residents between 40 and 80 years old with obesity (BMI ≥30 kg/m2) participated. Anthropometric assessment was used to calculate the BMI value, and a biochemical analysis of blood serum was performed to determine CRP and CEA levels. Results: Both markers had elevated values: CRP 95% CI: 32.6–68.0 mg/L and CEA 95% CI: 39.9–159.9 ng/mL. Additionally, a high positive correlation (ρ=0.841) was determined between C-reactive protein and Carcinoembryonic Antigen. Conclusion: There is a ** strong correlation between CRP and CEA** in obese adults from the small town of Cartavio in the province of Ascope, Peru, 2024.

Keywords: C-reactive protein, Carcinoembryonic Antigen, obesity, inflammatory biomarker, Cartavio.

INTRODUCTION

In 2022, one in eight people worldwide was obese. Furthermore, of the population over 18, 2.5 billion were overweight and 890 million were obese. Thus, the prevalence of overweight was 43% and obesity was 16% (1). The Americas region had the highest global prevalence of adult obesity at 33.8%, with 36.5% in women and 31.0% in men, respectively (2). Similarly, in Peru,
24.1% of the population aged 15 and older suffers from obesity, with women being more affected compared to men (3).

Obesity is linked to a state of chronic low-grade systemic inflammation, evidenced by the elevation of inflammatory biomarkers. High concentrations of interleukin-6 (IL-6), high-sensitivity C-reactive protein (hs-CRP), and other inflammatory mediators have been reported in obese versus non-obese patients (4, 5). Recently, new markers like the hyperglycemic stress index (SHR) and the pan-immune inflammation value (PIV) have shown correlation with increased mortality in overweight populations (6). In fact, adipose tissue exhibits a phenotypic shift of macrophages from the anti-inflammatory M2 type to the pro-inflammatory M1 type (7).

C-reactive protein (CRP), primarily synthesized by the liver in response to cytokines, is a key component of the inflammatory and immune response (8). This protein exists in two structural forms: pentameric (inactive) and monomeric (pro-inflammatory), with the latter being capable of activating endothelial cells and promoting processes like atherogenesis. Thus, CRP participates in immunological mechanisms like opsonization and complement activation, while its high-sensitivity version (hs-CRP) has emerged as a valuable biomarker for evaluating the risk of cardiovascular diseases, diabetes, and cancer, surpassing the native (pentameric) form in diagnostic specificity in conditions such as acute myocardial infarction (9, 10, 11). Studies highlight its therapeutic potential by modulating its serum levels, emphasizing its relevance as a diagnostic and prognostic biomarker.

Carcinoembryonic antigen (CEA) is an important tumor biomarker with clinical utility in the diagnosis, prognosis, and therapeutic follow-up of cancer. Elevated concentrations correlate with advanced stages of colorectal cancer and greater tumor aggressiveness (12), while a significant reduction in its levels is observed after surgery in advanced cases (13). In addition to its oncological application, CEA shows an association with various cardiometabolic risk factors, including harmful habits (smoking, alcohol consumption), chronic diseases (diabetes, cardiovascular pathologies), and oxidative stress (14). Its periodic monitoring is essential for evaluating disease progression and optimizing therapeutic management in oncological patients (13).

Given the evidence that obesity alters both biomarkers—CRP as an indicator of chronic inflammation and CEA associated with oncological risk— its relevance lies in the fact that, despite knowing the influence of hemodilution due to obesity on CEA levels (15), there are few local studies analyzing its link with CRP, a key marker for metabolic comorbidities. Furthermore, since Cartavio is a population with a high prevalence of obesity and limited access to oncological screening, the results could optimize diagnostic protocols by adjusting reference values based on the inflammatory profile, thus contributing to the early prevention of complications associated with these biomarkers in Peruvian rural settings.

We asked What correlation exists between C-reactive Protein and Carcinoembryonic Antigen in obese adults? Therefore, the objective was to estimate the correlation between C-reactive protein and Carcinoembryonic Antigen in adults with obesity in Cartavio-Ascope, Peru, 2024.

MATERIALS AND METHODS

Study Design

This was a correlational and cross-sectional study.

Population and Sample

Inclusion criteria: Adults between 40 and 80 years old, diagnosed with obesity (BMI ≥30 kg/m2).

Exclusion criteria: Chronic inflammatory diseases, diagnosed cancer. 137 individuals participated in the research, obtained through a non-probabilistic convenience sample during 2023.

Ethical Considerations

The research considered the Declaration of Helsinki (16). Participants were informed about the procedures and voluntarily signed their consent. Techniques and Procedures For the anthropometric assessment to measure weight and height, a digital platform scale with a stadiometer was used, and the BMI (kg/m2) was then calculated. Abdominal circumference was also measured with a 200 cm measuring tape (resolution: 1 mm) (17).

To quantify the biomarkers, venous blood samples were collected in BD Vacutainer tubes via peripheral puncture. After centrifugation at 4000 rpm for 10 minutes, the resulting serum was used to analyze C-reactive protein using the sandwich immunoassay technique and for carcinoembryonic antigen using chemiluminescence.

Statistical Analysis

The data were analyzed, obtaining the mean, standard deviation, 95% confidence intervals, and coefficient of variation. CRP and CEA data were subjected to the Kolmogorov-Smirnov test and did not meet the normality criterion. Subsequently, the Spearman's Rho test was performed to measure the monotonic correlation between the values of the two biomarkers. We used IBM SPSS version 30 software.

RESULTS AND DISCUSSION

The results are presented in the following tables and figures.

Table 1. Frequency of sex, weight level, and comorbidity risk in obese individuals from Cartavio-Ascope, Peru.

.Variable	Scale	Residents *fi*	% Residents *%hi*
Sex	Female	88	64.2
	Male	49	35.8
Weight Level	Obese I	28	20.4
	Obese II	84	61.3
	Obese III	25	18.3
Comorbidity Risk	Low	0	0.0
	High	11	8.0
	Very High	126	92.0

Table 1 shows that the obese individuals evaluated were mostly women (64.2%), had Type II obesity (61.3%), and predominantly had a very high risk of comorbidity (92.0%) based on abdominal circumference.

Table 2. Univariate analysis of anthropometric measurements: weight, height, body mass index, and abdominal circumference in obese individuals from Cartavio-Ascope, Peru.

Variable	Sex	□	S	Lower CI	Upper CI	CV
Weight (kg)	Both	98.5	8.9	95.7	101.3	9.05%*
Height (m)	Both	1.62	0.06	1.60	1.64	3.80%*
BMI (kg/m^2)	Both	37.6	2.8	36.7	38.4	7.40%*
Abdominal Circumference (cm)	Female	104.0	9.0	100.5	107.5	8.61%*
	Male	111.2	9.8	106.0	116.3	8.84%*

* Homogeneous distribution (CV<30%)

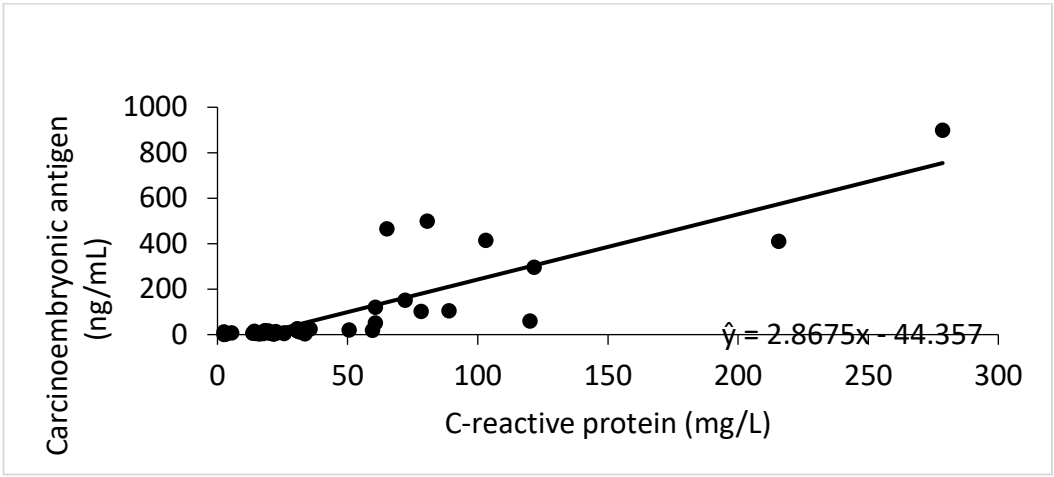
Table 2 shows the anthropometric measurements of the obese individuals in Cartavio: the weight is 98.5±8.9 kg (95% CI: 95.7–101.3 kg), the height is 1.62±0.06 m (95% CI: 1.60–1.64 m), and the BMI is 37.6±2.8 kg/m2 (95% CI: 36.7–38.4 kg/m2), which indicates Type II obesity. Furthermore, the female abdominal circumference is
104.0±9.0 cm (95% CI: 100.5–107.5 cm), while the male circumference is 111.2±9.8 cm (95% CI: 106.0–116.3 cm); therefore, both sexes presented abdominal obesity.

Table 3. Univariate analysis of biochemical markers: C-reactive protein and carcinoembryonic antigen in obese adults from Cartavio-Ascope, Peru.

Variable	□	S	Lower CI	Upper CI	CV
CRP (mg/L)	50.3	56.5	32.6	68.0	112.28%
CEA (ng/mL)	99.9	191.1	39.9	159.9	191.31%

Non-homogeneous distribution (CV>30%)

Table 3 shows the biochemical markers in obese adults from Cartavio: C-reactive protein 95% CI: 32.6–68.0 mg/L and carcinoembryonic antigen 95% CI: 39.9–159.9 ng/mL. This means both markers were highly elevated, above their normal values. ρ=0.841 (p=0.000)



ρ = 0,841 (p = 0,000)

Figure 1. Spearman's Rho Correlation Line between C-reactive protein (mg/L) and Carcinoembryonic Antigen (ng/L) in obese adults from Cartavio-Ascope, Peru.

Figure 1 provides evidence that in the obese sample studied, there is a high positive correlation (Spearman's Rho=0.841) between C-reactive protein and carcinoembryonic antigen.

DISCUSSION

The results reveal a high prevalence of Grade II obesity (61.3%) with a very high comorbidity risk in 92.0% of cases based on abdominal circumference measurements (Table 1). Currently, obesity is classified into two stages: preclinical (excess body fat without pathological manifestations) and clinical (adipose accumulation accompanied by persistent organ dysfunction and functional limitation) (18). Research shows that excess weight in adults significantly increases the risk of developing high to very high-grade comorbidities (19). Similarly, in patients with metabolic syndrome, a correlation has been identified between a sedentary lifestyle and an increased cardiovascular risk (20), which reinforces the need for early interventions based on the disease stage.

Anthropometric analysis shows an average BMI of 37.6±2.8 kg/m2 (95% CI: 36.7−38.4 kg/m2), confirming Type II obesity, with significant differences in abdominal circumference by sex: women 104.0±9.0 cm (95% CI: 100.5–107.5 cm) and men 111.2±9.8 cm (95% CI: 106.0−116.3 cm), values that exceed the cutoff points for abdominal obesity in both cases (Table 2). In this regard, the correlation between height, abdominal circumference (AC), and body mass index (BMI) offers a practical clinical tool to assess cardiovascular risk, with reference values of 44% for women and 45% for men in normal-weight populations (21). Recent studies propose specific AC cutoff points by sex: women show 86 cm and 95 cm for overweight and obesity respectively; while men show 89 cm and 99 cm for overweight and obesity in that order. Thus, a higher prevalence is shown in women than in men (22). However, the differences between indicators are notable: while BMI reports 26.8% obesity, AC and waist-to-height ratio detect 50.4% and 85.4% respectively, with the main prevalence in women and those over 30 years old (23).

The research analysis reveals significantly elevated levels of both C-reactive protein (32.6−68.0 mg/L, 95% CI) and carcinoembryonic antigen (39.9−159.9 ng/mL, 95% CI), exceeding the reference ranges (Table 3). In this regard, high concentrations of C-reactive protein (CRP) can reflect a chronic inflammatory process (24). Thus, a significant correlation has been found between obesity and increased CRP levels, indicating a greater inflammatory risk. Furthermore, the CRP concentration increases proportionally to the number of metabolic syndrome factors present (25). Similarly, a systematic review showed that obesity is associated with high CRP levels and cardiovascular risk. The association was more notable in women and in North American/European populations compared to men and Asians (26). On the other hand, a high body mass index (BMI) has been shown to be associated with increased plasma volume, which leads to
low carcinoembryonic antigen (CEA) concentrations (27). The findings suggest that obesity influences CEA measurements due to hemodilution (28), which could reduce the sensitivity of these tests in obese people with colorectal cancer (15).

However, a significant correlation has been explored between elevated CEA levels and metabolic syndrome and its components, such as low HDL and hypertension. Nevertheless, there may be an incorrect interpretation favored by smoking (29). Similarly, CEA levels were related to metabolic parameters such as visceral fat area,

fasting glucose, and triglycerides. In this way, CEA could be a link between metabolic alterations and carcinogenesis in visceral obesity, although more studies are needed to confirm its clinical relevance (30).

The results of this research show a strong positive correlation (rho=0.841) between C-reactive protein and carcinoembryonic antigen in obese individuals (Figure 1), suggesting a possible pathophysiological relationship between the chronic inflammatory state and tumor processes in this risk group. In this regard, studies show a notable interrelation between obesity and cancer, associating excess weight with an increased risk of at least 13 types of neoplasms, including colorectal, breast, pancreatic, and endometrial cancer (31, 32). Furthermore, the duration and severity of obesity in young adults has been described to significantly increase the risk of developing 18 types of cancer, including some hematological ones (33). Possible mechanisms include chronic inflammation, insulin resistance, and adipose tissue dysfunction that promote carcinogenesis (34) (Pati et al., 2023).

One study indicates that combining inflammatory markers (C-reactive protein and fibrinogen) with conventional tumor indicators (CEA and CA72−4) could optimize the diagnosis of colorectal cancer (35), although the results need to be validated (36). Gastric cancer, in turn, can be diagnosed using IL-6 with higher sensitivity (85%) compared to CRP (66%), CA19−9 (34%), and CEA (22%) (37). One investigation revealed that patients with metabolic syndrome had decreased CRP concentrations but increased CEA levels after colorectal cancer surgery (38). This evidence suggests that integrating inflammatory and tumor markers is necessary to increase diagnostic accuracy in gastrointestinal neoplasms.

CONCLUSIONS

The degree of correlation between C-reactive Protein and Carcinoembryonic Antigen was positive and high (ρ=0.841) in obese adults from Cartavio-Ascope, Peru, 2024.

RECOMMENDATIONS

Future research should expand the sample size to clarify the results with the potential for oncological screening, adjusting reference values based on the inflammatory profile.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

REFERENCES

1. World Health Organization (WHO). 1 March 2024. Obesity and Overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. Pan American Health Organization (PAHO). 2025. ENLACE: Data Portal on Noncommunicable Diseases, Mental Health, and External Causes. Overweight and Obesity. https://www.paho.org/en/enlace/overweight-and-obesity
3. Instituto Nacional de Estadística e Informática (INEI). 2024. Perú: Enfermedades No Transmisibles y Transmisibles, 2023. Lima, Perú. https://www.gob.pe/institucion/inei/informes-publicaciones/5601760-peru-enfermedades-no-transmisibles-y-transmisibles-2023
4. Ellulu, M. S., Khaza'ai, H., Rahmat, A., Patimah, I., & Abed, Y. (2016). Obesity can predict and promote systemic inflammation in healthy adults. International journal of cardiology, 215, 318-324. https://www.sciencedirect.com/science/article/pii/S0167527316307823
5. Osadnik, T., Bujak, K., Osadnik, K., Czarnecka, H., Pawlas, N., Reguła, R., ... & Gąsior, M. (2019). Novel inflammatory biomarkers may reflect subclinical inflammation in young healthy adults with obesity. Endokrynologia Polska, 70(2), 135-142. https://journals.viamedica.pl/endokrynologia_polska/article/view/EP.a2019.0002
6. Mohammed, A. Q., Liu, L., Alifu, J., Yin, G., Zhang, W., Xu, Y., ... & Che, W. (2025). Association of novel inflammatory and metabolic markers with mortality in individuals with overweight and obesity. Nutrition, Metabolism and Cardiovascular Diseases, 35(3), 103859. https://www.sciencedirect.com/science/article/pii/S0939475325000134
7. Khanna, D., Khanna, S., Khanna, P., Kahar, P., & Patel, B. M. (2022). Obesity: a chronic low-grade inflammation and its markers. Cureus, 14(2). https://pmc.ncbi.nlm.nih.gov/articles/PMC8967417/
8. Zhou, H. H., Tang, Y. L., Xu, T. H., & Cheng, B. (2024). C-reactive protein: structure, function, regulation, and role in clinical diseases. Frontiers in immunology, 15, 1425168. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1425168/full

9. Banait, T., Wanjari, A., Danade, V., Banait, S., & Jain, J. (2022). Role of high-sensitivity C-reactive protein (Hs-CRP) in non-communicable diseases: a review. Cureus, 14(10). https://pmc.ncbi.nlm.nih.gov/articles/PMC9650935/
10. Zeinolabediny, Y., Kumar, S., & Slevin, M. (2021). Monomeric C-reactive protein–A feature of inflammatory disease associated with cardiovascular pathophysiological complications?. in vivo, 35(2), 693-697. https://iv.iiarjournals.org/content/35/2/693.abstract
11. Moutachakkir, M., Hanchi, A. L., Baraou, A., Boukhira, A., & Chellak, S. (2017, March). Caractéristiques immunoanalytiques de la protéine C-réactive et de la protéine C-réactive ultrasensible. In Annales de Biologie Clinique (Vol. 75, No. 2, pp. 225-229).
12. Hall, C., Clarke, L., Pal, A., Buchwald, P., Eglinton, T., Wakeman, C., & Frizelle, F. (2019). A review of the role of carcinoembryonic antigen in clinical practice. Annals of coloproctology, 35(6), 294. https://pmc.ncbi.nlm.nih.gov/articles/PMC6968721/
13. Khushk, M., Khan, A., Rehman, A., Sheraz, S., Tunio, Y. M., Rehman, K., ... & Khan, M. E. (2021). The role of tumor markers: carcinoembryonic antigen and cancer antigen 15-3 in patients with breast cancer. Cureus, 13(7). https://pmc.ncbi.nlm.nih.gov/articles/PMC8352810/
14. Chang, C. H., Weng, H. H., Lin, Y. C., Lin, C. N., Huang, T. J., & Chen, M. Y. (2023). Association between serum carcinoembryonic antigen and cardiometabolic risks: Implication for cardiometabolic prevention. Frontiers in Endocrinology, 14, 1113178. https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2023.1113178/full
15. Chen, W., Liu, Q., Tan, S. Y., & Jiang, Y. H. (2013). Association between carcinoembryonic antigen, carbohydrate antigen 19-9 and body mass index in colorectal cancer patients. Molecular and clinical oncology, 1(5), 879-886. https://pmc.ncbi.nlm.nih.gov/articles/PMC3915429/
16. World Medical Association. (2024). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human participants. JAMA, 333(1), 71-74. doi:10.1001/jama.2024.21972
17. Aguilar Esenarro, L. A., Contreras Rojas, M. C., Del Canto Y Dorador, J. S. y Vílchez Dávila, W. (2012). Guía técnica para la valoración nutricional antropométrica de la persona adulta. Lima: Ministerio de Salud e Instituto Nacional de Salud.
18. Rubino, F., Cummings, D. E., Eckel, R. H., Cohen, R. V., Wilding, J. P., Brown, W. A., ... & Mingrone, G. (2025). Definition and diagnostic criteria of clinical obesity. The Lancet Diabetes & Endocrinology. https://www.thelancet.com/journals/landia/article/PIIS2213-8587(24)00316-4/fulltext
19. Rodríguez-Salvatierra, A. D., Bardales-Vásquez, C. B., Martin-Alva, E. A., Lezama-Escobedo, M. K., Gil-Ramírez, L. A., Medina-Vásquez, K. M. E., ... & León-Torres, C. A. (2024). Lifestyle and Risk Factors Related to Metabolic Syndrome in Administrative Workers: Universidad Nacional de Trujillo, Perú. Journal of Ecohumanism, 3(8), 2133-2143.
20. Rodríguez-Salvatierra, A., Bardales-Vásquez, C., León-Torres, C., Rodríguez-Plasencia, C., & Manno, N. 2022. Relación entre el nivel de actividad física y el riesgo coronario del personal administrativo de la Universidad Nacional de Trujillo, 2022. REBIOL, 42(2): 160-166.
21. Lucas, R. W. D. C., Nassif, P. A. N., Tabushi, F. I., Nassif, D. S. B., Ariede, B. L., Brites-Neto, J., & Malafaia, O. (2020). Can stature, abdominal perimeter and bmi index predict possible cardiometabolic risks in future obesity?. ABCD. Arquivos Brasileiros de Cirurgia Digestiva (São Paulo), 33(02), e1529. https://www.scielo.br/j/abcd/a/rMnsf3VKCgWMCHKRrM5T39D/
22. Tirado, A. G. (2024). Punto de corte del perímetro abdominal ajustado al índice de masa corporal para sobrepeso y obesidad en la población peruana. Revista del Cuerpo Médico Hospital Nacional Almanzor Aguinaga Asenjo, 17(2). https://doi.org/10.35434/rcmhnaaa.2024.172.2232
23. Aparco, J. P., & Cárdenas-Quintana, H. (2023). Correlación y concordancia del índice de masa corporal con el perímetro abdominal y el índice cintura-talla en adultos peruanos de 18 a 59 años. Revista Peruana de Medicina Experimental y Salud Publica, 39, 392-399. https://www.scielosp.org/article/rpmesp/2022.v39n4/392-399/
24. Briggs, M. S., Givens, D. L., Schmitt, L. C., & Taylor, C. A. (2013). Relations of C-reactive protein and obesity to the prevalence and the odds of reporting low back pain. Archives of physical medicine and rehabilitation, 94(4), 745-752. https://www.sciencedirect.com/science/article/abs/pii/S0003999312011872
25. Aronson, D., Bartha, P., Zinder, O., Kerner, A., Markiewicz, W., Avizohar, O., ... & Levy, Y. (2004). Obesity is the major determinant of elevated C-reactive protein in subjects with the metabolic syndrome. International journal of obesity, 28(5), 674-679. https://www.nature.com/articles/0802609

26. Choi, J., Joseph, L., & Pilote, L. (2013). Obesity and C-reactive protein in various populations: a systematic review and meta-analysis. Obesity reviews, 14(3), 232-244. https://onlinelibrary.wiley.com/doi/abs/10.1111/obr.12003
27. Li, F., Shen, Z., Lu, Y., Wang, L., & Song, W. (2014). How much does body mass index affect serum carcinoembryonic antigen concentration?. Cancer epidemiology, biomarkers & prevention, 23(3), 555-560. https://aacrjournals.org/cebp/article/23/3/555/70358/How-Much-Does-Body-Mass-Index-Affect-Serum
28. Park, J. S., Choi, G. S., Jang, Y. S., Jun, S. H., & Kang, H. (2010). Influence of obesity on the serum carcinoembryonic antigen value in patients with colorectal cancer. Cancer epidemiology, biomarkers & prevention, 19(10), 2461-2468. https://aacrjournals.org/cebp/article/19/10/2461/67771/Influence-of-Obesity-on-the-Serum-Carcinoembryonic
29. Kim, K. N., Joo, N. S., Je, S. Y., Kim, K. M., Kim, B. T., Park, S. B., ... & Lee, D. J. (2011). Carcinoembryonic antigen level can be overestimated in metabolic syndrome. Journal of Korean Medical Science, 26(6), 759. https://pmc.ncbi.nlm.nih.gov/articles/PMC3102869/
30. Lee, J. Y., Lee, H. K., Lee, D. C., & Lee, J. W. (2012). Serum carcinoembryonic antigen is associated with abdominal visceral fat accumulation in female Korean nonsmokers. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0043518
31. Avgerinos, K. I., Spyrou, N., Mantzoros, C. S., & Dalamaga, M. (2019). Obesity and cancer risk: Emerging biological mechanisms and perspectives. Metabolism, 92, 121-135. https://www.sciencedirect.com/science/article/pii/S0026049518302324
32. Svatetz, C. A. G., & Arnó, A. G. (2015). Obesity and cancer:“Dangerous friendship”. Medicina Clínica (English Edition), 145(1), 24-30. https://www.sciencedirect.com/science/article/pii/S2387020615003502
33. Recalde, M., Pistillo, A., Davila-Batista, V., Leitzmann, M., Romieu, I., Viallon, V., ... & Duarte-Salles, T. (2023). Longitudinal body mass index and cancer risk: a cohort study of 2.6 million Catalan adults. Nature Communications, 14(1), 3816. https://www.nature.com/articles/s41467-023-39282-y
34. Pati, S., Irfan, W., Jameel, A., Ahmed, S., & Shahid, R. K. (2023). Obesity and cancer: a current overview of epidemiology, pathogenesis, outcomes, and management. Cancers, 15(2), 485. https://www.mdpi.com/2072-6694/15/2/485
35. Bu, F., Cao, S., Deng, X., Zhang, Z., & Feng, X. (2023). Evaluation of C–reactive protein and fibrinogen in comparison to CEA and CA72–4 as diagnostic biomarkers for colorectal cancer. Heliyon, 9(5). https://www.cell.com/heliyon/fulltext/S2405-8440(23)03299-1
36. Nozawa, H., Yokota, Y., Emoto, S., Yokoyama, Y., Sasaki, K., Murono, K., ... & Ishihara, S. (2023). Unexplained increases in serum carcinoembryonic antigen levels in colorectal cancer patients during the postoperative follow-up period: An analysis of its incidence and longitudinal pattern. Annals of medicine, 55(2), 2246997. https://www.tandfonline.com/doi/full/10.1080/07853890.2023.2246997
37. Łukaszewicz-Zając, M., Mroczko, B., Gryko, M., Kędra, B., & Szmitkowski, M. (2011). Comparison between clinical significance of serum proinflammatory proteins (IL-6 and CRP) and classic tumor markers (CEA and CA 19-9) in gastric cancer. Clinical and experimental medicine, 11, 89-96. https://link.springer.com/article/10.1007/s10238-010-0114-5
38. Gačić, J., Dimitrijević-Srećković, V., Gačić, D., Petričević, S., Srećković, B., Lazić, B., ... & Ranđelović, T. (2017). Pre-and postoperative characteristics of metabolic syndrome in patients with colorectal cancer. Archives of Biological Sciences, 69(2), 215-222. https://www.serbiosoc.org.rs/arch/index.php/abs/article/view/679