ISSN 1850-1044

ARTÍCULO ORIGINAL (Versión en inglés)

Avances en la fisiopatología, el diagnóstico y el tratamiento del síndrome coronario agudo

Mohamed Abobaker[1,*]

Resumen

El síndrome coronario agudo (SCA) comprende la angina inestable (AI), el infarto de miocardio sin elevación del segmento ST (IAMSEST) y el infarto de miocardio con elevación del segmento ST (IAMCEST), todos resultantes de una isquemia miocárdica aguda debida a una obstrucción brusca de las arterias coronarias. Es una causa importante de morbilidad y mortalidad a nivel mundial y exige un diagnóstico y tratamiento rápidos. El mecanismo subyacente implica la disrupción de la placa aterosclerótica, la formación de trombo y la lesión miocárdica, influenciadas por la inflamación y el estrés oxidativo. El diagnóstico se basa en la presentación clínica, los cambios en el ECG y las troponinas de alta sensibilidad, apoyados por técnicas de imagen como la ecocardiografía y la angiografía coronaria por tomografía computarizada (CCTA). El manejo se centra en restaurar la perfusión, limitar el daño miocárdico y prevenir recurrencias; el IAMCEST requiere reperfusión urgente (ICP primaria o fibrinólisis), mientras que el IAMSEST y la AI se guían por escalas de riesgo como GRACE o TIMI, y el tratamiento estándar incluye doble terapia antiplaquetaria (DAPT), anticoagulantes, betabloqueantes, estatinas, inhibidores de la ECA y nuevos inhibidores $P2Y_{12}$ e inhibidores de PCSK9. Los retrasos persistentes en el diagnóstico y el acceso limitado a la atención especializada subrayan la importancia del abordaje multidisciplinar, la rehabilitación cardiaca y las herramientas digitales y de inteligencia artificial emergentes para mejorar los desenlaces a largo plazo.

Insuf Card 2025;20 (1): 12–19.

Palabras clave: síndrome coronario agudo, angina inestable, IAMSEST, IAMCEST, isquemia miocárdica, estratificación del riesgo

Summary

Advances in Acute Coronary Syndrome Pathophysiology, Diagnosis and Treatment

Acute coronary syndrome (ACS) comprises unstable angina (UA), non–ST-segment elevation myocardial infarction (NSTEMI), and ST-segment elevation myocardial infarction (STEMI), all resulting from acute myocardial ischemia due to abrupt coronary artery obstruction. It is a major global cause of morbidity and mortality and demands rapid diagnosis and treatment. The underlying mechanism involves atherosclerotic plaque disruption, thrombus formation, and myocardial injury, influenced by inflammation and oxidative stress. Diagnosis is based on clinical presentation, ECG changes, and high-sensitivity troponins, supported by imaging such as echocardiography and coronary CT angiography (CCTA). Management focuses on restoring perfusion, limiting myocardial damage, and preventing recurrence, with STEMI requiring urgent reperfusion (primary PCI or fibrinolysis), NSTEMI and UA guided by GRACE or TIMI risk scores, and standard therapy including DAPT, anticoagulants, beta-blockers, statins, ACE inhibitors, and newer $P2Y_{12}$ and PCSK9 inhibitors. Persistent delays in diagnosis and limited access to specialized care highlight the importance of multidisciplinary management, cardiac rehabilitation, and emerging digital and AI-based tools to improve long-term outcomes.

Keywords: acute coronary syndrome, unstable angina, NSTEMI, STEMI, myocardial ischemia, risk stratification

[1]College of Science, Sebha University, Sabha, Libya
Correspondencia: Mohamed Abobaker. College of Science, Sebha University, Sabha, Libya
E-mail: m.abobker@gmail.com

Recibido: 21/12/2024
Aceptado: 07/03/2025

Introduction

ACS represents an acute cardiac disease that comes as a form of acute myocardial ischemia resulting from compromised or obstructed blood flow to the coronary arteries. It essentially presents in three major clinical entities: unstable angina (UA), non-ST-elevation myocardial infarction (NSTEMI), and ST-elevation myocardial infarction (STEMI) [1]. As a collective group, it contributes to morbidity and mortality in the whole world at rates that are of concern [2]. Early recognition, accurate diagnosis, and timely intervention are the keys to optimizing outcomes and minimizing complications [3].

The pathophysiology of ACS derives from the atherosclerotic plaque tear or erosion culminating in the thrombus which, in due course, fills up the ostia of one or more segments of the coronaries. Subsequent mechanisms by which ischemia and myocardial injury occur encompass vasospasm, microvascular dysfunction, as well as spontaneous coronary artery dissection [4]. All these together have driven advanced diagnostic methods, and therapeutic management to make treatments more precise as well as better in management scope [5].

In the last few years, not just high-sensitivity cardiac biomarkers but also advanced imaging techniques as well as risk stratification systems transformed the approach to ACS care [6]. Similarly, pharmacologic and interventional advancements, including dual antiplatelet therapy, drug-eluting stents, and revascularization techniques, improved the best outcomes of the patients involved [7]. Challenges persist, such as ensuring timely access to care and addressing regional disparities in healthcare resources [8].

This paper aims to discuss the current scenario of ACS, focusing on the latest developments in diagnosis, management, and prevention. By pointing out these developments, we are trying to stress the importance of a multidisciplinary, patient-centered approach in dealing with this critical public health challenge [9].

Search strategy

We conducted a literature search using the databases PubMed, Scopus, Web of Science, and Google Scholar. The keywords used included "Acute Coronary Syndrome," "STEMI," "NSTEMI," "unstable angina," "myocardial infarction," "revascularization," and "risk stratification." Studies, clinical guidelines, and systematic reviews published within the last ten years were preferred.

Pathophysiology of acute coronary syndrome

Acute Coronary Syndrome, or ACS, is primarily driven by the disruption of acute myocardial ischemia due to an abrupt interference in coronary blood flow. Underlying mechanisms for this interference have proved to be complex and include plaque instability due to atherosclerosis, thrombus formation, vasospasm, and, rarely, spontaneous dissection of the coronary arteries.

Plaque rupture or erosion

Most initiating events for ACS is the rupture or erosion of an atherosclerotic plaque within the coronary artery [10]. This event exposes the lipid core and subendothelial matrix to circulating blood, which results in platelet activation, aggregation, and the coagulation cascade. The resulting thrombus partly or completely occludes the coronary artery leading to ischemia and myocardial injury [11].

Inflammatory processes

Inflammation plays a key role in the pathogenesis of plaque instability. Increased levels of inflammatory markers, including C-reactive protein (CRP), have been linked to increased risk of ACS [12]. Inflammatory cells, such as macrophages and T-lymphocytes, infiltrate the plaque, releasing enzymes such as matrix metalloproteinases (MMPs) that weaken the fibrous cap and predispose it to rupture [13].

Vasospasm and microvascular dysfunction

In some instances, ischemia might be caused by coronary vasospasm, that is, the sudden, transient narrowing of coronary arteries. In this mechanism, the condition Prinzmetal's angina often comes into consideration [14]. Finally, microvascular dysfunction, meaning impaired vasodilation and enhanced vascular resistance, is another contribution to myocardial ischemia and is especially encountered in patients suffering from nonobstructive CAD [15].

Spontaneous coronary artery dissection (SCAD)

Although it is rare, SCAD is an important non-atherosclerotic cause of ACS. It occurs due to the formation of an intramural hematoma or an intimal tear within the coronary artery that leads to obstruction of blood flow. SCAD predominantly affects younger women, often in the context of pregnancy or connective tissue disorders [16].

Systemic responses to ischemia

Acute ischemia elicits systemic inflammatory and oxidative stress response, which worsens the myocar-

dial injury. These responses invite further endothelial dysfunction, increased vascular permeability, and enhanced thrombus formation based on [17].

Clinical presentation and diagnosis

Clinical presentation

ACS is a presentation of acute coronary syndrome that may differ from patient to patient depending on age, gender, and other comorbidities. Chest pain is the classic symptom that is often described as a sensation of pressure, tightness, or burning and radiates to the left arm, neck, jaw, or back according to cite [18]. Other symptoms include dyspnea, diaphoresis, nausea, and fatigue. Atypical presentations are more common in women, the elderly, and diabetic patients, where symptoms such as epigastric discomfort, dizziness, or syncope may dominate [19].

Diagnostic tools

Accurate and timely diagnosis of ACS is critical to optimizing outcomes. Diagnosis relies on a combination of clinical evaluation, electrocardiography (ECG), and cardiac biomarkers:

- **Electrocardiography (ECG):** ECG is the cornerstone of initial ACS diagnosis. It helps differentiate ST-elevation myocardial infarction (STEMI), which requires urgent revascularization, from non-ST-elevation myocardial infarction (NSTEMI) and unstable angina (UA) [20]. Classic findings in STEMI include ST-segment elevation in two contiguous leads, while NSTEMI and UA may present with ST-segment depression or T-wave inversions [21].
- **Cardiac Biomarkers:** High-sensitivity troponins (hs-cTn) have revolutionized ACS diagnostics, enabling the detection of myocardial injury with high sensitivity and specificity. Elevated hs-cTn levels are a key criterion for diagnosing NSTEMI [22]. Serial measurements are essential to distinguish acute events from chronic elevations due to other conditions [23].
- **Imaging Modalities:** Echocardiography provides valuable information about left ventricular function, regional wall motion abnormalities, and complications such as pericardial effusion [24]. Coronary computed tomography angiography (CCTA) is increasingly used for evaluating coronary anatomy and ruling out significant obstructions in low- to intermediate-risk patients [25].

Risk stratification

Risk stratification is a vital component of ACS management, guiding therapeutic decisions. Tools such as the GRACE (Global Registry of Acute Coronary Events) and TIMI (Thrombolysis in Myocardial Infarction) scores assess the likelihood of adverse outcomes, assisting clinicians in determining the need for invasive versus conservative approaches [26].

Management of acute coronary syndrome

Goals of management

The primary goals in managing Acute Coronary Syndrome (ACS) are to restore coronary perfusion, minimize myocardial damage, prevent complications, and reduce the risk of recurrent ischemic events [27]. Management strategies are tailored based on the ACS subtype (STEMI, NSTEMI, or UA) and the patient's clinical profile.

Revascularization strategies

- **ST-Elevation Myocardial Infarction (STEMI):** In STEMI, immediate reperfusion is critical. Primary percutaneous coronary intervention (PCI) is the preferred method, ideally performed within 90 minutes of first medical contact. PCI techniques have advanced with the use of drug-eluting stents (DES) and intravascular imaging, improving outcomes [28]. When PCI is unavailable, fibrinolysis within 30 minutes is recommended as an alternative [29].
- **Non-ST-Elevation Myocardial Infarction (NSTEMI) and Unstable Angina (UA):** Management of NSTEMI and UA depends on risk stratification. High-risk patients benefit from early invasive strategies, including angiography and PCI, while low-risk patients may be managed conservatively with close monitoring and medical therapy [30]. Complete revascularization, particularly in patients with multivessel disease, has shown to improve long-term outcomes [31].

Pharmacological therapy

Pharmacological treatment forms the backbone of ACS management, with the following key components:

- **Dual Antiplatelet Therapy (DAPT):** DAPT, consisting of aspirin and a P2Y12 inhibitor (e.g., clopidogrel, ticagrelor, or prasugrel), is essential to prevent thrombosis. Newer agents

like ticagrelor and prasugrel have shown superior efficacy but carry a higher bleeding risk [32].

- **Anticoagulants:** Agents such as unfractionated heparin, low-molecular-weight heparin (LMWH), or direct oral anticoagulants (DOACs) are used to reduce thrombotic complications [33].

- **Other Medications:** Beta-blockers, ACE inhibitors (or ARBs), and statins address ischemia, control blood pressure, and manage dyslipidemia. PCSK9 inhibitors are increasingly used in patients with residual lipid abnormalities despite statin therapy [34].

Adjunctive and supportive measures

Cardiac rehabilitation programs are crucial for secondary prevention, focusing on lifestyle modifications, psychological support, and adherence to pharmacotherapy. Smoking cessation, a healthy diet, and regular physical activity are integral to improving long-term outcomes [35].

Addressing disparities and timely access to care

Delays in symptom recognition, prehospital care, and access to advanced diagnostic and therapeutic modalities remain significant challenges. Streamlined care pathways, public awareness campaigns, and equitable healthcare policies are essential to bridge these gaps and improve outcomes across diverse populations [36].

Emerging therapies and future directions

Ongoing research is exploring hybrid approaches combining PCI and coronary artery bypass grafting (CABG) for complex cases. Digital health technologies, such as remote monitoring and AI-based decision-making tools, hold promise for improving care precision and efficiency [37].

Recent advances and emerging therapies

Advancements in revascularization techniques

Revascularization remains a cornerstone in the management of Acute Coronary Syndrome (ACS). Advances in percutaneous coronary intervention (PCI) techniques, including the development of second-generation drug-eluting stents (DES) and intravascular imaging technologies, have significantly improved outcomes by reducing restenosis and ensuring precise stent placement [38]. Additionally, complete revascularization strategies, particularly in multivessel disease, have demonstrated superior long-term benefits compared to culprit-only interventions [39]. Hybrid approaches, combining PCI with coronary artery bypass grafting (CABG), are being explored for complex cases to individualize care [40].

Innovations in pharmacological therapies

- **Antiplatelet Therapy:** Newer P2Y12 inhibitors, such as ticagrelor and prasugrel, have shown enhanced efficacy in reducing ischemic events compared to clopidogrel. These agents, however, require careful consideration of bleeding risks, especially in high-risk patients [41].

- **Lipid-Lowering Agents:** Proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors have revolutionized dyslipidemia management, providing additional LDL-C reduction in patients with residual lipid abnormalities despite statin therapy. These agents significantly lower the risk of recurrent cardiovascular events [42].

- **Anticoagulants:** Direct oral anticoagulants (DOACs) are being evaluated for their role in ACS, particularly in patients with concomitant atrial fibrillation. Early trials suggest potential benefits in specific patient subsets [43].

Digital health and artificial intelligence

The integration of digital health technologies into ACS care has gained momentum. Remote monitoring systems and wearable devices enable continuous tracking of vital parameters, enhancing early detection and management of complications [44]. Artificial intelligence (AI)-based tools are being developed to support clinical decision-making by analyzing large datasets for personalized risk stratification and treatment optimization [45].

Inflammation as a therapeutic target

Inflammation is a critical contributor to atherosclerosis and ACS pathogenesis. Targeting inflammatory pathways has shown promise, as evidenced by the success of therapies like canakinumab, an IL-1β inhibitor, in reducing cardiovascular events in high-risk patients. Ongoing trials are exploring other anti-inflammatory agents to further refine this approach.

Regenerative and stem cell Therapies

Regenerative medicine emerges as a promising direction for the treatment of myocardial damage following an acute coronary syndrome. Stem cell-based therapies target repair or replacement of damaged cardiac tissue, although clinical use remains in the experimental stage. Initial results from early studies in the area have included some promising improvements in cardiac function and scar reduction.

Reducing health disparities, cost, and access

Recent efforts have focused on addressing inequities in ACS care. Initiatives promoting access to advanced therapies, such as mobile PCI units and telemedicine platforms, are being implemented in underserved regions. Additionally, public health campaigns emphasizing symptom recognition and early presentation are helping reduce delays in care.

Future directions

Ongoing research is exploring novel therapies, including gene-editing technologies and targeted molecular interventions, to address the underlying mechanisms of atherosclerosis and thrombosis. Personalized medicine approaches leveraging genomic and proteomic data are also being developed to optimize therapy selection and improve patient outcomes.

Conclusion

Acute Coronary Syndrome (ACS) is a leading cause of morbidity and mortality worldwide and continues to be a challenge to healthcare systems. The condition necessitates a comprehensive approach, integrating rapid diagnosis, risk stratification, and evidence-based management. Recent advances in revascularization techniques, pharmacological therapies, and diagnostic technologies have significantly improved patient outcomes. Innovations such as drug-eluting stents, high-sensitivity troponins, and PCSK9 inhibitors have further refined the management of ACS, while emerging technologies such as artificial intelligence and digital health tools promise to enhance care precision and accessibility. Despite these advances, there are still challenges such as unequal access to care, delayed recognition of symptoms, and unequal outcomes among different socioeconomic groups. Overcoming these barriers is important for equitable delivery of healthcare. Multidisciplinary care, public health awareness campaigns, and cardiac rehabilitation programs are essential for improving the long-term prognosis of patients with ACS.

Acknowledgment

We extend our sincere gratitude to Al-Bayan University for its valuable contribution in providing a conducive environment through its library and laboratories, which significantly facilitated the completion of our scientific research. Your unwavering support for researchers reflects the university's commitment to fostering knowledge and innovation.

Referencias bibliográficas

[1] Raja, S. "Surface functionalization of bio-based polymers in FDM: A pathway to enhanced material performance." *Applied Chemical Engineering* 7 (2024): ACE-5536.

[2] Kadhum, Hussam H., et al. "Potential pharmaceutical applications and molecular docking study for green fabricated ZnO nanoparticles mediated raphanus sativus: In vitro and in vivo study." *Nanotechnology Reviews* 13.1 (2024): 20240113.

[3] Jawad, Zainab Nizar. "Molecular detection of caspase 3, 8, 9 genes and ADIPOR1 (rs2275738) polymorphism in colorectal cancer." *Applied Nanoscience* 13.8 (2023): 5365-5368.

[4] Jawad, Zainab Nizar. "Association between APC gene SNPs and the risk of occurrence of colorectal cancer." *AIP Conference Proceedings*. Vol. 2414. No. 1. AIP Publishing, 2023 : 020021.

[5] Jawad, Zainab Nizar, and Weaam Awad. "The effect of montelukast on CD14 gene expression in asthmatic patient in Kerbala." *AIP Conference Proceedings*. Vol. 2290. No. 1. AIP Publishing, 2020: 020053.

[6] Jawad, Zainab Nizar, and Weaam Awad. "Association of urokinase and Vitamin D receptor genes SNPs and urolithiasis in an Iraqi population." *Meta Gene* 24 (2020): 100679.

[7] Al-Abodi, Hiba Riyadh, et al. "Novel gold nanobiosensor platforms for rapid and inexpensive detection of Vibrio cholerae." *Reviews and Research in Medical Microbiology* 31.2 (2020): 70-74.

[8] Jawad, Zainab Nizar, and Kamal AR. "Association of additive risk of pioglitazone use with the presence of CYP1A1 polymorphisms in the occurrence of bladder cancer." *Systematic Reviews in Pharmacy* 11.5 (2020): p375.

[9] Jawad, Zainab Nizar, Kamal Abdul Rasool, and Weaam Awad. "The relationship between smoking and urokinase gene 3'-UTR T/C expression on occurrence of bladder cancer." *Indian Journal of Forensic Medicine & Toxicology* 14.1 (2020): 1169-1171.

[10] Jawad, Zainab Nizar. "Molecular diagnosis of CD14 and MnSOD genes and their effect on asthma in Holy Karbala, Iraq." *Indian Journal of Public Health Research & Development* 10.8 (2019): p1156.

[11] Jawad, Zainab Nizar. "The association of urokinase gene 3'-UTR T/C polymorphism with urinary bladder cancer." *Biochemical & Cellular Archives* 18.1 (2018): p587.

[12] Jawad, Zainab Nizar, Zuhair Mohammed Ali Jeddoaa, and Riadh Rasheed Al-Toama. "Association of MDM2 (T309G) gene polymorphism with interstitial urinary bladder cancer." *Biochemical & Cellular Archives* 18.2 (2018): p2505.

[13] Jalal, Bnar J., and Mustafa RM Alqaisi. "Improving the production and quality of white button mushroom (agaricus bisporus) by adding biochar and ash to the casing layer." *Tikrit Journal for Agricultural Sciences* 24.1 (2024): 22-33.

[14] Karim, Kamaran Khattab, and Nazim Rasul Abdulla. "Use of various sources of calcium in the diets of broiler and its effects on carcass and some meat quality." *Tikrit Journal for Agricultural Sciences* 24.1 (2024): 45-56.

[15] Mustafa, Mahbuba A., and Soran A. Othman. "Effect of adding natural and synthetic antioxidants to broiler drinking water as antistressor on productivity, antioxidant statues and hematological traits under heat stress." *Tikrit Journal for Agricultural Sciences* 24.1 (2024): 94-104.

[16] Mohammed, Arkan B., Oday K. Hamad, and Thamer A. Khttab. "Effect of zinc oxide nanoparticles in drinking water on growth rate, biochemical parameters, and intestinal histology of broilers." *Advances in Agriculture* 2023.1 (2023): 8523516.

[17] Mohammed, A. B., A. S. Abdulwahid, and S. M. Raouf. "Effect of Thymus vulgmus addition to the diet of laying hens on egg production, egg quality, biochemical and antioxidant parameters." *Advances in Animal and Veterinary Sciences* 10.2 (2022): 427-433.

[18] Abdulwahid, Ammar Salah, Arkan Baraa Mohammed, and Akeel A. Al-Mjbel. "Onion (Allium cepa) and sumac (Rhus coriaria) powder as dietary supplements for Japanese quail (Coturnix japonica): effect on egg production, blood parameters and antioxidant activity." *International Journal of Agriculture & Biology* 28 (2022): 156-160.

[19] Saadh, Mohamed J., et al. "Advances in chitosan-based blends as potential drug delivery systems: A review." *International Journal of Biological Macromolecules* (2024): 132916.

[20] Hsu, Chou-Yi, et al. "Rechargeable Batteries for Energy Storage: A review." *e-Prime-Advances in Electrical Engineering, Electronics and Energy* (2024): 100510.

[21] Subramani, Raja, et al. "Exploring the use of biodegradable polymer materials in sustainable 3D printing." *Applied Chemical Engineering* (2024): 3870-3870.

[22] Raja, S., et al. "Unlocking the potential of polymer 3D printed electronics: Challenges and solutions." *Applied Chemical Engineering* (2024): 3877-3877.

[23] Raja, S., et al. "An analysis of polymer material selection and design optimization to improve structural integrity in 3D printed aerospace components." *Applied Chemical Engineering* (2024): 1875-1875.

[24] Mustafa, Mohammed Ahmed, et al. "Cardiovascular Diseases in Iraq: The impact of hypertension on heart and vascular health." *Journal of Rare Cardiovascular Diseases* 4.5 (2022): 199-203.

[25] Al-Saadi, Ahmed Rashid, and Shahad Abdullah Shwan. "Advances in the management of cardiomyopathies: A comprehensive review." *Journal of Rare Cardiovascular Diseases* 4.8 (2024): 185-192.

[26] Jawad, Omar Thaer, et al. "Advances in Cardiovascular Research: Integrating Multidisciplinary Insights." *Journal of Rare Cardiovascular Diseases* 4.8 (2024): 179-184.

[27] Qasim, Maytham T., and Zainab I. Mohammed. "Investigating treatment response and viral immunity in early rheumatoid arthritis via immune response profiling." *Journal of Rare Cardiovascular Diseases* 4.8 (2024): 166-173.

[28] Al-Badry, Marwa Shakir Mahmood, Maroof Sabti Juma Al-Ammash, and Ahmed Hamid Ahmed. "Comparison the effect of Cuminum cyminum and Cinnamomum zeylanicum extracts in Mice Balb/C experimentally infected with protoscolices of hydatid cyst." *AIP Conference Proceedings.* Vol. 2394. No. 1. AIP Publishing, 2022: 020041.

[29] Al-Ammash, Maroof Sabti Juma, et al. "Detection of toxocara canis infection by eliza, with follow-up some biochemical and histological changes." *Journal of Advanced Pharmacy Education and Research* 11.1 (2021): 182-188.

[30] Shakir, Ohood Mozahim, Maroof Sabti Juma Al-Ammash, and Shahad Maohammed Mahmood. "The effect of Entamoeba histolytica parasite infection on iron Fe+, total iron binding capacity and hepcidin hormone." *Biochemical & Cellular Archives* 20.2 (2020): pp. 4893-4897.

[31] Ahmad, Hanan Shihab, Araf Sabah Abdulwahed, and Marwan Abdulrazzaq Kamil. "Evaluation of serum levels of irisin, tumor necrosis factor and some biochemical variables in males with prostate cancer in Baghdad City." *Cellular and Molecular Biology* 70.12 (2024): 152-156.

[32] Ahmad, Hanan Shihab, and Saja Jamal Noman. "Correlation study of hemoglobin and hematocrit levels with BMI, age, and gender and determination of the risk of anaemia in adult residents of Iraq." *Applied Nanoscience* 13.8 (2023): 5357-5364.

[33] Noman, Saja Jamal, and Hanan Shihab Ahmad. "Effects of some fungal secondary metabolite against some cancer cell line." *Bangladesh Journal of Medical Science* 22 (2023): p133.

[34] Zangana, Ashraf Jamal Mahmoud, Hanan Shihab Ahmad, and Isra'A. Ismail Al-Taii. "A therapeutic attempt by water extract of mentha piperita for amoebic dysentery in vivo and its effect on blood image." *AIP Conference Proceedings*. Vol. 2394. No. 1. AIP Publishing, 2022: 020037.

[35] Alhaqmuhamad, Asmaa Abd, Mostafa Ali Abdulrahman, and Hanan Shihab Ahmad. "Effect of nanoparticles on liver functions and antioxidant in female rabbits treated with Domperidone." *Indian Journal of Forensic Medicine & Toxicology* 13.4 (2019): 553-557.

[36] Ahmad, Hanan Shihab, et al. "Study of some hematological and biochemical among for employees of al-dour technical institute." *Biochemical & Cellular Archives* 19.1 (2019): pp. 63-67.

[37] Majeed, Moazaz Abd Alrida, et al. "Effect of costus specious extract on some types of pathogenic bacteria." *Journal of Global pharma Technology* 11 (2019): 481-485.

[38] Laylani, L. S., et al. "The effect of carotenoids of Rhodotorula glutinis and probiotic of Lactobacillus acido-philus on physiological and histological variables of the kidney in male rats exposed to ultraviolet radiation." *Journal of Animal Health and Production* 12.s1 (2024): 326-331.

[39] Ahmad, Hanan Shihab, Araf Sabah Abdulwahed, and Marwan Abdulrazzaq Kamil. "Evaluation of serum levels of irisin, tumor necrosis factor and some biochemical variables in males with prostate cancer in Baghdad City." *Cellular and Molecular Biology* 70.12 (2024): 152-156.

[40] Al-Aubaidi, Israa Kasim, Marwa Ali Al-Oqaily, and Sadia Shahab Hamad. "Role of interleukin 33 during infection with toxoplasmosis in rheumatoid arthritis patients." *Indian Journal of Forensic Medicine & Toxicology* 14.1 (2020): 526-531.

[41] Abdulwahhab, Intisar Ghanim. "Detection of genetic variability within the rop-17 gene in women infertility with toxoplasmosis and its relationship to levels of some antioxidants." *Annals of Agri-Bio Research* 27.2 (2022): 168-172.

[42] Hamad, Sadia Shahab, Halala Mohammed Abdulla, and Israa Kasim Al-Aubaidi. "Epidemiological study of toxoplasmosis in patients with renal failure form Kirkuk City/Iraq." *Journal of Global Pharma Technology* 11.02 (2019): 578-584.

[43] Mustafa, M. A., et al. "Virulence factors of proteus mirabilis isolated from urinary tract infection patients." *Latin American Journal of Pharmacy* 42 (2023): 418-421.

[44] Mustafa, Harith Ahmed, Husham Naji Hameed, and Thabet Mudheher Khalaf. "Prevalence of ticks and lice parasites on a certain number of buffaloes in the district of Samarra/Iraq." *Indian Journal of Forensic Medicine & Toxicology* 13.4 (2019): p637.

[45] Mustafa, Harith A., et al. "Study on some physiological, biochemical and hormonal parameters of seminal fluid of infertile men." *Biochemical and Cellular Archives* 19.Supplement 1 (2019): 1943-1947.