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Predictive Parameters for Hospital Admission Among Liver Transplant Recipients Presenting to the Emergency Department: A 5-Year Study

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Abstract

Aim: Liver transplantation (LT) has significantly improved patient outcomes, leading to increased numbers of LT recipients seeking emergency department (ED) care. However, there is a lack of comprehensive information regarding their outcomes and parameters influencing hospital admission decisions. This study aims to address the gap in knowledge by analyzing critical parameters influencing hospital admission decisions for LT recipients presenting at the ED.

Materials and Methods: A retrospective observational case-control study was conducted with 247 consecutive LT patients who visited a tertiary care center's ED between 2018 and 2023. Demographic information, transplantation details, presenting complaints, laboratory results, and ED outcomes were evaluated. Univariate analysis identified significant predictors for an artificial neural network (ANN) analysis to predict admission decisions.

Results: Among 247 LT recipients presenting at the ED, 48.2% were admitted. The most common complaints among admitted patients were abdominal pain and fever. Patients admitted had higher levels of alanine aminotransferase, aspartate aminotransferase (AST), alkaline phosphatase, gamma-glutamyl transferase, and C-reactive protein (CRP) and lower levels of total protein and albumin compared to discharged patients. Ultrasonography findings of perihepatic fluid collection were more common in admitted patients. The ANN analysis identified total protein, conjugated bilirubin, CRP, total bilirubin, and AST as the most influential factors predicting hospital admission decisions.

Conclusion: The ANN analysis identified total protein, conjugated bilirubin, CRP, total bilirubin, and AST influencing hospital admission decisions for liver transplant recipients in the ED. Emphasizing the significance of these parameters can guide evidence-based guidelines for improved patient care and resource allocation in emergency settings.

Keywords: Liver transplantation, hospital admission decisions, emergency department outcomes, artificial neural network analysis, clinical decision-making

Introduction

Liver transplantation (LT) represents the established treatment for end-stage liver diseases within contemporary medical practice (1). The historical trajectory of this medical advancement has significantly improved patient outcomes in terms of both quality of life and long-term survival (2). Pioneered in 1967 by Dr. Starzl in the United States (US) and later achieved in Turkey by Dr. Haberal in 1988, the success of LT has since been fortified by advancements in surgical techniques, augmented public awareness initiatives, and dedicated efforts from transplant centers (3). As a result, the number of successful LTs has substantially increased, positively impacting an estimated 100.000 patients in the US alone (4). While Turkey's annual

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liver transplant volume may differ from the US, the country's per capita transplantation rate remains commendable on the global stage (3). The expanding success and improved survival rates post-transplantation have concurrently led to a notable rise in LT recipients seeking care at emergency departments (ED) (5). Approximately 30-45% of patients have been observed to present to EDs within the first two years post-transplantation, underscoring the clinical significance of this subject matter (6,7).

After LT, the occurrence of various early and late complications has been extensively documented (8). Early complications often involve intricate aspects such as surgical technique, liver graft dysfunction, rejection, or infection (9). In the medium to long-term, complications are primarily linked to the administration of immunosuppressive therapy, with the exception of chronic rejection (10,11). Following LT, patients initially receive care from transplant surgeons and/or hepatologists. However, after several months, the overall medical management of LT recipients is typically handed back to primary care clinicians (12). While practices may differ among transplant centers, managing immunosuppressive agents to treat recurrent liver disease and address biliary complications constitutes standard responsibilities of transplant centers. Consequently, when patients encounter unforeseen medical issues or require urgent care outside regular working hours, EDs become the primary recourse for immediate medical attention. The management of LT recipients requires a multi-systemic evaluation and a multi-hierarchical approach. The roles of emergency physicians in LT patients include the recognition and management of various emergent conditions that may arise due to LT, such as acute or chronic rejection, emergencies related to hypertension, kidney failure, infections, diverse dermatological conditions, and acute metabolic states associated with diabetes mellitus, in addition to being proficient in recognizing and managing complications related to immunosuppression, biliary complications, and the recurrence of primary liver disease, while ensuring early referral of patients to their primary transplant centers for appropriate management (7,10,13,14).

Notably, despite the abundance of guidelines for managing liver diseases, there is a conspicuous dearth of specific algorithms concerning the management of emergency visits by LT recipients, whether pertaining to liver-related complications or unrelated medical issues (15). Despite extensive attention devoted to early and late complications in the literature, the significance of lifelong care to ensure graft and patient survival remains emphasized (16). This underscores the crucial roles played by emergency physicians, to some extent general practitioners, and primary care centers in the ongoing follow-up care of these patients, particularly when dealing with issues directly associated with transplantation or other medical conditions necessitating attention within the context of transplant recipients. Furthermore, there is a notable lack of guidance and shared experiences for non-transplant team physicians in managing post-transplant care (16). This is attributed to the fact that while the transplant team predominantly comprises professionals responsible for identifying the need for transplantation, performing the transplantation procedure, and monitoring post-transplant care, emergency physicians are often not integrated into these teams in many centers (17-19). Nevertheless, considering the medications employed, surgical history, and pre-existing conditions of transplant recipients, the identification of clearly defined indications for transferring these patients to transplant centers or teams remains an area yet to be fully addressed.

Upon meticulous review of the literature, it is evident that there exists only partial analysis of postoperative complications and ED visit reasons among LT recipients. This dearth of parameters influencing admission and discharge decisions from the ED presents a notable gap, hindering the formulation of essential guiding principles for emergency physicians. Thus, our study's primary objective is to undertake a comprehensive analysis of the critical parameters impacting the decision-making process regarding the admission of LT recipients who present at the ED.

Materials and Methods

Study Design

This study was designed as a retrospective observational case-control study and obtained ethical approval from the Memorial Şişli Hospital Ethics Committee prior to its commencement (ethics committee decision no: 003, date: 03.06.2023). Written consent was obtained from the patients or their legal guardians, and in the case of deceased individuals, from their next of kin, prior to the study. The study adhered to the principles outlined in the Helsinki Declaration.

Study Setting and Population

Consecutive LT patients who presented to the Memorial Şişli Hospital ED between 2018 and 2023 were included in this study. The hospital, a tertiary care center, performs a considerable number of liver transplants annually (approximately 60 LT operations per year), while its ED handles approximately 20.000 visits each year. The study encompassed both orthotopic and liver donor transplant recipients. The study excluded patients with pre-hospital cardiac arrest, as well as those with in-ED cardiac arrest, and trauma patients.

All LT patients presenting to the ED during the study period were initially considered for inclusion. The total number of patients identified was Each patient's eligibility was assessed, and their records were reviewed. Out of the 301 patients identified, 247

met the inclusion criteria and were included in the study. Fifty-four patients were excluded based on the following criteria: pre-hospital cardiac arrest (1 patients), in-ED cardiac arrest (1 patients), trauma (46 patients), and patients whose files could not be reached (6 patients). No patients declined participation after being approached.

Study Protocol and Measurements

Data were extracted from the hospital's electronic medical records system. The collected data included demographic information (age, gender), details about the transplantation procedure (emergency or elective), time elapsed from transplantation to ED visit, presenting complaints (including the four most common complaints: fever, weakness, nausea, and abdominal pain), complete blood count parameters [white blood cells (WBC), hematocrit (HCT), platelet count (PLT), activated partial thromboplastin time (aPTT), international normalized ratio (INR), biochemical parameters (alanin aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), lactate dehydrogenase (LDH), total bilirubin, conjugated bilirubin, albumin, total protein, urea, creatinine, c-reactive protein (CRP)], ultrasonography findings (perihepatic fluid, perihepatic collection, free abdominal fluid), and ED outcomes (admission or discharge). Relevant parameters had <5% missing data, which was addressed using the multiple imputation method.

Statistical Analysis

Data were evaluated using Statistical Package for Social Sciences v29 (IBM Corp., Armonk, NY). For categorical variables, descriptive statistics included frequency and percentage, while continuous variables were presented as mean ± standard deviation or median with interquartile range (25^{th} -75^{th}). The normality of data distribution was assessed using the Shapiro-Wilk test and histograms. For between group comparisons of categorical variables (e.g., gender, presenting symptoms), the Chi-Square test was applied. The Chi-Square test was chosen because it evaluates whether there is a significant association between two categorical variables, which is appropriate for determining the relationship between patient characteristics and admission status. The assumptions of the Chi-Square test were confirmed for all categorical variables. For normally distributed continuous variables (e.g., age), the t-test was used to compare the means between groups. This test was chosen because it is suitable for comparing the means of two independent groups when the data are normally distributed. For non-normally distributed continuous variables (e.g., time elapsed from transplantation to ED visit), the Mann-Whitney U test was applied to compare medians. This non-parametric test was chosen because it does not assume normal distribution and is appropriate for comparing medians of two independent groups. Univariate analysis identified statistically significant parameters as predictors for the artificial neural network (ANN) analysis. ANN was chosen for this study due to its ability to model complex, non-linear relationships between multiple predictors and outcomes, which traditional statistical methods might not capture effectively. The ANN method involved the use of a multilayer perceptron with one hidden layer, employing hyperbolic tangent as the activation function for the hidden layers and softmax for the output layer (Figure 1). This architecture was selected to balance model

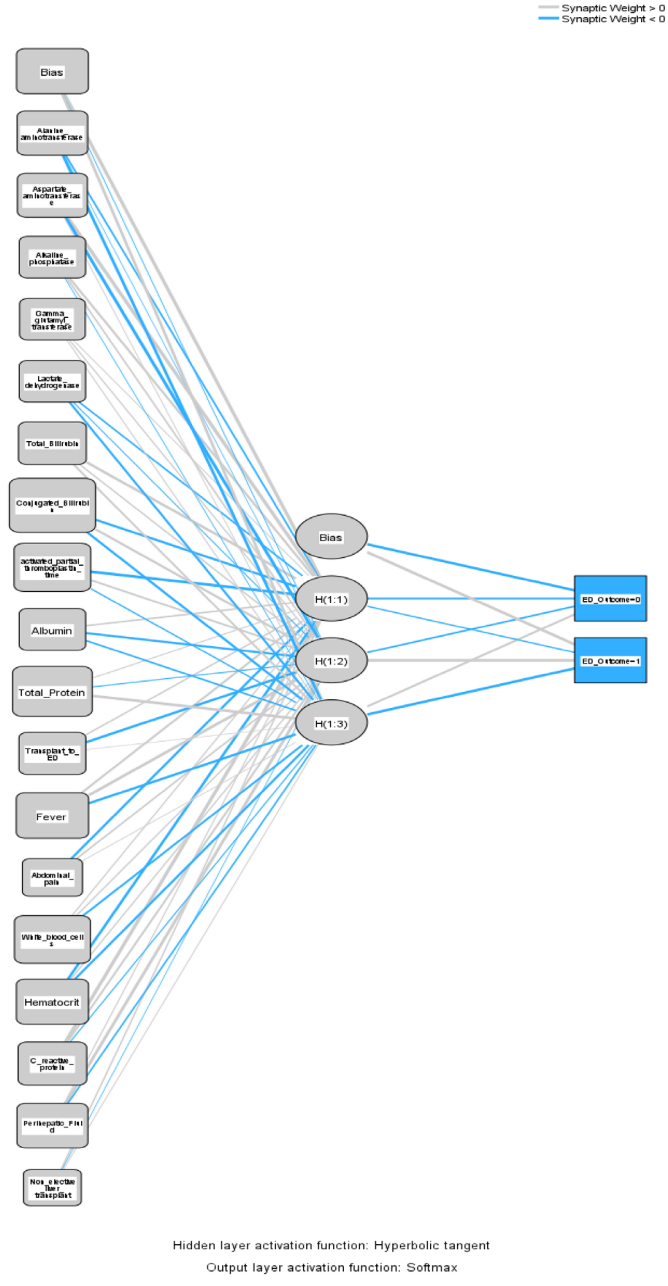

Figure 1. Synaptic weight figure of the neural network analysis model

complexity and interpretability. The model was trained using 70% of the data and validated using the remaining 30% to assess its robustness and generalizability. The ANN was specifically chosen to leverage its strengths in handling large datasets with numerous predictors, allowing for the identification of subtle patterns and interactions. The diagnostic accuracy of the model was assessed using the area under the receiver operator characteristics.

To control for potential confounding factors, we included all significant variables from the univariate analysis as input features in the ANN model. The ANN inherently considers multiple variables simultaneously, thereby accounting for the potential confounding effects by analyzing the combined influence of these variables on the outcome. Additionally, we performed sensitivity analyses by systematically excluding individual variables to assess their impact on the model's performance and ensure robustness of the findings. This approach helps to minimize the risk of biased results due to confounding factors.

Results

A total of 247 LT recipients were enrolled in this study. Based on their ED outcomes, the patients were categorized into two groups: admission (n=119, 48.2%) and discharge (n=128, 51.8%). There were no statistically significant differences in median age and gender distribution between the two groups (Table 1) (Man-Whitney U test for age comparison p=0.105, Chi square test for gender distribution p=0.127). Notably, the admission group exhibited a statistically higher proportion of patients presenting with fever and abdominal pain compared to the discharge group (Chi-square test for both comparisons; p<0.001, p=0.007, respectively). Furthermore, the median duration between transplantation and ED visit was found to be significantly longer in the admission group [122.5 days (IQR 58.25-232 days)] compared to the discharge group [98 days (IQR 42-234 days)] (Mann-Whitney U test; p=0.004).

In the discharge group (Table 2), the mean WBC (8.81 ± 5.18 $x10^9$/L) was observed to be 1.35 (95% CI 0.69-2.02) $x10^9$/L lower than that of the admission group (10.16 ± 7.77 $x10^9$/L) (Students' t-test; p<0.001). Additionally, the mean HCT (34.09 ± 4.42 %) was found to be 0.75% [(95% confidence Interval (CI) 0.24% -1.26%)] units higher than the admission group (33.34 ± 5.61%) (Students' t-test; p=0.005). However, there was no statistically significant difference in mean PLT between the two groups (Students' t-test; p=0.519).

Interestingly, the admission group exhibited statistically higher median levels of ALT, AST, ALP, GGT, LDH, total bilirubin, and conjugated bilirubin compared to the discharge group (Table 3) (Mann-Whitney U test; p<0.001 for all parameters). Moreover, the mean albumin (3.83 ± 0.54 g/dL) in the admission group was 0.3 g/dL (95% CI 0.24-0.35 g/dL) lower than the discharge group (4.13 ± 0.41 g/dL) (Students' t-test; p<0.001), while the mean total protein (6.27 ± 0.72 g/dL) in the admission group was 0.59 g/dL (95% CI 0.51-0.67 g/dL) lower than the discharge group

Table 1. Demographic characteristics, transplant history, and presenting complaints of patients

		discharge (n=119)	admission (n=128)	p value
Age (in years)		40 (27-56)	46 (16-60)	0.105
Sex (female)		63 (54.3%)	57 (44.5%)	0.127
Liver transplantation status (emergent)		26 (21.8%)	14 (10.9%)	0.02
Time to ED after transplant (days)		98 (42-234)	122.5 (58.25-232)	0.004
Presenting symptom	Fever	29 (24.4%)	59 (46.1%)	<0.001
	Fatigue	17 (14.3%)	29 (22.7%)	0.091
	Nausea	19 (16%)	28 (21.9%)	0.237
	Abdominal pain	22 (18.5%)	43 (33.6%)	0.007

ED: Emergency department

Table 2. Comparison of complete blood count and bleeding profile parameters between groups

	discharge (n=119)	admission (n=128)	p value	Mean difference (95% CI)
WBC ($x10^9$/L)	8.81 ± 5.18	10.16 ± 7.77	<0.001	1.35 (0.69-2.02)
HCT (%)	34.09 ± 4.42	33.34 ± 5.61	0.005	0.75 (0.24-1.26)
Platelet ($x10^3$/µL)	242.44 ± 124.3	237.57 ± 164.8	0.519	
aPTT (seconds)	31 (28-34.7)	33.45 (30-37.37)	<0.001	
INR	1.25 (1.09-1.59)	1.24 (1.11-1.46)	0.6	

WBC: White blood cell, HCT: Hematocrit, aPTT: Activated partial thromboplastin clotting time, INR: International normalized ratio, CI: Confidence Interval

Table 3. Comparative analysis of hepatic and inflammatory blood markers between discharge and admission groups				
	discharge (n=119)	**admission (n=128)**	**p value**	**Mean difference (95% CI)**
ALT (U/L)	26 (15-62)	31 (19-76)	<0.001	
AST (U/L)	26 (17-48)	32 (22-52)	<0.001	
ALP (U/L)	113 (82-233)	148 (93-239)	<0.001	
GGT (U/L)	43 (27-90)	63 (23-133)	<0.001	
LDH (U/L)	208 (172-287)	236 (184-310)	<0.001	
Total bilirubin (mg/dL)	0.58 (0.36-0.86)	0.86 (0.48-1.48)	<0.001	
Conjugated bilirubin (mg/dL)	0.29 (0.18-0.45)	0.42 (0.2-0.87)	<0.001	
Albumin (g/dL)	4.13±0.41	3.83±0.54	<0.001	0.3 (0.24-0.35)
Total protein (g/dL)	6.86±0.67	6.27±0.72	<0.001	0.59 (0.51-0.67)
Urea (mg/dL)	37 (27-46)	38 (27-51)	0.068	
Creatinin (mg/dL)	0.77 (0.53-1.07)	0.78 (0.5-1.02)	0.115	
CRP (mg/L)	6.17 (2.38-18.92)	23.22 (5.22-69.13)	<0.001	

AST: Aspartate aminotransferase, ALT: Alanine transaminase, ALP: Alkaline phosphatase, GGT: Gamma-glutamyl transferase, LDH: Lactate dehydrogenase, CRP: C-Reactive Protein, CI: Confidence Interval

Table 4. Comparison of groups based on pathological findings in ultrasonography imaging			
Pathologic sign	**discharge (n=119)**	**admission (n=128)**	**p value**
Perihepatic fluid	4 (3.4%)	18 (14.1%)	0.003
Perihepatic collection	5 (4.2%)	13 (10.2%)	0.072
Free fluid in the abdomen	7 (5.9%)	16 (12.5%)	0.074

(6.86 ± 0.67 g/dL) (Students' t-test; p<0.001). Surprisingly, there was no statistically significant difference in median INR values between the groups (Mann-Whitney U test; p=0.6). However, the admission group showed a statistically higher median aPTT value [33.45 (IQR 30-37.37)] compared to the discharge group [31 (IQR 28-34.8)] (Mann-Whitney U test; p<0.001). Additionally, there were no statistically significant differences in median urea and creatinine values between the two groups (Mann-Whitney U test for both; p=0.068, p=0.115, respectively).

Furthermore, the admission group demonstrated a statistically higher median CRP level [23.22 (IQR 5.22-69.13) mg/L)] compared to the discharge group [(6.17 [IQR 2.38-18.92)] mg/L) (Mann-Whitney U test; p<0.001). (Table 4) The rate of perihepatic fluid collection was significantly higher in the admission group (14.1%) than in the discharge group (3.4%) (Chi-Square test; p=0.003). Nevertheless, there were no statistically significant differences in the rates of perihepatic collection and free fluid in the abdomen between the two groups (Chi-Square test; p=0.072, p=0.074, respectively).

For the ANN analysis, we incorporated the parameters that exhibited statistical significance in the univariate analysis into the model. Following gradient descent optimization, the final

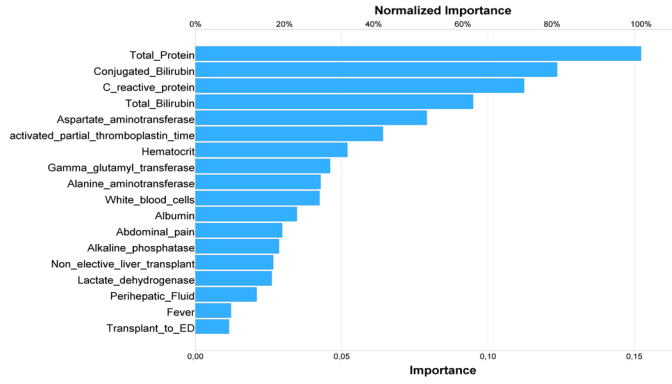

Figure 2. Importance analysis results from artificial neural network analysis

model displayed an accuracy of 77.6% in predicting the outcome. Notably, the most influential predictor variables in the model were total protein, conjugate bilirubin, CRP, total bilirubin, and AST (Figure 2). In the derivation cohort, the model's area under the curve was 0.826 (95% CI 0.761-0.879).

Discussion

In this study, a significant observation was made, indicating that nearly half of all patients who presented to the ED were ultimately admitted to the hospital. This finding aligns with a similar study conducted by Savitsky et al. (13) in 2000, where approximately two-thirds of LT recipients seeking care at the ED were admitted, demonstrating a higher probability of hospital admission. Conversely, the National Hospital Ambulatory Medical Care Survey of 2020 reported a hospital admission rate of 14.2% for all ED visits in the general population (20). This suggests that

when seeking medical attention, LT patients are admitted to the hospital at a rate approximately 3-5 times higher than that of the general population. Consequently, clinicians should be cognizant of the potential necessity for hospital admission to manage treatment and follow-up when these LT patients seek care at an ED outside their transplant center.

Previous studies have suggested that urgent LT for acute liver failure is (ALF) is associated with poorer short and medium-term outcomes compared to non-urgent cases (21). In our study, we observed that urgent LT (10.9% of admitted patients) had a significant impact on hospital admission rates compared to non-urgent cases (21.8% of admitted patients) in the univariate analysis ($p=0.02$). This finding aligns with existing literature indicating that urgent LT cases tend to have more complex clinical presentations requiring hospitalization. However, despite this significant difference, our ANN analysis revealed that urgency of LT was not among the most important predictors for hospital admission. This suggests that while urgency of LT plays a role, other biochemical parameters are more influential in guiding hospital admission decisions for LT recipients in the ED.

According to Stolper et al. (22) proposed concept of the "sense of alarm" specific symptoms are triggered in certain diseases, prompting physicians to take action. As is well-known, individuals with a history of LT who present with acute or chronic graft rejection may have undergone prior organ or tissue transplants (e.g., kidney, liver, and lung) for various medical conditions (23). The manifestation of rejection symptoms can vary among individuals and may include a range of manifestations such as high fever, jaundice, dark urine, itching, abdominal swelling, pain or tenderness, fatigue, irritability, and headaches (24). In our study, despite four prominent complaints being identified among patients seeking ED care (fever, weakness, nausea, and abdominal pain), it was observed that abdominal pain and fever were more prevalent in admitted patients compared to discharged patients. Specifically, fever was reported in 46.1% of admitted patients compared to 24.4% of discharged patients ($p<0.001$), and abdominal pain was reported in 33.6% of admitted patients compared to 18.5% of discharged patients. This suggests that abdominal pain and fever might be considered "highly probable complaints" indicative of graft rejection in LT patients, potentially evoking a "sense of alarm" among clinicians and leading to the decision to hospitalize and closely monitor these patients.

In this study, we investigated the complete blood count parameters of LT recipients who presented to the Transplant Center ED and underwent decisions regarding hospital admission or discharge. The results showed that admitted patients had lower HCT per cents compared to those who were discharged. Lower HCT levels are expected in patients with compromised liver function, and maintaining such levels has been recommended to reduce the risk of hepatic artery thrombosis in LT recipients (25). Factors like liver disease, bleeding, and medications can cause HCT fluctuations post-transplantation, with the immunosuppressive drug FK506 potentially impacting HCT pharmacokinetics and clinical outcomes 26 whole blood has been selected as the matrix to monitor concentrations of tacrolimus (FK506). Hence, close monitoring of HCT levels is crucial for patient management, with patients exhibiting low HCT values being admitted for appropriate follow-up and treatment. Additionally, we observed higher WBC counts in admitted patients (10.16 ± 7.77 x10^9/L) compared to those discharged (8.81 ± 5.18 x10^9/L). Elevated WBC counts can indicate the presence of infections, which are a leading cause of mortality and morbidity in LT recipients (27). Elevated WBC counts have been associated with post-LT mortality and graft survival, but the significance of perioperative procalcitonin and CRP levels has been debated (28). Our findings contradict the mentioned study, as both CRP and WBC values were significantly higher in admitted patients. Our findings are consistent with previous studies that identify bacterial infections as prevalent and difficult to diagnose in LT patients due to immunosuppression (27). Post-transplant infections remain a leading cause of mortality, particularly in the first three months after LT, with infection-related mortality rates being notably higher during this period (29,30). Moreover, our research identified the third and fourth months post-transplant as the most common periods for ED visits. Taken together, this suggests that patients with elevated infectious parameters are more likely to be admitted to the hospital for close monitoring and timely interventions.

When assessing the association between the time of admission and the length of hospital stay, it was observed that patients who presented to the ED and were subsequently admitted had a longer hospital stay compared to those who were discharged. LT extends beyond a mere surgical procedure, as it categorizes individuals as "transplant recipients," introducing a distinct category. Consequently, both LT and organ transplantation, in general, entail specific risk factors and complications (31). These encompass short-term risks associated with the surgical procedure, medium-term risks related to LT, and medium to long-term risks that may arise from organ transplantation (32,33). Although our study identified a statistically significant difference in the time from LT to ED presentation between the two groups, the clinical significance of this duration and its relatively low importance in the neural network analysis suggest that it may have limited significance in the decision-making process. In this study, we assessed the bleeding profile as an essential parameter in LT recipients who presented to the ED. Surgical Intensive Care Units commonly use a combination of surgical drain fluid

characteristics, INR, Partial Thromboplastin Time (PTT), PLT, and functional assessment to manage post-transplant coagulopathy (34). Scoring systems like Model for End-Stage Liver Disease (MELD), MELD-Na, and Chronic Liver Failure-Specific Organ Failure Assessment have been incorporated to evaluate liver disease severity (35). However, perioperative and postoperative approaches for parameters like INR and PLT vary, and there is no consensus on routine institution-wide procedures. The study found no significant difference in PLT between admitted and discharged patients. aPTT was significantly lower in admitted patients, but no notable difference in INR was observed between the two groups.

A definitive follow-up profile for LT patients has not been established; however, a comprehensive metabolic profile panel for liver diseases typically includes AST, ALT, ALP, bilirubin, and albumin (15). Hepatic-origin high levels of ALP can be confirmed with elevated GGT or ALP fractionation. LDH is believed to be associated with acute hepatic hypoxic conditions during the development of ALF and excessive macrophage activation in the liver (36). In this study, the admission group showed statistically significant elevations in ALT, AST, ALP, GGT, LDH, total bilirubin, and conugated bilirubin, while albumin levels were significantly lower compared to the discharge group. These results suggest that clinicians may have utilized the comprehensive metabolic profile panel for liver diseases when making decisions about hospital admission during the initial ED presentation of these patients. Additionally, the admitted patients had lower total protein levels in peripheral blood compared to those who were discharged. The total serum protein test primarily measures the quantities of two main protein groups in the blood, albumin, and globulin (37). In our study, albumin levels were significantly lower in the admitted group, while univariate analysis in the ANN model identified total protein as the most important predictor variable, along with conjugated bilirubin, CRP, total bilirubin, and AST. Notably, albumin was not among the most important predictors, which raises questions about the marked decrease in globulin levels, particularly Gc-globulin levels, argued to decrease in liver disease, especially ALF 38 its main physiologic function is presumably actin binding and actin scavenging. Actin is a major cellular protein released during cell necrosis that may cause fatal formation of actin-containing thrombi in the circulation if the actin scavenging capacity of Gc-globulin is exceeded. In my studies, I found serum Gc-globulin levels to be reduced in liver disease, most so in patients with ALF. Research findings regarding test interpretations in the follow-up of LT patients often lack specificity. Nevertheless, both ED clinicians and transplant teams utilize their expertise to devise algorithms for determining ED dispositions and planning the management of post-transplant patients who seek care in the ED. In this study, we focused on evaluating total protein as a crucial parameter influencing clinicians' treatment decisions for LT patients following their ED visits.

In post- LT patient follow-ups, imaging findings play a crucial role in decision-making and management. This study examined liver imaging indications, which revealed significant perihepatic fluid in admitted patients compared to discharged ones. Ultrasonography is a valuable noninvasive method for assessing liver vessels and nonvascular complications in LT recipients (39). However, no imaging method has proven sensitivity or specificity for diagnosing rejection; graft biopsy remains the reliable diagnostic approach (40). Large-volume perihepatic fluid may indicate potential complications like hepatic venous outflow obstruction, renal failure, or infection (41 although uncommon, usually represents a serious adverse event. The pathogenesis of this complication has not been adequately investigated. To determine the incidence, characteristics, and pathogenic factors of massive ascites after LT (ascitic fluid > 500 mL/d for >10 days). Therefore, vigilant monitoring is essential. Overall, imaging findings hold importance in the clinical assessment of post-LT patients. Notably, this study also found perihepatic fluid to be more frequently observed in admitted patients.

In this study, we analyzed patients who underwent LT and subsequently presented to the ED for various reasons. Among them, those who were admitted displayed distinctive characteristics compared to those who were discharged. The primary complaints upon ED arrival were abdominal pain and fever, which were more prevalent in the admitted group. Additionally, the complete blood count revealed significantly higher WBC and lower HCT levels in the admitted patients. Regarding the bleeding profile, there were no significant differences in PLT and INR values between the two groups, but aPTT was notably lower in the admitted patients. In terms of biochemical parameters, the admitted group showed significantly elevated levels of ALT, AST, ALP, GGT, LDH, total bilirubin, and conjugated bilirubin, while albumin and total protein levels were significantly lower. Moreover, the ultrasound imaging revealed a frequent occurrence of perihepatic collection in the admitted patients. Our model analysis identified five predictive factors for admission: total protein, conjugated bilirubin, CRP, total bilirubin, and AST. Notably, total protein deficiency emerged as the most robust predictor, suggesting its potential significance as an indicator of ALF.

Despite the advancements in LT management and existing research, there remains a need for guidelines in handling emergency situations that may arise either related or unrelated to the transplantation process during ED presentations of these patients. This study aimed to identify factors influencing post-

ED management decisions for liver transplant recipients within a 5-year period at our international transplant center.

In summary, this study provides new insights into the management of LT recipients in the ED by identifying total protein, conjugated bilirubin, CRP, total bilirubin, and AST as key predictors of hospital admission using an ANN model. While previous studies have highlighted the importance of clinical symptoms and urgent LT status, our findings underscore the superior predictive value of specific biochemical parameters. This novel application of ANN in this context offers a more nuanced understanding of the factors driving admission decisions, which can enhance clinical practice by prioritizing critical metabolic markers over traditional indicators. By integrating these predictors into clinical protocols, emergency physicians can make more informed, evidence-based decisions, ultimately improving the care and outcomes of LT patients.

Study Limitations

This study has several limitations that should be considered when interpreting the results. First, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Different centers may have varying patient populations and management approaches, impacting the admission decisions in the ED. Second, the retrospective design of the study relied on data from electronic medical records, which might introduce biases and limitations in data completeness and accuracy. Despite efforts to address missing data through multiple imputation, there may still be residual confounding or unmeasured variables that could influence the results. Additionally, while the study identified important predictors for hospital admission using the ANN model, the model's validation was based on a single 70-30 split of the data. Although this provided insights into the model's performance, external validation using independent datasets would increase the model's reliability. Furthermore, not all potential confounding variables may have been accounted for in the analysis. Despite adjusting for relevant parameters, there might be other factors influencing admission decisions that were not included in the study. Moreover, the decision-making process in the ED involves complex clinical judgment, taking into account various factors beyond the examined parameters. The model, while helpful, cannot capture the full breadth of clinical considerations made by emergency physicians.

Conclusion

In conclusion, this study highlights the crucial role of specific parameters in determining hospital admission for LT recipients in the ED. Total protein, conjugated bilirubin, CRP, total bilirubin, and AST emerged as the most influential factors. These findings underscore the importance of a comprehensive metabolic profile, guiding clinicians in making informed decisions and optimizing care for these patients. Further research and guidelines are needed to enhance our understanding and improve the management of liver transplant recipients in emergency settings.

Ethics

Ethics Committee Approval: The study was approved by Memorial Şişli Hospital Ethics Committee (ethics committee decision no: 003, date: 03.06.2023).

Authorship Contribution

Surgical and Medical Practices: Ö.F.A, T.G., A.C.T., S.Y., Concept: Ö.F.A, S.Y, Design: Ö.F.A, A.C.T., Data Collection or Processing: T.G., Analysis or Interpretation: A.C.T., Literature Search: Ö.F.A, S.Y., Writing: Ö.F.A, A.C.T., S.Y.

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