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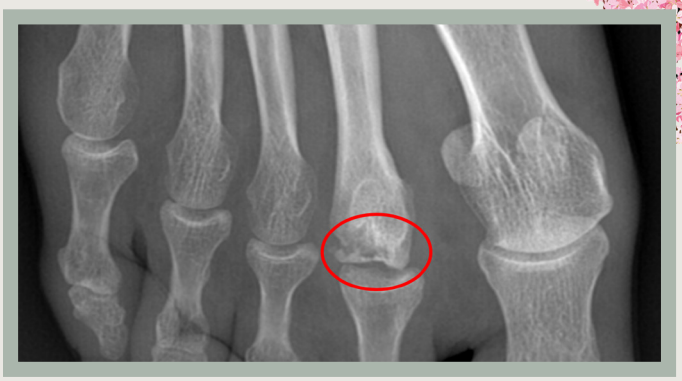

Figure 1. Radiographic appearance of Freiberg's disease. Direct radiography showed irregularity and flattening of the joint surface at the second metatarsal head (red circle), with the radiographic findings consistent with Smillie stage III Freiberg's disease

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Clinical Characteristics of Patients with Cellulitis and Risk Factors for Recurrence: A Single-Center Study

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What is known on this subject?

Cellulitis is a common bacterial skin infection with high rates of recurrence despite appropriate antibiotic treatment. Several studies have identified risk factors such as advanced age, lymphedema, venous insufficiency, obesity, and vascular interventions as contributors to recurrent episodes. However, data from Türkiye are limited, and there is a need for local evidence to guide targeted prevention strategies.

What this study adds?

This study identifies clinical and microbiological factors associated with cellulitis recurrence in a large single-center cohort. We found that advanced age, lymphedema, peripheral arterial disease, higher body mass index, and living alone were significantly associated with recurrence. These findings provide locally relevant evidence to support risk stratification and targeted prevention strategies in clinical practice.

ABSTRACT

Objective: This study aimed to evaluate the clinical, microbiological, and sociodemographic characteristics of patients diagnosed with cellulitis and to identify risk factors associated with the development of recurrence.

Material and Methods: This retrospective, single-center observational study included 120 adult patients (aged ≥18 years) treated for cellulitis as inpatients or outpatients over a one-year period. Demographic, clinical, and laboratory data were extracted from electronic medical records. Predisposing factors, infection sites, treatment characteristics, and variables associated with recurrence were evaluated. Recurrence was defined as a history of at least two episodes of lower extremity cellulitis. Univariable and multivariable logistic regression analyses were performed to identify factors associated with recurrence. Statistical significance was set at a p value <0.05.

Results: Among the 120 patients diagnosed with cellulitis, the mean age was 56.4±15.7 years; 51% were male. The most commonly affected site was the lower extremity (91%). Although all patients presented with edema and erythema, increased local temperature (96%) and pain (80%) were also frequent findings, whereas fever was less common (15%). The most prevalent predisposing factors were tinea pedis (64.2%), obesity (56.7%), and onychomycosis (47.5%). The recurrence rate was 36.7%. Statistically significant associations were found between recurrence and advanced age, lymphedema, peripheral arterial disease, higher body mass index (BMI), and living alone or being homeless (p<0.05). In multivariable logistic regression analysis, living alone or being homeless [odds ratio (OR): 6.27, 95% confidence interval (CI): 1.36-28.87, p=0.018], older age (OR: 1.03 per year, 95% CI: 1.001-1.06, p=0.045), and the presence of lymphedema (OR: 3.08, 95% CI: 1.17-8.14, p=0.023) were independently associated with recurrence, while BMI showed a borderline association (OR: 1.06, 95% CI: 0.99-1.14, p=0.084). Additionally, C-reactive protein levels were positively correlated with duration of antibiotic treatment and length of hospital stay.

Conclusion: The findings suggest that cellulitis recurrence is closely associated not only with the treatment of the acute infection but also with the comprehensive management of underlying chronic conditions. In particular, controlling modifiable risk factors such as lymphedema, peripheral arterial disease, and higher BMI may play

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ABSTRACT

a crucial role in reducing recurrence rates. These results highlight the importance of risk-based and individualized approaches in clinical management.

Keywords: Cellulitis, predisposing factors, recurrence, risk factors

Introduction

Cellulitis is an acute bacterial skin infection involving the dermis and subcutaneous tissue, characterized by inflammatory signs such as erythema, warmth, edema, and tenderness. The most common causative agents are Gram-positive bacteria, particularly *Streptococcus pyogenes* (groups A, C, and G) and *Staphylococcus aureus* (1,2).

Although it can affect any part of the body, approximately 70% of cellulitis cases are localized in the lower extremities (1). Due to age-related structural changes in the skin and increased comorbidity burden, the incidence of cellulitis increases notably in older adults (2). Predisposing factors for infection are classified into systemic (e.g., obesity, smoking, alcohol use, immunosuppression) and local (e.g., tinea pedis, lymphedema, venous insufficiency, trauma, dermatitis, or a history of vascular interventions) categories (3,4,5).

Although cellulitis generally responds well to antibiotic therapy, the risk of recurrence remains high in individuals with persistent predisposing factors. Previous studies have reported recurrence rates ranging from 22% to 49% following the initial episode (2). This not only increases individual morbidity but also poses a significant burden on the healthcare system due to increased healthcare utilization, antimicrobial resistance, and loss of productivity (6).

In this study, we aimed to evaluate the demographic, clinical, and microbiological characteristics of patients diagnosed with cellulitis and identify risk factors associated with recurrence, thereby contributing to the development of risk-based preventive strategies for the management of cellulitis.

Material and Methods

Study Design and Patient Population

This single-center retrospective observational study was conducted at the Department of Infectious Diseases and Clinical Microbiology of a tertiary education and research hospital. The study included all adult patients (≥18 years) who were diagnosed with cellulitis and were followed up, either during hospitalization or in the outpatient clinic, between April 2015 and April 2016. Patients with suppurative or chronic infectious foci, such as cutaneous abscesses, necrotizing fasciitis, septic arthritis, osteomyelitis, or diabetic foot infections, were excluded. In addition, individuals receiving immunosuppressive therapy, human immunodeficiency virus-positive patients, and pregnant women were excluded; four patients with cellulitis who met these criteria were also excluded from the analysis.

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee of University of Health Sciences Türkiye, Şişli Hamidiye Etfal Training and Research Hospital (approval number: 675, date: 24.05.2016); the requirement for informed consent was waived because of the retrospective nature of the study.

Definitions and Variables

The diagnosis of cellulitis was made by infectious diseases specialists based on inflammatory signs such as poorly demarcated erythema, edema, local warmth, and tenderness in the affected skin area, as well as systemic symptoms including fever, chills, and shivering. The diagnosis was further supported by elevations in acute-phase reactants.

Data extracted from patient records included age, sex, body mass index (BMI), comorbidities, smoking and alcohol use, history of surgical procedures, and predisposing dermatological conditions (e.g., tinea pedis, onychomycosis). The presence of lymphedema was determined from clinical evaluation findings documented in the patient records (e.g., chronic non-pitting edema, positive Stemmer sign) and by review of relevant International Classification of Diseases diagnostic codes in the electronic medical records. These dermatological diagnoses were recorded based on clinical findings. Obesity was defined as a BMI ≥30 kg/m².

In patients with a history of cellulitis, the number of previous episodes and the involved body region were also assessed. Recurrent cellulitis was defined as at least two prior documented episodes of cellulitis. Additionally, presenting complaints, physical examination findings, laboratory values, and imaging results were documented. For patients who

received antibiotic treatment, the selected antibiotic regimen, treatment duration, and length of hospital stay were recorded.

Statistical Analysis

All statistical analyses were performed using SPSS for Windows version 15.0 (Chicago, IL: SPSS Inc.). Descriptive statistics were presented as counts (n) and percentages (%) for categorical variables and as mean ± standard deviation for continuous variables. The distribution characteristics of continuous variables were assessed using the Kolmogorov-Smirnov test. For comparisons between two independent groups, Student's t-test was used when data followed a normal distribution, while the Mann-Whitney U test was applied when the assumption of normality was not met. The chi-square (χ^2) test was used to evaluate differences between categorical variables. All tests were two-tailed, and a p value of <0.05 was considered statistically significant. Logistic regression analyses were performed to identify factors associated with recurrence. Candidate variables were selected based on clinical relevance and univariable associations; model selection was guided by Akaike information criterion to yield a parsimonious final model. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

Results

Patient Profile and Clinical Characteristics

A total of 120 patients were included in the study. Of these, 67 (55.8%) were male and 53 (44.2%) were female. Eighty patients received outpatient treatment, while forty patients were hospitalized. The mean age of all cases was 56.4±15.7 years (range, 18-87 years). The mean age was 53.2±15.7 years in males and 60.5±14.9 years in females, and this difference was statistically significant (p=0.01). When participants were stratified by age group, the most common age range was 61-70 years (26.7%, n=32), followed by 51-60 years (21.7%, n=26) and 41-50 years (16.7%, n=20).

Regarding anatomical localization, the majority of cases involved the lower extremities (91.6%, n=110). Upper extremity involvement was observed in 7 patients (5.9%). Involvement of the neck, abdomen, and gluteal region was rare; each was identified in only one case (0.8%).

The most commonly reported symptom at presentation was pain in the affected area (80%, n=96). Other symptoms included fatigue (28%, n=34), nausea and vomiting (17%, n=20), and fever (15%, n=18). Physical examination findings revealed erythema and increased temperature in the affected area in all patients (100%, n=120). Edema was present in 81% (n=97), and tenderness was present in 74% (n=89). Bullae formation was uncommon, occurring in only 6.7% (n=8) of patients.

Predisposing Factors and Findings Associated with Recurrence

The most commonly identified predisposing factor among the included patients was tinea pedis (64.2%; n=77). This was followed by obesity (56.7%; n=68), onychomycosis (47.5%; n=57), and diabetes mellitus (DM) (33.3%; n=40). Among the patients diagnosed with DM, 90% had type 2 diabetes, and 10% had type 1 diabetes. Additionally, three patients were newly diagnosed with DM during their cellulitis episode. The mean glycated hemoglobin level measured within the previous three months in these patients was 8.63% (range: 5.8%-12.9%).

Of the 120 patients included in the study, 26 (21.6%) had a history of vascular surgery involving the lower extremity. In 92.3% of these cases, cellulitis occurred on the same side as the previous surgical intervention. The detailed distribution of predisposing factors is presented in Table 1.

Among the patients, 76 (63.3%) experienced their first episode of cellulitis, while 44 (36.7%) had a prior history of cellulitis. None of the patients with recurrent cellulitis had received antibiotic prophylaxis. Among the 44 patients with recurrent cellulitis, the most common counts were two episodes (n=15) and three episodes (n=15), followed by four episodes (n=7), five episodes (n=2), and six episodes (n=4). The highest number of episodes observed was ten, recorded in one patient. In 88.6% (n=39) of patients with a history

Table 1. Risk factors and comorbidities identified in cellulitis cases (n=120)

Predisposing factor	n	%
Tinea pedis	77	64.2
Obesity	68	56.7
Onychomycosis	57	47.5
Diabetes mellitus	40	33.3
Vascular pathologies (lymphatic drainage disorder, lymphedema, venous insufficiency)	28	23.3
History of lower extremity vascular surgery	26	21.6
Congestive heart failure	24	20.0
Trauma (e.g., contusion, blunt injury)	16	13.3
Skin lesion (e.g., wound, fissure, ulcer)	9	7.5
Penetrating/cutting injury (e.g., nail puncture, IV access)	5	4.2
Bite/scratch (cat, dog, human)	4	3.3

IV: Intravenous

of recurrence, the infection recurred in the same extremity, whereas 11.4% (n=5) had recurrence in a different extremity.

Table 2 summarizes the relationship between sociodemographic, clinical, and laboratory characteristics and recurrent lower-extremity cellulitis. The mean age of patients with recurrence was significantly higher (p<0.001). Additionally, statistically significant associations were observed between recurrence and lymphedema (p<0.001), peripheral arterial disease (p=0.045), BMI ≥30 (p=0.016), and living alone or being homeless (p=0.007).

No significant associations were found between recurrence and variables such as tinea pedis, onychomycosis, DM, coronary artery disease, history of lower extremity surgery, smoking, or alcohol consumption (p>0.05). Similarly, no significant differences were observed between the groups in terms of initial C-reactive protein (CRP), white blood cell (WBC) count, and procalcitonin (PCT) levels, length of hospital stay, or duration of antibiotic therapy (p>0.05).

Factors associated with recurrence identified by univariable logistic regression analysis are presented in Table 3. In multivariable logistic regression analysis, living alone

Table 2. Comparison of socio-demographic, clinical, and laboratory characteristics according to recurrence status

Variable	Non-recurrent cases (n,%) (n=76)	Recurrent cases (n,%) (n=44)	p value
Socio-demographic characteristics			
Age (mean ± SD)	54.4±15.7	59.7±14.5	**<0.001**
Sex			0.86
Male	44 (57.9%)	23 (52.3%)	
Female	32 (42.1%)	21 (47.7%)	
Educational level			**0.038**
Illiterate	6 (7.9%)	11 (25%)	
Primary school	58 (76.3%)	29 (65.9%)	
Secondary school	10 (13.2%)	2 (4.5%)	
University	2 (2.6%)	2 (4.5%)	
Smoking	27 (35.5%)	9 (20.5%)	0.10
Alcohol use	7 (9.2%)	3 (6.8%)	0.46
Living arrangement (living alone or being homeless)	3 (3.9%)	9 (20.5%)	**0.007**
Predisposing factors			
Tinea pedis	47 (61.8%)	30 (68.2%)	0.48
Onychomycosis	36 (47.4%)	24 (54.5%)	0.48
Diabetes mellitus	23 (30.3%)	17 (38.6%)	0.23
Lymphedema	11 (14.5%)	17 (38.6%)	**<0.001**
Coronary artery disease	14 (18.4%)	7 (15.9%)	0.87
Peripheral artery disease	6 (7.9%)	7 (15.9%)	**0.045**
History of lower extremity surgery	13 (17.1%)	13 (29.5%)	0.12
BMI ≥30	31 (40.8%)	32 (72.7%)	**0.016**
Clinical and laboratory findings			
CRP (>200 mg/L)	12 (15.8%)	9 (20.5%)	0.61
WBC (>17000/mm³)	10 (13.2%)	9 (20.5%)	0.31
PCT (>0.5 ng/mL)	33 (43.4%)	17 (38.6%)	0.64
Hospitalization >7 days	16 (21.1%)	14 (31.8%)	0.22
Antibiotic duration >14 days	55 (72.4%)	28 (63.6%)	0.32

p values were calculated using chi-square test or independent t-test, as appropriate

SD: Standard deviation, BMI: Body mass index, CRP: C-reactive protein, WBC: White blood cell count, PCT: Procalcitonin

or being homeless (OR: 6.27, 95% CI: 1.36–28.87, p=0.018), older age (OR: 1.03 per year, 95% CI: 1.001-1.06, p=0.045), and the presence of lymphedema (OR: 3.08, 95% CI: 1.17-8.14, p=0.023) were independently associated with recurrence. BMI showed a borderline association with recurrence (OR: 1.06, 95% CI: 0.99-1.14, p=0.084).

Microbiological, Laboratory, and Treatment Data

Blood cultures were obtained from all 40 hospitalized patients, and growth was detected in 5% (n=2); one isolate was MRSA (methicillin-resistant *Staphylococcus aureus*), and the other was MSSA (methicillin-sensitive *Staphylococcus aureus*). Among 21 patients with lesions (e.g., abscesses, bullae), tissue cultures yielded microbial growth in 19% (n=4), of which three isolates were *S. aureus* and one was *E. coli*.

The relationships between pre-treatment laboratory parameters (WBC, CRP, PCT) and clinical outcomes are summarized in Table 4. CRP level was strongly positively correlated with hospital stay duration and moderately correlated with antibiotic use; both correlations were statistically significant. WBC showed a weaker but significant correlation with hospital stay. No significant correlation was observed for PCT.

Amoxicillin-clavulanic acid was initiated as first-line treatment in the majority of outpatients (65%, n=52); combination therapy including ciprofloxacin was

Table 3. Univariable and multivariable logistic regression analysis of factors associated with recurrence

Characteristics	Univariable analysis OR (95% CI)	p value	Multivariable analysis OR (95% CI)	p value
Sociodemographic and clinical characteristics				
Age (years)	1.041 (1.014-1.070)	**0.003**	1.03 (1.001-1.06)	**0.045**
Sex				
Male	2.621 (1.223-5.621)	**0.013**		
Female	Reference			
Body mass index	1.073 (1.012-1.139)	**0.019**	1.06 (0.99-1.14)	0.084
Education level				
No formal education	Reference			
Primary education	0.27 (0.09-0.81)	**0.019**		
Secondary education	0.11 (0.02-0.67)	**0.017**		
University education	0.55 (0.06-4.92)	0.589		
Living alone/homeless	6.257 (1.594-24.559)	**0.009**	6.27 (1.36-28.87)	**0.018**
Smoking	0.467 (0.195-1.110)	0.086		
Alcohol use	0.721 (0.177-2.944)	0.649		
Comorbidities and local predisposing factors				
Diabetes mellitus	1.451 (0.665-3.164)	0.349		
Coronary artery disease	0.838 (0.310-2.265)	0.727		
Peripheral artery disease	2.207 (0.691-7.047)	0.181		
History of surgery	2.032 (0.842-4.904)	0.115		
Lymphedema	3.721 (1.541-8.981)	**0.003**	3.08 (1.17-8.14)	**0.023**
Tinea pedis	1.322 (0.603-2.900)	0.486		
Onychomycosis	1.333 (0.633-2.808)	0.449		
Laboratory parameters				
White blood cell count (per 1 × 10^3/μL increase)	1.000 (1.000-1.000)	0.624		
C-reactive protein (per 1 mg/L increase)	1.002 (0.998-1.005)	0.353		
Procalcitonin (per 1 ng/mL increase)	0.998 (0.939-1.061)	0.952		

Statistically significant p values (p<0.05) are shown in bold
OR: Odds ratio, CI: Confidence interval

Table 4. Relationship between acute phase reactants and length of hospital stay and duration of antibiotic use (pearson correlation analysis)

Parameter	Length of hospital stay (r)	Length of hospital stay (p value)	Duration of antibiotic use (r)	Duration of antibiotic use (p value)
WBC	0.18	**0.04**	0.08	0.35
CRP	0.62	**<0.001**	0.30	**<0.001**
PCT	-0.08	0.37	-0.03	0.70

p values <0.05 were considered statistically significant

r: Pearson correlation coefficient

WBC: White blood cell count; CRP: C-reactive protein; PCT: Procalcitonin

administered to a smaller subset. Among hospitalized patients, the most frequently prescribed antibiotic was ampicillin-sulbactam (65%, n=26), followed by tigecycline.

The average duration of antibiotic therapy for all patients was 14 days, ranging from a minimum of 8 days to a maximum of 28 days. Clinical follow-up revealed a favorable response in all patients, who achieved complete clinical recovery.

Discussion

Cellulitis is a common superficial soft-tissue infection that is frequently encountered in clinical practice and may require hospitalization. Given its economic burden on the healthcare system and potential complications, effective diagnostic and treatment strategies are of great importance. In this study, the sociodemographic, clinical, laboratory, and microbiological characteristics of patients diagnosed with lower extremity cellulitis were evaluated, with a particular focus on identifying risk factors associated with recurrence.

Several epidemiological studies have reported that cellulitis is more common among males, which has generally been attributed to greater exposure to risk factors, such as trauma, tinea pedis, and environmental conditions (7,8). In our study, the proportion of male cases was 55.8%, consistent with the previously reported prevalence range. The significantly higher mean age observed among female patients compared with male patients suggests that age-related physiological changes may play a role in the development of cellulitis. In particular, the decrease in estrogen levels during the postmenopausal period may negatively affect lymphatic drainage, connective tissue integrity, and immune response, thereby increasing susceptibility to infection (9). However, to better understand this relationship, prospective studies stratified by age groups are needed.

The recurrence rate in the studied patient group was 36.7%, which is consistent with the reported incidence range of 22-49% in the literature (10,11,12,13). Notably, a retrospective study involving patients diagnosed with cellulitis and followed for up to three years reported a recurrence rate of 47% (14). Similarly, in another study of 233 patients, a recurrence was reported in 29% of cases within three years of the initial episode (15). The fact that recurrent cases predominantly occurred in the same extremity suggests that local risk factors -particularly lymphedema and venous insufficiency- may not have been adequately controlled. The findings revealed that both individual and environmental risk factors, such as advanced age, lymphedema, peripheral arterial disease, high BMI, and living alone, have a significant impact on cellulitis recurrence.

Advanced age is a significant risk factor for cellulitis recurrence. Fisher et al. (16) demonstrated that individuals aged 65 years and older had a markedly higher risk of rehospitalization and recurrence of cellulitis. With aging, the weakening of the immune system and pathophysiological changes such as venous insufficiency and lymphedema are known to increase the risk of recurrent infection (1). Consistent with these findings, advanced age remained an independent predictor of recurrence in our multivariable analysis, underscoring the importance of age-specific preventive strategies. In this context, it is clinically important to consider elderly individuals a high-risk group for cellulitis and to implement long-term follow-up strategies after acute treatment.

Low socioeconomic conditions are significant risk factors for the recurrence of skin and soft tissue infections and should not be overlooked. Living alone, inability to maintain personal hygiene, difficulty managing chronic diseases, and limited access to healthcare services increase the likelihood of recurrent infection. Gregory et al. (17) demonstrated that infections such as cellulitis are common among homeless individuals with compromised skin integrity and that lack of access to hygiene facilities negatively affects the clinical course of these infections. Consistent with these observations, living alone or being homeless emerged as independent risk factors

for recurrence in our multivariable analysis, highlighting the critical role of social vulnerability in disease outcomes. These findings highlight that infections should be evaluated not only from a biological perspective but also in terms of their social dimensions, and that an effective management strategy requires a multidisciplinary approach.

Obesity is a significant risk factor for both the development and recurrence of cellulitis through systemic and local mechanisms. An increased BMI contributes to susceptibility to infection through mechanisms such as thickening of subcutaneous adipose tissue, impaired lymphatic drainage, and suppression of immune responses (18). Studies have reported significantly higher cellulitis recurrence rates in individuals with high BMI. In particular, individuals with a BMI ≥30 kg/m² have a markedly increased risk of recurrence compared to those with normal weight (19). However, in our multivariable analysis, BMI showed only a borderline association with recurrence, suggesting that obesity may contribute indirectly to recurrence through mechanisms such as impaired lymphatic drainage and chronic edema rather than acting as an independent risk factor. These findings highlight the necessity of close follow-up of obese individuals after infection, with an emphasis on long-term monitoring and lifestyle modifications.

Lymphedema and peripheral arterial disease are two major vascular risk factors prominently associated with cellulitis recurrence. Lymphedema, resulting from impaired lymphatic drainage, leads to chronic edema and inflammation, weakening tissue integrity and creating a predisposition to recurrent infections. Chronic edema has been identified as an independent risk factor for the development of cellulitis, with a reported 6.8-fold higher risk of infection in affected individuals (2). Additionally, approximately 26-56% of individuals with lymphedema experience recurrent cellulitis (20,21). Consistent with this evidence, lymphedema remained independently associated with recurrence in our analysis. Peripheral arterial disease may contribute to cellulitis recurrence by creating an ischemic tissue environment and has been identified as an independent risk factor in previous studies (22). Although peripheral arterial disease was more frequently observed among patients with recurrence in unadjusted analyses, this association was not significant in either univariable or multivariable logistic regression analyses in our study, suggesting that its effect may not be independent in this cohort.

Although tinea pedis, onychomycosis, and DM were among the most frequently observed predisposing factors in our study, no statistically significant association was found between these variables and recurrence. However, some publications have reported that these factors may influence recurrence (10). The discrepancies among studies may stem from differences in patient characteristics, follow-up durations, and diagnostic criteria. Therefore, larger prospective studies are needed to clarify the potential impact of these factors on recurrence.

In the present analysis, the most common clinical symptoms were erythema, edema, localized warmth, and pain, which are consistent with the classic clinical presentation of cellulitis. These findings align with the inflammatory symptom profile frequently reported in the literature (23). In addition, lower extremity involvement was observed in 92% of cases, supporting previous studies that emphasize the susceptibility of this anatomical region to cellulitis (24,25). The increased vulnerability of the lower extremities to infection is thought to result from factors such as circulatory disturbances (impaired lymphatic and venous return due to gravity and venous insufficiency) and common epidermal barrier defects (e.g., tinea pedis) in this region (26). These pathophysiological features highlight the lower extremities as high-risk regions for cellulitis.

Study Limitations

This study has certain limitations. Its single-center, retrospective design may limit the generalizability of the findings to broader patient populations. The relatively small sample size may have reduced the statistical power in some subgroups. Since the data were obtained from medical records, there is a risk of missing or inaccurate information. In particular, the recurrence interval (i.e., the time between cellulitis episodes) could not be assessed because the timing of previous episodes was not consistently documented. Additionally, the lack of microbiological data for all patients restricts the ability to draw conclusions regarding the causative pathogens.

Conclusion

This study demonstrated that advanced age, vascular pathologies, obesity, and low socioeconomic status are significant risk factors for recurrent lower-extremity cellulitis. Although predisposing dermatological conditions were frequently observed, they were not predictive of recurrence. Among laboratory markers, CRP emerged as a valuable biomarker for assessing infection severity, whereas PCT levels were shown to have limited prognostic value. The findings underscore the need to develop individualized treatment and follow-up strategies to reduce the risk of recurrence. Furthermore, adopting holistic approaches that consider social determinants may enhance infection control outcomes.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Ethics Committee of University of Health Sciences Türkiye, Şişli Hamidiye Etfal Training and Research Hospital (approval number: 675, date: 24.05.2016)

Informed Consent: The requirement for informed consent was waived because of the retrospective nature of the study.

Footnotes

Authorship Contributions

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Ultrasonographic Evaluation of the Abductor Pollicis Brevis Muscle in Patients with Carpal Tunnel Syndrome Classified According to EMG Findings

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What is known on this subject?

Ultrasonography is commonly used in carpal tunnel syndrome (CTS), mainly to assess median nerve enlargement. Electrophysiological studies are the standard method for determining disease severity and motor involvement. Although thenar muscle atrophy may occur in CTS, quantitative ultrasonographic evaluation of the abductor pollicis brevis across different severity stages has been insufficiently investigated.

What this study adds?

Quantitative ultrasonographic parameters of the abductor pollicis brevis muscle decrease proportionally with disease severity and correlate with electrophysiological findings.

ABSTRACT

Objective: To evaluate the relationship between quantitative muscle ultrasound parameters of the abductor pollicis brevis (APB) and disease severity in carpal tunnel syndrome (CTS).

Material and Methods: This cross-sectional, comparative clinical study included 76 patients. Participants were stratified into four electromyography (EMG)-based categories (EMG-normal, mild, moderate, and severe CTS). In the transverse ultrasound images of the APB, we measured cross sectional area and thickness of the muscle. Differences in muscle thickness, cross-sectional area (CSA), and pinch strength among four groups were analyzed.

Results: The CSA of the APB muscle decreases with increasing disease severity. Thickness and pinch strength are significantly decreased in severe CTS. There is a significant negative correlation between the CSA of the APB muscle and the distal motor latency of the median nerve.

Conclusion: Quantitative ultrasound parameters of the APB muscle are useful for evaluating disease severity in CTS.

Keywords: Abductor pollicis brevis, carpal tunnel syndrome, electromyography, pinch grip strength, thenar muscle

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Introduction

Carpal tunnel syndrome (CTS), the most common entrapment neuropathy, results from compression of the median nerve within the carpal tunnel, a confined fibro-osseous canal at the wrist (1). CTS occurs considerably more frequently in women than in men, with epidemiological data indicating an approximately threefold higher prevalence among women. Moreover, bilateral involvement is observed in a substantial proportion of affected individuals (2). As the disease progresses, motor fiber involvement may become clinically apparent, leading to reduced strength during thumb abduction and opposition. In the absence of timely intervention, ongoing denervation can ultimately result in atrophic changes in the median nerve–innervated hand muscles.

In most cases, a careful medical history combined with physical examination is sufficient for establishing the diagnosis of CTS. When clinical findings are equivocal, electrophysiological evaluation plays an important role in grading disease severity and guiding decisions regarding surgical management (3). Electromyography (EMG) and nerve conduction studies (NCS) provide sensitive information on both demyelinating processes and axonal injury or recovery. Needle EMG of the thenar muscles may be particularly useful for identifying early axonal involvement in patients with distal motor latency (DML) values exceeding 4.9 ms (4). Nevertheless, needle EMG is an invasive technique that can be uncomfortable for patients and, in certain situations, may be technically challenging, because obtaining reliable results depends on adequate patient cooperation.

Ultrasonography (US) represents a practical imaging modality owing to its non-invasive nature, broad availability, and ease of use in routine clinical settings. It is generally well tolerated by patients, does not involve significant adverse effects, and is considered a safe technique with no major contraindications (5).

In CTS, sustained compression within the carpal tunnel may result in proximal nerve swelling due to edema, while accompanying fibrotic changes contribute to structural enlargement of the median nerve (6). On transverse ultrasonographic evaluation, these pathological alterations are commonly reflected by an increase in the nerve's cross-sectional area (CSA). Edema-related changes may also cause the nerve to appear more hypoechoic, with reduced clarity of fascicular architecture due to loss of perineurial definition (7). Previous studies have shown that median nerve CSA values in healthy populations exhibit a wide normal range (reported between 6.1 and 10.4 mm^2), which has hindered the establishment of a universal diagnostic cut-off (8,9). To overcome this variability, Klauser et al. (10) proposed comparing CSA measurements at the wrist and forearm levels, reporting that a difference exceeding 2 mm^2 provides excellent diagnostic accuracy. In line with this approach, other investigations have suggested that ratios incorporating proximal median nerve measurements may further enhance diagnostic sensitivity (11,12). Additionally, a reduction in the forearm median nerve CSA has been associated with axonal loss in patients with CTS (13).

Beyond neural changes, sustained median nerve compression in CTS leads to denervation-related structural alterations in median-innervated muscles, most prominently affecting the abductor pollicis brevis (APB). Progressive motor fiber involvement may result in reductions in muscle thickness, CSA, and functional strength, reflecting disease severity at the muscular level. Despite the clinical relevance of thenar muscle involvement in CTS, ultrasonographic evaluation of APB muscle morphology has received considerably less attention than median nerve assessment, and available data remain limited, particularly across the full spectrum of CTS severity.

Although ultrasonographic evaluation of the median nerve is a well-established and sensitive method in CTS, most US-based studies have focused on structural alterations of the nerve (14,15). By comparison, investigations examining muscular alterations within the territory innervated by the median nerve in focal neuropathies, such as CTS, remain relatively limited (16,17). Notably, the study by Lee et al. (17) was restricted to patients with minimal, mild, and moderate disease severity and did not include individuals categorized as severe or extreme CTS based on the Padua criteria. While ultrasonographic evaluation of the median nerve is well established, data regarding structural changes in median-innervated muscles—particularly the APB—remain limited, especially across the full spectrum of CTS severity. Against this background, the present study aimed to assess, across different stages of CTS severity, APB muscle thickness and CSA and pinch grip strength, and to examine the relationships between these parameters and electrophysiological findings.

Material and Methods

This study was conducted at İstanbul Physical Medicine and Rehabilitation Training and Research Hospital. Patients provisionally diagnosed with CTS who voluntarily consented

to participate in the study were enrolled. Each participant received detailed information about the study procedures and provided signed consent before enrollment. This study was derived from a thesis project. Eligible participants included women between 18 and 75 years of age who had undergone NCS and/or EMG testing confirming a CTS diagnosis. Individuals with systemic or neurological disorders that could affect peripheral nerves—such as diabetes, malignancies, central nervous system diseases (e.g., multiple sclerosis, motor neuron disorders), prior wrist trauma or surgery, radiculopathy, or other neuropathies—were excluded.

This cross-sectional clinical study involved 76 participants. Collected data included demographic characteristics (e.g., age, height, weight, and body mass index), as well as information on hand dominance. Sample size calculation was performed a priori based on previously published APB muscle thickness data, yielding an effect size (Cohen's d) of 1.33. An unpaired t-test (α: 0.05, power: 0.95) indicated a required sample size of 13 participants per group, calculated using G*Power (17).

Ultrasound assessments were performed by a single investigator blinded to both clinical presentation and EMG results, using a diagnostic system (Esaote MyLab60) with a 7–12 MHz linear transducer. APB muscle thickness and CSA were measured bilaterally while participants sat in a relaxed position with neutral shoulder alignment, 90° of elbow flexion, forearm supination, neutral wrist alignment, and fingers fully extended. Muscle ultrasound assessments followed the standardized method outlined by Simon et al. (18) the probe was aligned perpendicularly over the midpoint of the first metacarpal bone, following its longitudinal orientation.

To reduce probe pressure during scanning, coupling gel was applied generously. APB thickness was quantified by measuring the distance across the muscle at its thickest section using the device's built-in function. CSA was determined by tracing the hyperechoic fascial border surrounding the muscle using the system's trace area tool. Intra-rater reliability was assessed by repeating APB thickness and CSA measurements in a randomly selected subset of 10 participants (20 hands) and quantified using the intraclass correlation coefficient (ICC).

Pinch grip strength was assessed on the same day as the US examination, using a Saehan SH50005 hydraulic pinch gauge (19). For each hand, three tip-to-tip pinch measurements were obtained at one-minute intervals while participants were seated.

Electrophysiological evaluations were carried out in a quiet, moderately lit environment maintained at 22–24 °C, with participants in the supine position, using a Dantec Keypoint 3-channel EMG system. Recordings included motor and sensory NCS parameters of the median and ulnar nerves (3).

Motor and sensory NCSs of both the median and ulnar nerves were performed in all participants. Median sensory NCS was obtained using a ring electrode placed on the second digit, with antidromic stimulation applied at the wrist to record latency, amplitude, and conduction velocity. Median motor NCS was conducted using surface electrodes positioned over the APB, with stimulation delivered at the wrist and the antecubital fossa to measure compound muscle action potential (CMAP) amplitude, latency, and conduction velocity. Needle EMG was performed when clinically indicated. Ulnar sensory NCS was recorded from the fifth digit using a ring electrode and antidromic wrist stimulation, while ulnar motor NCS was obtained from the adductor digiti minimi using surface electrodes, with stimulation applied at the wrist and above the elbow to evaluate CMAP parameters. In cases with normal routine findings, a fourth-finger median-to-ulnar sensory comparison study was performed using ring electrodes with equal-distance stimulation of both nerves. A peak latency difference greater than 0.5 ms was considered indicative of CTS.

Based on EMG findings, patients were classified using the severity grading system proposed by Sucher (20) in 2013. The grading criteria were defined as follows:

Mild CTS: Prolongation of sensory or mixed nerve latency with preserved DML and amplitudes, and no evidence of conduction block or abnormal findings on needle EMG. In some cases, comparative testing may reveal relatively prolonged sensory latency of the median nerve, even when absolute latency values are within normal limits.

Moderate CTS: Findings consistent with mild CTS accompanied by prolonged DML and a mild, non-significant reduction in recorded amplitudes.

Severe CTS: Absence of sensory nerve action potential (SNAP) or markedly prolonged sensory latency associated with reduced SNAP amplitude, or absent CMAP together with markedly prolonged DML and low motor amplitude. Alternatively, severe CTS may be characterized by abnormal needle EMG findings, including frequent fibrillation potentials, a reduced interference pattern during maximal voluntary contraction, and changes in motor unit action potentials.

In addition to the defined CTS severity groups, participants who had clinical symptoms suggestive of CTS but had no abnormal findings on NCS/EMG were assigned to the "EMG-normal" group. These individuals were not considered healthy controls.

All clinical assessment tools and quantitative measurement techniques applied in this study were derived from previously validated methods and were accessible for academic use. The ultrasonographic protocol was performed in accordance with Simon et al. (18); CTS severity classification was based on the system described by Sucher (20); and pinch grip strength was measured using a Saehan hydraulic pinch gauge (Model SH50005, Saehan Corporation, Korea) (19). No special authorization or licensing was required for the use of these instruments.

Written informed consent was obtained from all participants following a detailed explanation of the study objectives and procedures. Ethical approval was granted by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (decision number: 2019-02-17, date: 21.01.2019).

Statistical Analysis

Statistical analyses were performed using MedCalc® version 20.113 (Ostend, Belgium). The normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed data are presented as mean ± standard deviation; non-normally distributed data are presented as median (interquartile range). Categorical variables are presented as frequencies and percentages. Because measurements could be obtained from both hands of the same participant, the primary analysis was prespecified to include one hand per participant (the more severely affected hand according to EMG findings; if severity was equal, the dominant hand was selected) to avoid violating the assumption of independence. Group comparisons across EMG-defined categories were performed using one-way analysis of variance with Tukey post-hoc testing for parametric variables and the Kruskal–Wallis test followed by Bonferroni-adjusted Mann–Whitney U tests for non-parametric variables. Associations between ultrasonographic parameters, electrophysiological findings, and pinch strength were evaluated using Spearman correlation coefficients. A two-sided p value was considered statistically significant.

Results

Seventy-six patients were included in the study. Patient demographic data are presented in Table 1.

We evaluated 152 hands from 76 patients. According to EMG results, 43 hands were classified as normal, 54 as mild CTS, 29 as moderate CTS, and 26 as severe CTS. The statistical analysis of the demographic data is presented in Table 1.

The comparison of dominant- vs. non-dominant-hand distributions did not reveal statistically significant differences among groups (p>0.05).

Table 1. Demographic data

		Normal (n=43)	Mild CTS (n=54)	Modarate CTS (n=29)	Severe CTS (n=26)	p
		45 (11)	52 (10)	48 (12)	49 (15)	
Age	p^m	Normal–mild <0.001		Normal–severe 0.006	Mild–severe 0.719	<0.001^K
		Normal–modarate 0.013		Mild–modarate 0.198	Modarate–severe 0.413	
		27.55±4.7	30.69±4.3	30.07±5.4	31.74±2.8	
BMI	p**	Normal–mild 0.004		Normal–severe 0.001	Mild–severe 0.761	0.001*
		Normal–modarate 0.093		Mild–modarate 0.060	Modarate–severe 0.512	
		3 (4)	3 (9)	5 (6)	4.5 (5)	
Disease duration (years)	p^m	Normal–mild 0.464		Normal–severe 0.097	Mild–severe 0.358	0.042^K
		Normal–modarate 0.005		Mild–modarate 0.060	Modarate–severe 0.276	
Smoking (Yes/no)		6 (14%)/37 (86%)	22 (40.7%)/32 (59.3%)	12 (41.4%)/17 (58.6%)	4 (26%)/22 (84.6%)	0.004$^{X^2}$
Pack year		0 (0)	0 (10)	0 (8)	0 (0)	
Not working (Housewife)		31 (72.1%)	43 (79.6%)	23 (79.3%)	22 (84.6%)	
Job Worker		8 (18.6%)	9 (16.7%)	5 (17.2%)	4 (15.4%)	0.690$^{X^2}$
Retired		4 (9.3%)	2 (3.7%)	1 (3.4%)	0 (0%)	

Median (interquartile range), mean ± standard deviation, distribution of categorical variables n (%)

*^{K}: Kruskal–Wallis test, ^{m}: Post-hoc analysis Mann–Whitney U test Bonferoni correction applied, $^{X^2}$: Pearson chi-square test, *One way analysis of variance test, **Post-hoc analysis Tukey test*

BMI: Body mass index, CTS: Carpal tunnel syndrome

When evaluating EMG parameters, notable differences were identified across groups in median sensory latency, sensory conduction velocity and amplitude, and in median motor latency. In contrast, no significant between-group differences were found in median motor nerve conduction velocity. The findings on EMG and hand dominance are presented in Table 2.

Between-group analyses of APB muscle CSA demonstrated statistically significant differences ($p<0.001$). While no meaningful differences were found when comparing the normal group with the mild CTS group or the mild CTS group with the moderate CTS group, significant differences emerged between the normal and moderate CTS groups. Moreover, the severe CTS group differed significantly from all other groups ($p<0.05$; $p<0.001$). Statistical analysis of pinch grip strength using the Kruskal–Wallis test indicated overall significant group differences ($p<0.001$). Subsequent post-hoc evaluations revealed no notable variation between the normal and mild CTS groups, nor between the mild and moderate CTS groups. Nevertheless, the severe CTS group exhibited values that were significantly different from those of all other classifications, including the normal and moderate CTS groups ($p<0.001$), as outlined in Table 3.

Correlation analyses involving quantitative ultrasonographic parameters, pinch grip strength, and EMG findings are detailed in Table 4. Associations were not consistently observed within individual severity strata, which may reflect limited sample sizes within subgroups; however, when CTS cases were analyzed together using the prespecified one-hand dataset, APB CSA showed associations with electrophysiological parameters. However, when the data from all CTS patients were pooled, the CSA of the APB muscle showed significant associations with both sensory and motor electrophysiological parameters of the median nerve ($p<0.01$). Specifically, larger APB CSA values were associated with shorter latencies and higher amplitudes and conduction velocities. A significant negative correlation was observed between APB muscle CSA and median nerve DML (Figure 1). Although APB muscle thickness was also associated with certain sensory parameters, no significant relationships were noted with motor conduction velocity or motor amplitude. A moderate positive correlation was identified between APB muscle CSA and its thickness among CTS patients. While no meaningful association was found between pinch-grip strength and EMG measures in subgroup analyses, combined CTS data demonstrated moderate correlations with sensory

Table 2. Distribution of dominant/non-domiant hands into groups and EMG data

		Normal (n=43)	Mild CTS (n=54)	Modarate CTS (n=29)	Severe CTS (n=26)	p
Dominant/non-dominant hand		18 (41.9%)/25 (58.1%)	30 (55.6%)/24 (44.4%)	16 (55.2%)/13 (44.8%)	12 (46.2%)/14 (53.8%)	0.518$^{x^2}$
		2.92 (0.4)	3.35 (0.4)	4.12 (0.8)	5.50 (1.6)	
Median sensory latency	p^m	Normal–mild **<0.001**	Normal–severe **<0.001**	Mild–severe **<0.001**		**<0.001^K**
		Normal–modarate **<0.001**	Mild–modarate <**0.001**	Modarate–severe <**0.001**		
		41.20 (28.1)	30.00 (15.3)	18.80(8.9)	6.13 (11.6)	
Median sensory amplitude	p^m	Normal–mild **<0.001**	Normal–severe **<0.001**	Mild–severe **<0.001**		**<0.001^K**
		Normal–modarate **<0.001**	Mild–modarate **<0.001**	Modarate–severe **<0.001**		
		61.30 (8.9)	47.15 (8.5)	38.80 (8.9)	29.15 (33.1)	
Median sensory conduction velocities	p^m	Normal–mild <**0.001**	Normal–severe <**0.001**	Mild–severe **<0.001**		**<0.001^K**
		Normal–modarate **<0.001**	Mild–modarate **<0.001**	Modarate–severe **<0.001**		
		2.96 (0.6)	3.63 (0.4)	4.50 (0.5)	6.19 (1.8)	
Median motor latency	p^m	Normal–mild **<0.001**	Normal–severe **<0.001**	Mild–severe **<0.001**		**<0.001^K**
		Normal–modarate **<0.001**	Mild–modarate <**0.001**	Modarate–severe **<0.001**		
		10.20 (7.3)	9.61 (6.5)	9.40 (6.1)	3.45 (1.9)	
Median motor amplitude	p^m	Normal–mild 0.343	Normal–severe **<0.001**	Mild–severe **<0.001**		**<0.001^K**
		Normal–modarate 0.338	Mild–modarate 0.920	Modarate–severe **<0.001**		
		57.50 (6.3)	54.85 (7.2)	56.20 (5.2)	55.40 (8.2)	
Median motor conduction velocities	p^m	Normal–mild 0.141	Normal–severe 0.087	Mild–severe 0.517		0.257^K
		Normal–modarate 0.364	Mild–modarate 0.442	Modarate–severe 0.284		

Distribution of categorical variables n (%), median (interquartile range)

x^2: Pearson chi-square test, ^{K}: Kruskal–Wallis test, ^{m}: Post-hoc analysis Mann–Whitney U test Bonferoni correction applied

EMG: Electromyography, CTS: Carpal tunnel syndrome

and motor latencies and amplitudes of the median nerve (p<0.01). No correlation between APB muscle CSA and thickness was observed in the control group; this relationship became progressively stronger with increasing CTS severity.

To assess agreement of ultrasonographic measurements, intra-observer reliability ICC was re-evaluated in 10 patients (20 hands). The intra-observer reliability values are presented in Table 5. The reproducibility of the measurements was very high (p<0.001).

Table 3. Comparison of abductor pollicis brevis muscle thickness and cross-sectional area and pinch grip strength between groups

		Normal (n=43)	Mild KTS (n=54)	Modarate CTS (n=29)	Severe CTS (n=26)	p
		120.26±13.1	111.61±15.6	90.66±12.1	58.27±13.3	
APB cross-sectional area	p**	Normal–mild **0.015**	Normal–severe **<0.001**	Mild–severe **<0.001**		
		Normal–modarate **<0.001**	Mild–modarate **<0.001**	Modarate–severe **<0.001**		**<0.001***
		5.09±0.6	4.77±0.7	4.47±0.8	3.84±0.9	
APB thickness	p**	Normal–mild 0.148	Normal–severe **<0.001**	Mild–severe **<0.001**		
		Normal–modarate **0.004**	Mild–modarate 0.314	Modarate–severe **0.011**		**<0.001***
		3 (0.5)	2.66 (0.5)	2.5 (0.8)	1.6 (0.4)	
Pinch grip	p^m	Normal–mild 0.010	Normal–severe **<0.001**	Mild–severe **<0.001**		
		Normal–modarate **<0.001**	Mild–modarate 0.042	Modarate–severe **<0.001**		**<0.001**^{K}

Mean ± standard deviation, median (interquartile range)

**One way analysis of variance test, **Post-hoc analysis Tukey test, ^{K}: Kruskal–Wallis test, ^{m}: Post-hoc analysis Mann–Whitney U test Bonferoni correction applied*

APB: Abductor pollicis brevis, CTS: Carpal tunnel syndrome

Table 4. Correlation of APB muscle thickness and cross-sectional surface area and pinch grip strength with EMG data

			Median sensory			Median motor		
	APB CSA	APB thickness	Latency	Amplitude	Conduction velocities	Latency	Amplitude	Conduction velocities
Normal grup (n=43)								
APB CSA		0.065	0.095	-0.254	0.018	-0.088	0.120	0.003
APB thickness	0.065		0.086	0.127	0.011	**0.334***	-0.227	0.174
Pinch grip			0.215	-0.129	0.071	0.174	-0.242	-0.027
Mild CTS (n=54)								
APB CSA		0.408**	0.093	0.047	-0.102	-0.085	0.193	0.013
APB thickness	0.408**		0.210	-0.089	-0.078	0.195	-0.117	-0.011
Pinch grip			0.073	-0.187	-0.027	-0.037	0.071	-0.158
Modarate CTS (n=29)								
APB CSA		0.386*	0.012	0.161	0.121	0.088	0.081	0.126
APB thickness	0.386*		0.002	-0.116	-0.045	0.077	-0.108	-0.052
Pinch grip			0.143	0.014	0.020	0.343	0.233	-0.065
Severe CTS (n=26)								
APB CSA		0.763**	-0.096	0.152	0.070	-0.257	0.297	0.189
APB thickness	0.763**		-0.183	0.177	0.154	**-0.458***	0.095	0.039
Pinch grip			0.039	0.332	-0.077	-0.035	0.046	0.008
CTS group (n=109)								
APB CSA		0.544**	-0.632**	0.662**	0.648**	-0.720**	0.545**	0.056
APB thickness	0.544**		-0.254**	0.266**	0.274**	**-0.307****	0.166	-0.017
Pinch grip			-0.441**	0.470**	0.491**	-0.503**	0.478**	-0.010

**p value <0.05, **p value <0.01, Spearman's rho coefficients are given*

CSA: Cross-sectional area, CTS: Carpal tunnel syndrom, APB: Abductor pollicis brevis

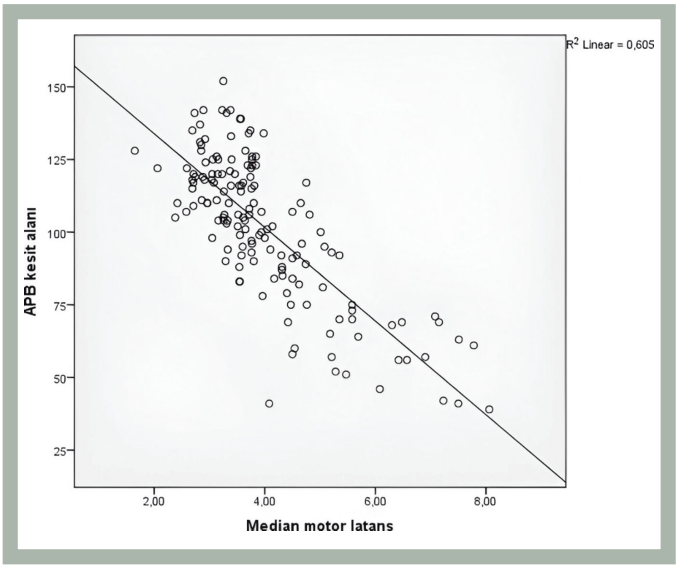

Figure 1. Correlation between APB muscle APB and median nerve DML

APB: Abductor pollicis brevis, DML: Distal motor latency

Table 5. Intra-observer reliability analysis

	ICC	95% confidence interval Lower bound	Upper bound	p
APB thickness	0.981	0.952	0.992	**<0.001**
APB cross-sectional area	0.988	0.969	0.995	**<0.001**

ICC: Intraclass correlation coefficient, APB: Abductor pollicis brevis

Discussion

This study aimed to compare ultrasonographic measurements across CTS severity groups classified by EMG findings and to examine their associations with electrophysiological parameters. Significant differences in APB muscle thickness and CSA were observed among severity levels. Intergroup variations were also evident in pinch grip strength. A notable negative correlation was identified between APB muscle CSA and median nerve DML. These findings suggest that APB muscle thickness and CSA may reflect motor involvement and EMG-defined disease severity in CTS, providing complementary structural information alongside electrophysiological assessment.

EMG is important for establishing the diagnosis of CTS and for determining the severity of the disease and, accordingly, the appropriate treatment. Nevertheless, it is often uncomfortable for patients and may be poorly tolerated by individuals with low pain thresholds or CTS-related neuropathic pain. In addition, EMG may delay definitive management in patients requiring surgical intervention and increase healthcare costs (21). Furthermore, while EMG reflects the functional severity of CTS, it provides limited information regarding underlying anatomical causes. In a retrospective analysis, Iyer evaluated 4,800 patients who were referred for EMG with a preliminary CTS diagnosis over a five-year period (22). Among those classified as having severe CTS based on EMG findings, subsequent median nerve US identified idiopathic CTS in most cases, whereas a small subset had specific structural pathologies, including lunate subluxation, schwannoma, lipofibromatous hamartoma, and trauma-related neuroma.

Musculoskeletal US is used to reveal changes in muscle thickness and volume in pathological conditions. Several recent publications have explored ultrasound applications in diagnosing CTS; however, these works have largely focused on identifying increases in the median CSA (23). In neurogenic diseases, muscles undergo structural changes, including atrophy. These changes can be displayed or even quantified using US (24). In addition to muscle thickness and CSA, echo intensity can be measured using US; however, this measurement was not used in our study because it varies from device to device and is less reproducible than measurements of muscle thickness and CSA (25,26). Additionally, previous studies have reported that patient sex significantly affects quantitative US measurements of muscles; therefore, only female participants were recruited in this study to reduce inter-individual variability (27,28).

In a 2016 study, Lee et al. (17) compared quantitative US findings between patients with CTS and healthy controls, and reported significantly reduced APB muscle thickness and CSA in the CTS group. Likewise, Simon et al. (26) evaluated quantitative US measurements of several muscles in patients with amyotrophic lateral sclerosis, CTS, and ulnar neuropathy and observed a decrease in APB muscle thickness compared with that of healthy individuals, with greater thinning accompanying increasing denervation severity. Consistent with these observations, our study also demonstrated a reduction in APB muscle thickness in CTS. Although Simon et al. (26) did not assess APB muscle CSA, Lee et al. (17) evaluated it, and our findings agreed with theirs. In the present study, APB muscle CSA was significantly lower in the CTS group than in the normal group, with a progressive reduction corresponding to increasing disease severity.

The study by Lee et al. (17), which examined the association between APB muscle CSA, thickness, and EMG findings, reported a significant positive correlation of APB echo intensity with both median sensory onset latency and DML, but found no association of APB muscle thickness or

CSA with EMG parameters. These findings differ from ours and may be explained by methodological differences. First, Lee et al. (17) applied a different severity classification and included predominantly mild CTS cases [78% (28 of 36 hands)], with the remaining cases classified as moderate CTS [22% (8 of 36 hands)]; no cases of severe CTS were included. Consistent with this, intragroup analyses in our study also showed no correlation between APB muscle CSA or thickness and EMG findings in mild and moderate CTS; however, when all CTS cases were analyzed together, significant associations emerged. Second, the smaller sample size in the study by Lee et al. (17) may have limited the study's statistical power to detect such relationships. In contrast, our study evaluated patients across the full spectrum of CTS severity, including severe cases, allowing a more comprehensive assessment of how disease severity affects quantitative US parameters.

Weakness of the opponens pollicis and APB muscles, which may be caused by CTS, can be compensated for by other synergist muscles, and thus CTS may not have a significant effect on gross grip strength and lateral grip strength. However, tip-to-tip pinch strength is mostly generated by the thenar muscles and is a more useful measurement in demonstrating motor involvement associated with CTS (19). In our study, intergroup comparison of pinch-grip strength showed a significant decrease in individuals with severe CTS compared with those in milder categories. The results of our study are consistent with previous studies (28,29). Atalay et al. (29) evaluated a cohort of 99 individuals, divided participants based on EMG-defined severity levels: mild, moderate, and severe, and identified notable differences between the severe CTS subgroup and the others in terms of tip pinch strength. Keskin et al. (28) ssessed the hands of 106 individuals with CTS categorized into three EMG-based subgroups. They found that patients with advanced CTS had significantly decreased pinch grip strength compared with the moderate and mild CTS groups. Moreover, they reported that pinch grip strength was moderately correlated with DML, and that grip strength decreased with increasing motor latency.

US is widely used in the evaluation of CTS-related structural changes (30). However, publications on the use of ultrasound for diagnostic purposes in CTS have primarily focused on measuring CSA in the median nerve. Our results indicate that APB muscle changes associated with median nerve entrapment can be detected by ultrasound and appear to relate to EMG-defined severity; Lee et al. (17) suggested that APB muscle CSA and thickness could be used in the diagnosis of CTS; however, they did not propose any cut off value. Ultrasonographic changes in the APB muscle appear to parallel electrophysiologically defined motor involvement in CTS. These findings should be interpreted as descriptive associations rather than indicators of diagnostic accuracy.

Study Limitations

This study has a number of limitations. First, since our study only included female patients, the results cannot be generalized to the whole population. Patients included in the study and classified as normal were referred from the outpatient clinic to the electrophysiology laboratory, and thus were already symptomatic. Although EMG results were negative in these patients, EMG and NCS may be negative in some patients with CTS. Because patients were grouped by disease severity, demographic homogeneity between groups could not be achieved.

Conclusion

The thickness and CSA of the APB muscle decline in parallel with increasing CTS severity. Similarly, pinch grip strength diminishes as the condition progresses. Among individuals diagnosed with CTS, both APB muscle thickness and CSA demonstrated meaningful associations with sensory and motor conduction parameters, including latency, amplitude, and velocity, as assessed via NCS.

In summary, this study indicates that quantitative ultrasonographic evaluation of the APB muscle can serve as an indicator of CTS-related thenar muscle alterations, reflecting disease severity.

Ethics

Ethics Committee Approval: Ethical approval was granted by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (decision number: 2019-02-17, date: 21.01.2019).

Informed Consent: Written informed consent was obtained from all participants following a detailed explanation of the study objectives and procedures.

Footnotes

Authorship Contributions

Concept: İ.A., B.H., K.Ö., Design: B.H., K.Ö., Data Collection or Processing: İ.A., B.H., Analysis or Interpretation: İ.A., M.D., B.H., K.Ö., Literature Search: İ.A., M.D., B.H., Writing: İ.A., M.D., B.H.

Conflict of Interest: One of the authors, Burcu Hazer, is a member of the journal's board. The editorial and peer-review process was conducted independently of this author. The other authors declare no conflicts of interest.

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Event Recorders in Pediatric Cardiology: Improving Diagnosis in Symptomatic Patients

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What is known on this subject?

Arrhythmia related symptoms such as palpitations, chest pain, and syncope are common reasons for referral to pediatric cardiology clinics, yet establishing a symptom rhythm correlation in children remains challenging due to the intermittent nature of symptoms. Conventional 24-hour rhythm Holter monitoring is widely used in clinical practice; however, its limited recording duration often results in low diagnostic yield in pediatric patients with infrequent or transient symptoms. Patient-activated cardiac event recorders (ER) enable longer-term electrocardiographic monitoring and have been shown to improve the detection of paroxysmal arrhythmias compared with short-term Holter monitoring. Previous studies have primarily focused on the detection of pathological arrhythmias, while the clinical value of documenting benign rhythms during symptomatic episodes in pediatric patients has been less emphasized.

What this study adds?

This study demonstrates that patient-activated ERs significantly increase diagnostic yield in symptomatic pediatric patients, particularly in those with intermittent complaints and initially normal 24-hour Holter monitoring. Beyond the detection of pathological arrhythmias, the documentation of benign rhythm patterns especially sinus tachycardia during symptomatic episodes provides valuable symptom–rhythm correlation and supports clinical decision-making. Studies evaluating the use of ERs in pediatric populations are limited, and real-world single-center data with comparable patient numbers are scarce in the literature. In this context, our findings contribute meaningful evidence regarding the clinical utility of ERs in children. The results highlight the role of ERs not only as a diagnostic tool but also as an effective noninvasive method for excluding cardiac causes, reducing unnecessary investigations, and promoting the rational use of healthcare resources in pediatric practice.

ABSTRACT

Objective: To determine the diagnostic efficiency of using an event recorder (ER) in evaluating paroxysmal symptoms such as palpitations, syncope, and chest pain in children and to compare it with 24-hour rhythm Holter monitoring.

Material and Methods: The study included 61 pediatric patients who presented with paroxysmal symptoms and could not be diagnosed using standard tests. Patients' demographic data, clinical complaints, 24-hour Holter recordings, and ER records were analyzed retrospectively.

Results: The most common reason for admission was palpitations (57.4%). The most common rhythm finding detected by the ER was sinus tachycardia, identified in 28 patients (73.7%) during symptomatic episodes. Pathological arrhythmias were detected in 10 cases: ventricular extrasystoles (n=8), including uniform and bigeminal patterns and supraventricular tachycardia (n=2). Notably, while supraventricular extrasystoles were detected in two patients on 24-hour Holter monitoring, these findings were absent from the symptomatic recordings obtained with the ER. Gender, age, and the presence of structural heart disease had no statistically significant effect on the success of the ER (p>0.05).

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CAM & SAKURA MEDICAL JOURNAL

ABSTRACT

Conclusion: ERs offer significantly higher diagnostic success than 24-hour Holter monitoring in the diagnosis of infrequent rhythm disorders in children. Given their effectiveness in establishing symptom-rhythm correlation and promoting patient compliance, they should be considered a priority option for evaluating symptoms that cannot be explained by conventional methods.

Keywords: Child, arrhythmia, event recorder, Holter monitoring, palpitation

Introduction

Cardiac arrhythmias in children vary depending on the patients' ages and underlying cardiac events. They are observed in 1.5-2.5% of the general population (1,2). Various clinical situations are encountered, ranging from mild palpitations to syncope and sudden cardiac death (3). Palpitations are the most common reason for visits to pediatric cardiology outpatient clinics (4,5).

A detailed history and physical examination, in addition to electrocardiography (ECG) and echocardiography, constitute the gold-standard approach for diagnosing arrhythmias (6). Although ECG is a primary tool in diagnosing rhythm disorders, recordings obtained in the absence of symptoms are insufficient for diagnosis due to the paroxysmal nature of arrhythmias (7,8). For this reason, 24–48-hour Holter monitoring is routinely used to overcome this limitation and establish a symptom-rhythm relationship (9,10).

Nevertheless, 24-hour recordings are insufficient for definitive diagnosis in patients with less frequent symptoms (4,11). In patients with less frequent symptoms, event recorders (ERs) that can be activated at the time of symptom onset, have automatic detection capabilities, and offer recording for up to 30 days provide significant diagnostic advantages (12,13). While these devices have proven effective in adult patients, more data are needed on their effectiveness in pediatric patients and on their comparative effectiveness with other devices offering short-term recording capabilities (14).

The aim of our study is to determine the diagnostic value of ER use in children presenting to the pediatric cardiology outpatient clinic with complaints of palpitations, syncope, or chest pain, and to contribute to the literature by comparing ER data with other diagnostic tests.

Material and Methods

Sixty-one patients aged 0–18 years who presented to the pediatric cardiology clinic between March 2020 and March 2022 with various complaints, such as palpitations, chest pain, syncope, abdominal pain, and convulsions, were included.

Patients included in the study underwent routine history-taking, physical examination, 12-lead ECG, laboratory testing, echocardiography, and 24-hour Holter monitoring. An ER was used in patients without findings related to etiology. Patients over 18 years of age whose data and medical histories could not be accessed were not included in our study.

In this study, data from patients who presented with various complaints and had ER data were retrospectively reviewed.

The CardioMem® CM 100 XT (Getemed Medical and Information Technology) was used to record symptoms at onset. The patient initiated recordings by pressing the record button whenever they experienced symptoms. After the record button was pressed, the device recorded an electrocardiogram and stored it in memory along with the recording date and time. The recorded electrocardiograms were evaluated by the pediatric cardiology clinic. The study was approved by University of Health Sciences Türkiye, Çam and Sakura City Hospital Clinical Research Ethics Committee (decision number: 154, date: 11.05.2022). The study was conducted in accordance with the Declaration of Helsinki.

The rhythm findings obtained from the recordings were defined as follows: supraventricular tachycardia (SVT) –a rapid heart rhythm originating above the ventricles– was defined by three or more consecutive premature atrial beats at a rate exceeding age-specific normal limits. Supraventricular extrasystoles (SVE) are defined as premature beats originating from an ectopic atrial focus. Premature ventricular contractions (PVC) were defined as early ventricular beats characterized by a wide QRS complex and absence of a preceding P wave. Bigeminy is defined as a rhythm in which every normal beat is followed by a premature contraction. Uniform PVCs are ventricular premature beats originating from a single ectopic focus, resulting in identical QRS morphologies.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 21.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation.

Descriptive statistics such as mean, standard deviation, and percentage distributions were provided. Chi-square analysis was used to assess associations between categorical variables, and the Mann-Whitney U test was used for comparisons between two groups.

Findings

Data from 61 patients were included in the study: 38 (62.3%) were female and 23 (37.7%) were male. The ages of the patients included in the study ranged from 10 to 215 months, with a mean of 146.3±51.8 months (12.2±4.3 years).

The most common presenting complaint was palpitations (35 of 61, 57.4%), followed by chest pain, syncope, abdominal pain, murmur, and cramping (Table 1).

In the initial ECG evaluation, sinus tachycardia was observed in four patients; however, no other pathological findings were identified during the baseline examination.

The 24-hour Holter rhythm analysis revealed findings in 8 of 61 patients (13.1%). Pathological arrhythmias and conduction abnormalities were identified in 6 patients: including ventricular extrasystoles (n=3), SVE (n=2), and a prolonged PR interval with wide QRS (n=1). Additionally, sinus tachycardia during symptomatic episodes was recorded in two patients (25%).

On echocardiographic evaluation, 48 (78.7%) had normal findings, whereas 13 (21.3%) had abnormal findings. Three (23.3%) of the patients with a pathology had mitral valve insufficiency; other pathologies identified are shown in Table 2.

It was recommended that ERs be activated when patients experienced symptoms. Patients recorded a mean of 67.1±73.6 events (range, 2–308 events). Upon review, 38 of the event recordings were found to be abnormal.

The most common rhythm finding detected by the ER was sinus tachycardia, identified in 28 patients (73.7%) during symptomatic episodes. Pathological arrhythmias were detected in 10 cases, consisting of ventricular extrasystoles (n=8, including uniform and bigeminal patterns) and SVT (n=2). Notably, 31 (81.6%) of these 38 patients had no pathology detected during their initial 24-hour rhythm Holter monitoring, while pathology was detected in only 7 (18.4%). Conversely, among the 23 patients with normal ER results, sinus tachycardia was identified in the Holter recording of one patient (4.3%). This discrepancy was attributed to the initiation of beta-blocker therapy following the Holter diagnosis; the therapy subsequently suppressed the arrhythmia during ER monitoring.

When comparing patients' 24-hour Holter and ER results, sinus tachycardia was detected in two patients by the 24-hour Holter and in 28 patients by the ER. The comparison of 24-hour Holter rhythm and ER data is summarized in Table 3.

Table 1. Distribution of patients according to their presenting complaints

Complaint	n	%
Palpitations	35	57.4
Chest pain	13	21.3
Syncope	8	13.1
Abdominal pain	2	3.3
Rattling	2	3.3
Contraction	1	1.6
Total	61	100.0

Table 2. Distribution of echocardiographic findings

Finding	n	%
Mitral valve insufficiency	3	23.1
Ventricular septal defect	1	7.7
Coronary fistula	1	7.7
Left ventricular hypertrophy	1	7.7
Operated atrial septal defect	1	7.7
Cardiomyopathy and mitral valve insufficiency	1	7.7
Williams syndrome and supravalvular aortic stenosis	1	7.7
Tricuspid valve insufficiency mitral valve insufficiency	1	7.7
Mitral valve prolapse	1	7.7
Total	13	100.0

Table 3. **Comparison of pathological and symptom-related findings detected by 24-hour Holter and event recorder**

Findings	24-hour Holter (n)	Event recorder (n)
Pathological arrhythmias		
Supraventricular tachycardia	0	2
Ventricular extrasystoles	3	8
Supraventricular extrasystole	2	0
Long PR interval/Wide QRS	1	0
Symptom-related rhythms		
Sinus tachycardia	2	28
Total	8	38

Discussion

This study examined the diagnostic effectiveness of an ER for evaluating arrhythmia-associated symptoms in children, such as palpitations, chest pain, and syncope. The results showed that the ER system had a higher diagnostic rate compared with the 24-hour Holter monitor (62.3% vs. 13.1%), indicating its use was beneficial.

In the study by Wu et al. (15), patient-activated ER systems were shown to provide high sensitivity in the diagnosis of paroxysmal arrhythmia and to be effective in recording symptoms in real time. Furthermore, patient compliance was high because of the device's portable, user-friendly design (15). In another study, Makowska et al. (16) reported that patient-activated ER systems were highly effective in establishing symptom-rhythm correlation and diagnosing paroxysmal arrhythmia. Considering these findings, ERs appear to be a superior method for diagnosing intermittent and symptom-associated arrhythmias.

Similarly, the literature indicates that ERs offer an effective alternative in the diagnosis of rhythm disorders in pediatric patients when conventional methods are limited. In a large case series, Saygi et al. (8) reported that 73% of the 583 pediatric patients presented with palpitations, and pathology was detected in 39.4% of them. Similarly, in our study, the most common presenting symptom was palpitations at 57.4%. This parallelism indicates that palpitations are the most common symptom of arrhythmia during childhood.

While the 24-hour rhythm Holter is a widely used method for diagnosing arrhythmias, it often fails to capture arrhythmias during symptomatic episodes because the monitoring duration is limited. In our study, the diagnostic yield (defined as the detection of either pathological arrhythmias or a definitive symptom-rhythm correlation) was 13.1% for 24-hour Holter monitoring and 62.3% for the ER. The fact that the ER captured a rhythm in 62.3% of symptomatic episodes, even when the finding was a benign rhythm such as sinus tachycardia, demonstrates its superior clinical utility by providing a definitive clinical diagnosis and ruling out serious arrhythmias. This difference supports the findings of Park et al. (11), who reported that specific arrhythmias, such as atrioventricular reentrant tachycardia and atrioventricular nodal reentrant tachycardia, were identified in patients whose diagnoses were not confirmed by Holter monitoring but were detected with an ER (17).

In our study, the most frequently detected rhythm by the ER was sinus tachycardia (73.7%). A similar study by Ekşi et al. (18) also reported sinus tachycardia as the most common finding, with a prevalence of 50%. Although sinus tachycardia is a benign rhythm, confirming it during symptomatic episodes is clinically significant as it provides definitive symptom-rhythm correlation and rules out serious arrhythmias. In our study, pathological arrhythmias were detected in 26.3% of cases in which a rhythm was captured; these comprised ventricular extrasystoles (21%) and SVT (5.3%). In a study by Gass et al. (19) that used implantable loop recorders, serious arrhythmias such as SVT, ventricular tachycardia, and atrial fibrillation were detected. Similarly, Ergul et al. (17) diagnosed sinus bradycardia, AV block, and SVT in children with unexplained syncope, resulting in a change in clinical diagnosis in 29% of cases. Our findings, along with these studies, highlight that ERs are valuable tools for capturing both pathological arrhythmias and benign rhythms during symptomatic episodes, thereby facilitating a more accurate clinical assessment.

In a study by de Asmundis et al. (20) in an adult population, the detection rate was 1.8% with a 24-hour Holter monitor, whereas it reached 89% with an ER. Another study supporting this, conducted by Ekşi et al. (18), found that the diagnostic rate of the ER was 42.1%, whereas that of the 24-hour Holter monitor was 9.5%. These results are similar to the findings we obtained in pediatric patients and demonstrate that patient-triggered long-term recording systems significantly increase diagnostic success compared with conventional methods.

Our study clearly demonstrates the diagnostic power of ERs in providing a definitive clinical diagnosis for 31 patients for whom 24-hour Holter monitoring was insufficient. Zimetbaum et al. (7) also emphasized that ER systems contribute significantly to clinical practice by providing symptom–rhythm correlation. Furthermore, Gutgesell and Lindsey (14) stated that portable rhythm recording technologies increase diagnostic accuracy in pediatric cardiology; Galli et al. (12) emphasized that longer-term, patient-activated systems, such as ERs, are rapidly being integrated into clinical practice to address these limitations. Satou et al. (13), on behalf of the American Heart Association, emphasized in a scientific report that mobile health technologies, such as ERs, contribute to early diagnosis and follow-up, while potentially reducing clinical visits. Although Holter monitoring has been widely used in pediatric cardiology for many years, it remains limited by its short recording time and its frequent inability to capture data simultaneously with symptoms.

The most important advantage of ERs is that they can provide an ECG recording during symptomatic events (e.g., palpitations) and offer high patient comfort because of their size, mobility, and the absence of external electrodes attached to the patient's chest (21). Usadel et al. (22) reported that, in a study of 226 patients aged 0–17 years, the ER had a sensitivity of 92% for diagnosing SVT, 77% for detecting abnormal ECGs, and a specificity of 92%. Furthermore, the Pediatric and Congenital Electrophysiology Society/Heart Rhythm Society consensus report by Kusumoto et al. (23) emphasized that delays in diagnosing arrhythmia-related symptoms in childhood can lead to consequences, including cardiomyopathy, sudden cardiac events, and substantial deterioration in quality of life. It was noted that pediatric patients exhibit distinct characteristics relevant to arrhythmia diagnosis: symptoms are typically transient, irregular, and short-lived, and common misrepresentation of symptoms in younger age groups limits the effectiveness of other diagnostic methods (23). These findings emphasize that mobile diagnostic devices, such as ERs that patients can activate when symptoms develop, offer advantages over ECG and Holter monitoring for early diagnosis, particularly in the pediatric population. Furthermore, ERs yielded the same findings in most patients in whom Holter monitoring detected pathology, demonstrating that ERs also have high diagnostic accuracy. In this respect, they constitute a reliable alternative for diagnosis and follow-up.

Rossano et al. (24) found that in almost half of children presenting with syncope and palpitations, the symptoms were psychogenic rather than cardiac. This situation demonstrates that, especially in children with unexplained but recurrent symptoms, the diagnostic process is not limited to identifying pathology but also includes differentiating psychogenic causes and detecting normal rhythm (24). In this context, the ER is a valuable tool for excluding noncardiac causes in the differential diagnosis.

Study Limitations

Considering the limitations of this study, its retrospective and single-center design and the relatively limited number of patients restrict the applicability of the findings to other patient groups. Furthermore, the coincidence of the treatment process with the recording period in some patients is a potential limitation that may affect diagnostic accuracy. The lack of long-term follow-up data also prevented an assessment of the clinical course of arrhythmias. Therefore, larger, prospective, and multicenter studies are needed to evaluate the diagnostic efficacy of ER systems. Furthermore, advanced studies comparing new-generation mobile ECG technologies, wearable devices, and remote monitoring systems in the pediatric population will contribute to the personalization of diagnostic algorithms based on patient characteristics.

Conclusion

In conclusion, the data obtained in this study demonstrate that the use of ERs in patients presenting with suspected arrhythmia during childhood significantly contributes to the diagnostic process. In children with transient, recurrent symptoms such as palpitations, syncope, and chest pain, conventional diagnostic methods are often inadequate; however, the ER significantly increases diagnostic yield because it can record during symptomatic episodes. In our study, the diagnostic rate increased from 13.1% with 24-hour Holter monitoring to 62.3% with the ER, demonstrating that this method should be used more effectively in pediatric cardiology practice. Considering diagnostic accuracy, patient comfort, and ease of use, ER systems should be considered a priority option, especially for evaluating symptoms that cannot be explained by conventional tests.

Ethics

Ethics Committee Approval: The study was approved by University of Health Sciences Türkiye, Çam and Sakura City Hospital Clinical Research Ethics Committee (decision number: 154, date: 11.05.2022).

Informed Consent: Because of the retrospective design of the study, individual informed consent was waived.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.Ö., M.H.H.T., İ.C.T., Concept: M.Ö., İ.C.T., Design: E.Ö., İ.C.T., Data Collection or Processing: M.Ö., E.Ö., M.H.H.T., İ.C.T., Analysis or Interpretation: M.Ö., E.Ö., M.H.H.T., Literature Search: M.Ö., İ.C.T., Writing: M.Ö.

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Peripartum Hysterectomy for Uncontrolled Obstetric Hemorrhage Under Predominantly Emergency Conditions: A 10-Year Single-Center Experience (2015–2025)

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What is known on this subject?

Peripartum/postpartum hysterectomy is a rare but life-saving last-resort intervention for uncontrolled obstetric hemorrhage and is associated with substantial maternal morbidity; worldwide, uterine atony and placenta accreta spectrum (PAS) are the leading indications, and the burden of PAS has increased in parallel with rising cesarean delivery rates, with outcomes and complication profiles strongly shaped by whether PAS is managed in a planned multidisciplinary setting or under urgent/emergent conditions despite stepwise hemorrhage protocols (uterotonics, tranexamic acid, tamponade, and devascularization techniques) and frequent need for intensive care.

What this study adds?

This 10 year single-center series quantifies hemorrhage-related peripartum/postpartum hysterectomy in a setting where PAS is encountered almost exclusively under urgent/emergent conditions, describes real-world stepwise hemorrhage management and perioperative resource use (including transfusion and intensive care unit admission), and clarifies that fetal losses recorded in the atony category reflected intrauterine fetal demise present prior to delivery rather than a direct fetal effect of uterine atony.

ABSTRACT

Objective: Peripartum/postpartum hysterectomy is a rare but life-saving intervention for uncontrolled obstetric hemorrhage. Placenta accreta spectrum (PAS) and uterine atony are the most common indications; yet their clinical context and operative pathways may differ, particularly in centers where PAS is managed under urgent or emergent conditions. We evaluated indications, surgical management, and outcomes over a 10-year period and explored differences between uterine atony–related and PAS-related cases.

Material and Methods: This retrospective, single-center study included women who underwent peripartum or postpartum hysterectomy for uncontrolled obstetric hemorrhage between January 2015 and June 2025. Cases were classified as uterine atony or PAS/placenta previa–related hemorrhage based on operative findings, clinical course, and pathology. Continuous variables were summarized as median [interquartile range (IQR)] and compared using the Mann–Whitney U test; categorical variables were compared using Fisher's exact test. Effect estimates with 95% confidence intervals (bootstrap for continuous variables) are provided in the tables; comparisons were exploratory.

Results: Among 31,571 deliveries, 34 hemorrhage-related peripartum/postpartum hysterectomies were identified (incidence: 1.1 per 1,000 deliveries): 18 for uterine atony (52.9%) and 16 for PAS-related hemorrhage (47.1%). All PAS cases met an a priori definition of urgent or emergent. Transfusion requirements were higher in the uterine atony group than in the PAS group, with median packed red blood cells (PRBCs) of 4 (3-6) vs. 2 (0.8-3.2) units (p=0.003),

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ABSTRACT

and median fresh frozen plasma of 2 (2-4) vs. 1 (0-2.2) units (p=0.020). Intensive care unit (ICU) admission occurred in 66.7% of uterine atony cases and in 43.8% of PAS cases (p=0.300). Overall ICU length of stay (including 0.0 days for non-admitted patients) was 1.0 (0.0–2.0) days vs. 0.0 (0.0–1.0) days (p=0.048). Median hospital stay was 6.5 (5.0–11.0) vs. 5.5 (4.0-7.0) days (p=0.265). One maternal death occurred in the uterine atony group; none occurred in the PAS group.

Conclusion: Hemorrhage-related peripartum/postpartum hysterectomy was rare but associated with substantial maternal morbidity. PAS cases were managed predominantly in urgent or emergent conditions. Exploratory comparisons suggested a greater transfusion burden and longer ICU stays among uterine atony cases, underscoring institutional preparedness, timely escalation, and multidisciplinary hemorrhage management.

Keywords: Peripartum hysterectomy, postpartum hemorrhage, placenta accreta spectrum, uterine atony, emergency obstetric care

Introduction

Postpartum hysterectomy remains one of the most dramatic yet life-saving interventions in obstetric practice, representing the final step in the management of uncontrollable obstetric hemorrhage (1). Postpartum hemorrhage continues to be a leading contributor to maternal morbidity and mortality worldwide, and timely escalation from medical and conservative measures to definitive surgical control is critical when bleeding persists (1,2,3,4).

Placenta accreta spectrum (PAS) and uterine atony are consistently reported as the two most common indications for peripartum hysterectomy (1). The global increase in cesarean delivery rates has been accompanied by a substantial rise in PAS, which is associated with massive hemorrhage, technical surgical complexity, and high rates of maternal morbidity (5,6,7). Uterine atony, defined by inadequate uterine contraction after delivery, remains the leading cause of postpartum hemorrhage and can rapidly progress to hemorrhagic shock and coagulopathy when unresponsive to uterotonics and conservative surgical techniques (1,2).

Although both etiologies can culminate in hysterectomy, their clinical contexts and operative pathways often differ. In many settings, PAS is increasingly managed through planned, multidisciplinary care in appropriately resourced centers, and the commonly accepted surgical approach is cesarean hysterectomy with the placenta left in situ to avoid catastrophic bleeding (3,6). However, this model is not universally available. In institutions without dedicated perinatology services or structured referral pathways, suspected or unrecognized PAS may present as an emergency, and hysterectomy may be performed under urgent conditions (8). Conversely, atonic hemorrhage typically occurs unexpectedly and demands rapid resuscitation and stepwise escalation (9). Importantly, adverse fetal outcomes observed among cases requiring hysterectomy for uterine atony may reflect the severity of the underlying obstetric condition at presentation [e.g., intrauterine fetal demise (IUFD) or placental abruption] rather than a direct fetal effect of uterine atony.

In Türkiye, published data on postpartum hysterectomy remain limited, and longer-term single-center experiences may provide valuable insight into institutional case-mix, emergency surgical decision-making, and maternal outcomes over time (10).

Therefore, this study aimed to evaluate the indications, surgical management, and outcomes of peripartum/postpartum hysterectomy casesat our institution between 2015 and 2025 and to provide an exploratory comparison of hysterectomy cases for PAS-related hemorrhage and for uterine atony-related hemorrhage, examining differences in operative course, transfusion burden, intensive care unit (ICU) utilization, and maternal morbidity (without implying etiologic equivalence).

Material and Methods

This study was a retrospective, descriptive, single-center analysis conducted in the Clinic of Obstetrics and Gynecology at the University of Health Sciences Türkiye, Gaziosmanpaşa Training and Research Hospital. Archival delivery records were reviewed for the period between January 1, 2015, and June 30, 2025. During this interval, 31,571 deliveries occurred at our institution, and all cases that underwent peripartum/postpartum hysterectomy were retrospectively identified and evaluated.

Ethical Approval

The study was approved by the Clinical Research Ethics Committee of Gaziosmanpaşa Training and Research Hospital (approval number: 147; date: 15.10.2025). Because of the retrospective design of the study, individual informed consent was waived. All data were anonymized in accordance with the Declaration of Helsinki.

Study Population

Women aged ≥18 years who underwent hysterectomy due to uncontrolled obstetric hemorrhage occurring during delivery or in the postpartum period were included. Hysterectomies performed for non-obstetric indications (e.g., benign gynecologic disease or malignancy) and cases with incomplete clinical records were excluded. A small number of hysterectomies performed after vaginal delivery were included and evaluated together with cases following cesarean delivery because the focus of the study was hemorrhage-related hysterectomy regardless of delivery mode.

Case Classification and Clinical Context

Eligible cases were classified into two etiologic groups based on operative notes, clinical course, and pathology reports when available:

1. Uterine atony: Persistent postpartum hemorrhage attributed to inadequate uterine tone and refractory to medical therapy and stepwise conservative surgical interventions.

2. PAS/placenta previa–related hemorrhage: Hysterectomy performed for hemorrhage in the setting of placenta previa and/or suspected PAS intraoperatively and/or confirmed by pathology (accreta, increta, percreta).

In this study, PAS cases were classified as "urgent/emergent" when hysterectomy was performed in a non-elective, unscheduled setting due to an acute obstetric indication, including one or more of the following: (i) unplanned presentation to our unit (transfer-in or direct admission without a scheduled operative plan), (ii) active vaginal bleeding or ongoing hemorrhage, (iii) labor or membrane rupture prompting an urgent delivery, (iv) maternal hemodynamic instability or need for immediate resuscitation, or (v) an emergent indication for cesarean delivery (e.g., fetal distress). Because our institution does not have an in-house perinatology service and does not operate a dedicated PAS program or a structured referral pathway for planned multidisciplinary PAS care, scheduled elective cesarean hysterectomies were not performed during the study period. Accordingly, all PAS hysterectomies included in the analytic cohort met the above urgent/emergent definition.

Neonatal outcomes were recorded where applicable. Stillbirth events were interpreted in their clinical context. In this cohort, stillbirth reflected IUFD that was present prior to delivery at admission or prior to the onset of delivery rather than fetal compromise attributable to uterine atony itself.

A single non-hemorrhagic postpartum hysterectomy case, related to mechanical ileus secondary to inadequate uterine involution, was documented as an additional clinical observation and not included in the hemorrhage-focused analytic cohort.

Data Collection and Outcomes

Data were obtained through a detailed review of patient files, operative reports, laboratory results, discharge summaries, and pathology reports. The following variables were recorded: maternal age; parity; body mass index (BMI); number of previous cesarean deliveries; gestational age; indication for delivery; mode of delivery; type of hysterectomy (total or subtotal); hemostatic techniques (e.g., uterine artery ligation; internal iliac/hypogastric artery ligation; compression sutures; intrauterine balloon tamponade); transfusion requirements [packed red blood cells (PRBCs), fresh frozen plasma (FFP), and platelet suspension]; need for admission to the ICU; length of hospital stay; postoperative complications; and maternal mortality. Postoperative complications were graded according to the Clavien-Dindo classification (10). ICU length of stay is recorded in the electronic record for all patients; non-admitted patients are coded as 0.0 days. Therefore, ICU admission (yes/no) and ICU length of stay were analyzed and reported separately, and length of stay among ICU-admitted patients was additionally summarized. ICU admission was defined as transfer to the ICU for postoperative management due to clinical instability or the need for advanced monitoring/support, including hemodynamic instability or vasopressor requirement; massive transfusion/ongoing resuscitation; invasive hemodynamic monitoring; ventilatory/respiratory support; persistent coagulopathy [e.g., disseminated intravascular coagulation (DIC)]; or other organ dysfunction requiring ICU-level care.

All collected data were entered into an anonymized electronic database by the investigators. Data quality control was performed through verification sampling by two independent researchers. ICU-related variables were cross-checked for internal consistency, and ICU admission was defined a priori as described above.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed by the Shapiro–Wilk test and by visual inspection of the distributions. If the Shapiro–Wilk test yielded $p<0.05$ or visual inspection suggested non-normality, non-parametric methods were preferred. Given the small sample size and skewed distributions for key outcomes, continuous variables are reported as median [interquartile range (IQR)] and compared using the Mann–Whitney U test. Categorical variables are

presented as n (%) and compared using Fisher's exact test. Effect estimates are reported as median differences (atony-PAS) with 95% confidence intervals (CIs) obtained via bootstrap resampling (20,000 resamples) for continuous variables, and as odds ratios with 95% CI for categorical variables. Two-sided p values are reported for exploratory comparisons. Available-case analysis was used for variables with missing values. Given the retrospective design and limited sample size, the findings were interpreted cautiously.

Results

During the study period (January 2015–June 2025), a total of 31,571 deliveries were performed at our institution. Within the hemorrhage-focused analytical cohort, 34 patients underwent peripartum or postpartum hysterectomy due to uncontrolled obstetric hemorrhage, corresponding to an incidence of 1.1 per 1,000 deliveries.

The etiologic categories of hemorrhage-related hysterectomy were uterine atony (n=18, 52.9%) and PAS or placenta previa-related hemorrhage (n=16, 47.1%). No hysterectomies performed for non-obstetric gynecologic indications (e.g., benign disease or malignancy) were included in the analytic cohort.

Demographic and Obstetric Characteristics

Maternal demographic and obstetric characteristics are summarized in Table 1.

In the uterine atony group, the median maternal age was 33.0 (29.2-37.8) years, and the median BMI was 27.5 (26.0-28.0) kg/m^2. The median gestational age at delivery was 38.0 (35.5-39.0) weeks. The median parity was 3.0 (1.2-4.0), and the median number of previous cesarean deliveries was 2.0 (0.0-3.0). In 94.4% of cases, delivery was by cesarean section.

In the PAS group, median maternal age was 31.0 (28.0-38.0) years and median BMI was 27.5 (26.0-28.0) kg/m^2. Median gestational age at delivery was 36.5 (34.0-37.2) weeks. Median parity and median number of previous cesarean deliveries were both 3.0 (2.0-3.0). All PAS cases were delivered by cesarean section. All PAS cases in this cohort were managed under urgent or emergent conditions.

Neonatal outcomes are presented in Table 1. The median birth weight was 2970.0 (2717.5-3422.2) g in the uterine atony group and 2745.0 (2367.5-3066.2) g in the PAS group. Three cases in the uterine atony group had a stillbirth; in all three, IUFD was present at presentation/admission prior to delivery. All neonates in the PAS group were born alive. The median 1-minute Apgar score was 9.0 (5.5-9.0) in the uterine atony group and was 9.0 (9.0-9.0) in the PAS group. An American Society of Anesthesiologists score ≥3 was recorded in 5.6% of uterine atony cases and 6.2% of PAS cases.

Intraoperative and Surgical Characteristics

Intraoperative management is presented in Table 2.

Among patients in the uterine atony group, 61.1% had intraoperative atony and 38.9% developed postoperative atony. All patients received medical treatment; tranexamic acid was administered in 88.9% of patients and an intrauterine balloon (Bakri) was used in 27.8% of patients. Hemostatic procedures included uterine artery ligation (88.9%), internal iliac/hypogastric artery ligation (83.3%),and uterine compression sutures (61.1%).

In the PAS group, hysterectomy was performed following cesarean delivery as part of hemorrhage control. Prophylactic salpingectomy was performed in 87.5% of PAS cases and 88.9% of uterine atony cases. Total hysterectomy was performed in 55.6% of uterine atony cases and in 75.0% of PAS cases. Intraoperative bladder injury occurred in 16.7% of uterine atony cases and in 18.8% of PAS cases.

Transfusion requirements are shown in Table 2. In the uterine atony group, transfusion requirements were higher, with a median of 4 (3-6) units of PRBCs and 2 (2-4) units of FFP, compared with medians of 2 (0.8-3.2) PRBC units and 1 (0-2.2) FFP unit in the PAS group. Platelet transfusion was uncommon in both groups [median 0 (0-0) units].

Postoperative Outcomes and Complications

Postoperative outcomes are summarized in Table 3.

The median length of hospital stay was 6.5 (5.0-11.0) days in the uterine atony group and 5.5 (4.0-7.0) days in the PAS group. ICU admission (ICU stay >0 days) was required in 66.7% of uterine atony cases and in 43.8% of PAS cases. Overall ICU length of stay (including 0.0 days for non-admitted patients) was 1.0 (0.0-2.0) days in the uterine atony group and 0.0 (0.0-1.0) days in the PAS group; among ICU-admitted patients, it was 2.0 (1.0-3.8) vs. 1.0 (1.0-1.0) days, respectively. No rehospitalizations after discharge were documented. One maternal death occurred in the uterine atony group (Clavien-Dindo grade V); no deaths were recorded in the PAS group. The patient underwent an emergency hysterectomy for uncontrolled obstetric hemorrhage, required postoperative intensive care, and, despite ongoing resuscitative management, died in the early postoperative period from DIC. Spinal anesthesia was used in most cases (Table 3).

Early postoperative complications in the uterine atony group included single cases of acute kidney injury, sepsis, shock, and coronavirus disease-2019 (COVID-19) infection.

In the PAS group, one case of pneumothorax was reported. No late postoperative complications were observed during the follow-up period. According to the Clavien-Dindo classification, complications of grade II or higher occurred in 38.9% of uterine atony cases and 25.0% of PAS cases.

Histopathological examination of PAS specimens demonstrated grade 1 invasion in 43.8% of cases, grade 2 in 37.5% of cases, and grade 3 in 18.8% of cases.

Additional Observation

One patient underwent hysterectomy on postoperative day 3 due to progressive mechanical ileus following elective cesarean delivery. Despite conservative management, serial imaging demonstrated persistent bowel distension and minimal intra-abdominal fluid. Exploratory laparotomy revealed no intestinal injury; however, the uterus was markedly enlarged (17×15×9 cm) and compressing adjacent bowel loops. A supracervical hysterectomy was performed; symptoms resolved afterward, and the patient was discharged on postoperative day 5. Histopathological examination demonstrated PAS (grade 1) with no evidence of infection or necrosis. This case was not included in Tables 1-3 because the indication for hysterectomy was non-hemorrhagic and clinically distinct from hemorrhage-related hysterectomy.

Discussion

Postpartum hysterectomy remains one of the most critical and life-saving procedures in obstetric practice. Although uncommon, it continues to represent a severe maternal morbidity ("near-miss") event and is typically performed for uncontrolled obstetric hemorrhage (11). Reported rates vary by setting and case-mix, with systematic reviews and population-based data generally placing emergency peripartum hysterectomy around approximately 1 per 1,000 births, while acknowledging wide between-country variation (1,12). In our institution, the hemorrhage-related peripartum/postpartum hysterectomy rate over the 2015–2025 period was 1.1 per 1,000 deliveries, which falls within the range reported in the literature (1).

Table 1. Maternal, delivery, and neonatal characteristics of hemorrhage-related peripartum/postpartum hysterectomy cases, presented by etiologic group

Variable	Uterine atony (n=18)	PAS (n=16)	p value
Maternal characteristics			
Age (years)	33.0 [29.2-37.8]	31.0 [28.0-38.0]	0.904[a]
BMI (kg/m²)	27.5 [26.0-28.0]	27.5 [26.0-28.0]	0.839[a]
Parity	3.0 [1.2-4.0]	3.0 [2.0-3.0]	0.331[a]
Gestational age at delivery (weeks)	38.0 [35.5-39.0]	36.5 [34.0-37.2]	0.053[a]
Number of prior cesarean deliveries	2.0 [0.0–3.0]	3.0 [2.0-3.0]	0.112[a]
Mode of delivery			
Cesarean delivery	17 (94.4%)	16 (100%)	1.000[b]
Vaginal delivery	1 (5.6%)	0 (0%)	—
Neonatal outcomes			
Birth weight (g)	2970.0 [2717.5-3422.2]	2745.0 [2367.5-3066.2]	0.129[a]
1 minute Apgar score	9.0 [5.5-9.0]	9.0 [9.0-9.0]	0.038[a]
Live birth	15 (83.3%)	16 (100%)	0.230[b]
IUFD at admission (pre-delivery)[†]	3 (16.7%)	0 (0%)	—
Preoperative status			
ASA score ≥3	1 (5.6%)	1 (6.2%)	1.000[b]
Antepartum/obstetric context			
Placental abruption	2 (11.1%)	0 (0%)	0.487[b]
Fetal macrosomia	1 (5.6%)	0 (0%)	1.000[b]

Data are presented as median [IQR] or n (%). Between-group inferential comparisons were performed using the Mann–Whitney U test. [a]For continuous variables and Fisher's exact test, [b]for categorical variables. For complementary binary categories (e.g., cesarean/vaginal delivery; live birth/IUFD), the p value is shown once for readability. Available-case analysis was used for variables with missing values. [†]IUFD indicates intrauterine fetal demise present prior to delivery (at presentation/admission) and is reported to provide clinical context; it is not interpreted as a fetal effect attributable to uterine atony

BMI: Body mass index, PAS: Placenta accreta spectrum, IUFD: Intrauterine fetal demise, ASA: American Society of Anesthesiologistss

Table 2. Intraoperative and surgical characteristics of hemorrhage-related peripartum/postpartum hysterectomy cases, presented by etiologic group

Variable	Uterine atony (n=18)	PAS (n=16)	Effect estimate [median difference (atony-PAS), 95% CI]/ odds ratio (atony vs. PAS), 95% CI	p value
Transfusion requirements				
PRBC transfused (units)	4 [3-6]	2 [0.8-3.2]	Δmedian 2 (0.5-4)	**0.003**[a]
FFP transfused (units)	2 [2-4]	1 [0-2.2]	Δmedian 1 (0-3.5)	**0.020**[a]
Platelets transfused (units)	0 [0-0]	0 [0-0]	Δmedian 0 (0-0)	0.179[a]
Atony-specific hemorrhage-control measures				
Perioperative atony timing (intraop/postop)	Intraop 11 (61.1%); postop 7 (38.9%)	N/A	—	—
Medical treatment	18 (100.0%)	N/A	—	—
Tranexamic acid use	16 (88.9%)	N/A	—	—
Intrauterine balloon (Bakri)	5 (27.8%)	N/A	—	—
Internal iliac (hypogastric) artery ligation	15 (83.3%)	N/A	—	—
Uterine artery ligation	16 (88.9%)	N/A	—	—
Uterine compression sutures	11 (61.1%)	N/A	—	—
Procedure characteristics				
Type of hysterectomy: total/supracervical	Total 10 (55.6%); supracervical 8 (44.4%)	Total 12 (75.0%); supracervical 4 (25.0%)	OR 0.42 (0.10-1.80)	0.297[b]
Prophylactic salpingectomy	16 (88.9%)	14 (87.5%)	OR 1.14 (0.14-9.21)	1.000[b]

Data are presented as median [IQR] or n (%). Between-group comparisons were performed using the Mann–Whitney U test. [a]For continuous variables and Fisher's exact test. [b]For categorical variables. Effect estimates are reported as median difference (Atony-PAS) with 95% CI (bootstrap, 20,000 resamples) for continuous variables and odds ratio (Atony vs. PAS) with 95% CI for categorical variables. p values are reported for variables applicable to both groups; atony-specific management variables are shown descriptively (N/A for PAS)

PRBC: Packed red blood cells, FFP: Fresh frozen plasma, PAS: Placenta accreta spectrum, N/A: Not applicable, IQR: Interquartile range, CI: Confidence interval, OR: Odds ratio

In this cohort, the leading etiologies were uterine atony and PAS, consistent with contemporary obstetric hemorrhage literature and guidelines (3,13). Rising cesarean delivery rates are recognized as a major driver of PAS, and the history of prior cesarean deliveries commonly observed among PAS cases in our series aligns with this established association (6,13).

The operative course for hemorrhage-related hysterectomy typically follows a stepwise escalation strategy: it begins with medical therapy, progresses through conservative surgical measures, and proceeds to definitive surgery if bleeding remains uncontrolled. This approach is consistent with major guidelines and hemorrhage bundles emphasizing rapid recognition, early escalation, and structured algorithms for postpartum hemorrhage management (3,14,15). In our series, uterotonics, tranexamic acid, balloon tamponade, vascular ligation procedures, and compression sutures were used as part of hemorrhage control, with hysterectomy performed when these measures did not achieve adequate hemostasis (16). PRBC and FFP transfusion requirements were higher in the uterine atony group than in the PAS group (Table 2), with median PRBC of 4 (3-6) vs. 2 (0.8-3.2) units and median FFP of 2 (2-4) vs. 1 (0-2.2) units, respectively. These differences should be interpreted cautiously, given the retrospective design and limited sample size, and should be viewed as exploratory estimates with associated uncertainty (effect estimates with 95% CIs are provided in Table 2). A possible explanation is that severe uterine atony may progress rapidly despite sequential medical and surgical hemorrhage control measures, resulting in ongoing blood loss before a definitive hysterectomy is undertaken. Although PAS cases in this cohort were also managed under urgent/emergent conditions, the surgical team may have entered the procedure with greater anticipation of major hemorrhage and earlier preparation for transfusion. This interpretation

Table 3. Postoperative outcomes and complications of hemorrhage-related peripartum/postpartum hysterectomy cases, presented by etiologic group

Variable	Uterine atony (n=18)	PAS (n=16)	Effect estimate (95% CI)	p value
Hospital course				
Hospital stay (days), median [IQR]	6.5 [5.0-11.0]	5.5 [4.0-7.0]	Δmedian 1.0 (−1.5 to 4.5)	0.265[a]
ICU length of stay (days), median [IQR][†]	1.0 [0.0-2.0]	0.0 [0.0-1.0]	Δmedian 1.0 (−0.5 to 2.0)	0.048[a]
ICU length of stay (days), among ICU-admitted, median [IQR]	2.0 [1.0-3.8]	1.0 [1.0-1.0]	Δmedian 1.0 (0.0 to 3.5)	0.054[a]
ICU admission (ICU stay >0 days), n (%)	12 (66.7%)	7 (43.8%)	OR: 2.57 (0.64-10.34)	0.300[b]
Rehospitalization, n (%)	0 (0%)	0 (0%)	—	—
Maternal mortality, n (%)	1 (5.6%)	0 (0%)	OR: 2.83 (0.11-74.46)*	1.000[b]
Anesthesia and intraoperative complication				
Anesthesia: spinal, n (%)	15 (83.3%)	13 (81.2%)	OR: 1.15 (0.20-6.74), p: 1.000[b]	1.000[b]
Anesthesia: general, n (%)	3 (16.7%)	3 (18.8%)	—	—
Intraoperative bladder injury/perforation, n (%)	3 (16.7%)	3 (18.8%)	OR: 0.87 (0.15-5.06), p: 1.000[b]	1.000[b]
Early postoperative complications, n (%)				
Any early postoperative complication	4 (22.2%)	1 (6.2%)	OR: 4.29 (0.43-43.14)	0.340[b]
Acute kidney injury	1 (5.6%)	0 (0%)		—
Sepsis	1 (5.6%)	0 (0%)		—
Shock	1 (5.6%)	0 (0%)		—
COVID-19 infection	1 (5.6%)	0 (0%)		—
Pneumothorax	0 (0%)	1 (6.2%)		—
Clavien-Dindo grade, n (%)				
Clavien-Dindo grade ≥II (composite)	7 (38.9%)	4 (25.0%)	OR: 1.91 (0.44-8.35)	0.477[b]
Grade I	0 (0%)	0 (0%)		—
Grade II	1 (5.6%)	0 (0%)		—
Grade III[a]	0 (0%)	0 (0%)		—
Grade III[b]	3 (16.7%)	4 (25.0%)		—
Grade IV	2 (11.1%)	0 (0%)		—
Grade V	1 (5.6%)	0 (0%)		—
Pathology (PAS invasion grade), n (%)				
PAS grade 1	N/A	7 (43.8%)		—
PAS grade 2	N/A	6 (37.5%)		—
PAS grade 3	N/A	3 (18.8%)		—

*Data are presented as median [IQR] or n (%). Between-group comparisons were performed using the Mann–Whitney U test. [a]For continuous variables and Fisher's exact test. [b]For categorical variables. Effect estimates are reported as median difference (Atony-PAS) with 95% C I(bootstrap, 20,000 resamples) for continuous variables and OR with 95% CI for categorical variables. ICU length of stay (days), median [IQR][†] includes non-admitted patients coded as 0.0 days in the electronic record; ICU admission is therefore reported separately, and ICU length of stay among ICU-admitted patients is additionally shown. *Mortality OR uses a continuity correction due to a zero cell*

ICU: Intensive care unit, PAS: Placenta accreta spectrum, IQR: Interquartile range, OR: Odds ratio, COVID-19: Coronavirus disease-2019, N/A: Not applicable

is hypothesis-generating and should be considered in light of the retrospective design and limited sample size. The higher rates of internal iliac artery ligation in uterine atony cases reflect the need for escalating pelvic devascularization in refractory hemorrhage.

A key contextual factor in interpreting our PAS cases is the absence of an in-house perinatology service and a structured referral pathway for planned PAS management. As a result, PAS-related hysterectomies in this cohort were managed under urgent or emergent conditions rather than as scheduled

elective cesarean hysterectomies. This is clinically relevant because planned, multidisciplinary PAS management is widely recommended to optimize preparedness, blood product availability, surgical support, and perioperative coordination (6,13,17). Our experience, therefore, reflects the realities faced by many centers where suspected or unrecognized PAS may present as emergencies, reinforcing the importance of strengthening referral networks and institutional readiness.

The choice between subtotal and total hysterectomy is typically individualized and driven by bleeding site (especially lower uterine segment and cervical involvement), anatomic distortion, and the patient's hemodynamic condition. In our cohort, both approaches were used, reflecting pragmatic intraoperative decision-making under hemorrhagic conditions. Current guidance similarly emphasizes tailoring the surgical approach to operative findings and available expertise rather than a single universal technique (3).

Urinary tract injury, particularly bladder injury, is a recognized complication of cesarean hysterectomy and is commonly discussed in the PAS literature due to adhesions, distorted anatomy, and the surgical planes encountered at the vesicouterine interface (6,13,18). In our series, bladder injuries occurred in both etiologic categories and were identified intraoperatively and repaired immediately. Importantly, even in cases classified as uterine atony, factors such as prior uterine surgery, emergency operative conditions, limited visualization, and hemodynamic instability can increase the risk of iatrogenic injury during rapid dissection. Documentation of intraoperative recognition and immediate repair, together with postoperative follow-up, remains essential for contextualizing these events and assessing longer-term sequelae.

Postoperative morbidity was substantial in this cohort, with frequent ICU utilization and a spectrum of complications. Such findings are consistent with the clinical reality that postpartum hysterectomy represents an endpoint of severe hemorrhage and physiologic decompensation rather than an isolated surgical event (3,12). ICU admission and ICU length of stay likely reflected both clinical severity and postoperative monitoring needs (e.g., hemodynamic instability, hemorrhagic shock/resuscitation requirements, transfusion burden, invasive monitoring or ventilatory support, and postoperative complications). As ICU length of stay is recorded for all patients in the electronic record—with non-admitted patients coded as 0.0 days—ICU admission (yes/no) and ICU length of stay were reported separately; length of stay among ICU-admitted patients was additionally summarized. In the uterine atony group, isolated events such as acute kidney injury, sepsis, shock, and COVID-19 infection were observed; in the PAS group, pneumothorax occurred in one case. Given the sample sizes inherent in hysterectomy cohorts, reporting these complications as counts, in addition to percentages, is important to avoid overinterpretation.

In addition, dispersion in postoperative length-of-stay metrics warrants careful interpretation. Variability in hospital length of stay, particularly for the uterine atony group, likely reflects heterogeneity in hemorrhage severity, hemodynamic instability, transfusion burden, postoperative complications, and recovery after emergency surgery. Given the small sample size and skewed distributions, length-of-stay outcomes were summarized using medians IQR and reported with effect estimates and 95% CIs (Table 3). Medians are less sensitive to extreme values than means.

Interpretation of fetal outcomes in hemorrhage-related hysterectomy requires careful consideration of the clinical context. Uterine atony is defined as inadequate uterine tone after delivery and does not represent a direct fetal pathophysiologic mechanism. In our cohort, stillbirths recorded under the uterine atony category reflected IUFD that was present at presentation/admission prior to delivery, rather than fetal compromise attributable to uterine atony. This distinction is essential to avoid misleading causal inferences and accurately reflect the acuity and severity of the underlying obstetric presentation.

We documented a single non-hemorrhagic case of progressive postoperative mechanical ileus associated with a markedly enlarged postpartum uterus and bowel compression, in which hysterectomy resulted in rapid clinical improvement. Pathology demonstrated a grade 1 PAS. Although rare and not included in the hemorrhage-focused analytic cohort, this observation underscores that postpartum surgical follow-up may reveal uncommon mechanical complications, and that atypical clinical trajectories warrant prompt evaluation.

Study Limitations

This study has limitations inherent to retrospective, single-center analyses, including reliance on documentation quality and limited generalizability. The sample size, although representative of a single-center hysterectomy cohort, reduces the granularity of subgroup analyses and limits causal inference. The absence of a planned PAS program and referral pathway at our institution shifts the case-mix toward more urgent/emergent presentations, which should be considered when interpreting operative characteristics and outcomes. Because the study focused on hysterectomy cases, it does not quantify the total number of uterine atony or PAS cases managed

without hysterectomy over the same period and therefore does not provide hysterectomy conversion rates for these conditions.

Detailed information regarding antenatal PAS diagnosis and referral pathways was not uniformly documented in the retrospective records, limiting more granular analysis of planned versus unplanned presentations.

Between-group analyses were exploratory, and we, therefore, emphasized transparent reporting of effect estimates and CIs alongside p-values to reflect statistical uncertainty.

Conclusion

Peripartum/postpartum hysterectomy remains a rare but essential life-saving intervention for uncontrolled obstetric hemorrhage and is associated with substantial maternal morbidity. Institutional preparedness, including standardized hemorrhage protocols, timely escalation of care, rapid access to blood products, surgical expertise, and multidisciplinary coordination, is critical for optimizing outcomes, particularly in settings where PAS frequently presents under urgent or emergent conditions.

Ethics

Ethics Committee Approval: The study was approved by the Clinical Research Ethics Committee of Gaziosmanpaşa Training and Research Hospital (approval number: 147; date: 15.10.2025).

Informed Consent: Because of the retrospective design of the study, individual informed consent was waived.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.S.C., H.B.B., Concept: E.S.C., Design: E.S.C., Data Collection or Processing: E.S.C., H.B.B., Analysis or Interpretation: E.S.C., H.B.B., Literature Search: E.S.C., Writing: E.S.C.

Conflict of Interest: No conflict of interest was declared by the authors.

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Letter to the Editor: Dextrose Prolotherapy in Freiberg's Disease: A Clinical Observation

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Keywords: Freiberg's disease, osteochondrosis, metatarsal, prolotherapy

To the Editor,

Freiberg's disease is a rare form of osteochondrosis that most commonly affects the head of the second metatarsal. It is thought to involve avascular necrosis resulting from repetitive microtrauma, mechanical loading and local circulatory impairment (1,2). It usually occurs during adolescence and young adulthood, and is more prevalent in females (3). Clinically, this condition presents with pain and tenderness in the forefoot that increase with weight-bearing and pose difficulties in selecting a treatment, particularly in cases that do not respond to conservative treatment.

A 44-year-old woman presented with a one-month history of pain localised to the forefoot region of the second toe on her right foot, worsened by walking and relieved by rest. At presentation, pain was 2/10 at rest and 8/10 with walking on the visual analog scale (VAS). Physical examination showed normal skin findings and marked tenderness over the second metatarsal head. Plain radiography demonstrated irregularity and flattening of the second metatarsal head consistent with Smillie stage III Freiberg's disease (Figure 1). Magnetic resonance imaging revealed deformity and T1-weighted signal loss at the second metatarsal head, findings compatible with osteonecrosis.

The patient was advised to use a metatarsal pad, modify footwear, and use oral and topical nonsteroidal anti-inflammatory drugs. She also underwent 15 sessions of physical therapy, including electrotherapy and underwater pulsed ultrasound (1.5 W/cm^2), without meaningful improvement. One month after physical therapy, approximately 2 cc of a 5% dextrose solution was injected around the second metatarsal head using a 27G, 40-mm needle. This procedure is known as periarticular prolotherapy and uses the palpation technique. One week later, the patient was re-evaluated, and the VAS score was 0/10 at rest and 5/10 when walking. A second periarticular injection was administered using 10% dextrose with the same technique. At the 3-week follow-up after the second injection, the patient was pain-free. At 6 and 12 month follow-up evaluations, she reported no recurrence of pain or functional limitations. No local or systemic adverse events were observed throughout follow-up.

Prolotherapy is a non-surgical injection approach intended to stimulate reparative processes in ligaments, tendons, joint capsules, and entheses (4).

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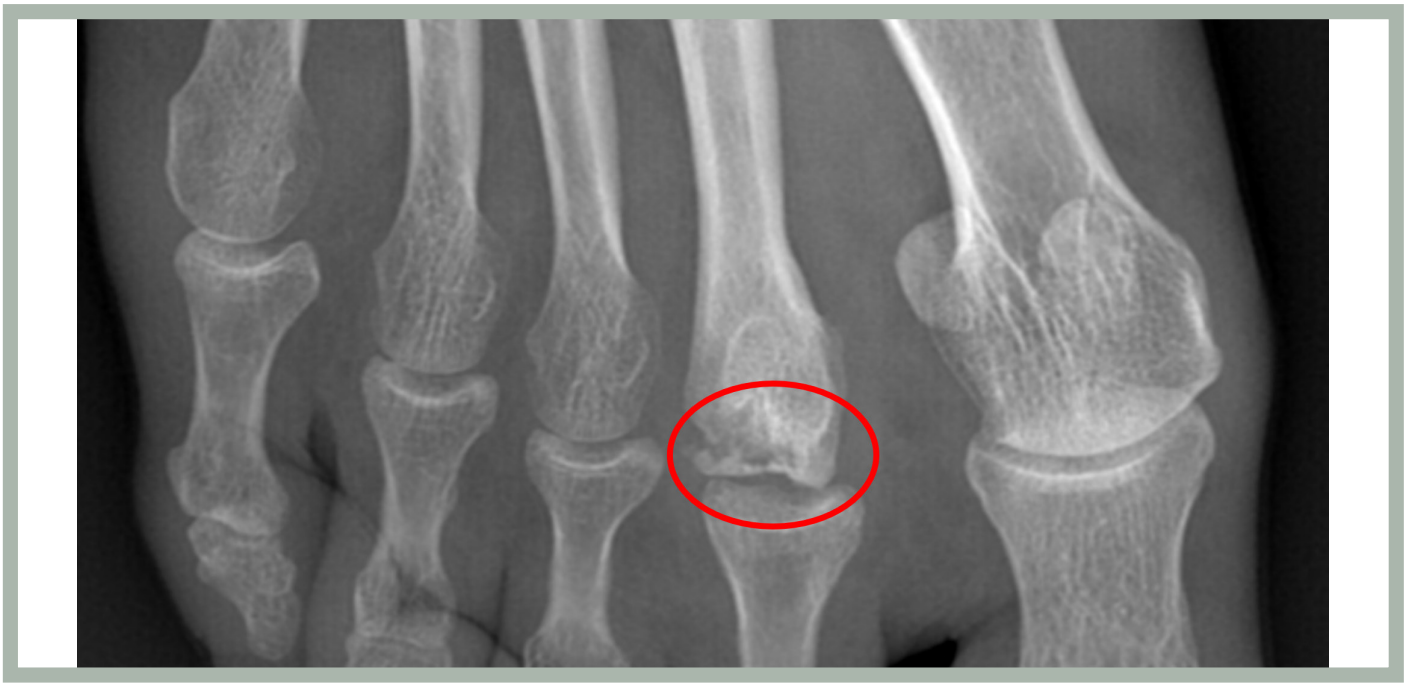

Figure 1. Radiographic appearance of Freiberg's disease. Direct radiography showed irregularity and flattening of the joint surface at the second metatarsal head (red circle), with the radiographic findings consistent with Smillie stage III Freiberg's disease

Proposed mechanisms for dextrose include local osmotic stress followed by an inflammatory response that may promote growth factor signaling, extracellular matrix remodeling, and collagen synthesis (5). Preclinical data provide mechanistic support: Harting et al. (6) reported rebound fibroblast responses after exposure to clinically relevant dextrose concentrations, and Johnston et al. (7) showed that hypertonic dextrose stimulated chondrogenic cell proliferation and collagen deposition. However, such *in vitro* findings do not establish clinical efficacy. While clinical studies suggest potential benefits of prolotherapy in osteoarthritis and selected chronic ligament conditions, its role in osteonecrosis-related pain remains supported by limited clinical data (8,9). There is no consensus on the dosage or frequency of application. However, concentrations below 10% are considered non-inflammatory (10). Therefore, a test dose of 5% dextrose was administered to the patient, and their pain and inflammatory response were monitored one week later. After a significant reduction in pain, prolotherapy was administered using a 10% dextrose solution.

In this Smillie stage III case, the absence of symptom recurrence over a 1 year period after periarticular dextrose prolotherapy is noteworthy. This observation suggests that periarticular dextrose prolotherapy may be considered a non-operative option for symptom control in selected patients with mid-stage Freiberg's disease refractory to conservative care. Larger case series stratified by standard staging systems and, if feasible, controlled studies are warranted to clarify efficacy, durability, and safety.

Footnotes

Informed Consent: Written informed consent was obtained from the patient for participation in this report and for the publication of clinical data and images.

Conflict of Interest: The author, Dilara Ekici Zincirci, is a member of the journal's review board. The editorial and peer-review process was conducted independently of this author.

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