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Monoclonal Gammopathy of Undetermined Significance and Associated Clinical Risk Factors in Patients from Southern Thailand

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Abstract:

Objective: To assess the percentage among suspected individuals and clinical characteristics of MGUS in a Southern Thai population and examine the correlation between comorbidities and MGUS risk classifications.

Material and Methods: This retrospective cross-sectional study analyzed 1,359 patients with suspected MGUS at Songklanagarind Hospital from 2013 to 2024. Patients were stratified into risk categories based on laboratory criteria, and associations between demographic factors, comorbidities, and risk classifications were evaluated.

Results: A total of 64 MGUS cases were identified, yielding a percentage of 4.7%. IgG was the most commonly observed type of M protein (64.1%), followed by IgA (28.1%) and IgM (7.8%). MGUS was more common in males, while anemia, chronic kidney disease, and neurological disorders were less frequently observed among MGUS cases. These associations remained significant in multivariate analysis.

Conclusion: This study provides insights into the prevalence and clinical characteristics of MGUS in Southern Thailand, highlighting the impact of comorbidities on risk classifications. The findings underscore the importance of considering comorbid conditions in MGUS risk stratification beyond conventional laboratory parameters, warranting further research to refine patient care strategies.

Keywords: Monoclonal Gammopathy of Undetermined Significance, Paraproteinemia, Thai, risk factors

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Introduction

Monoclonal gammopathy of undetermined significance (MGUS) is a plasma cell disorder defined by the presence of monoclonal protein (M protein) in the blood, without associated end-organ damage or myeloma-defining events (MDE)[1,2]. MGUS is regarded as a premalignant condition, with an annual rate of progression to malignancies such as multiple myeloma (MM) or lymphoma of approximately 1%[1]. MGUS is most commonly observed in older adults, with studies reporting a prevalence of 3.2% in individuals over 50 years and 8.9% in those above 85 years of age[1]. The literature on the global burden of MGUS is extensive; however, the data on Asian populations remain limited, particularly Southern Thai populations, whose unique demographic and clinical factors may influence the prevalence and progression of the disease.

The majority of MGUS cases are asymptomatic and are generally detected incidentally during routine health checkups or laboratory investigations for unrelated conditions[3]. The absence of distinctive clinical features complicates the early detection of the disorder, emphasizing the crucial role of laboratory testing in diagnosis. Beyond the assessment of M-protein levels, immunofixation electrophoresis (IFE) and serum free light chain (FLC) ratio analysis are essential to the diagnosis of MGUS and the stratification of patient risk. Early identification through these tools enables timely monitoring and helps prevent progression to more severe plasma cell disorders[1,2,4].

Risk assessment in MGUS is essential for effective monitoring and involves classifying patients into low-, intermediate-, or high-risk categories based on key factors such as M-protein levels >1.5 g/dL, non-IgG M protein (IgA/IgM), and an abnormal serum FLC ratio (<0.26 or >1.65). High-risk patients face a 60% likelihood of progression over 20 years.1 Regular follow-up is crucial for early intervention, reducing complications, and improving survival in cases of malignant transformation. Monitoring strategies incorporate clinical and laboratory "red flags" including constitutional symptoms of malignancy, anemia, hypercalcemia, organomegaly, elevated M protein or FLC ratio, and significant urine M protein levels. While low-risk cases without red flags may not require routine follow-up, intermediate- and high-risk patients, as well as those exhibiting red flags, warrant ongoing evaluation[5,6]. However, these risk factors are based exclusively on laboratory parameters, with no established clinical indicators currently available to predict progression risk.

This study aimed to assess the percentage among the suspected individuals and clinical characteristics of MGUS in Southern Thailand and explore the association between risk classification and clinical presentations in this population.

Material and Methods

Study design

This retrospective cross-sectional study was conducted at Songklanagarind Hospital between 2013 and 2024. The study population included all patients for whom immunofixation electrophoresis (IFE) was ordered to evaluate for possible monoclonal gammopathy. These patients were identified at the time of test ordering, regardless of whether the test had been performed or reported. Clinical indications for IFE included unexplained elevated total protein, increased globulin gap, normocytic anemia, renal insufficiency of unclear cause, hypercalcemia, or the presence of rouleaux formation on peripheral blood smear. Among these patients, suspected MGUS cases were further evaluated using the International Myeloma Working Group (IMWG) criteria: serum M-protein <3 g/dL, absence of CRAB features (hypercalcemia, renal insufficiency, anemia, or bone lesions), and no myeloma-defining events. Patients with a known diagnosis of smoldering multiple myeloma (SMM) or multiple myeloma (MM) were excluded.

Data collection

Clinical and laboratory data were retrieved from patient records, with laboratory parameters selected based on proximity to the IFE test date. The sample size for prevalence estimation was calculated to be 959 patients, using a prevalence rate of 2.3%[7] (based on prior Thai studies), a 95% confidence interval (CI), and a 1% margin of error. To account for potential incomplete data, a 10% adjustment was incorporated into the calculation.

Definition of variables

MGUS

According to the International Myeloma Working Group (IMWG) criteria[2], MGUS is defined by a serum M-protein level of <30 g/L, bone marrow plasma cell infiltration of <10%, and the absence of myeloma-defining CRAB features—including hypercalcemia, renal impairment, anemia, and bone lesions—or amyloidosis[2]. To ensure that all included cases met this definition, we excluded patients with serum calcium >11.5 mg/dL, serum creatinine >2.0 mg/dL, hemoglobin ≤10 g/dL with normocytic normochromic morphology, or bone lesions identified by ICD-10 codes C40–C41.

Risk classification

The Mayo Clinic stratification model[18] identifies 3 primary risk factors for MGUS progression: an abnormal serum FLC ratio, non-IgG MGUS, and a high serum M-protein level (≥1.5 g/dL). Patients exhibiting all 3 risk factors are classified as high-risk, while those with 2 risk factors fall into the high-intermediate-risk category. Low-intermediate-risk MGUS is defined by the presence of a single risk factor, whereas patients with none are considered low-risk. The estimated 20-year risk of progression to lymphoplasmacytic malignancies, including multiple myeloma, is 5% for 1 risk factor, 21% for 2, and 58% for all 3[17–19].

Comorbidity

The 10 chronic conditions associated with MGUS were identified using ICD-10 diagnosis codes (2019 version), developed by the World Health Organization (WHO) and adapted in the U.S. by the Centers for Medicare & Medicaid Services (CMS) and the National Center for Health Statistics (NCHS). The complete list of ICD-10 codes used for comorbidity classification is provided in Supplementary Table 1. Additional details are available at [WHO Classification of Diseases] (https://www.who.int/standards/classifications/classification-of-diseases).

Statistical analysis

Descriptive statistics, including frequencies and percentages, were used to summarize MGUS percentage and risk stratification. The chi-square test was applied to assess associations between clinical factors and MGUS (p-value<0.05), while logistic regression was used to evaluate the impact of clinical variables on MGUS risk. Univariate and multivariate analyses were conducted to adjust for potential confounders and identify independent risk factors. Results were reported as odds ratios (ORs) with 95% CIs, with the statistical significance set at p-value<0.05. Data management and statistical analyses were performed using Microsoft Excel and R Studio.

Ethical considerations

Patient data were anonymized through coded identifiers, and the study protocol was approved by the Ethics Committee of Prince of Songkla University (REC-67-237-5-8).

Results

Demographic data

This retrospective cross-sectional study analyzed 1,359 patients with suspected MGUS based on medical

records from Songklanagarind Hospital between 2013 and 2024. The demographic and clinical characteristics of the study population are summarized in Table 1. The median patient age was 64 years (range: 4–99), with 62.6% of cases occurring in individuals aged 60 years or older. Specifically, 30.3% of patients were between 60 and 69 years old, while 32.3% were aged 70 years or above. The study population exhibited a slight male predominance, with males accounting for 52.2% of cases. Additionally, 65% of patients presented with comorbidities relevant to the study objectives. Notably, none of the included patients had a prior diagnosis of hematologic malignancies, minimizing potential confounding factors. Furthermore, at the time of data collection, no patients were diagnosed with monoclonal gammopathy of renal significance, immunoglobulin light chain amyloidosis, cold agglutinin disease, or other clinically significant monoclonal gammopathies.

Table 1 Study patient characteristics (n=1,329)

Variable	Number (%)
Gender	
Male	710 (52.2)
Female	649 (47.8)
Age (years)	
Median Age (IQR)	64 (54,72)
Range	4–99
<50	220 (16.2)
50–59	288 (21.2)
60–69	412 (30.3)
≥70	439 (32.3)
Comorbidity	
Patients with these comorbidities	884 (65.0)
Anemia	459 (33.8)
Chronic kidney disease	261 (19.2)
Dermatologic disorders	138 (10.2)
HBV infection	2 (0.1)
Heart failure	95 (7.0)
HIV infection	10 (0.7)
Liver disease	132 (9.7)
Neurological disorder	241 (17.7)
Rheumatological disease	51 (3.8)
Transplant	10 (0.7)
Patients without or other than those comorbidities	475 (35.0)

IQR=interquartile range

Percentage of MGUS

Among the 1,359 suspected cases, MGUS was diagnosed in 4.7% (64 cases), while 95.3% (1,295 cases) did not exhibit the condition, as shown in Table 2. MGUS percentage was significantly higher in males (3.1%) than in females (1.6%) (p-value=0.039). Age also emerged as a significant factor (p-value=0.021), with the highest percentage observed in the 60–69 age group (1.84%). The median age of MGUS patients was slightly lower than that of non-MGUS patients (60.5 years; IQR: 52–65.2 vs. 64 years; IQR: 55–73), a difference that was statistically significant (p-value=0.011). The age range of MGUS patients spanned 31–91 years, whereas non-MGUS patients ranged from 4–99 years.

Table 2 Distribution and percentage of MGUS among 1359 patients with clinically suspected monoclonal gammopathies

Variable	Number (%)		p-value
	MGUS	without MGUS	
Total	64 (4.7)	1,295 (95.3)	
Gender			0.039
Male	42 (3.1)	668 (49.2)	
Female	22 (1.6)	627 (46.1)	
Age group (years)			0.021
<50	10 (0.74)	210 (15.45)	
50–59	19 (1.40)	269 (19.79)	
60–69	25 (1.84)	387 (28.48)	
≥70	10 (0.74)	429 (31.57)	
Median Age (IQR)	60.5 (52,65.2)	64 (55,73)	0.011
Range	31–91	4–99	

IQR=interquartile range, MGUS=monoclonal gammopathy of undetermined significance

The analysis of MGUS trends over the study period, illustrated in Figure 1, reveals notable fluctuations in both case numbers and percentages. While the overall trend showed variability, a significant peak was observed in 2023, with the highest recorded number of cases (n=17) and a percentage of 7.5%. Other notable increases occurred in 2015 and 2017, with percentage rates of 8.9% and 7.1%, respectively. In contrast, certain years, such as 2016, 2019, 2020, and 2024, reported the lowest case counts (n=2) and correspondingly low percentage rates. These fluctuations suggest that external factors may influence MGUS diagnosis rates, setting a precedent for further investigation.

Characteristics of MGUS

Among patients diagnosed with MGUS, IgG was the most frequently identified M-protein subtype (64.1%), followed by IgA (28.1%) and IgM (7.8%), as shown in Table 3. The majority of patients had M-protein concentrations more than 1.5 to 3.0 g/dL (56.2%), while 37.5% had levels of 0.5–1.5 g/dL, and 6.2% had levels below 0.5 g/dL. The serum FLC ratio was abnormal (<0.26 or >1.65) in 53.1% of cases, normal (0.26–1.65) in 25.0%, and unknown in 21.9%.

Regarding risk classification, most patients were categorized as intermediate risk, with 23.4% classified as low-intermediate risk and 39.1% as high-intermediate risk. Low-risk and high-risk classifications accounted for 7.8% each, while 21.9% of patients had an unknown risk classification.

As shown in Table 4, among the 1,359 patients, those with comorbidities had significantly lower odds of MGUS compared to those without comorbid conditions

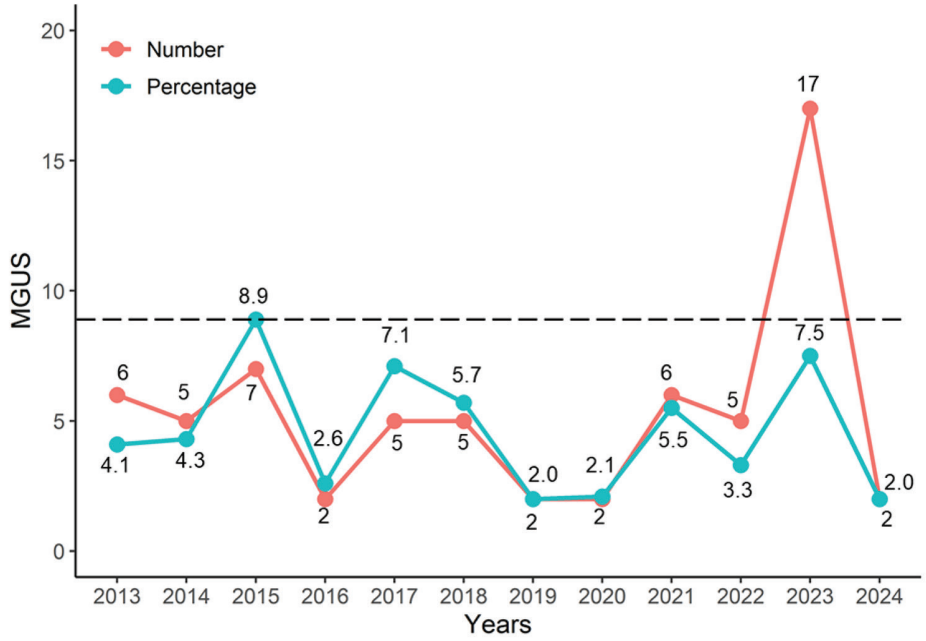

Figure 1 Annual percentage of MGUS from 2013 to 2024: Yearly trends in MGUS cases, Showing the absolute number of cases (red) and percentage (blue) over the study period

(crude OR 0.26; 95% CI: 0.14–0.48; p-value<0.001). In univariate analysis, anemia (OR 0.19; p-value<0.001), neurological disorders (OR 0.22; p-value=0.011), and chronic kidney disease (OR 0.27; p-value=0.012) were significantly associated with decreased odds of MGUS. Transplant status demonstrated a positive association (OR 5.17; p-value=0.040), although the small number of cases limited precision. Other comorbidities, such as dermatologic disorders, liver disease, heart failure, and HBV infection, were not statistically significant. No MGUS cases were observed among patients with HIV infection or rheumatologic disease.

Multivariate analysis, as demonstrated in Table 4, further identified male sex as an independent risk factor for MGUS (adjusted OR 1.73; p-value=0.044). Anemia (adjusted OR 0.21; p-value<0.001), neurological disorders (adjusted OR 0.17; p-value<0.001), and chronic kidney disease (adjusted OR 0.38; p-value=0.037) remained significantly associated with reduced odds of MGUS. Transplant status showed a non-significant trend towards increased risk (adjusted OR 4.93; p-value=0.100).

Table 3 Characteristics of Monoclonal Gammopathy of Undetermined Significance (n=64)

Variable	Number (%)
Type of M protein	
IgG	41 (64.1)
IgA	18 (28.1)
IgM	5 (7.8)
M-protein concentration, g/dL	
>1.5–3.0	36 (56.2)
0.5–1.5	24 (37.5)
<0.5	4 (6.2)
Serum FLC ratio	
<0.26 or >1.65	34 (53.1)
0.26–1.65	16 (25.0)
Unknown	14 (21.9)
Risk classification	
Low risk	5 (7.8)
Intermediate Risk	
Low intermediate Risk	15 (23.4)
High intermediate Risk	25 (39.1)
High risk	5 (7.8)
Unknown	14 (21.9)

FLC=free light chain, MGUS=monoclonal gammopathy of undetermined significance

Discussion

This study analyzed 1,359 patients with suspected MGUS based on medical records from Songklanagarind Hospital between 2013 and 2024. The percentage of MGUS among these cases was 4.7%, with a significantly higher occurrence in males than in females. Age was also a significant factor, with the highest percentage observed in patients aged 60–69 years. Among those diagnosed with MGUS, IgG was the most common M-protein subtype, and most cases exhibited M-protein concentrations between >1.5 and 3.0 g/dL. Abnormal serum FLC ratios were identified in more than half of the MGUS cases. Risk classification analysis revealed that the majority of cases fell within the intermediate-risk category. Notably, MGUS percentage was significantly lower among individuals with anemia, neurological disorders, and chronic kidney disease, while male gender remained an independent risk factor in both univariate and multivariate analyses.

Watanaboonyongcharoen et al. (2012) reported an MGUS prevalence of 2.3% in the Thai population among individuals aged 50–93 years[7]. In contrast, our study identified MGUS in 4.7% of patients. Both studies observed an increasing percentage with age; however, a prevalence of 2.8%, exhibited in individuals aged 70 years or older, was the highest noted in the earlier study, whereas the peak percentage identified in the current study was 1.84%, exhibited in the 60–69 age group. The median age of MGUS diagnosis in our study was 60.5 years, compared to 58 years in the previous study. The disparities between the study populations may account for this discrepancy, as our data were derived from individuals who underwent

Table 4 Demographic characteristics and comorbidities associated with monoclonal gammopathy of undetermined significance (MGUS)

Variable	MGUS, n (%) N=64	Crude OR (95% CI)	Univariate p-value	Adjusted OR (95% CI)	Multi-variate p-value
Demographics					
Gender					
Male	42 (3.1)	1.79 (1.06, 3.04)	0.030	1.73 (1.00, 2.96)	0.044
Female	22 (1.6)	Reference		Reference	
Age group (years)					0.110
<50	10 (0.7)	Reference		Reference	
50–59	19 (1.4)	1.48 (0.68, 3.26)	0.326	1.53 (0.68, 3.42)	
60–69	25 (1.8)	1.36 (0.64, 2.88)	0.427	1.45 (0.67, 3.12)	
≥70	10 (0.7)	0.49 (0.20, 1.19)	0.116	0.66 (0.26, 1.64)	
Median Age (IQR)	60.5 (52, 65.2)	NA	0.011		
Range	31–91	NA	NA		
Patients with comorbidities	22 (34.4)	0.26 (0.14, 0.48)	<0.001		
Comorbidity types					
Anemia	6 (9.4)	0.19 (0.08, 0.45)	<0.001	0.21 (0.09, 0.50)	<0.001
Neurological disorder	3 (4.7)	0.22 (0.07, 0.70)	0.011	0.17 (0.05, 0.55)	<0.001
Chronic kidney disease	4 (6.2)	0.27 (0.10, 0.75)	0.012	0.38 (0.13, 1.07)	0.037
Dermatologic disorders	10 (15.6)	1.69 (0.84, 3.40)	0.142	1.93 (0.94, 3.98)	0.093
Transplant	2 (3.1)	5.17 (0.52, 26.70)	0.040	4.93 (0.93, 26.15)	0.100
Liver disease	4 (6.2)	0.61 (0.22, 1.70)	0.343	NA	NA
Heart failure	1 (1.6)	0.20 (0.01, 1.20)	0.124	NA	NA
HBV infection	1 (1.6)	20.39 (0.26, 1589.40)	0.092	NA	NA
HIV infection	0 (0.0)	–	–	NA	NA
Rheumatological disease	0 (0.0)	–	–	NA	NA

CI=confidence interval, HBV=hepatitis B virus, HIV=human immunodeficiency virus, IQR=interquartile range, MGUS=monoclonal gammopathy of undetermined significance, NA=not applicable, OR=odds ratio

testing due to clinical suspicion, rather than from healthy screening participants. Additional contributing factors may include regional genetic and cultural variations, as Southern Thais share closer ties with Malays, while central Thais may exhibit characteristics more aligned with other Central Asian populations[8,9]. Moken and Urak Lawoi' sea nomads and Maniq negrito are the minority, while the southern Thai groups (Buddhist and Muslim Sex distribution also differed, with no significant difference reported in the earlier study (2.5% in males vs. 2.2% in females), whereas our study demonstrated a significant male predominance (3.1% vs. 1.6%, p-value=0.039). Our findings align with the global data[10], suggesting that male sex may be a potential risk factor for MGUS, warranting further research into the underlying causes.

Our study highlights fluctuating trends in MGUS percentage and case numbers over time, mirroring findings from a nationwide study in South Korea. The sharp surge in cases observed in 2023 may be attributed to intensified clinical surveillance, corroborating previous reports of an increasing MGUS prevalence[11]. The sharp rise in MGUS cases observed in 2023 may be attributed to multiple factors, including the updated guidelines, which likely enhanced detection rates[12], as well as an increase in incidental findings during investigations for unrelated conditions. Although the annual detection rate of MGUS appears relatively stable,

interpreting these trends in isolation may underestimate the broader clinical implications. To more fully understand the spectrum of plasma cell dyscrasias and the true burden of disease, it is essential to consider related entities such as SMM and MM. Incorporating these conditions into trend analyses would provide a more comprehensive view of disease progression and support more informed clinical planning.

Moreover, IgG was the predominant type of M protein identified, which aligns with the results of other studies[7,10,13]. This predominance is noteworthy, as IgG is generally associated with a lower risk of progression compared to non-IgG types, such as IgA or IgM.

Regarding serum FLC, in comparison to the study by Robert et al., which reported an abnormal FLC ratio in 33% of patients,[13] our study observed a higher percentage of abnormal FLC ratios in MGUS cases, a discrepancy that may stem from differences in study populations.

Epstein et al. identified hypertension, hyperlipidemia, arthritis, anemia, and chronic kidney disease as the most common comorbidities among patients with MGUS, with anemia and chronic kidney disease significantly more prevalent in MGUS cases compared to controls.[14] These findings underscore their potential roles in the clinical presentation and progression of the disease.[2] In contrast, our study revealed a negative association between MGUS and these comorbidities, with anemia and chronic kidney disease being less prevalent among MGUS cases than in the control group. This divergence may have resulted from differences between the study populations, as our cohort likely included a higher proportion of individuals with suspected MM, potentially introducing selection bias. Further investigation is warranted to elucidate the impact of these disparities on the findings.

Previous studies have established that immunoglobulin (Ig) type, FLC ratio, and M-protein level are key factors influencing the risk of the progression of MGUS to malignancy[1,3,6]. These parameters stratify patients into low-, intermediate-, and high-risk groups based on the likelihood of progression.

While prior research has primarily focused on biological markers, our study aimed to examine the correlation between comorbidities and MGUS risk classifications. We observed an association between certain comorbidities, including dermatologic disorders, and MGUS events, though statistical significance was not established. Notably, dermatologic disorders are well-documented in connection with monoclonal gammopathy, with various cutaneous manifestations linked to the condition[15]. In our study, despite the lack of statistical significance, dermatologic disorders were relatively frequent among MGUS cases, and the limited sample size may have constrained the power to detect a meaningful association. This finding supports the need for further investigation with larger datasets to clarify this potential link.

The association between HBV infection and MGUS in our study was not statistically significant, consistent with previous findings by Li et al., which suggested a potential but inconclusive link between HBV infection and plasma cell disorders, including MM[16]. The lymphotropic properties of HBV and its capacity to infect and replicate in lymphocytes suggest a potential role in lymphoproliferative disorders. While our study did not establish a direct association with MGUS, our findings align with those of Li et al., underscoring the need for further research to elucidate the molecular mechanisms linking HBV to monoclonal gammopathies and plasma cell disorders. From a clinical perspective, identifying patterns of comorbidities associated with MGUS may support earlier recognition of patients at risk, particularly in populations undergoing evaluation for unrelated conditions. Such insights could inform risk-based screening strategies and long-term surveillance planning for patients with specific

comorbidity profiles that may predispose them to plasma cell dyscrasias.

Our study has several limitations that should be considered when interpreting the results. First, the retrospective design relies on existing medical records, which may introduce selection bias, as only patients with suspected MGUS who sought medical attention were included. This potentially excludes undiagnosed or asymptomatic individuals, limiting the generalizability of the findings to the broader population. Furthermore, due to the nature of retrospective data collection, the final diagnoses or clinical outcomes of patients evaluated but not diagnosed with MGUS could not be determined. Additionally, while we explored the correlation between comorbidities and MGUS risk classification, other influential factors, such as genetic predisposition and environmental exposures, were not accounted for despite their potential role in disease progression.

Another limitation is the reliance on single-time-point laboratory measurements, which may not adequately capture the dynamic changes in M protein levels or FLC ratios, both of which are critical for monitoring MGUS progression. The cross-sectional nature of the study further precludes the ability to establish causal relationships or assess the temporal association between comorbidities and disease risk. Moreover, we did not conduct long-term follow-ups to evaluate clinical outcomes or the progression of MGUS to malignancy, restricting our ability to assess the long-term implications of comorbidities and risk stratification.

Lastly, as this study was conducted in a single institution in Southern Thailand, the findings may reflect unique demographic and clinical characteristics that are not necessarily representative of other regions or populations. Future research should address these limitations by incorporating larger, multicenter cohorts, longitudinal follow-up data, and additional risk factors to provide a more comprehensive understanding of MGUS progression and its associated risks.

Conclusion

This study provides valuable insights into the prevalence and clinical characteristics of MGUS in a Southern Thai population, highlighting the correlation between comorbidities and MGUS risk classification. Our findings indicate that male sex is a significant risk factor for MGUS, while anemia, chronic kidney disease, and neurological disorders exhibit strong negative associations. Future studies should address the limitations of this retrospective, single-center design by incorporating larger, multicenter cohorts and prospective follow-ups to improve generalizability and assess disease progression. Additionally, tracking long-term outcomes would clarify the impact of comorbidities on MGUS progression and its transformation into malignancy. These efforts would contribute to a more comprehensive understanding of MGUS and improve clinical management strategies.

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Conflict of interest

There are no potential conflicts of interest to declare.

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Supplementary Table 1: ICD-10 codes used to define comorbidities

This supplementary file outlines the ICD-10 diagnosis codes used to identify comorbid conditions among the study population. The classification is based on the 2019 version of the ICD-10, developed by the World Health Organization (WHO) and adapted by the U.S. Centers for Medicare & Medicaid Services (CMS) and the National Center for Health Statistics (NCHS).

Comorbidity categories included rheumatologic diseases, neurologic disorders, chronic kidney disease, anemia, dermatologic disorders, heart failure, liver disease, HIV infection, hepatitis B virus (HBV) infection, hepatitis C virus (HCV) infection, and history of organ transplantation. Patients were classified as having a specific comorbidity if any of the corresponding ICD-10 codes listed in Table S1 were recorded in their medical records during the study period.

Supplementary Table 1 ICD-10 codes used to identify comorbidities potentially associated with MGUS in the study population

Comorbidities	ICD-10 codes
[1] Rheumatological disease	I73.1, L93, L94.0-L94.3, M02.3, M05-M06, M07.0-M07.3, M08, M09.0, M30-M35, M45, M46.0, M46.1, M46.8, M46.9
[2] Neurologic disorder	G04.1, G10-G12, G13.1, G13.2, G13.8, G14, G20-G23, G26, G32, G35-G37, G40-G41, G60-G62, G63.1-G63.6, G70-G72, G80-G83
[3] Chronic kidney disease	I12-I13, N0, N18-N19, T86.1, Z49.1, Z49.2, Z94.0
[4] Anemia	D50-D53, D55-D59, D60-D64
[5] Dermatologic disorders	R20-23, E85, D89
[6] Heart failure	I11.0, I13.0, I13.2, I42, I50
[7] Liver disease	B18-B19, I85, I98.3, K70-K74, K75.2-K75.4, K75.8, K75.9, K76, K77
[8] HIV infection	B20-B24
[9] HCV infection	B17.1,B18.2
[10] HBV infection	B16, B16.9, B18.1
[11] transplant	Z94, T86

The use of standardized ICD-10 codes ensures consistency in comorbidity identification and facilitates reproducibility of the study methodology.