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The triple impact of Enoxaparin: Moderating comorbidities, reducing hospitalization, and rationalizing medications

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Enoxaparin is a low molecular weight heparin which has revealed clinical efficacy through its anticoagulant properties. While it has been thoroughly investigated for coagulation prophylaxis and treatment, its therapeutic role in multiple domains of patient care remains underexplored. This study sought to evaluate the integrated role of Enoxaparin therapy on three healthcare domains: comorbidity management, hospitalization rates, and medication optimization in diverse patient populations. In this prospective observational study, the data were collected directly from patients. A record was placed for each patient to collect their demographic parameters, Enoxaparin dose, admission date, hospitalization stays and compelling diseases. A total of 125 subjects enrolled in the present study (age 58.2 ± 15.4 years, male 54.4% and females 45.6%). Enoxaparin was used at a daily dose 5280 ± 1147 IU (range 4000–8000 IU) with most patients receiving their dose once or twice daily . The majority of patients (71.2%) were administered Enoxaparin for therapeutic purposes and 28.8% received prophylactic doses. Gender differences showed non-significant age-related effects (P = 0.320), with 20 male (16.0%) patients in the younger group and 29 (23.2%) patients in the older group (>60) , while females were equally matched in each age category. The duration of therapy with Enoxaparin demonstrated a non-significant (P = 0.675) difference between prophylaxis (3.2 ± 2.6 days) and treatment groups (3.4 ± 2.6 days). Enoxaparin was mainly indicated for treatment rather than prophylaxis, with the polypharmacy group showing the highest utilization (60.8% for treatment compared to 23.2% for prophylaxis). The duration of Enoxaparin therapy increased non-significantly with polypharmacy severity (2.4 ± 1.5 days in the non-polypharmacy group to 6.3 ± 3.6 days in the hyperpolypharmacy group). The number of medications increased across groups: 3.7 ± 0.5 in non-polypharmacy, 7.6 ± 1.6 in polypharmacy, and 12.2 ± 1.4 in hyperpolypharmacy patients. The hospitalization duration followed similar trends, 2.4 ± 1.5 days in non-polypharmacy patients to 5.8 ± 3.5 days in hyperpolypharmacy patients. The majority of patients had good outcomes, with the polypharmacy group (99 patients, 79.2%) having the most favourable outcomes. Enoxaparin revealed extensive properties outside its anticoagulant role, providing clear benefits to patients through comorbidity reduction, hospitalization moderation, and medication optimization. These findings suggest that strategic utilization of Enoxaparin may enhance overall healthcare efficiency while improving patient outcomes across multiple therapeutic domains. The triple effects of Enoxaparin make it worthy of consideration as a multifaceted therapeutic biomolecule in patient individualized complexity, potentially integrating the care of patients and proper utilization of healthcare resources.

Keywords: Enoxaparin; comorbidity: hospitalization admission; medication profile; anticoagulation; healthcare.

Introduction

Enoxaparin is a low molecular weight heparin (LMWH) obatained from unfractionated heparin through controlled depolymerization. It has demonstrated progress in coagulantion management that has achieved prevention and treatment of thromboembolic disorders (Fareed et al., 2003; Iqbal & Cohen, 2011). Enoxaparin has an improved pharmacokinetic profile compared to the original unfractionated derivative (Ornstein et al., 2001; Siddiqui & Wagstaff, 2005). The mechanism of action of Enoxaparin involves the inhibition of factor Xa and, to a lesser extent, thrombin (factor IIa), through its binding to antithrombin III, thereby hindering the coagulation cascade at multiple positions (Deitcher, 2000; Hofmann, 2004; Prithvinathan & Thirunavikkarasu, 2025). Clinical use of Enoxaparin include prophylaxis against deep vein thrombosis in surgical and medical patients, acute coronary syndromes, pulmonary embolism, and prevention of thrombosis in patients with atrial fibrillation (Champion et al., 2024). Compared to heparin, Enoxaparin use is associated with a better adverse effects profile in the context of heparin-induced thrombocytopenia and osteoporosis, alongside convenient dosing regimen and subcutaneous route of administration (Jacobson et al., 2020; AlLehaibi et al., 2023; Xie et al., 2025).

In patients with cardiovascular ailments, Enoxaparin reduced the inflammatory cascade associated with acute coronary syndromes, diminishing myocardial injury and refining endothelial function via mechanisms that modulate of cytokine release and the preservation of microvascular integrity (Shastri et al., 2015; Saithong et al., 2022; Fan et al., 2023). In patients with coexisting cardiovascular diseases (CAD), such as diabetes, angina pectoris, myocardial infarction, heart failure, and diabetes, Enoxaparin has been used for prophylaxis and treatment (Ornstein et al., 2001; Becker et al., 2011). Moreover, old-age patients with multiple comorbidities benefit from Enoxaparin, allowing more stable anticoagulation management in the context of polypharmacy, while its subcutaneous administration route enhances medication adherence and reduces hospitalization requirements, thereby improving overall quality of life and healthcare resource utilization in this vulnerable population (Triscott et al., 2015; Mottier et al., 2023). The present study is designed to assess the impact of Enoxaparin in moderating comorbidities, reducing hospitalization, and rationalizing medications.

Patients and methods

This prospective observational study sought to assess the impact of Enoxaparin over three areas, moderating comorbidities, reducing

hospitalization, and rationalizing medications, allowing the determination of clinical outcomes over different patient populations. The data were collected directly from patients.

Inclusion criteria include patients with cardiovascular diseases eligible for Enoxaparin administration.

Exclusion criteria include patients sensitive to low molecular weight heparin, patients with cancer, and pregnant women.

A record were placed for each patient to collect their demographic parameters, Enoxaparin dose, admission date, hospitalization stays and compelling diseases.

Non-parametric data were expressed as number and percentage and these data were analysed using Chi-square. Parametric data were expressed as mean and standard deviation and these data were analysed using the paired t-test (two groups comparison) or one way ANOVA (three groups comparison). The p values less than 0.05 were considered significant. The software used was GraphPad Prism (V10, USA).

Results

A total of 125 subjects enrolled in the present study (age 58.2 ± 15.4 years, males 54.4% and females 45.6%). Enoxaparin was used at a daily dose 5280 ± 1147 IU (range 4000–8000 IU) with most patients receiving the dose once or twice daily . The majority of patients (71.2%) were administered Enoxaparin for therapeutic and 28.8% for prophylactic purposes. The duration of Enoxaparin therapy was relatively short, 3.3 ± 2.6 (range of 1–14) days. The patient population demonstrated significant polypharmacy, with an average of 7.7 ± 2.3 concurrent medications per patient. Comorbidity demonstrated that 76% of patients had one compelling disease, with DM and HTN being the most prevalent conditions, 24% with no compelling diseases, 15.2% with diabetes alone, 19.2% with hypertension alone, 21.6% with combined diabetes and hypertension, 8.0% with heart failure, 8.8%.with lung diseases Duration of hospitalization averaged 3.3 ± 2.5 days, with 94.4% of patients achieving good outcomes and only 5.6% dying.

Gender differences showed non-significant age-related effects (P = 0.320), with 20 (16%) male patients in the younger (<60) group and 29 (23.2%) male patients in the older (>60)_group, while females were equally matched in each age category. The use of Enoxaparin was similar between both age groups (P = 0.906), with prophylaxis used in 17 (13.6%) of the younger patients compared to 19 (15.2%) of the older patients, and treatment was indicated in 41 (32.8%) of the younger patients compared to 48 (38.4%) of the older patients. Duration of Enoxaparin therapy was similar between groups, with the younger patients receiving treatment for 3.4 ± 2.9 days (range 1–14) compared to 3.2 ± 2.2 days (range 1–12) in the older patients (P = 0.675). Polypharmacy burden showed a slight but non-significant trend toward higher medication use in the older patients (8 ± 2 drugs, range 4–14) compared to the younger patients (7.4 ± 2.4 drugs, range 3–13, P = 0.126), which is consistent with expected age-related comorbidity patterns. Hospitalization duration remained comparable (P = 0.834) between age groups, with younger patients staying 3.4 ± 3.0 days versus 3.3 ± 2.3 days for older patients. Clinical outcomes revealed that patients younger than 60 years old had good outcomes (55 cases (44%)) with only 3 deaths (2.4%). The patients older than 60 years old also demonstrated good outcomes (63 cases (50.4%)) with 4 deaths (3.2%).

Table 1
Demographic and clinical profile
of the studied patient treated with Enoxaparin

Parameters		Results
Age, years		58.2 ± 15.4
Sex	Male, n (%)	68 (54.4)
	Female, n (%)	57 (45.6)
EPN dose, IU		5280 ± 1147
Range		(4000–8000)
Dosing frequency, m ± SD		1.70 ± 0.45
Indication, Px/Rx	Prophylaxis, n (%)	36 (28.8)
	Treatment, n (%)	89 (71.2)
Duration of therapy, days		3.32 ± 2.60
Range		(1–14)
Polypharmacy status, number of drugs, n (%)		7.7 ± 2.3
Compelling diseases	None	30 (24.0)
	DM	19 (15.2)
	HTN	24 (19.2)
	HF	10 (8.0)
	DM+HTN	27 (21.6)
	Lung	11 (8.8)
	DM+HTN+HF	3 (2.4)
	DM+HTN+IHD	1 (0.8)
Duration of hospitalization, days		3.3 ± 2.5
Outcome	Good, n (%)	118 (94.4)
	Dead, n (%)	7 (5.6)

Table 2
Triple impact of Enoxaparin on comorbidities,
hospitalization, and medications profile based on age

Parameters, (n = 125)		<60 years	≥60 years	P value	Chi-square
Sex	Male, n (%)	20 (16)	29 (23.2)	0.320	0.99
	Female, n (%)	38 (30.4)	38 (30.4)		
Indication, Px/Rx	Prophylaxis, n (%)	17 (13.6)	19 (15.2)	0.906	0.014
	Treatment, n (%)	41 (32.8)	48 (38.4)		
Duration of therapy, days		3.4 ± 2.9	3.2 ± 2.2	0.675	
Range		(1–14)	(1–12)		
Polypharmacy status		7.4 ± 2.4	8.0 ± 2.0	0.126	
Range		(3–13)	(4–14)		
Duration of hospitalization, days		3.4 ± 3.0	3.3 ± 2.3	0.834	
Fate	Good, n (%)	55 (44)	63 (50.4)	0.862	0.030
	Dead, n (%)	3 (2.4)	4 (3.2)		

The distribution of Enoxaparin indications showed no significant gender bias, with males receiving prophylaxis in 19 cases (15.2%) and treatment in 49 cases (39.2%), while females received prophylaxis in 17 cases (13.6%) and treatment in 40 cases (32%), yielding no statistically significant difference (P = 0.832). The duration of Enoxaparin therapy was similar between males (3.0 ± 2.3 days) and females (3.7 ± 2.9 days, P = 0.155). The polypharmacy burden was similar between groups, with both males and females averaging exactly 7.7 drugs (± 2.2 for males, ± 2.4 for females, P = 1.00). Similarly, hospitalization duration showed non-significant (P = 0.141) difference, males of 3.0 ± 2.1 days compared to females at 3.7 ± 2.9 days. The clinical outcomes were non-significant between genders (P = 0.377). Males had good outcomes in 63 cases (50.4%) with 5 deaths (4.0%), while females also had good outcomes in 55 cases (44.0%) with 2 deaths (1.6%).

Table 3
Triple impact of Enoxaparin on comorbidities, hospitalization, and medications profile based on gender

Parameters (n = 125)		Male, n (%)	Female, n (%)	P-value	Chi-square
Indication, Px/Rx	prophylaxis, n (%)	19 (15.2)	17 (13.6)	0.832	0.045
	treatment, n (%)	49 (39.2)	40 (32.0)		
Duration of therapy, days		3.0 ± 2.3	3.7 ± 2.9	0.155	–
Polypharmacy status, number of drugs		7.7 ± 2.2	7.7 ± 2.4	1.000	–
Duration of hospitalization, days		3.0 ± 2.1	3.7 ± 2.9	0.141	–
Outcome	good, n (%)	63 (50.4)	55 (44.0)	0.377	0.78
	died, n (%)	5 (4.0)	2 (1.6)		

The duration of therapy with Enoxaparin demonstrated a non-significant (P = 0.675) difference between prophylaxis (3.2 ± 2.6 days) and treatment groups (3.4 ± 2.6 days). Similarly, the polypharmacy burden was similar (P = 0.810) between groups, with prophylaxis patients (7.6 ± 2.2 drugs) compared to (7.7 ± 2.3 drugs) in the treatment group. Moreover, hospitalization duration in prophylaxis patients was 3.2 ± 2.6 days versus 3.3 ± 2.5 days for treatment patients (P = 0.834). Mortality rate showed non-significant differences between groups (P = 0.407).

Table 4
Triple impact of Enoxaparin on comorbidities, hospitalization, and medications profile based on indication status

Parameters (n=125)		Prophylaxis, n (%)	Treatment, n (%)	P-value	Chi-square
Duration of therapy, days		3.2 ± 2.6	3.4 ± 2.6	0.675	–
Polypharmacy status, number of drugs		7.6 ± 2.2	7.7 ± 2.3	0.810	–
Duration of hospitalization, days		3.2 ± 2.6	3.3 ± 2.5	0.834	–
Outcome	good, n (%)	35 (28.0)	83 (66.4)	0.407	0.69
	died, n (%)	1 (0.8)	6 (4.8)		

Enoxaparin was mainly indicated for treatment rather than prophylaxis, with the polypharmacy group showing the highest utilization (60.8% for treatment compared to 23.2% for prophylaxis). Duration of Enoxaparin therapy increased non-significantly with polypharmacy severity (2.4 ± 1.5 days in the non-polypharmacy group to 6.3 ± 3.6 days in the hyperpolypharmacy group). The number of medications increased across groups: 3.7 ± 0.5 in non-polypharmacy, 7.6 ± 1.6 in polypharmacy, and 12.2 ± 1.4 in hyperpolypharmacy patients. The hospitalization duration followed similar trends, 2.4 ± 1.5 days in non-polypharmacy patients to 5.8 ± 3.5 days in hyperpolypharmacy patients. The majority of patients had good outcomes, with the polypharmacy group (99 patients, 79.2%) having the highest percentage of favorable outcomes.

Patient outcomes by comorbidity status: Patients with no comorbidities showed no deaths (0/31), while the death rate in those with HT alone was 3 patients, diabetes and hypertension 2 deaths, diabetes mellitus alone and those with the triple combination of diabetes, hypertension,and heart failure 1 death each (P = 0.349, Table 6 and Fig. 1).

Patients with no comorbidities showed short hospitalization (~3 days), while those with comorbidities showed a different pattern, with only 47.1% (8/17) having short stays, suggesting this condition may contribute to prolonged hospitalization (Table 6 and Fig. 1).

Polypharmacy patterns showed an increasing association with comorbidity (P = 0.037). Patients without comorbidities had a favorable medication profile, 29.0% taking 5 medications and 64.5% required 6–10 drugs. Patients with both diabetes and hypertension with or without heart failure received more than 10 drugs. Diabetic alone patients maintained moderate medication with all of them receiving < 10 drugs (Table 6).

Table 5
Triple impact of Enoxaparin on comorbidities, hospitalization, and medications profile based on polypharmacy status

Parameters (n = 125)		Non-polypharmacy (<5 drugs)	Polypharmacy (5–10 drugs)	Hyperpolypharmacy (>10 drugs)	P-value	Chi-square
Indication	Prophylaxis, n (%)	3 (2.4)	29 (23.2)	4 (3.2)	0.860	0.649
	Treatment, n (%)	7 (5.6)	76 (60.8)	6 (4.8)		
Duration of therapy, days		2.4 ± 1.5	3.1 ± 2.4	6.3 ± 3.6	0.230	0.540
Polypharmacy status, number of drugs		3.7 ± 0.5[a]	7.6 ± 1.6[b]	12.2 ± 1.4[c]	0.001	–
Duration of hospitalization, days		2.4 ± 1.5[a]	3.1 ± 2.4[b]	5.8 ± 3.5[c]	0.001	–
Outcome	Good, n (%)	10 (8)	99 (79.2)	9 (7.2)	0.001	–
	Died, n (%)	0 (0)	6 (4.8)	1 (0.8)		

Table 6
Triple impact of Enoxaparin on comorbidities, hospitalization, and medications profile based on compelling diseases

Parameters		None	DM	HTN	HF	DM+HTN	Lung	DM+HTN+HF	DM+HTN+IHD	
Fate	good	31	19	21	10	20	3	7	7	0.349
	dead	0	1	3	0	2	0	1	0	(6.71)
Duration of hospitalization (days)	≤3	24	8	17	8	15	3	2	2	0.331
	>3	7	9	7	2	7	1	2	2	(6.89)
Polypharmacy status, number of drugs	≤5	9	1	4	3	1	0	1	0	0.037
	6–10	20	18	20	6	17	3	6	9	(25.8)
	>10	2	0	0	1	5	0	1	0	

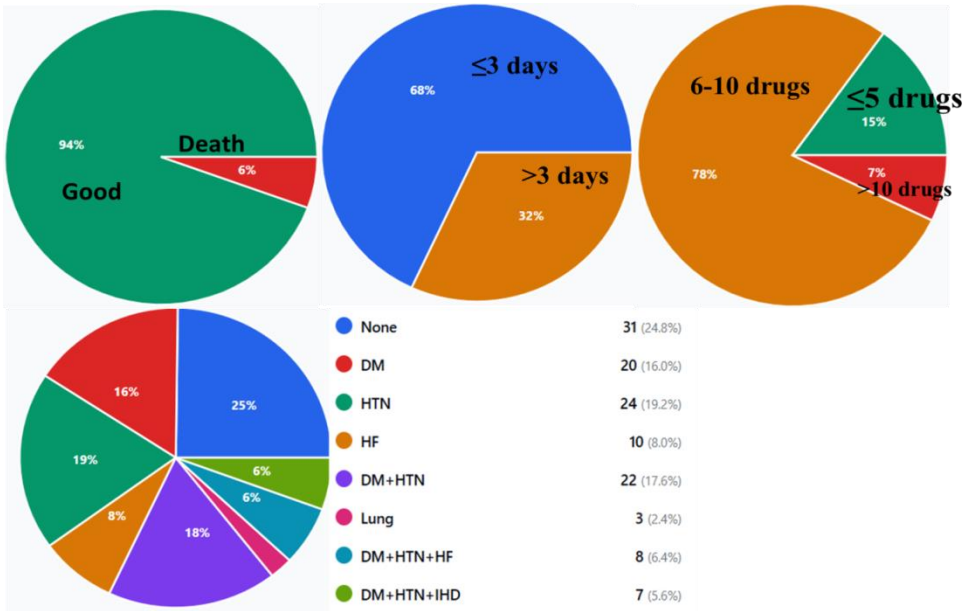

Fig. 1. The impacts of Enoxaparin on comorbidities, hospitalization, and medications profile based on compelling diseases

Discussion

The patients demographics involved hospitalization for those at moderate to high risk for thrombotic complications. The dosing was appropriate, with the 71.2% receiving doses 5280 IU daily, while the remaining 28.8% received a prophylactic Enoxaparin dose. The high rate of compelling diseases confirms the proper indication of Enoxaparin. Diabetes mellitus and hypertension are risk factors for thrombotic complications. The medication profile further suggests the eligibility for Enoxaparin therapy. The short duration of therapy combined with brief hospitalizations (3.3 days) and positive outcomes confirmed that Enoxaparin was used properly in the selected patients. The Enoxaparin therapy was properly implemented over a diverse range of patients with comorbidities. The low adverse event rate suggests that current eligibility criteria are effective.

This finding suggests that patient selection for Enoxaparin indication was directed by medical needs rather than gender-based or polypharmacy burden, suggesting equivalent comorbidity outcomes and therapeutic complexity. Hospitalization patterns further reinforced these findings. Most significantly, clinical outcomes demonstrated no gender-based variation. Female patients demonstrated longer average duration Enoxaparin therapy and hospitalization compared to male patients, despite identical polypharmacy burdens between genders. Nevertheless, female patients achieved more favorable outcomes than males. This slight variation in gender response to Enoxaparin could be due to lower Enoxaparin dose in females producing more therapeutic anti-Xa levels than males (Tinchon et al., 2024b). Similarly, Modi et al. reported that male patients with trauma were more prone to have subprophylactic anti-Xa levels, while females were likely to have supraprophylactic levels, with similar findings in burn patients (Modi et al., 2023). Moreover, Leri et al. (2009) reported that women were more prone to be within the predefined therapeutic target range than males, while Tinchon et al. revealed higher anti-Xa activity in female patients during the acute treatment of unstable cases CAD (Tinchon et al., 2024a). The distinctive gender response could be potentially linked to the pharmacokinetic consideration of Enoxaparin explained in the context that lower water content and reduced plasma volume in women could potentially concentrate hydrophilic substances, such as Enoxaparin, in the blood, suggesting that Enoxaparin, being hydrophilic, achieves higher concentrations in the smaller plasma volume of women (Hakeam et al., 2020; Modi et al., 2023). Perhaps, the pharmacokinetic properties of Enoxaparin being affected by sex-specific factors, involving variation in muscle and adipose tissue distribution, pulmonary and renal function, and hormonal impacts, could participate in varying drug absorption, distribution, excretion, and interaction profiles (Franconi & Campesi, 2017).

Patients with fewer medications needed Enoxaparin for 2.4 days on average, while those with hyperpolypharmacy required 6.3 days – more than double the duration. Hospitalization patterns closely matched anticoagulation duration. Non-polypharmacy patients were discharged after 2.4 days (matching their Enoxaparin duration), while hyperpolypharmacy patients required 5.8 days of hospitalization, nearly matching their 6.3-day anticoagulation course. Enoxaparin, best used in multiple CAD, coexisted with potential polypharmacy (Montalescot et al., 2003; Ferguson et al., 2004). Moreover, other conditions also coexisted , needing higher dose and longer duration of therapy, including acute ischemic stroke, atrial fibrillation to prevent recurrent events, thrombotic protection and cerebral venous thrombosis (Becker et al., 2011).

Despite the increasing complexity in polypharmacy groups, patient outcomes remained predominantly favorable. Among patients with comorbidities, mortality patterns emerged with hypertensive patients accounting for three deaths and diabetes-hypertension combinations causing two deaths. Patients without comorbid conditions achieved discharge within three days, while only 47.1% of those with comorbidities had short-stay hospitalizations, indicating that chronic conditions complicate clinical management beyond the primary indication for Enoxaparin. Patients with diabetes alone showed more moderate medication profiles, suggesting that isolated diabetes is more manageable than combined metabolic-cardiovascular conditions. The Italian study conducted by Albani et al provided evidences that Enoxaparin caused mortality reduction in COVID-19 patients (Albani et al., 2020).The reduction in mortality could perhaps be explained in the context of Enoxaparin's role in counteracting the coagulopathy associated with COVID-19 (Albani et al., 2020).

The short durations of therapy and hospitalization may limit the generalizability of these results to longer-term anticoagulation decisions. Additionally, the study's focus on hospitalized patients may not reflect outpatient eligibility considerations where different risk-benefit calculations may apply. The main advantages of low molecular weight heparins (e.g. Enoxaparin), is their usefulness for outpatient treatment or in reducing the admission duration when used in hospitalized patients (Spyropoulos et al., 2002; Boucher et al., 2003; Aujesky et al., 2005). Unfractionated heparin (UFH) requires laboratory monitoring tests and intravenous infusion settings, whereas Enoxaparin could be administered by subcutaneous injections and with no coagulation monitoring or infusion settings (Argenta et al., 2011).

The clinical implications for polypharmacy and Enoxaparin treatment duration indicate that the medication profile should provide careful arrangement of treatment and resource share. Second, the similar outcomes regardless of age and gender groups emphasize the demand for individualized diagnosis. Third, the positive outcomes enhance Enoxaparin's role in prophylactic and therapeutic settings. The study also demonstrated that the high prevalence of polypharmacy and its link with long-term therapy suggests that medication optimization could mitigate treatment complexity and resource utilization without affecting the clinical effectiveness.

Future studies should focus on prospective evaluation of the role of Enoxaparin in medication status, including strategies for enhancing concurrent therapies. Cost-effectiveness studies merging the relationship between medication profile, hospitalization stays and clinical prognosis, could inform healthcare policy decisions. Managing anticoagulation in polypharmacy patients, including assessments of drug interactions and monitoring strategies, would enhance clinical care.

Conclusion

This study revealed that Enoxaparin has a triple impact on comorbidity reduction, hospitalization duration, and medication profile. Patients with complex compelling diseases require critical care, the outcomes revealed Enoxaparin's safety and efficacy for patients with diverse clinical status. The outcomes clarified the role of patient diagnosis and suggest that Enoxaparin should be assimilated into broader strategies for optimizing care in critical patients.

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