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Epidemiological intelligence in response to hantavirus: evidence-based risk analysis and infodemic management

Inteligencia epidemiológica en respuesta al hantavirus: análisis de riesgo basado en la evidencia y gestión de la infodemia

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The recent hantavirus outbreak aboard the cruise ship MV Hondius has reignited, both in public opinion and within the medical community, the official perception of risk associated with global health crises. However, this phenomenon must be analyzed with scientific rigor, using the tools of epidemiological intelligence to strengthen an appropriate perception of risk, support evidence-based communication strategies, and proactively manage the infodemic.^{1,2}

Emerging and re-emerging zoonotic diseases are, for the most part, a direct reflection of ecosystem degradation, human mobility, anthropogenic pressure on wildlife interfaces, and climate change. Hantaviruses belong to a family of viral agents that have been widely studied for decades; however, their present behavior requires us to reconsider global containment strategies and the robustness of local response systems.

At present, more than 20 hantavirus variants associated with different reservoirs and geographic regions worldwide are recognized. Far from behaving as a clinically homogeneous entity, these pathogens are clearly divided into two major groups according to their phylogenetic evolution, geographic distribution, and the systemic syndrome they cause in humans:¹

Old world hantaviruses

Predominant in Europe and Asia, these are the etiological agents of Hemorrhagic Fever with Renal

Syndrome. Their clinical spectrum ranges from mild forms, such as nephropathia epidemica caused by Puumala virus, to severe clinical presentations with acute renal involvement and severe hemorrhage, associated with Hantaan and Dobrava-Belgrade viruses. Their case-fatality rate ranges from 1% to 12%.³

New world hantaviruses

Found in the Americas, these viruses have predominantly endothelial and pulmonary tropism and are responsible for Hantavirus Pulmonary Syndrome. This variant is considerably more aggressive, characterized by a non-specific prodromal phase that progresses extremely rapidly to severe respiratory distress, with a case-fatality rate ranging from 30% to 50%.

In nature, the exclusive reservoirs of hantaviruses are specific wild rodents, such as sigmodontine rodents in the Americas. Of relevance is the long-tailed pygmy rice rat, *Oligoryzomys longicaudatus*, which is associated with Andes virus, the strain for which limited person-to-person transmission has been documented. The virus is maintained in an enzootic cycle among wildlife without causing apparent disease in the animal.³

Classical transmission from the reservoir to humans occurs through contact with urine, feces, and saliva from infected rodents, or through inhalation of contaminated aerosols. Person-to-person transmission, when

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it occurs, is associated with close and prolonged contact.³

For risk communication purposes, it is imperative to clarify that not all rodent species pose the same risk. Hantaviruses are associated with specific reservoirs, primarily wild rodents, whose relevance depends on the region and the type of virus involved. In this regard, common domestic rats and mice should not be considered reservoirs of this disease in the context of the present outbreak.

The relevance of the outbreak identified on the MV Hondius lies in the fact that the agent identified corresponds to the Andes virus, the only variant that has demonstrated the capacity for person-to-person transmission.³ This characteristic requires a differentiated public health response focused on timely case identification, contact tracing, and risk communication. However, under no circumstances does it justify equating this event with pre-pandemic dynamics or with threats of sustained global transmission.

When comparing the epidemiological behavior of Andes hantavirus with that of pathogens capable of generating global health crises, the disparity is evident: Andes hantavirus consistently maintains a community basic reproduction number, R_0 , below 1.³ This means that, mathematically, transmission chains are not self-sustaining in the general population, and they tend to be interrupted when appropriate epidemiological surveillance, contact follow-up, and risk communication measures are implemented.

Therefore, to curb the infodemic, it is essential to clarify that, in epidemiological terms, classifying a person as a “suspected case” does not equate to confirming infection, nor does the existence of contacts under investigation represent community transmission or a pandemic scenario.

Under this logic, the detection of positive cases among persons who had been previously identified and placed under quarantine or strict isolation should not be interpreted as a failure of public health control. On the contrary, it may reflect that epidemiological surveillance, contact tracing, and containment actions were implemented in a timely manner. When cases are identified within a previously delimited group under follow-up, this demonstrates that the transmission chain was correctly identified, circumscribed, and contained before spreading to the community.

An increase in the epidemiological alert level to a higher scale of concern would have technical justification if a confirmed case with severe clinical status were documented without any direct or indirect

epidemiological link to the MV Hondius or to the network of contacts under international follow-up. As long as this scenario does not occur, the risk to the general population remains low, and public health measures should continue to be aligned with the identified level of risk.

The main recommendation is to remain calm, continue daily activities without altering routines out of fear of infection, and firmly reject rumors circulating on social media, prioritizing consultation of verified sources, particularly official and institutional sources.

Within this global context, Mexico has activated its epidemiological surveillance protocols through the issuance of the corresponding Epidemiological Notice, aimed at strengthening timely detection in healthcare units and at points of entry into the country, including international ports and airports. This measure constitutes an early warning and epidemiological intelligence action intended to identify risks, coordinate the public health response, and clearly and proportionally communicate the level of risk to the population.

The analytical conclusion from medical science is clear: Andes hantavirus does not possess the biological characteristics or transmission mechanisms required for sustained, efficient community spread that would allow it to become the next pandemic.

The present outbreak is geographically delimited, epidemiologically characterized, and subject to monitoring by international epidemiological intelligence networks, which will allow response measures to be guided proportionally to the level of risk.

However, on a planet subject to constant ecological disruptions, the evolution of zoonoses can never be considered completely predictable. The response will not depend on chance, but rather on sustained investment in epidemiological surveillance, environmental monitoring, timely diagnostic capacity, and effective risk communication mechanisms.⁴

In this context, infodemic management is as relevant as the biological containment of the event, since a distorted perception of risk can generate social alarm, misinformation, and unnecessary pressure on health services.

It is important to emphasize that, within containment strategies; strength does not lie solely in highly specialized hospitals, but also in the response and alert capacity of the first level of medical care. General practitioners, nursing personnel, and healthcare trainees constitute the first sensory nodes of the health system.

Their ability to conduct a thorough anamnesis, identify travel or exposure history, recognize compatible

prodromal symptoms, and immediately activate the epidemiological alert, including timely notification, is essential to preventing community spread of this disease or other emerging zoonotic events.

Similarly, epidemiological intelligence must translate scientific evidence into clear, timely, and risk-proportionate messages. It is not only a matter of detecting cases, but also of anticipating questions, rumors, and alarmist narratives; strengthening an appropriate perception of risk among the population and healthcare personnel; and ensuring that decisions are based on verified information.

In the face of hantavirus, public health preparedness requires surveillance, communication, and coordinated action: three essential elements not only to contain the

transmission of an infectious agent, but also to limit the spread of uncertainty.

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Nutritional and cardiovascular risk in older adults

Riesgo nutricional y cardiovascular en adultos mayores

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Abstract

Background: Malnutrition is highly prevalent, often underrecognized in older adults, and may coexist with cardiovascular risk (CR). Traditional anthropometric indicators may not adequately capture this relationship. **Objective:** This study aimed to determine the prevalence of nutritional risk and to analyze its coexistence with CR in outpatient older adults. **Method:** A cross-sectional and retrospective study was conducted in outpatient older adults. Nutritional status was assessed using the full Mini Nutritional Assessment (MNA). CR was evaluated using anthropometric methods. Statistical analyses included Chi-square or Fisher's exact test, Mann-Whitney U test, and Spearman correlation. **Results:** From 96 clinical records collected, 49% (n = 47) were at nutritional risk and 5.2% (n = 5) were malnourished by MNA. Body weight and body mass index were significantly lower in the groups of nutritional risk (p < 0.05). Calf circumference < 31 cm was frequent in the nutritional risk group (30.2% vs. 9.3%). CR was present in both groups (p > 0.05). **Conclusion:** Nutritional risk is common among outpatient older adults and may coexist with CR independently of traditional anthropometric assessment.

Keywords: Nutritional risk. Mini nutritional assessment. Older adults. Anthropometry. Cardiovascular risk.

Resumen

Antecedentes: La malnutrición es altamente prevalente y, con frecuencia, subdiagnosticada en los adultos mayores, pudiendo coexistir con riesgo cardiovascular. Los indicadores antropométricos tradicionales pueden no captar adecuadamente esta relación. **Objetivo:** El objetivo de este estudio fue determinar la prevalencia de riesgo nutricional y analizar su coexistencia con el riesgo cardiovascular en adultos mayores ambulatorios. **Métodos:** Se realizó un estudio transversal y retrospectivo en adultos mayores ambulatorios. El estado nutricional se evaluó mediante la Mini Nutritional Assessment (MNA) completa. El riesgo cardiovascular (RC) se evaluó mediante métodos antropométricos. Los análisis estadísticos incluyeron prueba de chi cuadrado o prueba exacta de Fisher, prueba U de Mann-Whitney y correlación de Spearman. **Resultados:** De 96 expedientes clínicos recolectados, el 49% (n = 47) presentó riesgo nutricional y el 5.2% (n = 5) presentó desnutrición según la MNA. El peso corporal y el IMC fueron significativamente menores en los grupos con riesgo nutricional (p < 0.05). La circunferencia de pantorrilla < 31 cm fue frecuente en el grupo con riesgo nutricional (30.2% vs 9.3%). El RC estuvo presente en ambos grupos (p > 0.05). **Conclusión:** El riesgo nutricional es común entre los adultos mayores ambulatorios y puede coexistir con riesgo cardiovascular independientemente de la evaluación antropométrica tradicional.

Palabras clave: Riesgo nutricional. Mini evaluación nutricional. Adultos mayores. Antropometría. Riesgo cardiovascular.

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Introduction

Malnutrition is a major public health concern in the general population and is highly prevalent among older adults. Most studies addressing malnutrition have focused on hospital settings, where it is associated with prolonged hospital stay, increased morbidity and mortality, and functional decline.¹ Older adults are especially vulnerable, especially when accelerated muscle loss is present, contributing to rapid deterioration in functional status and prognosis.²⁻⁴

In Mexico, it is estimated that between 20% and 50% of individuals aged 50 years and older are at risk of malnutrition, particularly in the presence of chronic disease.^{1,5} In contrast, the prevalence of nutritional risk in outpatient older adults has been reported to be lower, generally between 3% and 30% in Mexico; however, available evidence is variable according to the setting.^{6,7} Early identification of nutritional risk is essential, as it represents the first step toward timely and individualized nutritional interventions aimed at preventing adverse outcomes.^{8,9}

The assessment of nutritional status traditionally involves a comprehensive approach that includes anthropometric measurements, biochemical parameters, clinical evaluation, and dietary intake.¹⁰⁻¹² In older adults, this process also considers functional status and comorbidities. Screening tools such as the Mini Nutritional Assessment (MNA) have been widely used to identify individuals at risk of malnutrition for more than 25 years.¹³ The MNA classifies individuals into normal nutritional status, risk of malnutrition, and malnourished and has demonstrated good sensitivity in older adults in different clinical settings.^{14,15} MNA is an instrument that evaluates a multi-dimensional construct, encompassing anthropometric measurements, global health status, subjective perception of health, and dietary intake patterns, and it is widely recognized for its robust sensitivity and specificity in the screening for malnutrition among the geriatric population.^{14,15}

Beyond this multidimensional assessment, anthropometric indicators are commonly used for assessing nutritional status and cardiovascular risk (CR). Conventionally, indicators such as body mass index (BMI), calf circumference (CC), and mid-upper arm circumference (MUAC) are mainly used to identify malnutrition or nutritional risk, whereas waist circumference is strongly associated with visceral adiposity and CR.^{10,11,16} In clinical practice, these conditions are often evaluated separately, supposing that the presence of malnutrition excludes the coexistence of obesity or CR.

However, the mixed age-related changes in body composition, including reduced muscle mass and increased fat mass, may limit the ability of this indicator to provide an integrative assessment of nutritional and cardiovascular status in older adults. In this context, nutritional risk and CR may coexist in older adults but remain underrecognized when traditional anthropometric measurements are used to evaluate only one extreme of nutritional status. Therefore, the aim of this study was to determine the prevalence of nutritional risk and to analyze the coexistence of nutritional and CR in outpatient older adults using anthropometric indicators.

Material and methods

Study design and population

This was an observational, cross-sectional study with retrospective data collection, based on the analysis of clinical records from patients evaluated during 2 consecutive days as part of the National Week of Older Adults 2023-2025 at a public hospital in Mexico.

Clinical records of adults aged ≥ 60 years with complete MNA assessment were included. Demographic variables included age, sex, and self-reported comorbidities. Anthropometric data were included and described above. Clinical records with incomplete information were excluded.

Nutritional and anthropometric assessment

Nutritional status was assessed using the MNA tool. The total MNA score reported in clinical records was recalculated to ensure standardized scoring and categorized according to established cut-offs. For the nutritional assessment we used the full MNA scores according to the described literature, considering ≥ 24 points as normal nutritional status, 17-23.5 points as at risk of malnutrition, and < 17 points as malnourished.¹⁴ For analytical purposes, individuals classified as “at risk of malnutrition” and “malnourished” were combined into a single category defined as “nutritional risk” and compared against those with normal nutritional status. Items in the MNA related to food intake and hydration were analyzed between groups using the original qualitative categories and cut-off values established in the MNA tool. Anthropometric variables obtained from MNA assessment were extracted from clinical records including weight (kg) and height (cm), CC (cm) and MUAC (cm), and BMI which was calculated and classified

according to reference values for older adults. CC was categorized according to the original MNA cut-off values as upper or equal to 31 cm and lower than 31 cm. In addition, CC was used to estimate Appendicular Skeletal Muscle Mass (ASMM) in kilograms, using the equations proposed by Santos LP et al.¹⁷ $ASM (kg) = -10.427 + (CC \times 0.768) - (age \times 0.029) + (Sex: men = 1, female = 0 \times 7.523) + (Mexican American \times -0.540)$, including the adjustment by height² to compare groups of nutritional status according MNA.¹⁷ MUAC was categorized based on the 5th percentile according to sex- and age-specific reference to evaluate deficiency of muscular mass.¹⁸

CR assessment

In addition, CR was determined by WC measurement, using three approaches: (1) International cut-off points:¹⁹ > 88 cm for women and > 102 cm for men (WC1); (2) Cut-off points for Mexican population:²⁰ > 80 cm for women and > 90 cm for men (WC2); and (3) using waist-to-height ratio (WHR) with values > 0.5.¹⁶ These criteria were selected to provide a comprehensive assessment of CR by considering both internationally accepted criteria and cut-off points that better reflect the metabolic risk profile of the Mexican population. The inclusion of the WHr (> 0.5) also provides a height-adjusted indicator that may be particularly useful in older adults, in whom age-related changes in stature may affect the interpretation of anthropometric measurements alone.

Statistical analysis

All data were entered into a Microsoft Excel® database and subsequently analyzed using the Statistical Package for the Social Sciences version 23.0 (IBM Corp., Armonk, NY, USA).

Categorical variables were expressed as frequencies and percentages (%). Normal distribution was evaluated using the Shapiro-Wilk test, and variables were presented as mean \pm standard deviation. Non-normal distributed variables were expressed as median and interquartile range (25th-75th percentile).

Differences between categorical variables were evaluated using the Chi-square test or Fisher's exact test, as appropriate. Differences in continuous variables between groups were analyzed using Student's t-test or the Mann-Whitney U test, depending on data distribution. Correlations between continuous variables were

analyzed using Spearman's rank correlation coefficient and statistical significance was considered $p < 0.05$.

Results

The total sample of 144 clinical records from outpatient older adults was initially reviewed. Of this, 48 participants were excluded: 7.6% (n = 11) were younger than 60 years old, 6.3% (n = 9) lacked data on MUAC or CC, and 19.4% (n = 28) had no recorded waist circumference. A total sample of 96 participants were included in this analysis. Among them, 79.2% (n = 76) were women and 20.8% (n = 20) were male. Mean age was 70.4 ± 7.9 with a range of ages between 60 and 107 years old. Overall, 21.9% (n = 21) of participants were older than 75 years. Only 20.85 (n = 20) had no comorbidities. According to BMI, 21.9% (n = 21) of participants were classified as underweight, 35.4% (n = 34) as excess of body weight. CR assessment by different anthropometric cut-off points showed that between 50% and 93.8% (n = 90) of total population exhibited increased in values of waist-related measurements associated with CR. Markers of low muscle mass were identified in 21.9% (n = 21) of participants based on MUAC and in 20.8% (n = 20) based on CC. The characteristics of the study population are presented in table 1.

The median punctuation on full-MNA was 23 (20.1-25), and according to each classification were as follows: 25 (24.5-26.5) for well nutrition status, 20.5 (19-22.5) for nutritional risk, and 14.5 (13.5-16.3) for malnutrition. Overall, 44.8% (n = 43) of the population were classified in a well-nutrition status classification according to the full MNA assessment. Nutritional risk and malnutrition were presented in 49% (n = 47) and 5.2% (n = 5) of total population.

For the comparative analysis, participants classified as malnourished or at nutritional risk using the full version of MNA were combined into a single group and compared with those with normal nutritional status. No significant differences were observed between groups in sex ($p = 0.322$) or medians of age ($p = 0.941$). The anthropometric assessment presented in table 2 showed that all medians or means in anthropometric parameters were lower in the nutritional risk group compared with the normal nutritional status group but only current body weight and BMI presented significant differences between groups ($p < 0.05$). Weight presented a difference between medians of groups with 7.8 kg and BMI 2.9 kg/m². Even though measurements were lower in the group classified with nutritional risk,

Table 1. General characteristics of total population

General characteristics	% (n)
Age > 75 years	21.9 (21)
Sex	
Men	20.8 (20)
Women	79.2 (76)
Comorbidities reported	
Diabetes	31.3 (30)
Hypertension	45.8 (44)
Combined D + H	19.8 (19)
Other	51 (49)
Body Mass Index	
Underweight (< 23 kg/m ²)	21.9 (21)
Normal weight (23-28 kg/m ²)	42.7 (41)
Overweight (< 28-31 kg/m ²)	26 (25)
Obesity (> 31 kg/m ²)	9.4 (9)
Cardiovascular risk	
WC > 88 cm in females and 102 cm in males	50 (48)
WC > 80 cm in females and 90 cm in males	84.4 (81)
Waist/height ratio > 0.5	93.8 (90)
Muscular mass MUAC < P°5	21.9 (21)
CC < 31 cm	20.8 (20)

D: diabetes; H: hypertension; WC: waist circumference; MUAC: middle upper arm circumference; CC: calf circumference.

differences between groups were not observed in WHr, height, CC, MUAC, ASMM, and ASMM/Height ($p > 0.05$). However, consistent with these findings, correlation analyses demonstrated that nutritional status scoring was positively associated with weight ($r = 0.391$, $p < 0.0001$), BMI $r = 0.340$, $p = 0.001$, and waist circumference ($r = 0.264$, $p = 0.009$). In contrast, no significant correlations were observed for height ($r = 0.158$, $p = 0.125$), WHr ($r = 0.189$, $p = 0.065$), CC ($r = 0.174$, $p = 0.091$), MUAC ($r = 0.022$, $p = 0.833$), ASMM ($r = 0.177$, $p = 0.084$), or AMSS/Height ($r = 0.137$, $p = 0.182$).

Analyzing the differences between groups and the cut-off points of CC and MUAC according to their perspective cut-off points (> 31 cm and MUAC > 5th percentile), only CC showed significant differences between study groups whereas MUAC no presented differences ($p = 0.073$) (Fig. 1). Regarding this, 30.2% ($n = 16$) of patients with nutritional risk presented values of CC < 31 cm compared with the 9.3% ($n = 4$) of patients in the other group. Figure 2 shows the BMI distribution according to older adults, demonstrating that differences in the proportion between groups of nutritional status were significantly different ($p = 0.043$), mainly in the extreme values.

CR

In contrast, the prevalence of CR showed no statistical differences between nutritional status groups according to the anthropometric criteria applied. The difference between groups showed that standard waist circumference cut-offs (WC1; $p = 0.247$), international cut-offs (WC2; $p = 0.109$), or WHr ($p = 0.158$) (Fig. 3). Participants at nutritional risk and normal nutritional status had a similar distribution of CR in all methodologies used.

Dietary assessment based on full MNA-related items is presented in table 3. No significant differences were observed between groups in the number of complete meals per day or in the consumption of protein-rich foods, including dairy products, eggs or legumes, meat, poultry, or fish and the consumption of vegetables and fruits ($p > 0.05$). However, a significantly higher proportion of participants with nutritional risk reported regularly consuming 3-5 glasses/day or less ($p < 0.05$).

Discussion

Nutritional assessment

Malnutrition in older adults varies widely across clinical settings. Overall, prevalence rates of malnutrition across all countries ranged from 8.5% to 22% in the ambulatory to 28.0% for the hospital setting.^{1,21} In our study, 5% of outpatient older adults were classified as malnourished according to the MNA, while 49% were identified as being at nutritional risk. The study population prevalent were women, with no differences between sexes.

These findings are consistent with previous reports in Mexico, where the prevalence of malnutrition has been shown to vary depending on the clinical or social setting. Osuna-Padilla et al. reported prevalence rates between 3.5% and 32.1% among older adult outpatients, with lower prevalence observed in community-based cultural centers, reflecting a more active and socially engaged population compared with the day-house care or nursing homes.⁶ In our case, our population presented walking and voluntarily for nutritional assessment. In another study conducted in a community-based older adult population, 31% of participants presented malnutrition, particularly among women, individuals engaged in domestic work, those who were widowed, or those living alone.⁷ In our study, participants voluntarily attended a nutritional assessment and were able to walk independently, which may partially explain the lower prevalence of malnutrition observed. However, other potentially relevant

Table 2. Anthropometric evaluation between groups of nutritional status

Characteristics	Total population, n = 96	Nutritional risk, n = 52	Normal nutrition status, n = 43	p
Age	70 (64.3-74)	70 (64-74)	70 (64-74)	0.941
Weight (kg)	60 (53.4-66)	62.2 (57-68)	70 (51-65)	0.001
Height (m)	1.51 (1.47-1.58)	1.50 (1.46-1.58)	1.53 (1.47-1.59)	0.287
BMI (kg/m ²)	26.1 (23.2-29)	24.3 (22-29)	27.2 (24.2-29.5)	0.009
WC (cm)	91.4 ± 11.3	89.5 ± 11.7	93.7 ± 10.5	0.063*
WHR	0.59 (0.54-0.64)	0.58 (0.53-0.63)	0.6 (0.56-0.64)	0.216
CC (cm)	32.7 (31.1-35.5)	32.5 (30-34.9)	33.5 (32-35.8)	0.095
MUAC (cm)	27.5 ± 3.1	27.1 ± 3.6	27.9 ± 2.3	0.205*
ASMM (kg)	12.6 (11-16.8)	12.3 (10.4-16.4)	13.6 (11.5-18.8)	0.132
ASMM/Height (kg/m ²)	5.7 (4.9-6.8)	5.5 (4.4-6.6)	5.8 (5.1-7.4)	0.138

p values using the U Mann-Whitney test, expressed in medians (25th-75th).

*p values using t-student test, expressed in means ± standard deviation.

BMI: body mass index; WC: waist circumference; WHR: waist-to-height ratio; MUAC: middle upper arm circumference; CC: calf circumference; ASMM: appendicular skeletal muscle mass.

Table 3. Dietary assessment based on MNA-related items between groups of nutritional status

Dietary assessment	Nutritional risk, n = 52	Normal nutrition status, n = 43	p
Number of complete meals			
1 meal/day	5.7 (3)	2.3 (1)	0.391*
2 meals/day	32.1 (17)	27.9 (12)	0.415
3 meals/day	62.3 (33)	69.8 (30)	0.219
Sources of protein-rich foods			
Dairy products	69.8 (37)	74.4 (32)	0.655
Eggs or legumes	90.6 (48)	81.4 (35)	0.565
Meat, poultry, or fish	71.7 (38)	83.3 (35)	0.225
Vegetables and fruits	59.6 (31)	72.1 (31)	0.279
Daily fluid intake			
< 3 glasses/day	7.5 (4)	2.3 (1)	0.253*
3-5 glasses/day	69.8 (37)	46.5 (20)	0.018
> 5 glasses/day	22.6 (12)	51.2 (22)	0.003

*p values using Fisher's exact test.

MNA: Mini nutritional assessment.

Interestingly, only weight and BMI showed differences between nutritional status groups. This discrepancy is explained by the fact that correlation analyses capture continuous associations, whereas group comparisons are more dependent on effect size and variability within each category. In this context, BMI and body weight are more sensitive to global changes in nutritional status among midlife and older adults, while some circumferences may reflect more stable components compared to body weight in older adults.²²

Regarding MUAC, it reflects both muscle and subcutaneous fat reserves. Is a simple and practical indicator of muscle and fat reserves in older populations that even is related to frailty.²³ In our results, the groups at nutritional risk had twice as many patients with a MUAC below the 5th percentile compared to the normal nutrition status group (28% versus 14%), with no differences between groups (p > 0.05), possibly reflecting preserved functional status in this outpatient population and also a higher sample size.

demographic and social variables were not collected, limiting the ability to explore factors associated with poor nutritional status in this population.

In our study, MNA scores correlated positively with weight, BMI, waist circumference, and CC, indicating that poorer nutritional status was associated with lower anthropometric measurements in older adults.

CR

Cardiometabolic risk and malnutrition are not mutually exclusive conditions in older adults. The main finding of this study was the coexistence of nutritional risk and CR in outpatient older adults, despite the use of traditional anthropometric indicators that are

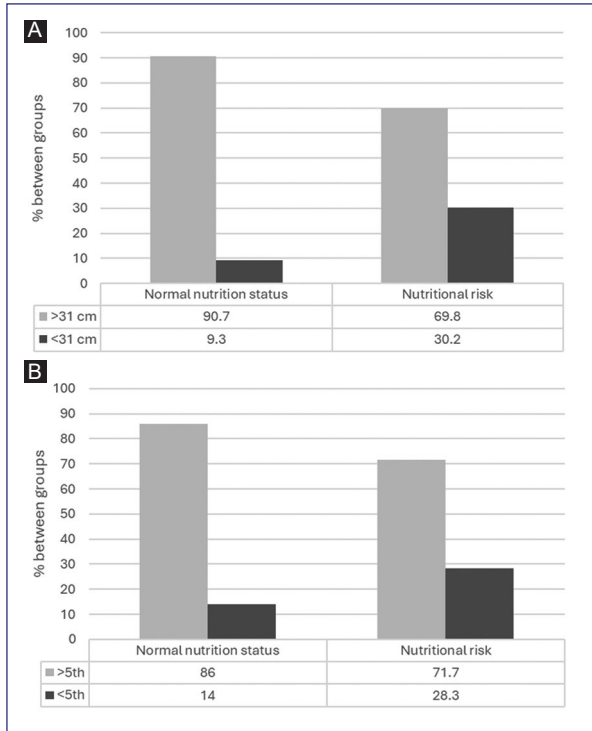


Figure 1. A and B: distributions of CC and MUAC according to cut-offs between groups of nutritional risk and normal nutrition status. CC: calf circumference; MUAC: mid-upper arm circumference.

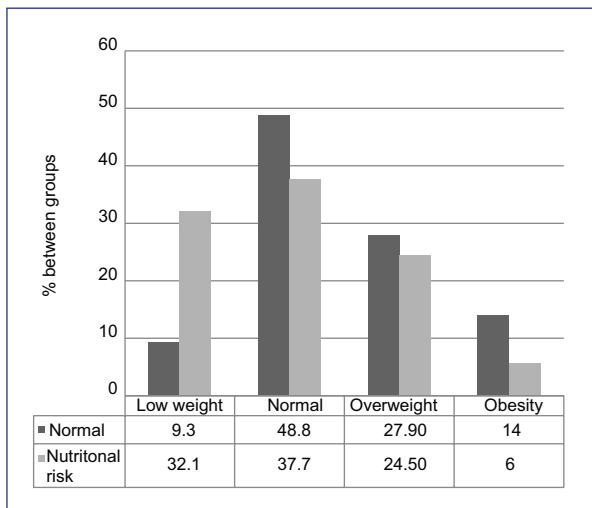


Figure 2. Body mass index distribution between patients at nutritional risk and normal nutritional status.

commonly interpreted as representing opposite nutritional conditions.

Aging is a process accompanied by complex changes in body composition, including a decrease in muscle

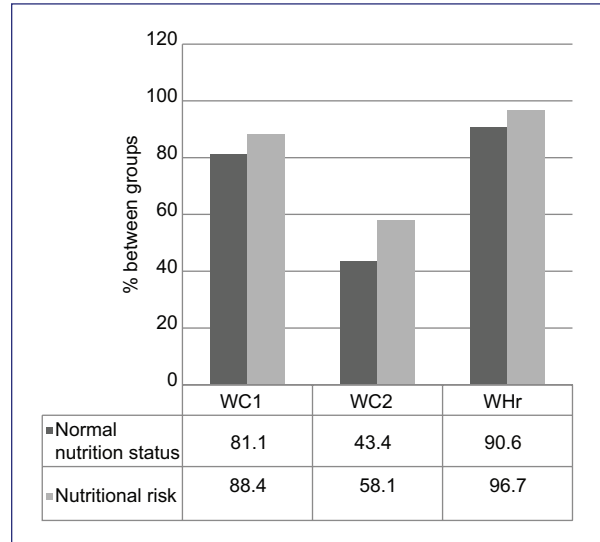


Figure 3. Cardiovascular risk assessment between patients at nutritional risk and normal nutritional status. WC1: waist circumference using cut-off values of 88 cm for women and 102 cm for men; WC2: waist circumference using cut-off values of 80 cm for women and 90 cm for men; WHr, waist-to-height ratio; ratio using values > 0.05.

mass (sarcopenia) and also an increase in fat mass, which may allow both conditions to coexist in the same individual.^{3,10,24} In addition, evidence shows that after age 60, humans experience a progressive loss of fat-free mass and a 0.7% annual decline in adjusted metabolic rate, together with an increase in fat mass. This shift limits the reliability of conventional anthropometric indicators in older adults when interpreted independently to evaluate malnutrition.²⁵

Our findings showed that CC and waist-related measures do not differ between nutritional status groups. According to this, CC and waist-related measures are good predictors of a decrease in muscle mass and an increase in CR, respectively.^{17,26} However, our results were not significant in CC and WC between groups of nutritional status, suggesting that nutritional risk and CR coexist independently of traditional nutritional classification.

While indicators such as BMI, CC, and MUAC are mainly used to identify malnutrition or reduced muscle reserves, waist-related measurements are commonly associated with visceral adiposity and CR because they reflect the central fat accumulation and body fat distribution more than BMI alone.²⁵ Increased visceral adiposity has been strongly associated with insulin resistance, systemic inflammation, metabolic dysfunction, and higher CR.^{16,27,28} Conventionally, BMI has

been used as an indicator associated with overweight, obesity, and cardiovascular. A study in Spain determined that an increased BMI in overweight or obesity classification was associated with a good nutritional status (odds ratio = 0.85) in older adults; however, this study classified BMI according to the ranges for general population.²¹ In this context, our findings suggest that CR may not be adequately captured by traditional assessment approaches and may occur independently of nutritional status, potentially reflecting underlying age-related degenerative processes. In this regard, waist circumference may provide additional value by better reflecting central adiposity and visceral fat accumulation, which are more closely related to cardiometabolic risk in older adults.

The coexistence of nutritional and CR has important implications for nutritional management, as both conditions require different intervention strategies. On the one hand, the treatment of malnutrition usually involves hypercaloric and protein-enriched nutritional approaches, whereas CR reduction typically focuses on caloric restriction and weight management strategies. Therefore, future studies should focus on the development of integrated assessment models that simultaneously consider nutritional status and cardiometabolic risk to better reflect the complex and overlapping nature of these conditions in aging populations.

Dietary assessment

Regarding dietary factors, the absence of significant differences in most intake-related variables between groups suggests that self-reported dietary patterns captured by the MNA may not fully reflect underlying nutritional status. Consistent with this, Montejano Lozoya et al., evaluated 660 older adults in Spain and did not find a relation between dietary intake and nutritional status, suggesting this relationship is not always directly correlated, as individuals may present with inadequate nutrient intake despite relatively preserved anthropometric or clinical indicators.²¹

Our findings suggest that liquid intake is different between groups. There was a higher proportion of individuals in the nutritional risk group who consumed between 3 and 5 glasses of water than those with a normal nutritional status. Half of the individuals in normal nutrition status showed a consumption of more than 5 cups of water, following the recommended fluid intake, which ranges from approximately 6-8 cups (1500-2000 mL/day) for older adults compared with those in the nutritional risk group ($p < 0.05$).²⁹ This

pattern may suggest a potential association between hydration status and overall nutritional condition in older adults. Dehydration affects older adults, especially those in frailty conditions, and its associated with increased mortality and worse prognosis.³⁰ This vulnerability is exacerbated by age-related declines in thirst sensation, the use of medications such as diuretics, and the presence of chronic conditions, which in our study were homogeneous in our groups of study.

This study has several limitations. First, its cross-sectional and retrospective design limits the interpretation of the findings. Second, the relatively small and non-probabilistic sample limits the generalizability of the prevalence to the general older adult population, and the results should therefore be interpreted with caution. Third, direct measurements of body composition and muscle strength, such as bioimpedance or dynamometry, were not available because the study was based on retrospective clinical records obtained during a community screening campaign.^{29,30}

In conclusion, this study provides relevant clinical insights into the coexistence of nutritional and CR in outpatient older adults, even when assessed using conventional anthropometric indicators that are often interpreted as representing opposite nutritional conditions. These findings underscore the importance of comprehensive nutritional assessment beyond the isolated use of traditional anthropometric measures and support the use of multidimensional tools such as the MNA in routine practice. Future research should incorporate longitudinal designs to better understand the temporal relationship between nutritional and CR, as well as include biochemical and functional markers to provide a more comprehensive evaluation. Furthermore, the development of population-specific cut-off points and validated tools for assessing body composition in older adults remains a priority.

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Conflicts of interest

The authors declare no conflicts of interest.

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Handling of biohazardous infectious waste among university students in schools of chemical and health sciences in Mexico

Manejo de residuos peligrosos biológico-infecciosos entre estudiantes universitarios en escuelas de ciencias químicas y de la salud en México

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Abstract

Biohazardous infectious waste (corresponds to Residuos Peligrosos Biológicos Infecciosos [RPBI], in Spanish) management in university settings is critical for safety and regulatory compliance. This systematic review synthesizes evidence on the level of knowledge regarding RPBI management among university students in health and chemical sciences in Mexico, where practices are governed by the Official Standard NOM-087-SEMARNAT-SSA1-2002. A systematic search was conducted in Google Scholar, ScienceDirect, Nature, SpringerLink, Cell, and PubMed for studies published until November 2025. Three cross-sectional studies ($n = 245$ students) were included in the study. Results indicate an acceptable general knowledge of RPBI definitions and classification (70-79% correct). However, significant gaps persist in practical components such as appropriate treatment, storage, and final disposal (28-60% correct). Methodological heterogeneity, lack of inferential statistical analysis, and the use of non-validated instruments limit the robustness of findings. We conclude that while theoretical knowledge is moderate, practical knowledge is insufficient. Strengthening practical training, standardizing evaluation tools, and employing longitudinal designs are urgently needed.

Keywords: Biohazardous infectious waste. Handling. Knowledge. University students. NOM-087.

Resumen

El manejo de residuos peligrosos biológico-infecciosos (RPBI) en entornos universitarios es crucial para la seguridad y el cumplimiento normativo. Esta revisión sistemática sintetiza la evidencia sobre el nivel de conocimiento respecto al manejo de RPBI entre estudiantes universitarios de ciencias de la salud y químicas en México, donde las prácticas se rigen por la Norma Oficial NOM-087-SEMARNAT-SSA1-2002. Se realizó una búsqueda sistemática en Google Scholar, ScienceDirect, Nature, SpringerLink, Cell y PubMed para estudios publicados hasta noviembre de 2025. Se incluyeron tres estudios transversales ($n = 245$ estudiantes). Los resultados indican un conocimiento general aceptable sobre definiciones y clasificación de RPBI (70-79% de aciertos). Sin embargo, persisten brechas significativas en componentes prácticos como el tratamiento, almacenamiento y disposición final adecuados (28-60% de aciertos). La heterogeneidad metodológica, la falta de análisis estadístico inferencial y el uso de instrumentos no validados limitan la solidez de los hallazgos. Concluimos que, si bien el conocimiento teórico es moderado, el conocimiento práctico es insuficiente. Se requiere urgentemente fortalecer la capacitación práctica, estandarizar herramientas de evaluación y emplear diseños longitudinales.

Palabras clave: Residuos peligrosos biológico-infecciosos. RPBI. Conocimiento. Estudiantes universitarios. NOM-087.

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Introduction

The generation of biohazardous infectious waste (corresponds to Residuos Peligrosos Biológicos Infecciosos [RPBI] in Spanish) in higher education institutions, particularly those with programs in health and chemical sciences, represents a significant occupational and environmental risk.¹ In Mexico, the management of this waste is strictly regulated by the Official Mexican Standard NOM-087-SEMARNAT-SSA1-2002, which establishes comprehensive criteria for its classification, handling, storage, treatment, and final disposal.² Adherence to this NORM is not only a legal obligation but a fundamental component of biosafety and environmental stewardship within academic laboratories and training clinics.

University students in these disciplines are both generators of RPBI during practical sessions and future professionals responsible for its management. Their knowledge and correct application of established protocols are therefore critical for preventing accidents, reducing biological risk, and ensuring regulatory compliance from the earliest stages of professional development.³

Previous isolated studies at Mexican universities have evaluated this knowledge, suggesting it is heterogeneous and often focused on theoretical aspects rather than practical application.^{4,5} However, a synthesis of the available evidence, which would allow for a robust assessment of the overall state of student knowledge, identify consistent gaps, and inform targeted educational interventions, is currently lacking.

Material and methods

Our research was conducted in accordance with a systematic review; our method is described in the flow diagram (Fig. 1). We searched: Google Scholar, ScienceDirect, Nature, SpringerLink, Cell Press, and PubMed databases without date limits until November 2025.

Our review was focused on observational studies (cross-sectional or longitudinal) with no language restrictions, but focused on Spanish or English. In these studies, we evaluated knowledge about RPBI management, focused specifically on university students in health or chemical science programs in Mexico, and presented empirical data. Exclusion criteria were studies not focused on students, narrative reviews, opinion articles, and studies without an accessible full text.

A systematic search was performed from July 07, 2024, to November 03, 2025, without date restrictions.

The search was conducted across Google Scholar, ScienceDirect, Nature, SpringerLink, Cell, and PubMed electronic databases. Search terms included: “RPBI”, “conocimiento” (knowledge), “manejo” (management), “estudiantes universitarios” (university students), “Mexico”, “biohazard”, “waste”, “university”, and “college”.

The selection process was conducted by the involun- crate authors. Records identified through database searching were screened by title and abstract. The full texts of potentially relevant studies were retrieved and assessed for eligibility. Data from included studies were extracted into a standardized form, capturing: authors, year, study population, sample size, study design, assessment instrument, main variables evaluated, and key results (percentages of correct answers by knowl- edge category).

The methodological quality of the included studies was assessed using the JBI Critical Appraisal Checklist for Analytical Cross-sectional Studies.

Therefore, this systematic review aimed to answer the following question based on the population, exposure, and outcome framework: Population, University students in health and chemical science programs in Mexico. Exposure, Academic training, and exposure to institu- tional protocols related to RPBI management. Outcome, Level of knowledge regarding RPBI management, mea- sured by validated or study-specific instruments.

The objective was to synthesize the existing evi- dence on the level of knowledge about RPBI man- agement among this population and to identify the main areas of strength and deficiency. The review’s protocol was registered in PROSPERO 2026 CRD420261357367.

Results

We found 15 records corresponding to our inclusion criteria in the databases mentioned above. There were no duplicates to eliminate; the date of publication is not a criterion for discrimination or the language used to report. After screening titles and abstracts, 12 were excluded for not meeting the population or outcome criteria student and multidisciplinary workforce in a University or a college (n = 8), also those investigations that apply for university and colleges but the waste evaluations were not biohazardous (n = 8). Three stud- ies underwent full-text review and met all eligibility cri- teria for inclusion (n = 3; 4,5,6; Fig. 1). No additional records were identified from other sources.

The methodological quality assessment using the JBI Critical Appraisal Checklist for Analytical Cross

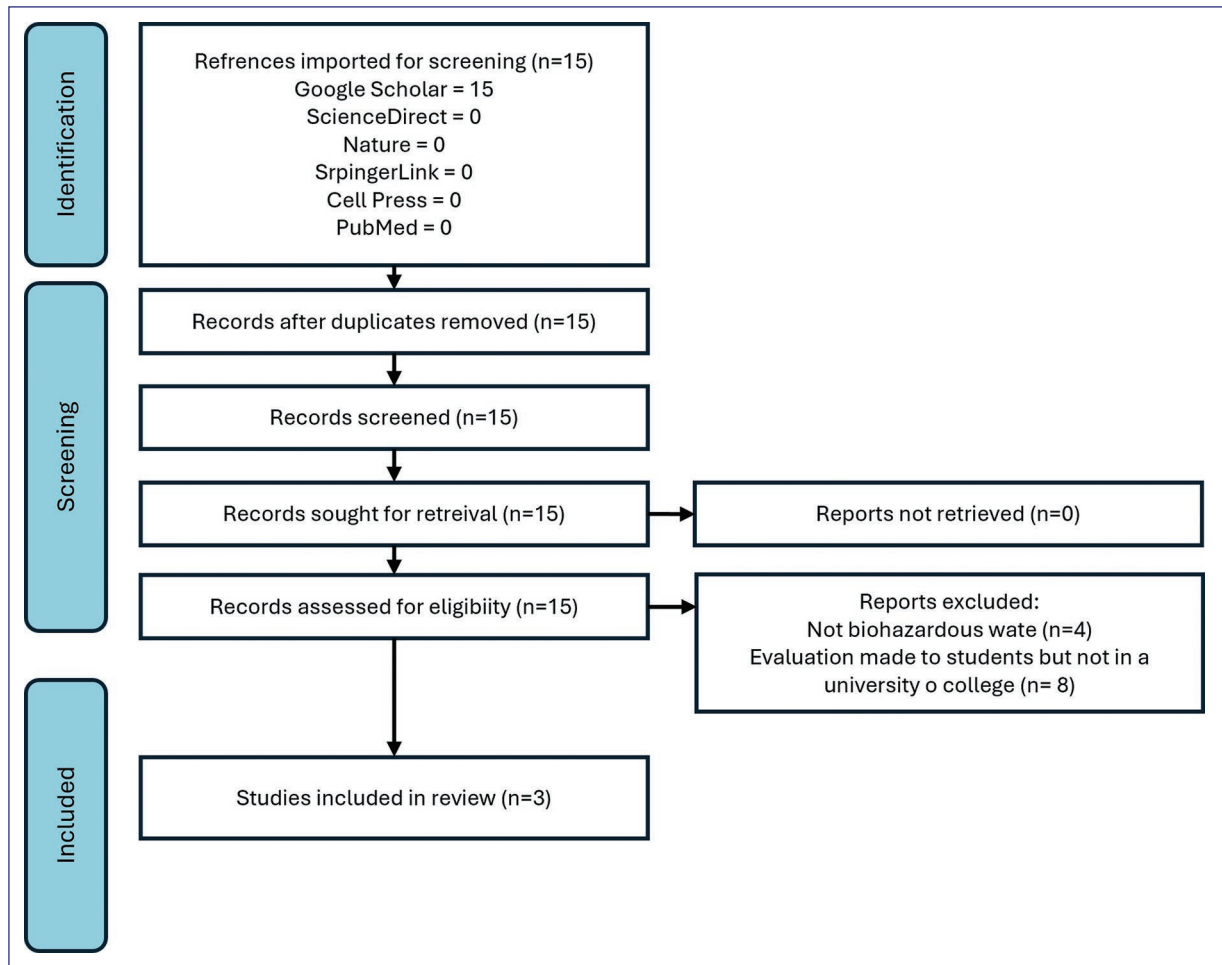


Figure 1. Flow diagram of study selection.

Sectional Studies showed that the three studies presented overall moderate methodological quality. All studies clearly defined the study population and setting and used the NOM-087-SEMARNAT-SSA1-2002 as the standard criterion for evaluating RPBI management knowledge. However, important limitations were identified, mainly related to insufficient control of confounding factors and limited evidence regarding the validity and reliability of the measurement instruments, particularly in the studies by Zúñiga-Lemus et al.⁴ and Pastor Durán et al.⁶. Mex-Álvarez et al.⁵ demonstrated stronger methodological rigor because the questionnaire underwent expert validation and pilot testing. Overall, the studies provide useful descriptive evidence regarding RPBI knowledge among health science students, although methodological weaknesses may limit the generalizability of the findings (Table 1).

The characteristics of the three included studies are summarized in table 2. All were descriptive

cross-sectional studies published between 2015 and 2024. The total sample size was 456 students from different universities and programs (Engineering, Chemistry, Clinical Laboratory, Nursing). All studies used questionnaires based on the NOM-087 standard, with the number of items ranging from 10 to 26.

All three studies presented significant methodological limitations: use of convenience sampling, lack of reported psychometric validation for the assessment instruments (except Mex-Álvarez et al.⁵), and presentation of results limited to descriptive percentages without inferential statistical analysis (e.g., no use of χ^2 , logistic regression) to explore associations between variables.

General knowledge

The global level of knowledge was variable. Zúñiga-Lemus et al.⁴ reported 70.25% correct answers overall. Pastor Durán et al.⁶ found that 79% of nursing

Table 1. Outcome of the JBI critical appraisal questions

JBI Critical Appraisal Question	Zúñiga et al., 2015 ⁴	Mex-Álvarez et al., 2020 ⁵	Pastor Durán et al., 2024 ⁶
1. Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	Yes
2. Were the study subjects and the setting described in detail?	Yes	Yes	Yes
3. Was the exposure measured in a valid and reliable way?	Unclear	Yes	Unclear
4. Were objective, standard criteria used for measurement of the condition?	Yes	Yes	Yes
5. Were confounding factors identified?	No	Partially Yes	Partially Yes
6. Were strategies to deal with confounding factors stated?	No	No	No
7. Were the outcomes measured in a valid and reliable way?	Unclear	Yes	Unclear
8. Was appropriate statistical analysis used?	Partially Yes	Partially Yes	Yes

Table 2. Characteristics of included studies

Study (Author, Year)	Population	Sample size	Instrument	Key evaluated domains	Validated instrument	Knowledge outcomes	JBI methodological quality
Zúñiga-Lemus et al., 2015 ⁴	Engineering and undergraduate students (UNCA)	53	24-item questionnaire	General knowledge, classification, treatment, disposal	Not reported	70.25% correct answers overall	Moderate
Mex-Álvarez et al., 2020 ⁵	Chemistry and Clinical Lab students (UAC)	92	10-item questionnaire	Classification, packaging, identification	Validated	76.4% of the students know about the right management, storage and disposal of biohazardous waste regulated by NOM-087-SEMARNAT-2002.	Moderate
Pastor Durán et al., 2024 ⁶	Nursing students (UAGro)	100	26-item questionnaire	Definitions, classification, handling, final disposal	Not reported	79% of nursing students had a knowledge level between “regular” and “good”.	Moderate

students had a knowledge level between “regular” and “good”. Mex-Álvarez et al.⁵ reported that 76.4% of the students know about the right management, storage, and disposal of biohazardous waste regulated by NOM-087-SEMARNAT-2002.

Definitions and classification

Knowledge in this theoretical area was the highest, with correct answer percentages exceeding 80% for basic identifiers.⁴

Treatment and final disposal

This was the area with the greatest deficiency. Only 22.7% knew the appropriate treatment,⁴ and 34% knew the correct final disposal method.⁶

Storage, transport, and identification

Knowledge was moderate (56-72% correct) for storage and transport.⁴ Significant gaps remained in identifying non-anatomical and pathological waste (43-47% incorrect).⁶

Differences by population

Nursing students showed superior knowledge in sharps management (95% correct) compared to engineering students (81.8%).^{4,6} Laboratory technicians demonstrated higher knowledge than students in classification and packaging.⁵

The methodological quality assessment using the JBI Critical Appraisal Checklist for Analytical Cross-sectional Studies showed that the three studies presented overall

moderate methodological quality. All studies clearly defined the study population and setting and used the NOM-087-SEMARNAT-SSA1-2002 as the standard criterion for evaluating RPBI management knowledge. However, important limitations were identified, mainly related to insufficient control of confounding factors and limited evidence regarding the validity and reliability of the measurement instruments, particularly in the studies by Zúñiga-Lemus et al.⁴ and Pastor Durán et al.,⁶ Mex-Álvarez et al.,⁵ demonstrated stronger methodological rigor because the questionnaire underwent expert validation and pilot testing. Overall, the studies provide useful descriptive evidence regarding RPBI knowledge among health science students, although methodological weaknesses may limit the generalizability of the findings (Table 1).⁴⁻⁶

Discussion

Principal findings

This systematic review synthesizes evidence from three studies conducted over a decade, finding a tendency in the results of how much each community knows about RPBI management among Mexican university students. While foundational, theoretical knowledge regarding definitions and classification appears relatively solid, there is a pronounced and consistent deficit in knowledge related to the practical, procedural stages of the waste management chain – specifically treatment and final disposal. This theory-practice gap is evident across different universities and student populations.

Interpretation and implications

The findings suggest that academic training may successfully convey the “what” (definitions) and “why” (risks) of RPBI but falls short in effectively teaching the “how” (application of NOM-087 procedures). This has direct implications for biosafety and regulatory compliance. The better performance of health science students (e.g., Nursing) in specific areas like sharps management likely reflects more direct and repeated exposure during clinical practice, underscoring the value of experiential learning.

From a regulatory perspective, these results acknowledge that the gaps represent direct points of non-compliance with NOM-087, which specifies exact treatment and disposal methods.² Furthermore, in Mexico, the General Health Law (Ley General de Salud) stipulates in Article 98, Section II, that any institution responsible for

university-level education must maintain a Biosafety Committee. In addition, Article 41 bis, Section III, mandates that this committee establish biosafety protocols in coordination with the Research and Ethics Committees. Of the studies included in this review, none addressed any of these committees and their oversight of waste management processes. University biosafety programs should be considered shifting from purely theoretical instruction to a program to educate the community on the impact of good hands-on training and simulation in RPBI handling based on regulatory for the country.

The main limitations of this review stem from the weaknesses of the primary studies: cross-sectional design, small convenience samples, and lack of validated, standardized measurement tools. The absence of inferential statistics prevents identifying factors (e.g., academic semester, type of practical training) associated with better knowledge. These limitations constrain the generalizability and strength of the conclusions.

Future studies should employ longitudinal or interventional designs to measure the impact of specific educational strategies. It is essential to develop and validate a standardized knowledge assessment instrument based on NOM-087. Research should also use appropriate inferential statistical tests (e.g., χ^2 , regression models) to analyze associations and predictors of knowledge.

Conclusion

While university students in health and chemical sciences demonstrate an acceptable level of theoretical knowledge regarding the definitions and classification of biohazardous infectious waste (RPBI), there is a significant deficiency in practical application. The data reveals critical oversights in the procedural stages of waste management - specifically regarding treatment and final disposal. This suggests that while curricula successfully cover regulatory concepts, they lack the technical depth required for students to achieve full compliance with NOM-087 protocols.

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Protection of human subjects and animals. The authors declare that no experiments on humans or animals were performed for this research.

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Garengot hernia: preperitoneal approach in the context of strangulation, case report

Hernia de Garengot: abordaje preperitoneal en el contexto de una estrangulación

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Abstract

Garengot's hernia is a femoral hernia in which the cecal appendix is located within the hernial sac; it is most common in adult or postmenopausal women. Its pathophysiology relates to the narrowness of the femoral ring and the abnormal attachment of the cecum, factors that increase the risk of incarceration and strangulation. Clinically, it presents as pain in the inguinal region, accompanied by an irreducible mass, which can sometimes be less evident, hence the difficulty in diagnosis, with most cases identified during surgery. Computed tomography helps guide the diagnosis and rules out the main differential diagnosis, Amyand's hernia. Treatment is surgical, individualized, and urgent, without standardization; the approach depends on the surgeon's experience. The main goal is to evaluate the appendix's condition, as this will determine whether a crural or inguinal approach is used for hernia repair or hernioplasty to prevent infection of the prosthetic mesh. We present the case of a patient initially diagnosed with a strangulated right inguinal hernia, presenting with pain and a palpable mass in the region. However, at the time of surgery, it was found that she had a femoral hernia that included the appendix; herniorrhaphy with prosthetic material placement was performed, followed by appendectomy. This represents a surgical condition of clinical interest.

Keywords: Garengot hernia. Appendicular strangulation. Amyand hernia. Preperitoneal repair. Femoral hernia.

Resumen

La hernia de Garengot es una hernia femoral con presencia del apéndice cecal en el saco herniario; incidiendo en mujeres de edad adulta o posmenopáusicas. Su fisiopatología está relacionada con la estrechez del anillo femoral y la implantación anormal del ciego, factores que aumentan el riesgo de incarceration y estrangulación. Clínicamente se presenta como dolor en la región inguinal, acompañado de una masa irreducible, en ocasiones menos evidente, y ahí recae la dificultad de su diagnóstico, realizándose la mayoría durante el acto quirúrgico. La tomografía computarizada orienta y descarta el principal diagnóstico diferencial, la hernia de Amyand. El tratamiento es quirúrgico, individualizado y urgente, sin estandarización; el abordaje depende del cirujano y su experiencia. Principalmente, es identificar el estado del apéndice, ya que dependerá si el abordaje es crural o inguinal, mediante plastia o herniorrafía, con el objetivo de prevenir una infección de la malla protésica. Se expone el caso de una paciente inicialmente diagnosticada con hernia inguinal derecha estrangulada, presentando dolor y una masa palpable en la región. Sin embargo, durante la cirugía se identificó una hernia femoral que contenía el apéndice; se realizó plastia y colocación de material protésico más apendicectomía. Siendo una entidad quirúrgica de interés clínico.

Palabras clave: Hernia de Garengot. Estrangulación apendicular. Hernia de Amyand. Reparación preperitoneal. Hernia femoral.

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Introduction

Hernias in the inguinal and femoral regions are one of the most common conditions in general surgery, with 1.6 million cases diagnosed annually and 500,000 patients undergoing surgical repair in the United States,¹ although rare variants have been described that continue to pose diagnostic and surgical challenges. Garegeot's hernia is a rare condition characterized by the presence of the cecal appendix within the femoral hernial sac, regardless of whether or not there is appendicular inflammation.²

It was first described by René Jacques Croissant de Garegeot;² this condition represents < 1% of femoral hernias, although the association with acute appendicitis is even rarer.³ Its low frequency and non-specific clinical presentation make preoperative diagnosis uncommon; in most cases, the diagnosis is established intraoperatively.⁴

The surgical treatment of Garegeot hernia is not standardized, with therapeutic decisions being individualized according to the condition of the appendix, the degree of local contamination, and tissue viability.⁵ In this regard, preperitoneal approach techniques with the placement of prosthetic material have gained increasing support, especially in selected cases, due to the anatomical and functional advantages they may offer.⁶

Garegeot's hernia is a rare variant of femoral hernia, which must be differentiated from Amyand's hernia, in which the cecal appendix is contained within in the inguinal canal. The location of the appendix in the femoral sac has been described in < 1% of femoral hernias, and appendicitis occurs in only a small proportion of these cases, ranging from 0.13% to 0.8%.^{3,7,8}

It occurs predominantly in women compared to men, at a ratio of 2:1, with characteristic risk factors: advanced age or postmenopause, anatomical changes caused by the increased intra-abdominal pressure resulting from pregnancy, smoking, and abnormalities in muscle and collagen tissue.^{8,9}

From an anatomical and pathophysiological point of view, different predisposing factors have been proposed that give rise to this type of hernia, including a low-lying cecum or abnormal attachment of the appendix due to rotation, resulting in a pelvic location, increased appendicular length, and alterations in peritoneal fixation.¹⁰ The femoral ring, being a narrow and rigid structure, favors incarceration of the hernial contents, increasing the risk of vascular compromise and appendicular inflammation. However, they also prevent intraperitoneal spread, and no clinical signs of

peritonitis are observed.^{7,9} From a clinical point of view, Garegeot hernia is generally characterized by a painful mass in the inguinal-crural region. Clear abdominal symptoms are very rare, making it difficult to distinguish from other pathologies such as incarcerated inguinal hernia, inguinal adenopathy, Amyand's hernia, umbilical lipoma, or local infections like psoas abscess.⁴ However, although computed tomography has proven useful for identifying appendicular contents within the hernial sac and guiding preoperative diagnosis, Garegeot's hernia remains uncommon in clinical practice.¹¹ There is no agreement on the ideal approach for surgical treatment.

Computed tomography scan findings can distinguish femoral hernias from inguinal hernias based on the relationship between the hernial sac and the pubic tubercle, as well as venous compression. If the hernial sac is located medial to the pubic tubercle, it is consistent with an inguinal hernia. However, if the hernial sac extends laterally to the pubic tubercle and compresses the femoral vein due to the narrowness of the femoral canal, it is likely to be a femoral hernia.¹²

Historically, management relied on open approaches, and mesh placement was reserved for cases without evidence of infection.¹³ However, the development of preperitoneal techniques has enabled improved visualization of the femoral defect, more precise anatomical repair, and reliable prosthetic mesh placement, with a potential decrease in the recurrence rate of hernia.^{6,14} The use of mesh in complicated femoral hernias remains a subject of debate, especially in the presence of local inflammation or contamination. The present case adds to the limited body of literature supporting the preperitoneal approach with mesh repair as a feasible and safe option in Garegeot hernia without frank contamination, reinforcing the need for individualized surgical decision-making and diagnosis based on this condition. Familiarity with this femoral hernia among primary care physicians, radiologists, and surgeons will lead to more accurate diagnoses and evidence-based standardized treatment protocols. This case report highlights the importance of studying this rare variant, focusing on risk factors that may raise suspicion and utilizing appropriate imaging methods to increase the accuracy of preoperative diagnoses.

Case report

A 62-year-old female patient, a Latin homemaker, whose current condition began on November 08, 2025, presented with pain in the right inguinal region that had

been present for 6 days, mainly associated with movement, which had progressively increased in frequency and intensity. Before admission, the patient self-medicated twice with butyl hyoscine without showing improvement. On admission, she was hemodynamically normal, within the average range: Blood pressure: 120/70 mmHg; heart rate: 100 beats/min; respiratory rate: 18 breaths/min; oxygen saturation: 98%; temperature: 36.5°C. The patient has a genetic predisposition to Type 2 diabetes from the father. Relevant personal medical history: no chronic degenerative diseases, five pregnancies and five births, and a previous surgical procedure: a salpingo-oophorectomy 35 years ago. Physical examination revealed a soft, depressible abdomen, no pain on superficial or deep palpation, no signs of peritoneal irritation, and normal audible peristalsis. A mass was identified in the right inguinal region, which was indurated, painful on palpation, non-reducible by manual maneuvers, associated with changes in the coloration of the overlying skin, which was erythematous in appearance, as well as clinical data compatible with vascular compromise: paresthesia and absence of a pulse (Fig. 1). The rest of the physical examination showed no relevant findings.

Laboratory findings showed leukocytosis ($15.1 \times 10^3/\mu\text{L}$) with neutrophilia (76%), consistent with an acute inflammatory process. Coagulation parameters and renal function were within normal limits. Urinalysis revealed leukocyturia and moderate bacteriuria. However, because she did not have symptoms of a urinary tract infection, such as dysuria or frequency, this result was deemed to be incidental and clinically irrelevant for immediate treatment (Table 1). An ultrasound of the right inguinal region was performed, which revealed an irreducible inguinal hernia with signs of strangulation. A hernial sac measuring approximately $42 \times 38 \times 40$ mm is identified, the contents of which correspond to an intestinal loop. Color Doppler evaluation showed no vascularization.

The patient was taken to the operating room for emergency surgery based on clinical and imaging findings. Under neuraxial anesthesia, an infraumbilical midline skin incision was created using a number twenty (No. 20) blade. Using an electrosurgical unit (ESU), the subcutaneous fat layer was dissected until reaching the anterior rectus sheath using the coagulation setting on the ESU at thirty-five watts. The anterior rectus sheath was opened sharply. After opening the anterior rectus sheath, the two rectus abdominis muscles were separated in the midline to allow access to the preperitoneal space. The peritoneum was carefully



Figure 1. Right inguinal region with a localized bulge at the inguinal crease, accompanied by mild edema and skin erythema. The arrow highlights a hernia sac with signs of strangulation below the inguinal ligament.

visualized, elevated, and cut open using Metzenbaum scissors to safely gain entry into the abdominal cavity.

During the procedure, the cecal appendix was identified in a subcecal location, contained in a right femoral hernial sac. Following the reduction and removal of the appendix from the femoral hernia sac, an appendectomy was performed. The appendiceal stump was managed using the Pouchet technique, consisting of a single ligature of the base with 0-silk. The appendix was found to be strangulated and necrotic, exhibiting a dusky, ischemic discoloration, with no macroscopic evidence of perforation or intraperitoneal contamination (Figs. 2 and 3).

Subsequently, a Cheatle technique was performed to make an initial preperitoneal dissecting plane. The first step was made by using Metzenbaum scissors in conjunction with traction on both the anterior rectus sheath and the parietal peritoneum; this provided a safe method for separating the peritoneum from the posterior aspect of the rectus abdominis muscle. After that, a combination of blunt dissection and sharp dissection was utilized to develop the Retzius space as well as extend the dissection into the Bogros space.

Digital blunt dissection in conjunction with a Metzenbaum scissor was employed to dissect the right Bogros space as the right femoral hernia sac was completely reduced into the peritoneal cavity. The dissection extended beyond the boundaries of the myopectineal

Table 1. Laboratory tests on admission

General examination urine			Blood chemistry		
Analysis	Result	Reference interval	Analysis	Result	Reference interval
Ph	5.0 *L	5.6-6.0	Glucosae	135 mg/dL *H	65-110
Density	1.015	1.015-1.025	Bun	13.21 mg/dL	7.00-20.00
Appearance	Clear	Clear	Urea	28.3 mg/dL	15.00-42.00
Color	Yellow		Creatinine	0.8 mg/dL	0.5-1.5
Bilirubin	Negative	Negative	Uric acid	5.28 mg/dL	2.50-8.50
Urobilinogen	Negative	Negative	Total cholesterol	242 mg/dL *H	140-239
Keton Bodies	Negative	Negative	Triglycerides	133 mg/dL	< 150
Glucose	Negative	Negative	Coagulation times		
Proteins	Negative	Negative	Tp	12 Seg	12-16
Blood	Negative	Negative	Tp%	100%	
Nitrites	Negative	Negative	INR	0.9740	
Leukocytes	25 Leu/uL *H	Negative	Ttp	31.1 Seg	
Microscopic examination			Hematological cytometry		
Analysis	Result	Reference interval	Analysis	Result	Reference interval
Leukocytes	3-5 By field *H	0-2 By field	Leukocytes	15.1×10³/μL *H	4.00-11.00
Erythrocytes	0-3 By field	0-2 By field	Erythrocytes	4.89×10 ³ /μL	4.00-6.20
Bacteria	Moderate ++*H	Scarce	Hemoglobin	14.60 g/dL	
Epithelial cells	4-6 0-2 By field	2-4 0-2 By field	Hematocrit	43%	35.0-55.0
Cylinders	Not observed	Negative	VCH	87.90 fL	80.00-100.00
Crystals	Moderate amorphous urate: scarce		HCM	29.9 pg *H	24.00-26.00
Mucin	Moderated by field	Negative	Platelets	315×10 ³ /μL	150.00-400.00
Sediment	Regular +		Neutrophis	76%	50.00-80.00

Bold values highlight results that fall outside the normal reference range.

*Out-of-range results: L: low, H: high, as applicable. A urinary tract infection has been detected, along with metabolic abnormalities in glucose and cholesterol levels. Leukocytosis with neutrophilia is also present, indicating an inflammatory and infectious process.

orifice and approximated 3-4 cm superior to the inferior epigastric vessels, 1-2 cm inferior to Cooper's ligament; 1-2 cm medially over the pubic symphysis; and laterally toward the right psoas major muscle.

The myopectineal orifice was clearly identified and adequately covered with a heavy polypropylene mesh measuring approximately 15 × 10 cm, placed in the preperitoneal space. The mesh was secured with 2-0 polypropylene sutures to Cooper's ligament medially and inferiorly and to the transversus aponeurotic arch superiorly, ensuring stable fixation. The prosthesis was extended to achieve a wide overlap of the defect,

providing tension-free coverage of the entire myopectineal orifice (Fig. 4).

Adequate approximation of the peritoneum to the anterior aponeurosis at the midline was ensured by means of a continuous running suture using 2-0 Vicryl, incorporating the anterior fascial layer and the free edge of the parietal peritoneum.

No drainage was left in place at the end of the procedure, as there was no evidence of active bleeding, residual contamination, or significant dead space, and adequate hemostasis had been achieved. The post-operative course was good, progressing without

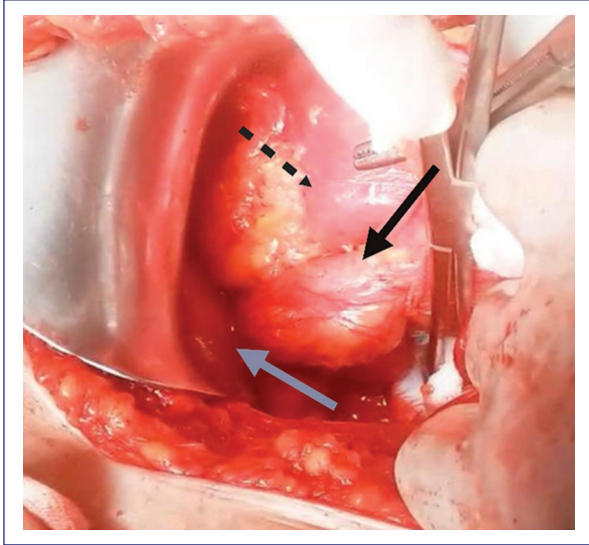


Figure 2. Preperitoneal view of the myopectineal orifice before femoral sac reduction. A retractor separates the right rectus muscle. Gray arrow: Cooper's ligament; black arrow: femoral sac (proximal end controlled with gauze tape); dashed arrow: parietal peritoneum.

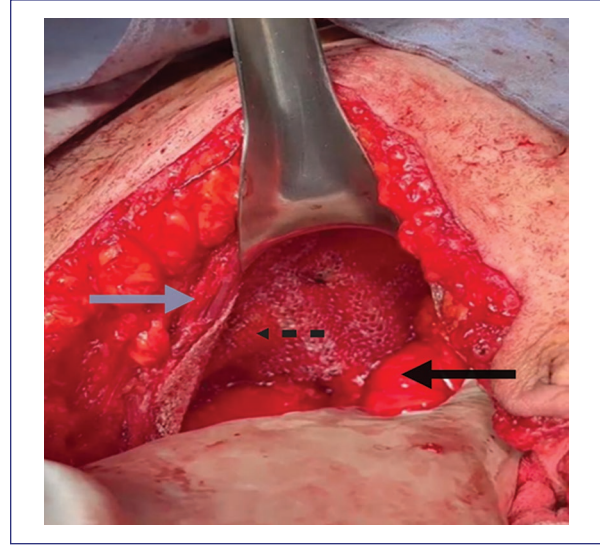


Figure 4. The figure demonstrates preperitoneal dissection of the Retzius space and Bogros space. A Richardson retractor is shown separating the rectus muscle from the parietal peritoneum. The gray arrow indicates the rectus muscle, the black arrow indicates the parietal peritoneum, and the dashed arrow indicates Cooper's ligament, visualized through the polypropylene mesh in the preperitoneal position.

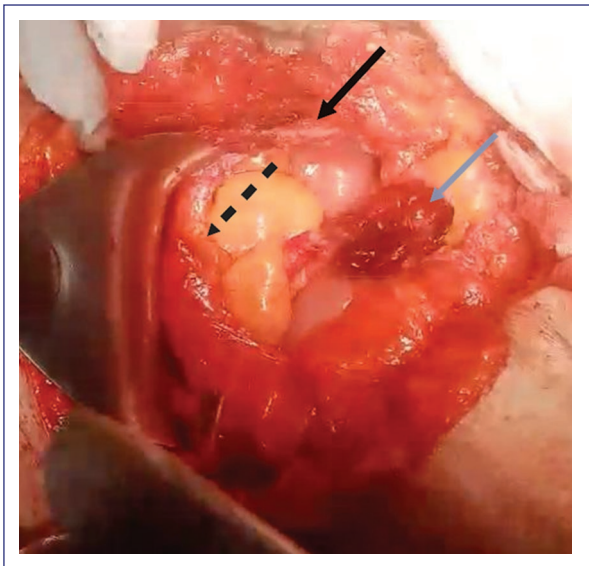


Figure 3. Appendix after reduction from the femoral sac. A retractor separates the right rectus muscle. Gray arrow: necrotic appendix without evidence of perforation; black arrow: anterior rectus sheath; dashed arrow: parietal peritoneum.

fever, with no wound complications, and with bowel function restored. The patient tolerated oral feeding and pain control and was discharged on the 3rd day. At a 5-month post-operative appointment, the patient had

no symptoms at all, no local or systemic issues, no signs of recurred hernia, and no pain in his groin area. The patient also reported that he had no restrictions to his normal day-to-day functions. Routine imaging studies were not done since the patient's post-operative recovery was going well.

Discussion

Recent literature highlights that a de Garengot hernia remains a rare surgical entity with highly variable presentations, including severe complications like perforated appendicitis.¹⁵ Therefore, it poses both a diagnostic and therapeutic challenge due to its low incidence and because its clinical presentation is non-specific.^{16,17} In reality, a diagnosis of a de Garengot hernia is generally performed during surgery (intraoperative), such as was done in this patient's case, because the clinical picture will almost always mimic an incarceration/strangulation of a femoral hernia but may lack the typical abdominal complaints seen in appendicitis. Due to non-specific imaging characteristics, preoperative diagnosis of a de Garengot hernia has historically been difficult. In the case we presented, the ultrasound

misidentified the appendix as an incarcerated small bowel loop.^{17,18}

The surgical treatment of Garegeot's hernia is not standard, and the choice of surgical approach will depend on the condition of the appendix, whether or not there is infection or contamination, and the experience of the surgeon.^{16,19} Surgical approaches through conventional opening, inguinal, and femoral dissection have been described. In these cases, simultaneous appendectomy and hernia repair are routinely performed during the same surgical procedure, as this represents the standard management strategy reported in the literature.¹⁷ However, these approaches may restrict adequate visualization of the femoral defect and hinder any possible anatomical repair.

The preperitoneal approach is supported by evidence demonstrating the favor of its use for the treatment of femoral hernias, including better visualization of the myopectineal orifice, better anatomical repair, and wide coverage of the defect, which may lead to a reduction in the recurrence rate.^{20,21} In the context of Garegeot hernia, this approach also allows direct evaluation of the peritoneal cavity and appendectomy in cases where it is required, such as those with a strangulated or necrotic appendix.²²

The use of prosthetic material in the management of Garegeot hernia remains a point of controversy. Historically, appendicular pathology or local contamination had been considered a relative contraindication for mesh placement due to the risk of infection.²³ However, numerous studies and reviews have shown that, in the absence of appendicular perforation or frank intraperitoneal contamination, mesh placement can be performed safely and without a significant increase in the risk of infectious complications.^{16,18} To adequately reinforce the content, preperitoneal repair with mesh adds the benefit of reinforcing the entire myopectineal orifice, which is relevant for patients with risk factors for recurrence.

Among the disadvantages of the preperitoneal approach are that it is a more complex approach, requiring a longer learning curve, as well as the risk of injury to vascular or nerve structures in surgeons without adequate training in this approach.²⁰ Similarly, in cases of established sepsis or severe contamination, this approach may not be the most appropriate, and the surgical strategy must be individualized.

The preperitoneal approach, whether open or minimally invasive, is a safe and effective alternative for the treatment of Garegeot hernia in selected cases, especially if there is no appendicular perforation or

significant contamination.^{18,21} Cases such as this one contribute to the existing literature and support the individualized use of mesh repair in carefully selected patients without perforation or frank contamination, which favor adequate anatomical repair and satisfactory post-operative outcome.

From the patient's perspective, she reported presenting with severe pain and a palpable inguinal mass, highlighting the prompt surgical management on the same day of admission. Postoperatively, she experienced a favorable recovery, without significant pain or fever, and with adequate oral intake. At 5-month follow-up, she reported only occasional mild discomfort at the surgical site, with no functional limitations or hernia recurrence.

This study had limitations in that it used a single-case design; thus, the ability to generalize findings to others was limited. In addition, misinterpretation of preoperative imaging occurred (which is consistent with the difficulty in diagnosing this condition), which limited the evaluation of the accuracy of ultrasound for assessing hernia presence. Even though the patient's post-operative course has been very good 5 months postoperatively, the duration of follow-up was inadequate for evaluating the potential for late recurrence, especially when using mesh.

Conclusion

Garegeot's hernia is an extremely infrequent diagnosis that generally occurs intraoperatively. With a preperitoneal incision, you can provide optimal visualization of the operative area; allow for proper anatomical reconstruction of the femoral defect; and safely place prosthetics in select patients who have been properly screened against potential contamination. The above case clearly shows that as long as there has been no perforation of the appendix, a preperitoneal mesh repair procedure is possible, safe, and results in satisfactory short-term clinical outcomes, with no signs of recurrent herniation at 5 months post-surgery.

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Ethical considerations

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Confidentiality, informed consent, and ethical approval. The authors have followed their institution's confidentiality protocols, obtained informed consent from all patients, and secured approval from the Ethics Committee. SAGER guidelines have been followed as applicable to the nature of the study.

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