Prevalence and Associated Factors of Adverse Reactions to Vancomycin in Hospitalized Patients in the Internal Medicine Department of a High-Complexity Hospital in Colombia: A Cross-Sectional Study

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Abstract

Objective: Identify the prevalence of adverse reactions associated with the use of vancomycin, as well as the factors related to their severity.

Materials and Methods: A descriptive cross-sectional study was conducted on patients admitted to a high-complexity hospital in the city of Neiva who were prescribed vancomycin. A probabilistic sampling was carried out, with a review of clinical histories and a survey, the dependent variable was the presence of adverse reactions. The data obtained were recorded in Excel and analyzed using statistical software, obtaining descriptive statistics with central tendency and dispersion measures. A bivariate analysis was performed, and the Chi-square test was used to analyze two qualitative variables.

Results: A total of 104 patients, of whom 51.9% were men; skin and soft tissues were the most commonly affected sites with 39.4%. Polypharmacy, hypertension, and advanced age were the most related comorbidities. 14% of the patients presented adverse drug reactions (ADR), nephrotoxicity being the most frequent at 53.3%. 85.6% of the patients had plasma level monitoring. 38.4% of the formulations had drug interactions, Piperacillin-tazobactam being the most commonly involved (45%). The pharmacological immunosuppression had a higher probability of presenting an adverse reaction.

Conclusions: The prevalence of adverse drug reactions to vancomycin is 14%, with nephrotoxicity and hypersensitivity reactions being the most common. Severe reactions were the most frequently found, and pharmacological immunosuppression was the most related factor with the occurrence of reactions.

Keywords: Vancomycin, adverse drug reaction.

Introduction

Vancomycin is a glycopeptide antimicrobial derived from *Streptomyces orientalis*. Its mechanism of action consists of inhibiting peptidoglycan synthesis in the bacterial cell wall by binding to the D-alanine-D-alanine termini, which confers bactericidal activity against methicillin-resistant Gram-positive cocci, *Clostridium* infections, and in patients with beta-lactam allergies (1–3).

Due to its narrow therapeutic margin and predominantly renal elimination, vancomycin requires dose adjustment and plasma level monitoring, particularly in patients with renal disease, in whom its half-life may extend from 6–12 hours to over 200 hours in advanced renal failure (4,5). Currently, therapeutic drug monitoring based on the calculation of the area under the curve (AUC) relative to the minimum inhibitory concentration (MIC), with recommended values between 400 and 600 mg·h/L, is the preferred strategy to optimize efficacy and minimize toxicity (6).

The use of vancomycin has been associated with a significant risk of adverse reactions, particularly nephrotoxicity, especially in patients with elevated plasma levels. The incidence of acute kidney injury ranges from 5% with levels <10 mg/L to 33% when concentrations exceed 20 mg/L (7).

The World Health Organization defines an adverse drug reaction (ADR) as any harmful, unintended effect that occurs following the administration of a drug at normal doses used in humans for prophylaxis, diagnosis, or treatment (8). ADRs are classified by mechanism as type A (predictable, dose-related), type B (non–dose-related, idiosyncratic or allergic), type C (associated with chronic use), and type D (delayed reactions) (8).

In the case of vancomycin, the main reported ADRs include nephrotoxicity, ototoxicity, hypersensitivity, phlebitis, hypotension, tachycardia, red man syndrome, and, less frequently, agranulocytosis, pseudomembranous colitis, and immune-mediated thrombocytopenia (1–3).

Several factors have been associated with an increased risk of ADRs from vancomycin, including advanced age, polypharmacy, drug interac-

tions, comorbidities, immunosuppression, prolonged therapy, inadequate monitoring, and sustained exposure to high concentrations. Moreover, prolonged exposure favors the emergence of bacterial resistance, particularly in *Staphylococcus and Enterococcus* (6,7,9,10).

Based on these considerations, the objective of this study was to determine the prevalence of adverse reactions associated with vancomycin use and the factors related to their occurrence in hospitalized patients in the internal medicine department of a high-complexity hospital, as well as to characterize ADRs according to severity, mechanism, and clinical outcome.

Materials and Methods

Study design

An observational, descriptive, cross-sectional study was conducted with the objective of characterizing adverse reactions occurring during the administration of vancomycin in hospitalized patients.

Population and inclusion criteria

The study population consisted of patients hospitalized at *Hospital Universitario Hernando Moncaleano Perdomo* (HUN) in Neiva, who received vancomycin during their hospital stay.

The following criteria were applied:

- Inclusion criteria: patients over 18 years of age who received vancomycin as part of their inpatient treatment.
- Exclusion criteria: patients who received vancomycin for fewer than three days; patients referred from other institutions whose vancomycin treatment was administered externally; and pregnant women.

Sample size

A probabilistic sampling method was used. The sample size was calculated using the following formula:

M=N·Z2·p·qe2(N−1)+Z2·p·qM = \frac{N \cdot Z^2 \cdot p \cdot q} {e^2 (N-1) + Z^2 \cdot p \cdot q}M=e2(N−1)+Z2·p·qN·Z2·p·q

Where:

- M = sample size
- N = total population (147 patients who received vancomycin at HUN)
- Z = 1.96 (95% confidence level)
- p = estimated prevalence (37%, based on a regional study)
- q = 1 – p
- e = maximum allowable error (0.05)

With these parameters, a sample size of 104 patients was obtained.

Data collection

A review of medical records was conducted using a structured instrument that included demographic data, medical and pharmacological history, main diagnosis, comorbidities, and the presence of adverse drug reactions (ADRs).

To minimize measurement bias, a questionnaire with clear questions was designed and the data collection team was trained to ensure consistent application of registration criteria. Selection bias was controlled by exclusively reviewing medical records of patients who had received vancomycin within HUN.

Study variables

Dependent variable: presence of adverse reactions to vancomycin.

Independent variables: appropriate dosing, renal disease, hypoalbuminemia, diabetes mellitus, arterial hypertension, advanced age, polypharmacy, pharmacological immunosuppression, HIV infection, obesity, duration of treatment, infusion time, and drug interactions.

Statistical analysis

Data were recorded in Excel and analyzed using Epi Info® statistical software. Descriptive statistics were applied using measures of central tendency and dispersion.

For bivariate analysis, 2x2 contingency tables were used, calculating odds ratios (ORs) with their corresponding 95% confidence intervals (CIs). The Chi-square test was applied to evaluate the association between qualitative variables and the dependent variable. The Kolmogorov-Smirnov test was used to assess the normality of quantitative variables.

Ethical considerations

The study was approved by the Ethics Committee of *Hospital Universitario Hernando Moncaleano Perdomo* in Neiva and was classified as risk-free research, in accordance with national and international ethical guidelines.

A total of 104 patients were included in the study, of whom 51.9% were male, with a predominance of urban origin from the city of Neiva. The **mean** body mass index (BMI) was 25.5 ± 6.5 kg/m^2.

The most frequent sites of infection were skin and soft tissue (39.4%) and lung (22.1%), followed by osteoarticular infections, catheter-associated infections, and bacteremia (Table 1).

Table 1. Sociodemographic characteristics of hospitalized patients in the internal medicine department of a high-complexity hospital in Colombia

Variable	Result
Gender, n (%)	
Male	50 (48,1)
Female	54 (51,9)
Variables of the patient, media DS	
Weight kg	68,3 +/- 19,2
Size cm	162 +/- 8
Body mass index	25,5 +/- 6,5
Place of infection, n (%)	
Skin and soft tissues	41 (39,42)
Lung	23 (22,12)
No focus	10 (9,62)
Bone	7 (6,73)
Catheter devices	5 (4,81)
Blood	5 (4,81)
Abdomen	3 (2,88)
Meninges	3 (2,88)
Comorbidities, n(%)	
Polypharmacy	73 (70)
High blood pressure	57 (55)
Advanced age	40 (39)
Diabetes	38 (37)
Kidney disease	32 (31)
Hypoalbuminemia	24 (23)
Obesity	20(19)
Pharmacological immunosuppression	15 (14)
HIV infection	3(3)
Final condition, n (%)	
Deceased	6 (5,77)
Alive	98 (94,23)

The main comorbidities observed were polypharmacy, arterial hypertension, advanced age, and diabetes mellitus.

Regarding vancomycin use, 85.6% of patients had plasma level monitoring, performed on average at the sixth dose. Of these, 51% required dose adjustment. The mean administered dose was 15.3 mg/kg/day, with a median treatment duration of 11 days.

Drug interactions were identified in 38.4% of prescriptions, with piperacillin-tazobactam (45%) and acetylsalicylic acid (27%) being the most

frequently involved. The prevalence of methicillin-resistant Staphylococcus aureus (MRSA) infection was 15.4% (Table 2).

Table 2. Characteristics of vancomycin administration in hospitalized patients in the internal medicine department of a high-complexity hospital in Colombia

Variable	Result
Measurement of plasma concentrations, n (%)	
Yes	89 (85,6)
No	15 (14,4)
Time of the measure, Median (RI)	6 (4-8)
Adjustment to plasma concentrations, n (%)	
Yes	53 (51)
No	51 (49)
Number of measures, average DS	2 +/-2
Dose (mg/K/D), median DS	15,3 +/- 4,2
Proper dosage, n (%)	
Yes	59 (56,7)
No	45 (43,3)
Duration of treatment, median (RI)	11 (7-19)
Indications for Vancomycin, n (%)	
Cellulitis	29 (27,9)
Severe pneumonia	17 (16,3)
MRSA	16 (15,4)
Sepsis	11 (10,6)
Soft tissue infection	10 (9,6)
Osteomyelitis	6 (5,8)
Collections	3 (2,9)
Others	12 (11,5)
Drug interactions, n (%)	
Yes	40 (38,4)
No	64 (61,6)
Interacting medications, n (%)	
Piperacillin Tazobactam	18 (45)
Acetylsalicylic Acid	11 (27)
Amikacin	4 (10)
Diclofenac	4 (10)
Gentamicin	1 (2,5)
Metotrexate	1 (2,5)
Naproxeno	1 (2,5)

Regarding adverse drug reactions (ADRs), 14% of patients experienced

an event associated with vancomycin use. The most frequent ADRs were nephrotoxicity (53.3%) and hypersensitivity reactions (26.6%). Less frequent events included chemical phlebitis, ototoxicity, nausea, and vomiting, each occurring in 6.6% of cases (Table 3).

Table 3. Adverse drug reactions to vancomycin in hospitalized patients in the internal medicine department

Variable	Result
Adverse reaction to medication, n(%)	
No	89 (86)
Yes	15 (14)
Name of the adverse reaction, n (%)	
Nephrotoxicity	8 (53,3)
Hypersensitivity	4 (26,6)
Chemical phlebitis	1 (6,6)
Nausea and vomiting	1 (6,6)
Ototoxicity	1 (6,6)
Severity of ADR, n (%)	
Mild	7 (46,67)
Severe	8 (53,33)
ADR mechanism, n (%)	
B	15 (100)
Antibiotic Changen (%)	
Yes	19 (18,27)
No	85 (81,73)

According to severity, 53.3% of ADRs were classified as serious, since they required medical intervention. Regarding the mechanism, all ADRs were classified as type B (not directly related to dose or pharmacological mechanism of action).

The bivariate analysis showed that pharmacological immunosuppression was significantly associated with a higher risk of vancomycin-related ADRs. Other variables—such as diabetes mellitus, drug interactions, arterial hypertension, hypoalbuminemia, and polypharmacy—did not show a statistically significant association with ADR occurrence (Table 4).

Table 4. Factors associated with adverse drug reactions to vancomycin

in hospitalized patients in the internal medicine department

Presence of ADRs				
	OR	**IC 95%**	**CHI 2**	**P FISHER**
Drug Interactions	1.13	0.37 - 3.46	1	1
Appropriate Dosage	1.63	0.52 - 5.17	0.58	0.57
Kidney Disease	2.2	0.72 - 6.72	0.27	0.22
Hypoalbuminemia	0.79	0.2 - 3.09	1	1
Diabetes	0.84	0.27 - 2.69	1	1
High Blood Pressure	0.93	0.31 - 2.79	1	1
Advanced Age	0.76	0.23 - 2.4	0.85	0.78
Polypharmacy	0.82	0.26 - 2.65	0.98	0.76
HIV Disease	3.1	0.26 - 36.5	0.91	0.38
PharmacologicalImmunosuppression	3.95	1.12 - 13.91	0.06	0.04
Obesity	1.65	0.47 - 5.88	0.66	0.48

Discussion

Vancomycin is an antimicrobial with specific indications, and current trends aim to restrict its use due to the risk of inducing resistant strains, particularly *Staphylococcus aureus* and *Enterococcus*. Nevertheless, it remains one of the most frequently used empirical antibiotics in intensive care units, mainly for skin and soft tissue infections, pneumonia, bacteremia, and in cases of Gram-positive cocci resistant to methicillin or in patients with β-lactam allergy (12). In this study, the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) infection was 15.4%, which is consistent with reports in the literature (12,13).

The main indications for vancomycin use in our study population were skin and soft tissue infections, pneumonia, and bacteremia, findings that align with those of other studies where these infectious foci predominate (13). Factors such as prolonged empirical administration, inadequate dosing, and use in contexts without microbiological confirmation have been associated with bacterial resistance and increased risk of adverse drug reactions (ADRs) (13).

ADRs represent a significant cause of hospital morbidity, prolong hospital stay, and compromise patient safety (14). The literature reports an ADR prevalence ranging from 1.7% to 28% (15,16). In our study, the prevalence was 14%, which falls within these ranges. This is consistent with previous reports indicating an overall ADR prevalence of 8.32%, and specifically 14.5% associated with antimicrobials (14).

At the national level, some studies have reported an ADR prevalence of

31.34%, with antimicrobials accounting for 14.77% of these events. Polypharmacy and drug interactions were the most frequent associated factors (17). Another study conducted in a hospital in Neiva reported a 50% prevalence of ADRs, with antimicrobials implicated in 37.9% of cases, among which vancomycin represented 6.6% of the drugs involved (18).

In our study, nephrotoxicity was the most common ADR (53.3%), followed by hypersensitivity reactions (26.6%). This finding is consistent with other studies where renal toxicity is the principal ADR linked to vancomycin (19–21). The causes of acute kidney injury in patients receiving vancomycin are multifactorial and may include sepsis, mitochondrial dysfunction, alterations in the renin–angiotensin–aldosterone axis, and microvascular injury (19,20).

Vancomycin-induced nephrotoxicity is characterized by rapid deterioration of renal function associated with elevated plasma concentrations, which is usually reversible after discontinuation of therapy (21). Histologically, it may present as acute interstitial nephritis, acute tubular necrosis, or granulomatous inflammation (21). Reported prevalence of nephrotoxicity ranges from 10% to 42.6%, with a median onset of 4.5 days after initiation of treatment and recovery in 70.6% of cases (22).

Moreover, intravenous vancomycin use has been associated with a higher risk of acute kidney injury compared with other antimicrobials, with a relative risk of 2.45 (95% CI: 1.69–3.55) (23). Another study reported that 26% of critically ill patients receiving vancomycin developed acute kidney injury, with an 18% mortality rate in this subgroup (20). Nephrotoxicity has also been documented in 23% of patients, mainly in association with heart failure, endocarditis, and pre-existing renal disease (24).

Hypersensitivity reactions to vancomycin are primarily related to infusion rate and histamine release rather than IgE-mediated mechanisms (25). The so-called "red man syndrome," now referred to as vancomycin infusion reaction, results from direct mast cell activation. Its clinical presentation ranges from mild flushing and pruritus to severe events such as angioedema and bronchospasm (26,27). These reactions are relatively common, including rash, pruritus, and infusion-related reactions (28). Reported cases also include bullous dermatoses (34 cases), DRESS syndrome (16 cases), acute interstitial nephritis (8 cases), and severe cutaneous adverse reactions such as Stevens-Johnson syndrome and toxic epidermal necrolysis (6 cases) associated with vancomycin use (29).

Drug interactions are an additional risk factor for ADRs. These may be pharmacokinetic or pharmacodynamic, resulting in adverse effects that compromise patient safety (30). In our study, the most frequent interactions occurred with piperacillin–tazobactam, acetylsalicylic acid, amikacin, and diclofenac. This is consistent with literature reports, where the combination of piperacillin–tazobactam and vancomycin has been associated with a 5.36-fold higher risk of nephrotoxicity (13).

According to severity classification, ADRs are categorized as mild (not requiring medical intervention), moderate (requiring intervention), severe (life-threatening), or fatal (leading to death) (32). From a pharmacokinetic perspective, vancomycin use is considered adequate when the AUC/MIC ratio remains between 400 and 600 mg·h/L, which usually corresponds to plasma levels of 15–20 mg/L (4). Plasma concentrations above this range are linked to a higher risk of nephrotoxicity and other ADRs.

Advanced age is a well-known risk factor for ADRs, due to comorbidities, frailty, polypharmacy, and higher risk of colonization with resistant *Staphylococcus aureus* (33). Similarly, conditions such as HIV infection, systemic lupus erythematosus, chronic kidney disease, and other states of immunosuppression increase the likelihood of ADRs (34,35).

In our study, pharmacological immunosuppression was the only factor significantly associated with ADR occurrence (OR: 3.45; 95% CI: 0.06–0.04). This finding is consistent with reports in the literature identifying additional risk factors such as Black race, obesity, treatment duration greater than 14 days, elevated plasma concentrations, and pre-existing renal disease (36).

Conclusions

The prevalence of adverse drug reactions (ADRs) associated with vancomycin use in the study population was 14%, with nephrotoxicity being the most frequent, followed by hypersensitivity reactions.

Pharmacological immunosuppression was the only factor significantly associated with the occurrence of ADRs.

The main indications for vancomycin prescription were skin and soft tissue infections, followed by pneumonia.

These findings underscore the importance of close monitoring in immunosuppressed patients receiving vancomycin, as well as the need to optimize dosing regimens and monitor for potential drug interactions to prevent adverse events.

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References

1. Bruniera FR, Ferreira FM, Saviolli LRM, et al. The use of vancomycin with its therapeutic and adverse effects: a review. Eur Rev Med Pharmacol Sci. 2015;19:694–700. Available from: https://www.europeanreview.org/wp/wp-content/uploads/694-7001.pdf
2. Zhu Y, Huang L, Zhang J, Liang L, Jin P. Incidence and risk factors of vancomycin-induced thrombocytopenia: a six-year real-world study. BMC Infect Dis. 2025;25:7. doi:10.1186/s12879-024-10393-1
3. Wen Y, Chen Y, Xiao G. A rare occurrence of vancomycin-induced gastrointestinal hemorrhage without thrombocytopenia: a case report and literature review. BMC Infect Dis. 2024;24:1105. doi:10.1186/s12879-024-09949-y
4. Orjuela Camargo A, Caviedes Pérez G. Patrones de administración de vancomicina en pacientes críticamente enfermos. Rev Med Risaralda. 2021;27(2). doi:10.22517/25395203.24682
5. Ramírez Osorio JF, Vélez Hernández JE, Fernández Castaño N, Rojas Hernández DF, Jaimes F. Impact of vancomycin trough levels monitoring on uncomplicated methicillin-resistant Staphylococcus aureus bacteremia in chronic kidney disease on hemodialysis: retrospective cohort. BMC Infect Dis. 2024;24:1212. doi:10.1186/s12879-024-10107-7
6. Scribel L, Galiotto A, de Souza Rodrigues I, Hahn R, Linden R, Zavascki A. Comparison of vancomycin assays in patients undergoing hemodialysis. Braz J Infect Dis. 2024;28(5):103869. doi:10.1016/j.bjid.2024.103869
7. Chander S, Kumari R, Wang HY, et al. Effect of low vs. high vancomycin trough level on the clinical outcomes of adult patients with sepsis or Gram-positive bacterial infections: a systematic review and meta-analysis. BMC Infect Dis. 2024;24:1114. doi:10.1186/s12879-024-09927-4
8. Ruczynski J, Prochera K, Kaźmierczak N, et al. New conjugates of vancomycin with cell-penetrating peptides: synthesis, antimicrobial activity, cytotoxicity, and BBB permeability studies. Molecules. 2024;29(23):5519. doi:10.3390/molecules29235519
9. Orjuela Rodríguez T, Rojas-Cortés R, Vergara V, et al. Reacciones adversas a medicamentos utilizados para la COVID-19 en cinco países de América Latina. Rev Panam Salud Publica. 2022;46:e178. doi:10.26633/RPSP.2022.178
10. Dagnew SB, Moges TA, Mengie Ayele T, Agegnew Wondm S, et al. Adverse drug reactions and its associated factors among geriatric hospitalized patients at selected comprehensive specialized hospitals of the Amhara Region, Ethiopia: a multicenter prospective cohort study. BMC Geriatr. 2024;24:955. doi:10.1186/s12877-024-05515-y
11. Colimon KM. Muestreo y tamaño muestral. In: Fundamentos de epidemiología. Medellín: Corporación para Investigaciones Biológicas; 2010. p. 167–86.
12. Bidone N, et al. Prescripción y uso de antibióticos en una unidad de cuidados intensivos pediátricos de la ciudad de Buenos Aires. Arch Argent Pediatr. 2008;106(5). Available from: https://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S0325-00752008000500007
13. Giachetto G, et al. Uso de vancomicina en servicios de internación pediátrica del Centro Hospitalario Pereira Rossell. Arch Pediatr Urug. 2006;77(2):118–24. Available from: http://www.scielo.edu.uy/scielo.php?script=sci_arttext&pid=S1688-12492006000200007
14. Insani WN, Whittlesea C, Alwafi H, et al. Prevalence of adverse drug reactions in the primary

care setting: a systematic review and meta-analysis. PLoS One. 2021;16(5):e0252161. doi:10.1371/journal.pone.0252161

15. Machado-Alba JE, Moncada-Escobar JC. Reacciones adversas medicamentosas en pacientes que consultaron a instituciones prestadoras de servicios en Pereira, Colombia. Rev Salud Publica (Bogota). 2006;8(2):200–8.

16. Budnitz DS, Pollock DA, Weidenbach KN, et al. National surveillance of emergency department visits for outpatient adverse drug events. JAMA. 2006;296(15):1858–66. doi:10.1001/jama.296.15.1858

17. Rangel CR, Rojas S, López M, Caviedes G. Prevalencia y factores asociados a la presencia de reacciones adversas a medicamentos en los pacientes tratados por medicina interna en el Hospital Universitario Hernando Moncaleano Perdomo. Rev Med Risaralda. 2016;22(2):87–90.

18. Beltrán C, Caviedes G. Adverse drug reactions occurring in the internal medicine service at University Hospital in Neiva. Rev Fac Salud. 2013;5(2):10–7. doi:10.25054/rfs.v5i2.137

19. González Delgado D, Vives M, Monedero P, Aldaz A. Uso de vancomicina y lesión renal aguda en pacientes críticos con sepsis o shock séptico: cohorte observacional retrospectiva. Rev Esp Anestesiol Reanim. 2025;72(2):501657. doi:10.1016/j.redar.2024.501657

20. Sales GTM, Foresto RD. Drug-induced nephrotoxicity. Rev Assoc Med Bras (1992). 2020;66 Suppl 1:82–90. doi:10.1590/1806-9282.66.S1.82

21. Ganesh RN, Edwards A, El Zaatari Z, et al. Vancomycin nephrotoxicity: a comprehensive clinico-pathological study. PLoS One. 2014;19(3):e0295136. doi:10.1371/journal.pone.0295136

22. Meaney CJ, Hynicka LM, Tsoukleris MG. Vancomycin-associated nephrotoxicity in adult patients: incidence, outcomes, and risk factors. Pharmacotherapy. 2014;34(7):653–61. doi:10.1002/phar.1423

23. Sinha Ray A, Haikal A, Hammoud KA, Yu ASL. Vancomycin and the risk of AKI: a systematic review and meta-analysis. Clin J Am Soc Nephrol. 2016;11(12):2132–40. doi:10.2215/CJN.05920616

24. Barberán J, Mensa J, Artero A, et al. Factores asociados con el desarrollo de nefrotoxicidad en pacientes tratados con vancomicina frente a daptomicina en infecciones graves por grampositivos: un estudio basado en la práctica clínica. Rev Esp Quimioter. 2019;32(1):22–30.

25. Huang V, Clayton NA, Welker KH. Glycopeptide hypersensitivity and adverse reactions. Pharmacy (Basel). 2020;8(2):70. doi:10.3390/pharmacy8020070

26. Zeng M, Wang H, Qiu H, Gao J. Oral vancomycin-induced flushing syndrome in a multiple myeloma patient: a case report and review of the literature. Medicine (Baltimore). 2024;103(47):e40640. doi:10.1097/MD.0000000000040640

27. Zhu LJ, Liu AY, Wong PH, Arroyo AC. Road less traveled: drug hypersensitivity to fluoroquinolones, vancomycin, tetracyclines, and macrolides. Clin Rev Allergy Immunol. 2022;62(3):505–18. doi:10.1007/s12016-021-08919-5

28. Purja S, Kim M, Elghanam Y, Shim HJ, Kim E. Efficacy and safety of vancomycin compared with those of alternative treatments for methicillin-resistant Staphylococcus aureus infections: an umbrella review. J Evid Based Med. 2024;17(4):729–39. doi:10.1111/jebm.12644

29. Minhas JS, Wickner PG, Long AA, Banerji A, Blumenthal KG. Immune-mediated reactions to vancomycin: a systematic case review and analysis. Ann Allergy Asthma Immunol. 2016;116(6):544–53. doi:10.1016/j.anai.2016.03.030

30. Olender A, Ślęzak W, Krzych ŁJ. Pharmacokinetic drug-drug interactions in the intensive

care unit: single-centre experience and literature review. Anaesthesiol Intensive Ther. 2017;49(4):259–67. doi:10.5603/AIT.a2017.0053

31. Erazo Díaz MC, Gómez Aroca AM, Gómez Aristizábal AL, et al. Prevalencia de interacciones medicamentosas en el Servicio de Medicina Interna del Hospital Universitario Hernando Moncaleano Perdomo: estudio transversal. Rev Fac Salud. 2014;6(2):26–31. doi:10.25054/rfs.v6i2.161

32. Laporte JR, Capellá D. Mecanismos de producción y diagnóstico clínico de los efectos indeseables producidos por medicamentos. In: Laporte JR, Tognoni G, editors. Principios de la epidemiología del medicamento. Barcelona: Ediciones Científico-Técnicas; 1993. p. 95–109.

33. Barber KE, Bell AM, Stover KR, Wagner JL. Intravenous vancomycin dosing in the elderly: a focus on clinical issues and practical application. Drugs Aging. 2016;33(12):845–54. doi:10.1007/s40266-016-0420-z

34. Granowitz EV, Brown RB. Antibiotic adverse reactions and drug interactions. Crit Care Clin. 2008;24(2):421–42. doi:10.1016/j.ccc.2007.12.011

35. Orekoya O, Farquharson NR, Coulson IH. Cutaneous adverse drug reactions. Med (Baltimore). 2021;49(7):428–34. doi:10.1016/j.mpmed.2021.04.006

36. Kim JY, Yee J, Yoon HY, Han JM, Gwak HS. Risk factors for vancomycin-associated acute kidney injury: a systematic review and meta-analysis. Br J Clin Pharmacol. 2022;88(9):3977–89. doi:10.1111/bcp.15429