

Original Contributions

Predictors of Early Failure in an Epley-First Approach for Posterior Canal Benign Paroxysmal Positional Vertigo in the Emergency Department

Muhammed Kamiloglu, MD, Keziban Uçar Karabulut, MD, and Seyit Ali Karagöz, MD

Department of Emergency Medicine, Faculty of Medicine, Başkent University, Ankara, Turkey

Reprint Address: Muhammed Kamiloglu, MD, Başkent University Konya Application and Research Center, Department of Emergency Medicine, Konya, Turkey, 42080.

Abstract—Background: Benign paroxysmal positional vertigo (BPPV) is a common cause of dizziness in the emergency department (ED), yet bedside diagnostic and therapeutic maneuvers remain underused, often leading to unnecessary imaging and resource utilization. **Study Objectives:** To evaluate the effectiveness of an Epley-first approach and identify predictors of early treatment failure in patients with posterior canal BPPV. **Methods:** In this retrospective observational study, 774 adult ED patients with posterior canal BPPV were managed with the Epley maneuver as the initial treatment strategy. Early treatment success was defined as symptom resolution without the need for additional intervention within 60 min. Logistic regression analysis was performed to identify independent predictors of treatment failure. **Results:** Early symptom resolution was achieved in 81.8% of patients, while 18.2% required additional interventions. Patients with treatment failure were significantly older and had longer symptom duration (both $p < 0.001$). In multivariable analysis, age (OR: 1.06, 95% CI: 1.04–1.08, $p < 0.001$) and symptom duration (OR: 1.03 per minute, 95% CI: 1.02–1.03, $p < 0.001$) were identified as independent predictors of failure. The predictive model demonstrated strong discriminative performance (AUC: 0.876). No newly identified focal neurological deficits suggestive of an acute central neurological disorder were documented during ED evaluation. **Conclusions:** The Epley-first approach was associated with rapid early symptom control in appropriately selected patients with posterior canal BPPV presenting to the ED. Age and symptom duration may facilitate early risk stratification and support more individualized diagnostic decision-making in appropriately selected

patients. © 2026 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

Keywords—benign paroxysmal positional vertigo; Epley maneuver; emergency department; treatment failure; risk factors

Introduction

Dizziness is a common presenting complaint in emergency departments (ED), accounting for a substantial proportion of visits and posing significant diagnostic challenges due to its broad differential diagnosis (1). Among these causes, benign paroxysmal positional vertigo (BPPV) is the most frequent peripheral vestibular disorder and a leading cause of episodic vertigo in clinical practice (2). BPPV is characterized by brief, recurrent episodes of vertigo triggered by head movements and most commonly results from the displacement of otoliths into the posterior semicircular canal (3).

The diagnosis of posterior canal BPPV can be reliably established using the Dix–Hallpike maneuver, which provokes characteristic positional nystagmus (4). Once diagnosed, BPPV can be effectively treated with canalith repositioning maneuvers, most notably the Epley maneuver, which aims to relocate displaced otoliths back to the utricle through a sequence of head movements (3). Strong evidence from randomized controlled trials and

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meta-analyses demonstrates that the Epley maneuver provides rapid symptom resolution and improves clinical outcomes compared with usual care or pharmacological therapy (5,6).

Despite this strong evidence base, the diagnosis and treatment of BPPV in ED settings remain suboptimal. Previous studies have shown that bedside diagnostic maneuvers such as the Dix–Hallpike test and therapeutic repositioning maneuvers are underutilized, while patients frequently undergo unnecessary imaging or receive symptomatic treatment alone (7). This gap between evidence and clinical practice contributes to increased healthcare costs, prolonged ED length of stay, and potential diagnostic inefficiencies.

In addition, although structured clinical approaches such as the HINTS examination and STANDING algorithm have been proposed to differentiate central and peripheral causes of vertigo, their application requires specific training and may not be consistently implemented in routine emergency practice (8). Moreover, early neuroimaging may fail to detect posterior circulation strokes in the acute phase, further complicating clinical decision-making in ED settings (9).

An “Epley-first” approach, in which patients with suspected posterior canal BPPV are promptly evaluated and treated with the Epley maneuver at the initial stage, may represent a practical, structured, and immediately applicable bedside strategy to improve patient outcomes while reducing unnecessary interventions. However, existing studies have primarily focused on the efficacy of repositioning maneuvers under controlled conditions, while data evaluating their structured early application as a first-line strategy in real-world emergency settings—particularly in terms of early clinical response and predictors of treatment failure—remain limited.

Therefore, this study aims to evaluate the clinical outcomes of an “Epley-first” approach in adult patients presenting to the emergency department with suspected posterior canal BPPV and without clinical features suggestive of central pathology, and to provide preliminary data for future prospective controlled studies.

Methods

This study was designed as a single-center, retrospective observational cohort study conducted in the emergency department of a tertiary care university hospital in Turkey. The study was conducted between January 2024 and January 2026. Adult patients (≥ 18 years) presenting to the emergency department with positional vertigo were initially evaluated by emergency medicine specialists. Pa-

tients were included if they were diagnosed with posterior canal BPPV and were managed according to the institutional Epley-first clinical pathway.

During the study period, the Epley-first approach represented the standard clinical pathway for patients with suspected posterior canal BPPV in our emergency department. Patients with a positive Dix–Hallpike test and no newly identified focal neurological findings or other clinical features suggestive of a central cause of vertigo underwent the Epley maneuver as the initial therapeutic intervention. Patients in whom the Dix–Hallpike maneuver could not be performed or interpreted reliably were not managed according to this pathway and were therefore excluded from the study.

Eligibility for inclusion was confirmed by retrospective review of the electronic medical records, including documentation of both the Dix–Hallpike test and the Epley maneuver. The diagnosis of posterior canal BPPV was established based on a compatible clinical history of positional vertigo and the presence of characteristic positional nystagmus elicited by the Dix–Hallpike maneuver, in the absence of newly identified focal neurological findings or other clinical features suggestive of central pathology. Patients were excluded if they had clinical suspicion of central vertigo requiring immediate advanced evaluation, persistent spontaneous nystagmus consistent with acute vestibular syndrome, recent head trauma, alternative peripheral vestibular diagnoses, or incomplete clinical records.

Data were retrospectively extracted from the hospital electronic medical records. Collected variables included demographic characteristics (age and sex), clinical presentation findings, Dix–Hallpike test results, application of the Epley maneuver, and findings during the observation period in the emergency department.

In addition, data regarding additional medical treatment following the maneuver, imaging studies (computed tomography or diffusion-weighted magnetic resonance imaging), consultation requests (otolaryngology or neurology), and patient disposition (discharge, hospitalization, or referral) were recorded. When available, early return visits to the emergency department were also evaluated.

The primary outcome of the study was defined as successful early clinical response, which was the absence of any need for additional diagnostic or therapeutic intervention within 60 min following the initial Epley maneuver, reflecting early symptom resolution without escalation of care.

Early treatment failure was defined as the requirement for escalation of diagnostic or therapeutic management within 60 min after the initial Epley maneuver, including additional medical treatment, diagnostic imaging, specialist consultation, or hospital admission.

Statistical Analysis

Continuous variables were expressed as median and interquartile range (IQR), while categorical variables were presented as frequencies and percentages.

Comparisons between the success and failure groups were performed using the Mann–Whitney U test for continuous variables and the Chi-square test for categorical variables.

Univariate logistic regression analysis was conducted to identify factors associated with treatment failure. Variables with statistical significance and clinical relevance were included in the multivariable logistic regression model.

Multicollinearity was assessed using variance inflation factors (VIF). Because hypertension, diabetes mellitus, history of stroke, and cardiovascular disease represent overlapping manifestations of vascular disease, they were combined into a single composite variable (*vascular_comorbidity*) rather than being included individually in the multivariable model. This approach was adopted to reduce multicollinearity and improve model stability. Variables with $p < 0.20$ in the univariable analysis, together with those considered clinically relevant, were included in the multivariable logistic regression model. Emergency department length of stay was not entered into the multivariable model because it represents a downstream variable that may be influenced by clinical decision-making and disease progression after presentation. Model calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test, and model discrimination was assessed using the area under the receiver operating characteristic curve (AUC).

A p -value < 0.05 was considered statistically significant. Statistical analyses were performed using Python (version 3.12.13). Python was used for data preprocessing, descriptive statistics, hypothesis testing, univariable and multivariable logistic regression analyses, receiver operating characteristic (ROC) curve analysis, model calibration using the Hosmer–Lemeshow goodness-of-fit test, and the generation of graphical outputs, including box-plots and ROC curve plots. The analyses were conducted using the pandas, NumPy, SciPy, StatsModels, Scikit-learn, and Matplotlib libraries.

This study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Ethical approval for this study was obtained from the institutional ethics committee (Approval No: KA26/191). The study was conducted in accordance with the principles of the Declaration of Helsinki. Due to its retrospective design and the use of anonymized data, informed consent was waived. All patient data were obtained from the hospital information system and anonymized prior to

analysis, and no additional diagnostic or therapeutic intervention was performed as part of this study.

Results

A total of 774 patients with posterior canal BPPV were included in the study. The baseline demographic and clinical characteristics of the study population are presented in [Table 1](#). The median age was 43 years (IQR: 31–63), and 67.4% of the patients were female. Hypertension was present in 17.2% of patients, diabetes mellitus in 21.7%, history of stroke in 8.3%, and cardiovascular disease in 15.1%. Overall, 36.6% of patients had at least one vascular comorbidity. No newly identified focal neurological deficits suggestive of an acute central neurological disorder were documented during emergency department evaluation.

Additional computed tomography (CT) or diffusion-weighted magnetic resonance imaging (MRI) were performed in 8.5% of patients, while ear, nose and throat (ENT) and neurology consultations were required in 1.6% and 0.3% of cases, respectively. Hospitalization occurred in 1.3% of patients ([Table 1](#)).

Among the 774 patients, symptom control without the need for additional intervention within the first 60 min was achieved in 633 patients (81.8%) following the Epley-first approach, whereas treatment failure occurred in 141 patients (18.2%).

Among patients with treatment failure, additional CT imaging and diffusion-weighted MRI were performed in 46.8% of cases. ENT consultation was required in 8.5% of patients, whereas neurology consultation was uncommon (1.4%). Hospitalization occurred in 7.1% of patients. Overall, patients with treatment failure required greater diagnostic evaluation and healthcare resource utilization.

The baseline characteristics of patients according to treatment outcome are presented in [Table 2](#). Significant differences were observed in age, symptom duration, and emergency department length of stay (all $p < 0.001$). Patients in the failure group were markedly older (median: 68 years, IQR: 60–75) than those in the success group (median: 39 years, IQR: 29–55) ([Figure 1](#)). Similarly, symptom duration was significantly longer in the failure group (median: 90 min, IQR: 60–150) than in the success group (median: 45 min, IQR: 30–60) ([Figure 2](#)). Emergency department length of stay was also substantially longer in the failure group (median: 95 min, IQR: 85–120) compared with the success group (median: 35 min, IQR: 30–45) ([Figure 3](#)). Regarding categorical variables, hypertension, diabetes mellitus, history of stroke, cardiovascular disease, and vascular comorbidity were significantly more prevalent in the failure group (all $p < 0.001$).

Table 1. Baseline Characteristics of the Study Population.

Variable	n (%) or Median (IQR)
Age, years, median (IQR)	43 (31–63)
Sex (Male)	252 (32.6)
Hypertension	133 (17.2)
Diabetes mellitus	168 (21.7)
History of stroke	64 (8.3)
Cardiovascular disease	117 (15.1)
Vascular comorbidity	283 (36.6)
Newly identified focal neurological deficit	0 (0.0)
CT or diffusion MRI imaging	66 (8.5)
ENT consultation	12 (1.6)
Neurology consultation	2 (0.3)
Hospitalization	10 (1.3)
Treatment failure	141 (18.2)

CT = computed tomography; MRI = magnetic resonance imaging; ENT = ear, nose and throat.

Table 2. Baseline Characteristics of Patients According to Treatment Outcome.

Variable	Success (n = 633)	Failure (n = 141)	p-Value
Age, median (IQR)	39.00 (29.00–55.00)	68.00 (60.00–75.00)	<0.001
Symptom duration (min), median (IQR)	45.00 (30.00–60.00)	90.00 (60.00–150.00)	<0.001
Emergency department length of stay (min), median (IQR)	35.00 (30.00–45.00)	95.00 (85.00–120.00)	<0.001
Sex, male, n (%)	205 (32.4)	47 (33.3)	0.906
Hypertension, n (%)	85 (13.4)	48 (34.0)	<0.001
Diabetes mellitus, n (%)	103 (16.3)	65 (46.1)	<0.001
History of stroke, n (%)	42 (6.6)	22 (15.6)	<0.001
Cardiovascular disease, n (%)	67 (10.6)	50 (35.5)	<0.001
Vascular comorbidity, n (%)	182 (28.8)	101 (71.6)	<0.001

In contrast, no significant difference was observed in sex distribution between the two groups ($p = 0.906$).

Univariate and Multivariable Logistic Regression Analyses

The results of the univariable and multivariable logistic regression analyses are presented in Table 3. In the univariable analysis, age, symptom duration, hypertension, diabetes mellitus, history of stroke, cardiovascular disease, and vascular comorbidity were all significantly

associated with treatment failure (all $p < 0.01$). Each 1-year increase in age was associated with an 8% increase in the odds of treatment failure (OR: 1.08, 95% CI: 1.06–1.09, $p < 0.001$). Similarly, longer symptom duration was significantly associated with higher odds of failure (OR: 1.03 per minute increase, 95% CI: 1.02–1.03, $p < 0.001$). Among the comorbid conditions, vascular comorbidity showed the strongest association with treatment failure (OR: 6.26, 95% CI: 4.18–9.37, $p < 0.001$). In contrast, sex was not significantly associated with treatment failure ($p = 0.828$).

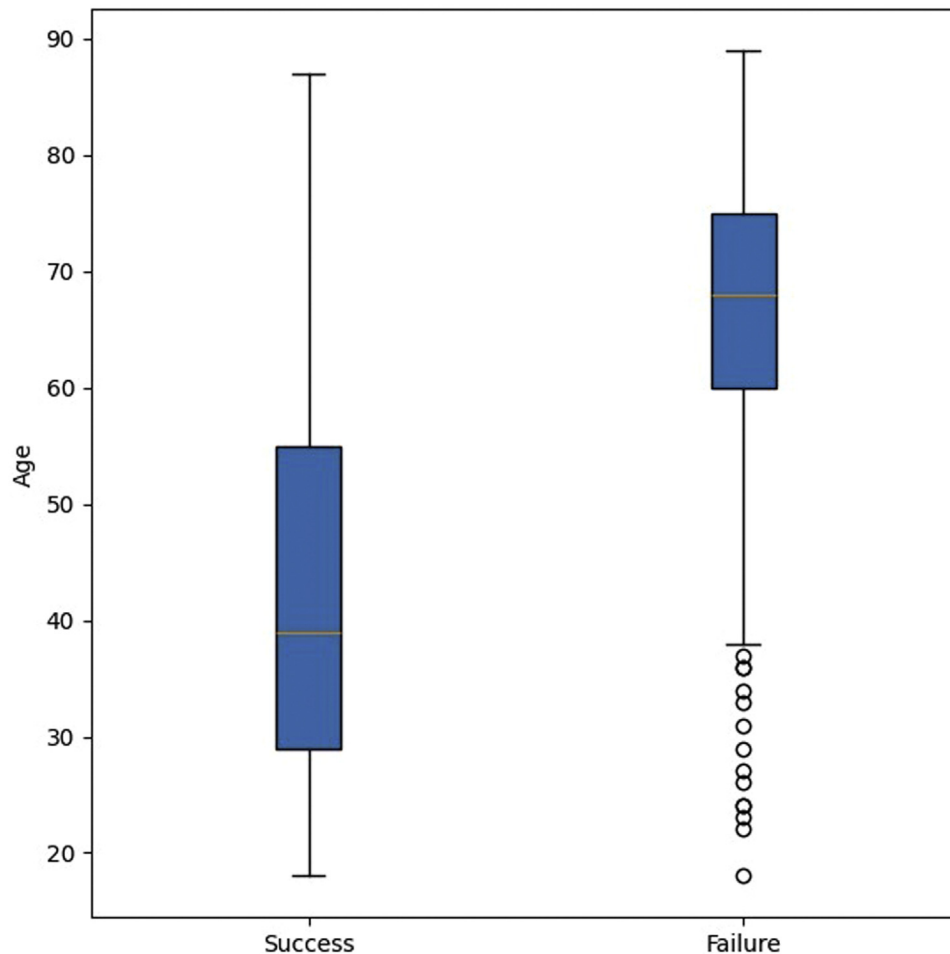


Figure 1. Distribution of age according to treatment outcome (success vs. failure groups).

Table 3. Univariable and Multivariable Logistic Regression Analyses of Factors Associated With Treatment Failure.

Variable	Univariable OR (95% CI)	<i>p</i> -Value	Multivariable OR (95% CI)	<i>p</i> -Value
Age	1.08 (1.06–1.09)	<0.001	1.06 (1.04–1.08)	<0.001
Sex	0.96 (0.65–1.41)	0.828	—	—
Symptom duration (min)	1.03 (1.02–1.03)	<0.001	1.03 (1.02–1.03)	<0.001
Hypertension	3.33 (2.19–5.05)	<0.001	—	—
Diabetes mellitus	4.40 (2.97–6.52)	<0.001	—	—
History of stroke	2.60 (1.50–4.51)	0.001	—	—
Cardiovascular disease	4.64 (3.03–7.12)	<0.001	—	—
Vascular comorbidity	6.26 (4.18–9.37)	<0.001	1.33 (0.72–2.44)	0.358

OR = odds ratio; CI = confidence interval.

Variables with $p < 0.20$ in the univariable analysis and those considered clinically relevant were entered into the multivariable logistic regression model. ORs for continuous variables represent the change in odds of treatment failure per one-unit increase (per 1 year for age and per 1 min for symptom duration). ORs for categorical variables compare the presence vs. absence of the corresponding condition.

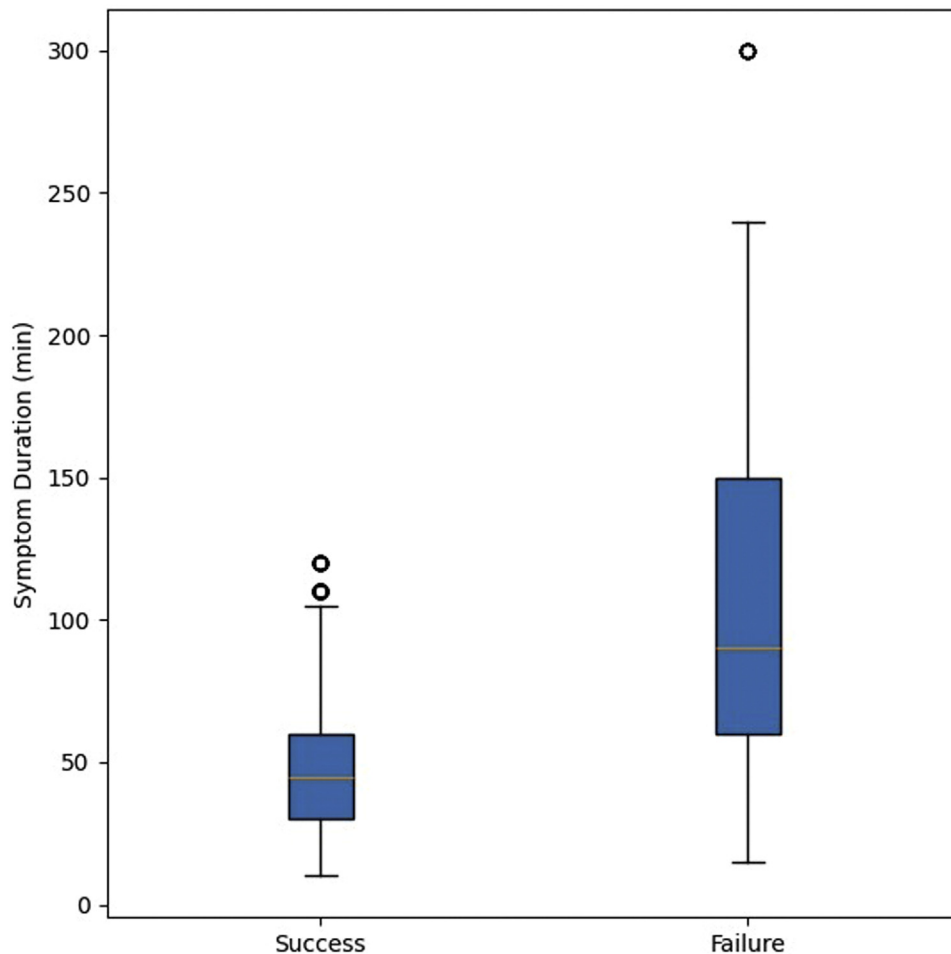


Figure 2. Distribution of symptom duration according to treatment outcome (success vs. failure groups).

Because hypertension, diabetes mellitus, history of stroke, and cardiovascular disease represent overlapping manifestations of vascular disease, they were combined into a single composite variable (vascular_comorbidity) rather than being included individually in the multivariable model. This approach was adopted to reduce multicollinearity and improve model stability. Emergency department length of stay was excluded because it represents a downstream variable that may be influenced by clinical decision-making and disease progression after presentation. Multicollinearity was assessed using variance inflation factors (VIF), and all variables had VIF values below five, indicating no significant multicollinearity.

In the multivariable analysis, only age and symptom duration remained independently associated with treatment failure. Each 1-year increase in age was associated with a 6% increase in the odds of treatment failure (OR: 1.06, 95% CI: 1.04–1.08, $p < 0.001$), while each 1-min

increase in symptom duration was associated with a 3% increase in the odds of treatment failure (OR: 1.03, 95% CI: 1.02–1.03, $p < 0.001$). In contrast, vascular comorbidity was not an independent predictor after adjustment (OR: 1.33, 95% CI: 0.72–2.44, $p = 0.358$), suggesting that its apparent association in the univariable analysis was explained by confounding with other variables, particularly age and symptom duration.

The multivariable model demonstrated good discriminatory performance, with an area under the receiver operating characteristic curve (AUC) of 0.876 (95% CI: 0.841–0.910). Model calibration was acceptable according to the Hosmer–Lemeshow goodness-of-fit test ($\chi^2 = 9.17$, $df = 8$, $p = 0.329$).

The discriminatory performance of the multivariable model is illustrated in Figure 4. The receiver operating characteristic (ROC) curve demonstrates the ability of the model to distinguish between patients with and without treatment failure.

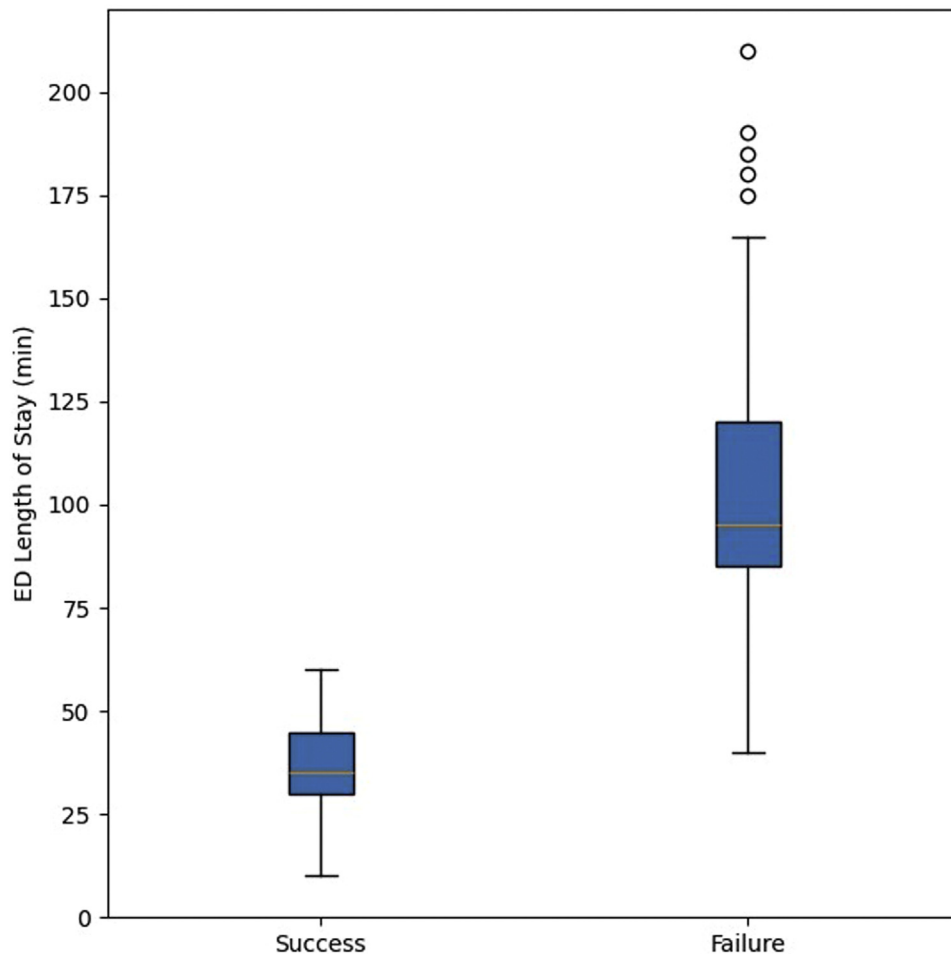


Figure 3. Distribution of emergency department length of stay according to treatment outcome (success vs. failure groups).

Discussion

BPPV is one of the most common causes of dizziness in ED presentations, accounting for a substantial proportion of visits and contributing significantly to healthcare utilization (1). In this study, we demonstrated that an “Epley-first” approach is highly effective for the early management of posterior canal BPPV in the ED, with more than 80% of patients achieving symptom resolution within the first 60 min without requiring additional intervention. These findings are consistent with a large body of evidence supporting the effectiveness of canalith repositioning maneuvers. Systematic reviews and meta-analyses have shown that the Epley maneuver significantly improves symptom resolution compared to control or sham interventions across both primary-care and subspecialty settings (2,4). Similarly, recent randomized and observational studies confirm that modified and standard Epley maneuvers are highly effective in posterior canal BPPV, reinforcing their role as first-line therapy (3). Network

meta-analyses further support the superiority of repositioning maneuvers over usual care, highlighting their central role in BPPV management (5).

A key finding of our study is that treatment failure following an Epley-first approach is not random but can be predicted based on patient characteristics. Increasing age and longer symptom duration were independently associated with a higher likelihood of treatment failure. These findings are clinically relevant and consistent with previous reports indicating that BPPV is more prevalent and potentially more complex in older populations (5,6). Age-related degenerative changes, altered vestibular function, and microvascular impairment may contribute to reduced responsiveness to repositioning maneuvers. Although vascular comorbidities (such as hypertension, diabetes mellitus, and prior stroke) were strongly associated with treatment failure in univariate analyses, this relationship did not persist after multivariable adjustment. This suggests that the observed association may be largely explained by confounding effects of age, em-

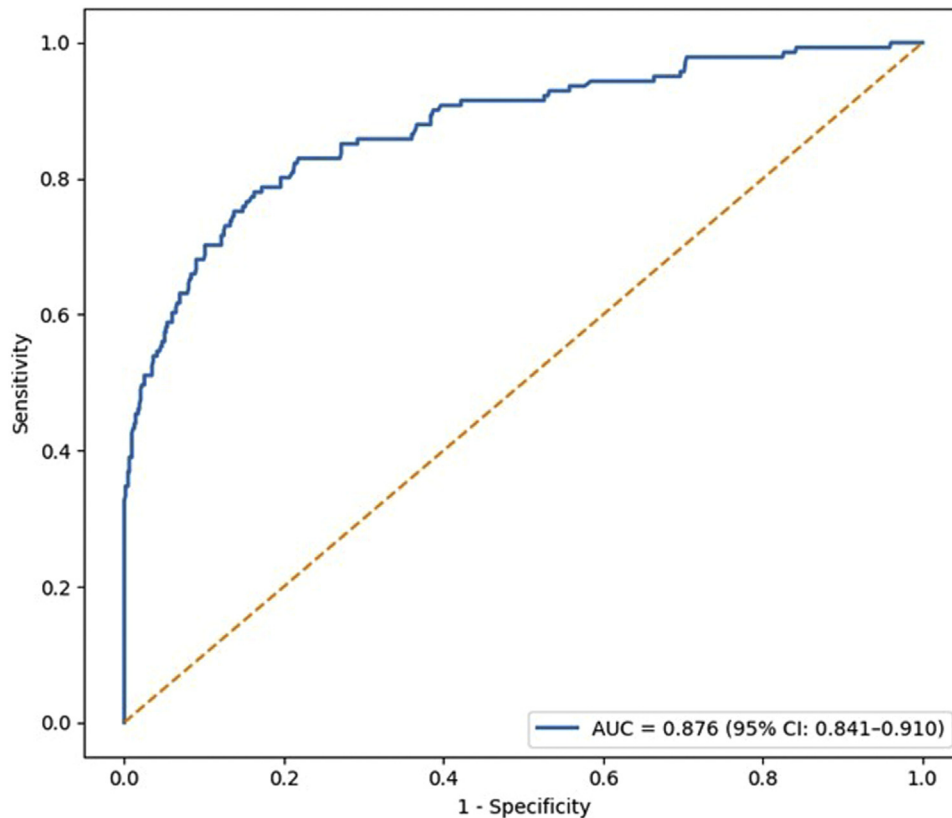


Figure 4. Receiver operating characteristic (ROC) curve of the multivariable logistic regression model predicting treatment failure (area under the curve [AUC] = 0.876).

phasizing the importance of multivariable modeling in identifying true independent predictors.

Importantly, our study extends beyond demonstrating treatment effectiveness by providing a clinically applicable prediction model for early treatment failure. The multivariable model, incorporating age and symptom duration, demonstrated strong discriminative performance with an AUC of 0.876. These findings suggest that clinicians may reliably anticipate treatment outcomes at the bedside using readily available clinical variables. In the time-sensitive ED environment, such predictive capability may facilitate more individualized patient management, thereby allowing early identification of patients who may require additional interventions, closer observation, or further diagnostic evaluation.

Another important observation from this study is that the Epley-first approach was successfully implemented in appropriately selected patients. Only patients with a positive Dix–Hallpike test and without newly identified focal neurological findings or other clinical features suggestive of central vertigo were managed according to this pathway. Patients in whom positional testing could not be performed or interpreted reliably were excluded from the study.

These findings should therefore be interpreted within the context of appropriate patient selection rather than as evidence that bedside maneuvers can replace comprehensive neurological evaluation or neuroimaging when clinically indicated. Early CT has limited sensitivity for posterior circulation stroke, and even diffusion-weighted MRI may be falsely negative during the first 24–48 h after symptom onset (9). Accordingly, bedside positional testing should complement, rather than replace, clinical judgment in the evaluation of patients presenting with vertigo. Likewise, bedside algorithms such as HINTS are valuable when applied to patients with acute vestibular syndrome by appropriately trained clinicians (8).

In addition to its clinical effectiveness, the Epley-first approach has important implications for healthcare resource utilization. Patients with treatment failure required significantly higher rates of imaging, specialist consultations, and hospital admissions. This observation is consistent with prior ED-based implementation studies suggesting that increased use of diagnostic and therapeutic bedside maneuvers may reduce unnecessary imaging and improve efficiency in patient flow (7). Given the high prevalence of dizziness presentations in the ED, optimizing BPPV management strategies has the potential to

substantially reduce healthcare costs and resource burden while improving patient outcomes.

Despite strong evidence and guideline recommendations, the Dix–Hallpike test and canalith repositioning maneuvers remain underutilized in emergency settings (4,7). Barriers such as lack of training, diagnostic uncertainty, and over-reliance on imaging contribute to this gap between evidence and practice. Our study provides real-world evidence supporting the feasibility of implementing an Epley-first strategy in routine ED care and suggests that this approach may improve adherence to evidence-based bedside management in appropriately selected patients.

Limitations

This study has several limitations. First, its retrospective design introduces the possibility of selection bias and limits its causal inference. Second, symptom duration was based on patient-reported data and may be subject to recall bias. Third, although no missed central neurological diagnoses were identified during the index ED visit, the absence of longitudinal follow-up means that delayed diagnoses cannot be completely excluded. In addition, the absence of a comparison group precludes direct evaluation of whether the Epley-first approach reduces imaging utilization or improves safety compared with alternative management strategies. Finally, as a single-center study, the generalizability of our findings to other healthcare settings may be limited.

Conclusions

In summary, the Epley-first approach was associated with rapid and effective early symptom control in the majority of carefully selected patients with posterior canal BPPV presenting to the emergency department. Older age and longer symptom duration were identified as independent predictors of early treatment failure, providing readily available variables for bedside risk stratification. These findings support the feasibility of a structured, maneuver-first approach for appropriately selected patients. Further prospective multicenter studies with longitudinal follow-up and appropriate comparison groups are warranted to validate these findings and to further evaluate their impact on clinical outcomes, imaging utilization, and patient safety.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Muhammed Kamiloğlu: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Keziban Uçar Karabulut:** Writing – review & editing, Visualization, Supervision, Conceptualization. **Seyit Ali Karagöz:** Writing – review & editing, Investigation, Data curation.

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Article Summary

1. Why is this topic important?

BPPV is a common cause of dizziness in the ED, yet bedside maneuvers are often underused, leading to unnecessary imaging.

2. What does this study attempt to show?

This study evaluates an Epley-first approach and identifies predictors of early treatment failure.

3. What are the key findings?

81.8% early success rate. Age and symptom duration predict failure. Strong model performance (AUC 0.876).

4. How is patient care impacted?

Findings support the feasibility of implementing an Epley-first bedside strategy for appropriately selected patients and may facilitate more individualized diagnostic decision-making.