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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

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საქართველოს სამედიცინო სიახლენი

**GEORGIAN MEDICAL NEWS**

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**GMN: Georgian Medical News** is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

**GMN: Медицинские новости Грузии -** ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

**GMN: Georgian Medical News –** საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

**WEBSITE**

www.geomednews.com

## К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

**При нарушении указанных правил статьи не рассматриваются**.

## REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.**

## ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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*Содержание:*

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# A DESCRIPTIVE STUDY ON THE TRENDS OF CAUSATIVE BACTERIA AND ANTIMICROBIAL RESISTANCE PROFILES IN PATIENTS WHO DEVELOPED SEPSIS FOLLOWING GASTRIC SLEEVE RESECTION

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## Abstract.

**Background and Aim:** The open gastric sleeve surgery is a morbidly obese patients with type 2 diabetes mellitus (T2DM) and bacterial sepsis is one of the major complications. This paper explains the trends in causative bacteria and antimicrobial resistance (AMR) profile of patients who developed sepsis after surgery, and the use of inflammatory and glycemic biomarkers as additional data to explain the pathophysiology of sepsis.

**Methods:** The participants in the study were 128 patients (aged between 25-40, BMI ≥ 40 kg/m 2, T2DM) who underwent open gastric sleeve surgery and 40 people who underwent open gastric sleeve surgery but did not contract sepsis. Fasting glucose, HbA1c, procalcitonin [PCT], interleukin-6 [IL-6], and tumor necrosis factor-alpha [TNF-alpha] were measured by means of Roche Cobas c111 and e411 analyses. The bacteria were identified using VITEK 2, and the resistance to antibiotics was determined through the Kirby-Bauer test. T-tests and chi-square tests ($p < 0.05$) were applied in statistical analysis.

**Results:** Sepsis cases (n=40) showed significantly elevated biomarkers compared to controls (n=40): fasting glucose (143.28 ± 37.79 vs. 82.85 ± 8.12 mg/dL), PCT (7.60 ± 3.07 vs. 0.055 ± 0.031 ng/mL), TNF-α (17.23 ± 5.04 vs. 6.62 ± 2.10 pg/mL), IL-6 (12.47 ± 4.63 vs. 3.06 ± 1.35 pg/mL), and HbA1c (9.37 ± 2.14% vs. 4.22 ± 1.14%) (all $p < 0.001$). *Escherichia coli* (70%) predominated, with high resistance to amoxicillin/clavulanate (78.57%), ciprofloxacin (67.86%), and gentamicin (60.71%); carbapenems showed minimal resistance. Multidrug-resistant (60.71%) and extensively drug-resistant (21.43%) isolates were prevalent.

**Conclusion:** In this population, *Escherichia coli* is the leading cause of postoperative sepsis, and AMR poses a big challenge to its treatment. These results focus on antibiotic treatment and individual prophylaxis. Higher inflammation and glucose imbalance biomarkers are beneficial in supporting preoperative optimization efforts to prevent sepsis.

**Key words.** Morbid obesity, type 2 diabetes mellitus, bacterial sepsis, gastric sleeve surgery.

## Introduction.

Morbid obesity and type 2 diabetes mellitus (T2DM) are growing global health issues that increase the risk of postoperative bacterial sepsis in gastric sleeve surgery patients [1]. Although bariatric surgery is successful for weight loss and glycemic management in persons with a BMI ≥ 40 kg/m², it can lead to a 1–5% risk of sepsis, a life-threatening illness caused by misregulated immunological responses to bacterial infections [2].

Pathogens, such as *Escherichia coli, Staphylococcus aureus,* and *Pseudomonas aeruginosa*, often cause systemic inflammation and organ malfunction known as sepsis [3]. These bacteria enter through surgical trauma, anastomotic leaks, and changed gut flora, especially in open gastric sleeve surgery, which causes significant tissue trauma [4]. Morbid obesity and T2DM patients with hyperglycemia, chronic inflammation, and AMR are more likely to develop sepsis, which increases hospital stays, healthcare costs, and mortality [5].

Bacterial sepsis is a major biomarker of procalcitonin (PCT), particularly in high-risk patients undergoing surgery, including gastric sleeve surgery. Unlike other signs of inflammation, PCT escalates rapidly when there is an invasion of bacteria throughout the body, but is stable during the course of viral or non-infectious inflammatory diseases [6]. A level of PCT more than 2 ng/mL during the 48 hours after surgery can be taken as a sign of sepsis, having excellent sensitivity and specificity [7]. PCT patterns are also used to assist physicians in differentiating sterile inflammation and bacterial sepsis, which minimizes the use of antibiotics and AMR [8].

T2DM enhances immunological suppression by hyperglycemia, neutrophil phagocytosis, chemotaxis, and oxidative burst. T2DM increases the susceptibility to infections [9]. Obesity results in high levels of inflammation, especially TNF-α, IL-6, and PCT, which are key antecedents of the severity of sepsis [10]. High HbA1c and RBS, as well as hyperglycemia, enhance the risk of sepsis because they promote bacterial growth and wound healing, particularly in open gastric sleeve surgery using an abdominal incision [11].

Treatment of sepsis in this population is complicated by the development of AMR, particularly in *E. coli* isolates. The stress on the problem of multidrug-resistant (MDR) and extensively drug-resistant (XDR) microorganisms [12]. A 2025 study of the rise in resistance rates to antibiotics in patients with T2DM undergoing bariatric surgery has observed that Perioperative antibiotics [13]. Gut flora disturbance and chronic inflammation drive these resistant infections, hence fostering a permissive environment for resistant bacteria [14]. The interactions between inflammatory signals, glycaemic disorder, and AMR in sepsis post gastric sleeve surgery have not been adequately researched despite increasing data, hence forming a huge gap in risk classification and management strategies of the population under question. The objective of this study is to investigate the effects of morbid obesity and T2DM on bacterial sepsis risk in patients undergoing open gastric sleeve surgery via abdominal incision and analyse inflammatory (PCT, IL-6, TNF-α) and glycaemic (HbA1c, RBS) biomarkers for effective risk stratification.

## Materials and Methods.

### Study Design and Participants:

An Iraqi hospital conducted a study from January to December 2024 to assess the risk of bacterial sepsis in patients with type 2 diabetes mellitus (T2DM) undergoing open abdominal incision

gastric sleeve surgery and BMI ≥ 40 kg/m². The study included 40 healthy individuals aged 25–40 as a control group, who underwent open gastric sleeve surgery without developing sepsis, and 128 patients of the same age, comprising morbidly obese T2DM patients, who underwent standard sleeve gastrectomy under the supervision of board-certified bariatric surgeons, as seen in Figure 1. A verified diagnosis of T2DM, BMI > 40 kg/m², and comprehensive medical records—including surgical results and biomarker data—formed inclusion criteria. Patients eliminated were those with preoperative infections or sepsis, a history of bariatric operations other than sleeve gastrectomy, inadequate records, or who fell outside the designated age range.

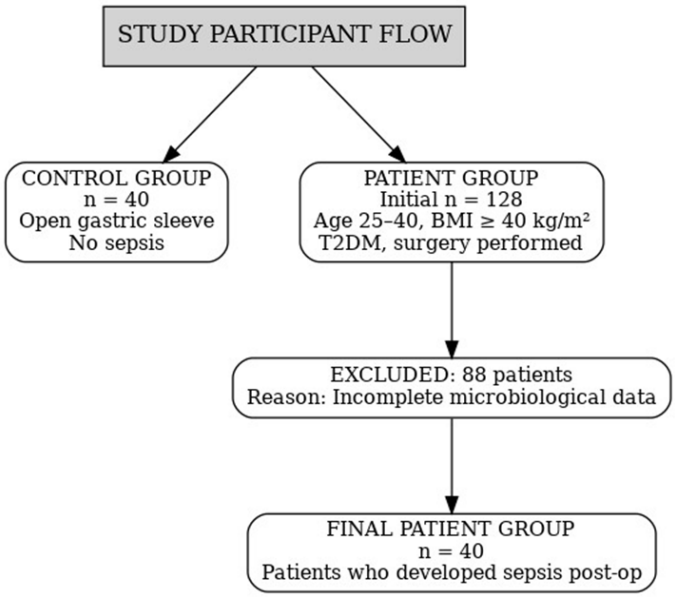


***Figure 1.*** *Flow chart of participants through the study.*

**Sample Collection.**

**Biomarker Analysis:**

Blood samples were acquired from all participants to measure inflammatory biomarkers (procalcitonin [PCT], interleukin-6 [IL-6], tumor necrosis factor-alpha [TNF-α]), glycated hemoglobin (HbA1c), and random blood sugar (RBS). For PCT, IL-6, and TNF-α, 5 mL of whole blood was drawn into serum separator tubes. Allow to clot at room temperature for 30 minutes, then centrifuge at 3000 × g for 10 minutes at 4°C. Aliquot volumes of 1.5 mL of serum were stored in -80 o C cryotubes until analysis [15]. In the case of HbA1c and RBS, 3 mL was sampled on the tubes with sodium fluoride and potassium oxalate to avoid glycolysis. RBS was assessed at the moment, and HbA1c was determined with the Cobas c111 analyzer (Roche, Germany). The PCT level, IL-6, and TNF levels were measured using the Cobas e411 analyzer (Roche, Germany) in electrochemiluminescence immunoassay (ECLIA) technology.

**Microbiological Sample Collection and Sepsis Symptoms:**

Blood samples (8-10 mL) and wound samples were taken from the patients after undergoing a gastrointestinal surgery on the stomach (gastric sleeve) in order to determine bacterial pathogens that help to produce sepsis. Aseptically collected blood was incubated in BacT/ Alert bottles (Sysmex bioMerieux) using an automated incubation system at 35 °C for not more than 5 days. The surgical sites were swabbed and inoculated on blood agar, MacConkey agar, chocolate agar, and anaerobic blood agar, and then incubated aerobically and anaerobically at 35°C after 48 hours. Sepsis symptoms, including fever, (>38°C), chills, tachycardia, (>90 beats/min), hypotension, (systolic blood pressure, <90 mmHg), altered mental status, and respiratory distress (respiratory rate, >20 breaths/min) were prioritized to undergo microbiological analysis to confirm the presence of infection and direct treatment. Aerobic positive cultures were grown on blood, MacConkey, and chocolate agars for 24-48 hours. The VITEK 2 system (bioMerieux) was applied to identify bacteria through the automated biochemical tests based on the Advanced Colorimetry system 2 through the use of the Advanced Colorimetry system 2 which produces a species-specific profile.

**Antibiotic Susceptibility Testing:**

*E. coli* antibiotic susceptibility was determined according to Clinical and Laboratory Standards Institute recommendations by means of a modified version of the Kirby-Bauer disc diffusion test [16]. Antibiotics that were used in the study were amoxicillin/clavulanate (20/10 µg), ceftriaxone (30 µg), levofloxacin (5 µg), ertapenem (10 µg), meropenem (10 µg), piperacillin/tazobactam (100/10 µg), ciprofloxacin (5 µg), and gentamicin (10 µg). The *E. coli* broth was plated on the surface of the Mueller-Hinton agar (McFarland 0.5). The plates were incubated at 37 °C during the application of the antibiotic discs and also during the incubation period of 18 hours. The zone of inhibition diameter was classified according to the CLSI criteria.

**Statistical Analysis:**

The result of group effects on the research variables was determined through SAS (2018). In this research T-test was used to compare means.

## Results.

**Inflammatory and T2DM Biomarkers:**

The analysis of the quantities of biomarkers in the two groups showed that there were significant differences in all of the measured parameters (Table 1 and Figure 2). The mean case group had a significantly high level of fasting glucose (143.28 ± 37.79mg/dl), which is significantly higher than the control group (82.85±8.12mg/dl), t= -10.24 and p= <0.001. Similarly, procalcitonin (PCT) levels were significantly elevated in cases (7.60 ± 3.07 ng/mL) versus controls (0.055 ± 0.031 ng/mL), with a t-value of -14.84 and $p < 0.001$. Tumor necrosis factor-alpha (TNF-α) concentrations were also higher in the case group (17.23 ± 5.04 pg/mL) compared to controls (6.62 ± 2.10 pg/mL), with a t-value of -12.53 and $p < 0.001$. Interleukin-6 (IL-6) levels showed a similar trend, with cases exhibiting elevated values (12.47 ± 4.63 pg/mL) compared to controls (3.06 ± 1.35 pg/mL), with a t-value of -12.43 and $p < 0.001$. Finally, the glycated hemoglobin (HbA1c) levels in the case group (9.37 ± 2.14%) were much higher than in the control group (4.22 ± 1.14%), the t-value (-13.39), and $p = 0.001$. Such results show that there are significant statistical differences ($p < 0.001$) between the two groups in all biomarkers, which may imply

***Table 1.*** *Comparison of Biomarker Levels between Controls and Cases.*

| Biomarker | Controls (n=40) Mean ± SD | Cases (n=40) Mean ± SD | t-value | p-value |
|---|---|---|---|---|
| Fasting Glucose (mg/dL) | 82.85 ± 8.12 | 143.28 ± 37.79 | -10.24 | <0.001 |
| PCT (ng/mL) | 0.055 ± 0.031 | 7.60 ± 3.07 | -14.84 | <0.001 |
| TNF-α (pg/mL) | 6.62 ± 2.10 | 17.23 ± 5.04 | -12.53 | <0.001 |
| IL-6 (pg/mL) | 3.06 ± 1.35 | 12.47 ± 4.63 | -12.43 | <0.001 |
| HbA1c (%) | 4.22 ± 1.14 | 9.37 ± 2.14 | -13.39 | <0.001 |

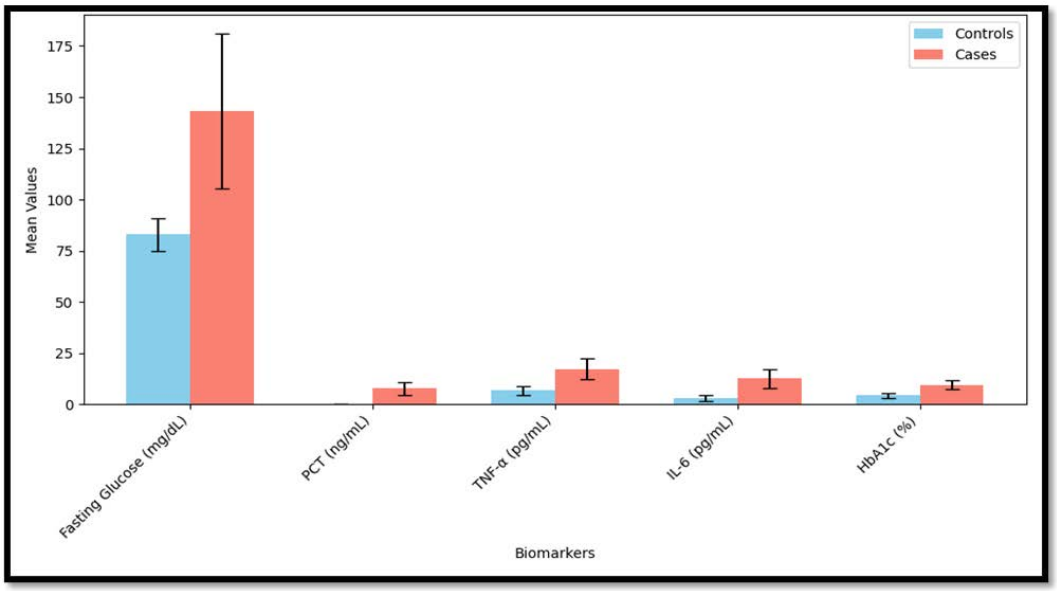


***Figure 2.*** *Comparison of Biomarkers between Controls and Cases.*

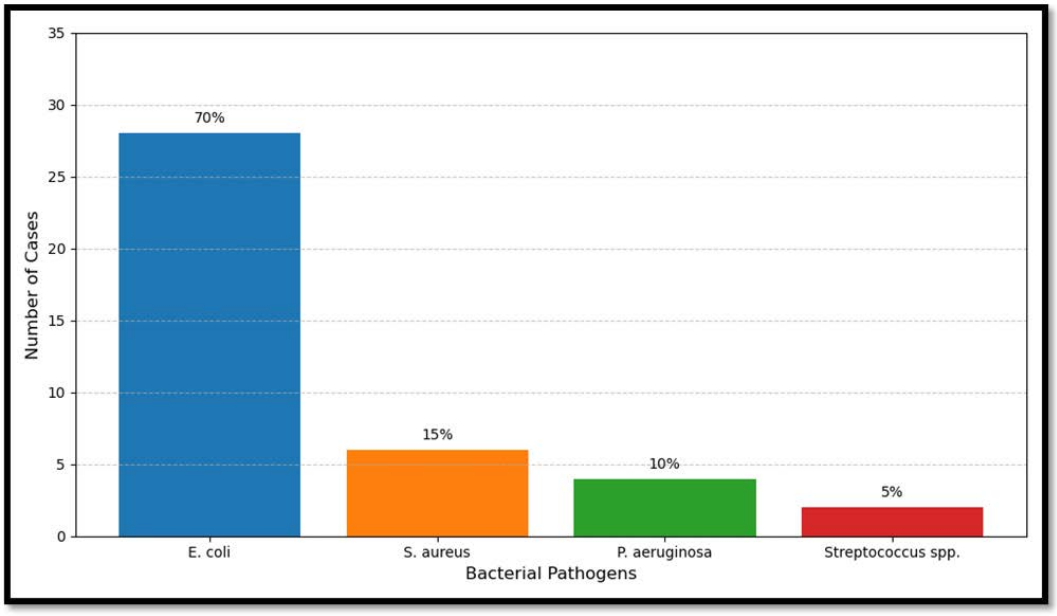


***Figure 3.*** *Bacterial pathogens in postoperative sepsis from 40 gastric sleeve surgery patients, identified by VITEK2.*

their usefulness in separating the two groups.

**Distribution of Bacterial Infections from Wound and Blood Cultures:**

Blood and wound cultures were obtained from 128 patients following gastric sleeve surgery to identify bacterial pathogens linked to postoperative sepsis. Of these, 40 /128 patients (31.25% of the cohort) were confirmed to have sepsis based on positive cultures. The VITEK2 Compact system was used for bacterial identification, with all isolates showing >92% similarity to reference strains. The remaining 88/128 (68.75%) patients were excluded due to incomplete microbiological or clinical data. Figure 3 illustrates the distribution of pathogens causing bloodstream infections (BSIs) and surgical site infections (SSIs). *Escherichia coli* was the dominant pathogen,

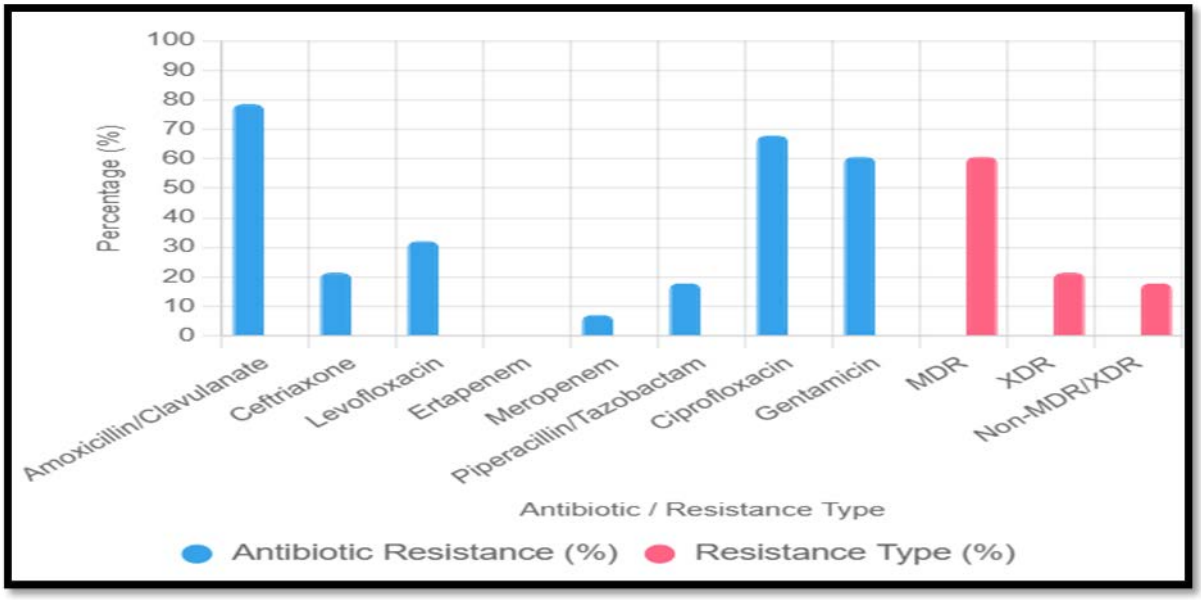


***Figure 4.*** *Antibiotic Resistance Rates and MDR/XDR Profiles of Escherichia coli Isolates from Postoperative Sepsis Cases.*

detected in 28 of 40 cases (70%), primarily from blood cultures. *Staphylococcus aureus* (6 of 40, 15%) and *Streptococcus spp.* (2 of 40, 5%) were mainly isolated from wound swabs or surgical site samples, while *Pseudomonas aeruginosa* (4 of 40, 10%) appeared in both sample types. A control group of 40 patients without sepsis exhibited no bacterial growth in blood or wound cultures.

**Antibiotic Resistance Profiles of *Escherichia coli* in Postoperative Sepsis:**

Antibiotic susceptibility testing of *Escherichia coli* isolates from 40 patients with postoperative sepsis following gastric sleeve surgery demonstrated pronounced resistance patterns, as shown in Figure 4. The highest resistance rates were seen in amoxicillin/clavulanate (22/28 isolates, 78.57%), ciprofloxacin (19/28 isolates, 67.86%), and gentamicin (17/28 isolates, 60.71%). In contrast, ertapenem exhibited no resistance (0/28 isolates, 0.00%), and meropenem showed minimal resistance (2/28 isolates, 7.14%). Furthermore, 17/28 isolates (60.71%) were classified as multidrug-resistant (MDR), and 6/28 isolates (21.43%) as extensively drug-resistant (XDR), underscoring the significant challenge of antimicrobial resistance in this patient cohort.

## Discussion.

This descriptive study clarifies the trends in causative bacteria and the profiles of antimicrobial resistance of patients who develop sepsis following open gastric sleeve resection. It was observed that there are significant differences between the profiles of the biomarkers, as the presence of fasting glucose, glycated hemoglobin (HbA1c), procalcitonin (PCT), tumor necrosis factor-alpha (TNF-alpha), and interleukin-6 (IL-6) has a significant statistical significance, highlighting hyperglycemia and inflammation as the main causes of the occurrence of sepsis. The significant antimicrobial resistance levels of sepsis-inducing pathogens, especially *Escherichia coli*, prove the severe necessity to implement specific antibiotic interventions and maximize the results of treatment.

The case group demonstrated very significantly bigger fasting glucose and HbA1c levels as compared to the control group, or acute or chronic hyperglycemia, which fits either severe metabolic dysfunction or poorly controlled T2DM. Hyperglycemia, which is a well-known risk factor of postoperative issues in open gastric sleeve surgery through abdominal incision, impairs immune functioning by decreasing the neutrophil phagocytosis, chemotaxis, and oxidative burst [17]. This immunological suppressive effect creates an amenable niche of bacterial growth, which, in combination with surgical trauma, potential anastomotic leakage, and gut flora change, provides pathways of attack by pathogens, such as *E. coli* and *S. aureus* [18]. Poor glycaemic control also disrupts fibroblast and collagen synthesis, hence, interfering with wound healing and increasing the risk of infections [19]. The metabolic burden associated with T2DM, typical of excessive obesity, exposes the patients to sepsis and slow tissue repair following surgery [20].

The glucose levels of the case group are associated with the high level of AMR profile, and high levels of inflammatory biomarkers (PCT, TNF-alpha, and IL-6). The elevation of blood sugar leads to the hypertrophic expression of pro-inflammatory cytokines such as TNF-2 and IL-6 by driving transcription factors such as the NF-kB [21]. These cytokines enhance insulin resistance via the signal transduction pathways, such as the JNK and IKK, which continue the metabolic and inflammatory impairment [22].

High procalcitonin (PCT) in the case group is a powerful sign of bacterial sepsis, which is mainly caused by *E. coli* (70% of isolates, mostly of blood cultures) and *S. aureus* (15% of isolates, mostly of wound swabs). Such specificity of PCT to bacterial infections allows detecting sepsis early and directing antibiotic stewardship by identifying systemic bacterial invasion versus non-infectious inflammation [23]. A study carried out by Kourabeti et al. in 2024 validated the high sensitivity and specificity of PCT in the detection of postoperative sepsis in

patients with bariatric surgery, effective in timely treatment and the prevention of excessive use of antibiotics [24]. On the same note, higher interleukin-6 (IL-6) indicates an increased inflammatory response to surgical stress and infection, which worsens immune dysfunction by T-cell exhaustion and neutrophil dysfunction [25,26]. *E. coli* preeminence in both bloodstream infections (BSIs) is probably due to the perturbation of gut microbiota and surgical trauma [27], whereas *S. aureus* in wound infections indicates a breakage of the skin flora of surgical sites [28]. A study by Bang et al. (2014) showed that the distributions of pathogens in bariatric sepsis were also similar (65% *E. coli*, 20% *S. aureus*) and high levels of PCT that were associated with gram-negative infections [29].

*E. coli* isolates exhibited high AMR, with 78.57% resistant to amoxicillin/clavulanate, 67.86% to ciprofloxacin, and 60.71% to gentamicin; 60.71% were multidrug-resistant (MDR) and 21.43% extensively drug-resistant (XDR), complicating treatment and increasing morbidity in bariatric surgery patients with obesity and type 2 diabetes mellitus (T2DM). These rates exceed those in community-acquired intra-abdominal or urinary tract infections, likely driven by obesity, T2DM, perioperative antibiotic use, and gut microbiota alterations selecting for resistant strains, such as those producing extended-spectrum beta-lactamases (ESBLs) [30]. Minimal resistance to carbapenems (0% to ertapenem, 7.14% to meropenem) suggests their efficacy as last-resort treatments, but rising global carbapenem resistance necessitates cautious use. A 2025 study by Dourliou et al. reported comparable MDR gram-negative sepsis in T2DM patients, with 75% resistance to amoxicillin/clavulanate and 65% to ciprofloxacin, advocating targeted antibiotic strategies [31]. In a 2008 review of surgical site infections (SSIs), the resistance in obese populations was high, and ESBL-producing *E. coli* and methicillin-resistant *S. aureus* (MRSA) have complicated the outcome of bariatric surgery, further supporting the importance of strong antibiotic stewardship and preoperative glycemic control to reduce the risk of sepsis caused by resistant pathogens [32].

Future studies must be conducted to confirm the predictive value of fasting glucose, HbA1c, PCT, TNF-α, and IL-6 on a larger, multicenter cohort study in determining the use of these evaluation parameters as a factor that classifies the risk of bariatric surgery patients. Also, there is a weakness of this study, namely, it is a single-center, retrospective study with a limited sample size (n=40 in each group), thus, it can be restrictive regarding generalizability and statistical power. This research suggests the preoperative glycemic optimization by using insulin or diet to minimize the risk of infection. The results of the study regarding open gastric sleeve surgery might not be entirely applicable to laparoscopic surgery, which is more widespread and less invasive. The patterns of biomarker and antimicrobial resistance during laparoscopic procedures should be confirmed by future studies to be applicable in a wider environment.

## Conclusion.

A critical nexus of glucose dysregulation, systemic inflammation, resistant infections, and postoperative complications in patients with morbid obesity and T2DM undergoing gastric sleeve surgery is demonstrated by the high levels of fasting glucose, HbA1c, PCT, TNF-α, and IL-6, and high rates of AMR among *E. coli* and other pathogens. Hyperglycemia encourages inflammation through the up-regulation of TNF-α and IL- 6 which, together with compromised immune action and MDR/XDR microorganisms, increases the susceptibility to sepsis and slow wound healing. These biomarkers have significant potential for risk stratification and early intervention, and the extreme AMR problem requires a strong antibiotic stewardship. The optimization of glycemia preoperative, monitoring of inflammatory markers in the postoperative period, and individual antibiotic prophylaxis are the necessary factors to enhance the performance of this at-risk group.

## Authors' Declaration.

We affirm that all tables included in the paper pertain to the current study. Authors acknowledge ethical considerations. Authorization — Ethical Clearance: The project received approval from the local ethical commission (University of Kirkuk, College of Medicine, Research Ethics Commission)


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## Disclosure of conflicts of interest.

The authors declare no conflicts of interest.

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