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Characterization of emergency department visits in pediatric patients within first year of liver transplantation: ten years experience in tertiary care center

Reem Elmokattaf[1], Ahmad Aljumaa[1], Majd Alani[1], Jihad Aljumaa[1*], Nayef Latta[1], Hossam Ali Basha[1], Ahmed Mohamed Elhassan[1], Ismail A. Abdullah[1], Mohammad Aljumaa[1], Saleh M. Al-Yahri[1] and Farooq Pasha[2]

Abstract

Background Liver transplantation is a complex procedure associated with significant post-operative challenges. Monitoring the frequency and timing of Emergency Department (ED) visits post-transplant in a vulnerable population like pediatrics can provide critical insights into patient outcomes and the effectiveness of post-operative care.

Objective This study aims to evaluate the indications, frequency, reasons and length of stay for ED visits among liver transplant recipients within the first year following discharge post-transplantation.

Methods A retrospective observational study was conducted on 361 liver transplant recipients, analyzing the frequency, timing, indications, reasons and length of stay for their ED visits post-discharge over 10 years.

Results 361 patients were analyzed in this study with a total of 1300 emergency department visits. (52%) of the patients were males and (48%) were females. Most transplants were from living donors (93%, $N=338$). Patients with at least one comorbidity accounted for 35% of total patients with hypertension 6% (20), congenital heart disease 5% ($n=18$), and seizure disorder 4% ($n=15$) representing the most common comorbidities. Most common indications for liver transplant were biliary atresia (21%) and progressive familiar intrahepatic cholestasis (20%). The most common reasons for ED visits were gastrointestinal symptoms (32%), pulmonary symptoms (22%), and infectious symptoms (16%). Patients' average length of stay in the hospital was 4 ± 10.7 days. Visits within the first 6 months accounted for 58% of total visits in the first year with first and second visits accounting for 47% of total emergency department visits.

Conclusion The study highlights the high frequency of emergency department visits in pediatric subgroup as well the first 6 months as a critical period for follow-up. The study also demonstrated the continuous representation to the emergency department which calls for a closer follow-up and interventions to prevent those revisits.

Clinical trial number Not applicable.

Keywords Pediatric, Emergency department, Liver transplantation, Emergency visits, Outcome

*Correspondence:
Jihad Aljumaa
jaljumaa@alfaisal.edu

[1]College of Medicine, Alfaisal University, Riyadh, Saudi Arabia
[2]Department of Emergency Medicine, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia

Introduction

Liver transplant is one of the major advances in medicine and one of the most performed surgeries in transplant. In the Kingdom of Saudi Arabia, the first liver transplant was performed in 1991. However, pediatric liver transplant didn't start until 1997, trailed by adult living donor transplant by 2001. By 2007, over 500 transplants have been done, with more than 300 deceased- donor liver transplants (DDLT) and over 200 living donor liver transplants (LDLT). By 2017, over 2000 liver transplants were done, with over half being performed at King Faisal Specialist hospital in Riyadh [1].

Liver transplant is a very extensive procedure that requires careful preoperative preparation and investigations and meticulous post-operative observation and management [2, 3]. With the advances in medicine and surgical procedures, liver transplant became a lifesaving procedure not only for adults but also for special groups like pediatrics. Liver transplants in children have an excellent prognosis and significantly improve the quality of life. Advances in medical and surgical fields have resulted in the 10-year patient survival rate after LT increasing to approximately 85% [4].

Literature on liver recipients' representation to the hospital is scarce and heterogeneous with few studies assessing hospital readmissions [5, 6, 7, 8], ICU readmissions [9, 10], and emergency visits [3, 11, 12]. Studies assessing emergency visits post-transplantation are especially scarce. A recent study, carried out in 2023 in Saudi Arabia, was the first to focus exclusively on emergency department visits in the adult subgroup. This study found that most initial post-transplant presentations occur within the first year, highlighting this period as critical for liver transplant patients [13]. Additionally, only five literary articles have focused on emergency visits for liver transplant recipients [3, 12, 14–16]. The earliest study, conducted in 1998, described the literature on emergency visits in liver transplant patients as sparse [14].

Indications for pediatric transplantation are similar to those of adults including acute or chronic liver disease, hepatic tumors in addition to genetic metabolic diseases [17]. Despite all the care provided, some complications might still arise. These complications might be related to the surgery itself, such as bleeding and thrombotic complications due to the complex nature of hemostasis in such procedures [18, 19]. It can also be related to infections post procedure, and immunological complications such as rejection might also take place [20]. Those complications can result in frequentation of emergency department. A recent multi-center study highlighted that while survival rate has improved compared to previous decade, many complications are presenting with the same rate as in previous decade [21].

Despite there being many studies addressing the liver transplantation in pediatrics encompassing indications, complications and outcomes, there are no papers to our knowledge addressing the emergency visits of pediatric liver recipients. As a result, our aim in this study is to assess and characterize the ED visits of pediatric liver transplant patients in King Faisal Specialist Hospital and Research Center within the last 10 years. This study will help shed light on the gaps that need to be addressed regarding complications associated with liver transplant and early diagnosis and management of patients presenting to the ED to provide an enhanced level of care to this population of patients.

Immunosuppressive drug protocols

Initial Regimen: Post-liver transplant, our pediatric patients are initiated on a combination of tacrolimus and corticosteroids as the primary immunosuppressive therapy. Tacrolimus dosing is guided by target trough levels adjusted for patient age, liver function, and clinical course. Steroids are typically started at standard doses immediately post-transplant and tapered over several months based on clinical stability, graft function, and absence of rejection episodes.

Long-Term Management: For stable recipients, tacrolimus monotherapy or low-dose dual therapy (e.g., tacrolimus plus minimal-dose steroids) are continued as deemed necessary. Adjustments are made on a case-by-case basis, taking into account the child's growth, development, graft status, and any comorbidities.

Vaccination protocols

Live Vaccines: Consistent with current transplant guidelines, no live vaccines are administered due to ongoing immunosuppression, as they pose unacceptable risk to this subgroup of patients.

Non-live Vaccines: We recommend resuming standard inactivated (non-live) vaccinations approximately six months post-transplant, once immunosuppression levels have typically been reduced to maintenance doses. This schedule includes vaccines for influenza, pneumococcal disease, Haemophilus influenzae type b, hepatitis B (if needed), and other recommended age-appropriate inactive vaccines.

Monitoring & Coordination: All vaccinations are closely coordinated with the transplant team to ensure optimal timing, minimize the risk of rejection, and maximize immunologic response.

Outpatient follow-up visits and emergency department visits protocols

Pediatric liver transplant recipients are followed intensively in the immediate postoperative period often with weekly or more frequent visits for the first 1–3 months

to closely monitor for acute rejection, infection, and medication adjustments. Over the next 3–6 months, visits may be spaced to every 2–4 weeks, transitioning to monthly or bimonthly checks between 6 and 12 months post-transplant as the child stabilizes. Beyond the first year, if the recipient remains stable, follow-ups typically occur every 3–6 months, eventually moving to annual evaluations. Throughout this process, a multidisciplinary team oversees immunosuppressive management, growth and developmental milestones, and the prevention and early detection of complications.

Patients are advised to visit the Emergency Department (ED) promptly under specific circumstances to ensure timely management of complications. Patients should have an immediate ED evaluation if they develop any signs of infection (e.g., fever > 38 °C, chills, or unusual lethargy), graft dysfunction (e.g., jaundice, dark urine, pale stools, or worsening liver function tests), or rejection (e.g., abdominal pain, fatigue, or unexplained weight loss), signs of bleeding (e.g., gastrointestinal or genitourinary bleeding), respiratory distress, significant fluid retention, or decreased urine output. For non-emergency concerns, such as minor medication side effects or routine blood work abnormalities, contacting the transplant team for guidance may suffice. Parents and caregivers are educated on red flag symptoms and encouraged to be extra vigilant, seeking emergency care whenever in doubt.

Table 1 Patients' characteristics

Patients' characteristics	*N* = 361 (%)
Male/Female	188 (52)/173 (52)
Age (mean ± SD)	9.7 ± 4.8
PELD Score (mean ± SD)	13.2 ± 11.87
MELD Score (mean ± SD)	16.8 ± 8.5
Comorbidities	
HTN	20 (6)
Congenital Heart Disease	18 (5)
Seizure Disorder	15 (4)
CKD	12 (3)
Dyslipidemia	11 (3)
Asthma	10 (3)
Hypothyroidism	6 (2)
Diabetes Mellitus	4 (1)
Rickets	4 (1)
Other	24 (7)
Past Surgical History	
Kasai Procedure	23 (6)
Laparoscopic Nissel Fundoplication	4 (1)
Inguinal Hernial Repair	4 (1)
Umbilical Hernial Repair	3 (1)
Laparoscopic Cholecystectomy	2 (0.5)
VP Shunt	2 (0.5)
Other	16 (4)
Consanguinity	
Yes	303 (84)
No	58 (16)

CKD, chronic kidney disease; HTN, hypertension; MELD, model for end stage liver disease; HTN, hypertension; PELD, pediatric end stage liver disease; VP, ventriculoperitoneal

Methodology

This is a retrospective single-center observational study conducted at King Faisal Specialist Hospital and Research Center (KFSH&RC), a tertiary care center in Riyadh, Saudi Arabia. The study received approval from the Institutional Review Board (IRB) at KFSH&RC. All research methodologies adhered to relevant standards and regulations. Informed consent was waived by the IRB due to the retrospective nature of the study.

Electronic medical records of all patients under 18 years who underwent liver transplantation at KFSH&RC and had an emergency visit from January 2013 to January 2022 were reviewed for the following data: demographics (age and gender), past medical and surgical history, PELD and MELD scores, transplant data (indication for transplant, source of organ, surgical complication, and length of stay), and emergency department visit data (frequency of visit, reason for visit, admission rate, and length of stay). Patients who underwent liver transplantation outside our center, are not following up in our center, had another solid organ transplant, or are older than 18 years were excluded from the study. No identifying data was used in the study.

Descriptive statistical analysis of the results was carried out using SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows). Categorical variables were expressed using frequencies and percentages, while numerical variables were presented with mean and median measures. Categorical variables were compared using Pearson x2 test, whereas continuous variables were compared using the two-sample independent t-test. A significance level of $p < 0.05$ was applied.

Ethical approval

This study was conducted in accordance with the principles set forth by the Declaration of Helsinki. As the research involved the use of retrospective, fully anonymized data, and did not include any direct patient interaction or collection of identifiable personal information, the requirement for informed consent was waived by King Faisal Specialist Hospital and Research Center' Institutional Review Board. **The study's IRB approval number is 2,231,461.**

Results

The study included a total of 361 patients. Patient demographics in Table 1 showed that the gender distribution was nearly equal, with 52% being male ($n = 188$) and 48%

female ($N = 173$). The mean age of the patients was 9.7 years with a standard deviation (SD) of 4.8 years. Pediatric End-Stage Liver Disease (PELD) calculated for pediatric patients 12 years old and younger had a mean score of 13.2 ± 11.87, while the Model for End-Stage Liver Disease (MELD) calculated for patients older than 12 years had a mean score of 16.8 ± 8.5. Comorbidities were common in this sample with 35% of the patients presenting with at least one comorbidity. Hypertension 6% [20], congenital heart disease 5% ($n = 18$), and seizure disorder 4% ($n = 15$) represented the most common comorbidities in our study sample. In our cohort, seizures were not attributed to Posterior Reversible Encephalopathy Syndrome (PRES), as none of the patients exhibited the clinical or radiological features typically associated with this condition (e.g., characteristic findings on brain MRI such as vasogenic edema predominantly in the parieto-occipital regions). Instead, seizures in our study population were due were mainly due to epilepsy and structural brain abnormalities. Few patients had past surgical procedures (14%) with Kasai surgery representing the most common procedure. Parental consanguinity was found in 84% ($n = 303$) of the liver recipients.

Table 2 Transplant characteristics

Transplant characteristics	*N* = 361 (%)
Transplant Indication	
Biliary Atresia	76 (21)
Progressive Familial Intrahepatic Cholestasis	69 (20)
Neonatal Cholestasis	29 (8)
Arginosuccinate Aciduria	19 (5)
Sclerosing Cholangitis	18 (5)
Acute fulminant Liver Failure	17 (5)
Glycogen Storage Disease	16 (4)
Alagille Syndrome	16 (4)
Propionic Acidemia	13 (4)
Crigler Najjar Syndrome	12 (3)
Maple Syrup Urine Disease	12 (3)
Primary hyperoxaluria	9 (2)
Tyrosinemia	8 (2)
Autoimmune Hepatitis	6 (2)
Hepatoblastoma	6 (2)
Citrullinemia	6 (2)
Choledochal Cyst	4 (1)
Hemochromatosis	3 (1)
Other	22 (6)
Donor	
Living Donor	336 (93)
Deceased Donor	25 (7)
Donor Related	62 (17)
Post-Operative Surgical Complications	
Chylous Ascites	32 (9)
Pleural Effusion	10 (3)
Massive Hemorrhage	9 (2)
Abdominal Hematoma	4 (1)
Perihepatic Collection	4 (1)
Abdominal Collection	3 (1)
Hepatic Biloma	2 (0.5)
Atelectasis	2 (0.5)
Biliary Leak	2 (0.5)
Other	19 (5)
Length of Stay Post Transplant (days)	29.7 ± 18.7

Table 2 provides a detailed overview of the transplantation and associated variables. Although there were many indications for liver transplantation, biliary atresia 21% ($n = 76$) and Progressive Familial Intrahepatic Cholestasis 20% (69) accounted for a large percentage (41%) of the total indications. Other indications for liver transplant included Bud-Chiari syndrome, polycystic liver disease, Wilson disease, alpha-1 antitrypsin deficiency, familial homozygous hyperlipidemia, and hepatocellular carcinoma. Living donors accounted for 93% ($n = 336$) of total donated organs with 18% ($n = 62$) of living donors being related to the recipient. Few patients developed surgical complications during their post-operative hospitalization with chylous ascites 9% ($n = 32$) accounting for the most common complications. Other surgical complications during initial post-operative stay included abdominal compartment syndrome, tension pneumothorax, cardiopulmonary arrest, pulmonary vein thrombosis, hepatic artery thrombosis, phrenic nerve palsy, and perihepatic hematoma. Patients had a mean length of stay of 29.7 ± 18.7 days post-transplant.

All patients in the study were on tacrolimus and steroid immunosuppressive therapy. All patients were up to date with their vaccination schedules, with 97.5% having received the complete courses of live vaccines, BCG, rotavirus, measles-mumps-rubella, varicella, and oral polio, prior to transplantation. Notably, the immunosuppressive and immunization statuses were consistent across patients, regardless of the nature of their presenting complaints. Vaccinating six months post liver transplant was not associated with infectious presentations to the ED ($p = 0.34$). The data presented in Table 3 provides a detailed analysis of emergency department (ED) visits over various time intervals following liver transplantation. It categorizes the number of ED visits within distinct periods: <15 days, < 30 days, < 3 months, < 6 months, and < 12 months, further breaking down these visits into first through fifth or more subsequent visits. For visits occurring within the first 15 days ($n = 3$), only the first visits ($n = 3$) were recorded, suggesting a low re-visitation rate shortly after the initial ED visit. When moving to the < 30-day mark ($n = 48$), there is a noticeable increase in the number of first visits ($n = 40$), with few second visits ($n = 8$), indicating that while a substantial number of patients return within a month, fewer make a second visit in this period. At the < 3 months interval ($n = 344$), the data shows a sharp increase in the cumulative number

Table 3 Frequency of emergency department visits over time

	Time After Discharge from Liver Transplantation				
	1–15 days (*n* = 3)	**15–30 days (*n* = 48)**	**31–90 days (*n* = 344)**	**91–180 days (*n* = 372)**	**181–365 days (*n* = 533)**
ED visits					
1st visit (355)	3	40	188	74	50
2nd visit (265)	0	8	100	86	71
3rd visit (195)	0	0	36	75	84
4th visit (131)	0	0	12	50	69
≥ 5th visit (354)	0	0	8	87	259

Table 4 Mean Time-interval between subsequent emergency department visits

ED visit	**Time from transplant discharge to ED presentation**
1st visit	93 ± 83 days
2nd visit	136 ± 87 days
3rd visit	172 ± 88 days
4th visit	196 ± 86 days
≥ 5th visit	243 ± 76 days

of ED visits, particularly for first visits ($n = 188$). Subsequent visits also increase—second visits at 100, third visits at 36, fourth visits at 12, and fifth or more visits at 8. This suggests that, as time progresses, the likelihood of subsequent ED visits increases, likely due to either unresolved or recurrent issues. The < 6 months interval ($n = 372$) reveals further increases, especially in the third ($n = 75$), fourth ($n = 50$), and fifth or more visits ($n = 87$). This period sees a more balanced distribution among the different visit numbers, implying a period of high healthcare utilization. The trend continues up to < 12 months ($n = 533$), where there is a significant concentration of fifth or more visits ($n = 259$), markedly surpassing the numbers of any prior visit sequence. Overall, the data highlights the first 6 months as a critical period for pediatric liver recipients as they account for 58% of total visits. Additionally, while first and second visits account for 47% of total visits, the increase in subsequent visits demonstrates continuous representation to the ED post first and second visits. Figure 1 provides a more visual diagram of Table 3. Table 4 provides further insight into the mean time between transplant discharge and the subsequent ED visits. It also provides insights into the mean time-interval between different visits.

The underlying reasons for Emergency Department (ED) visits following liver transplantation, as observed in a total of 1,297 visits, were systematically categorized into several distinct groups, as detailed in Table 5. Among the presenting complaints, gastrointestinal, pulmonary, and infectious etiologies emerged as the three most prevalent categories of emergency department visits in our post-transplant population. It should be noted that the term "infectious symptoms" encompasses both

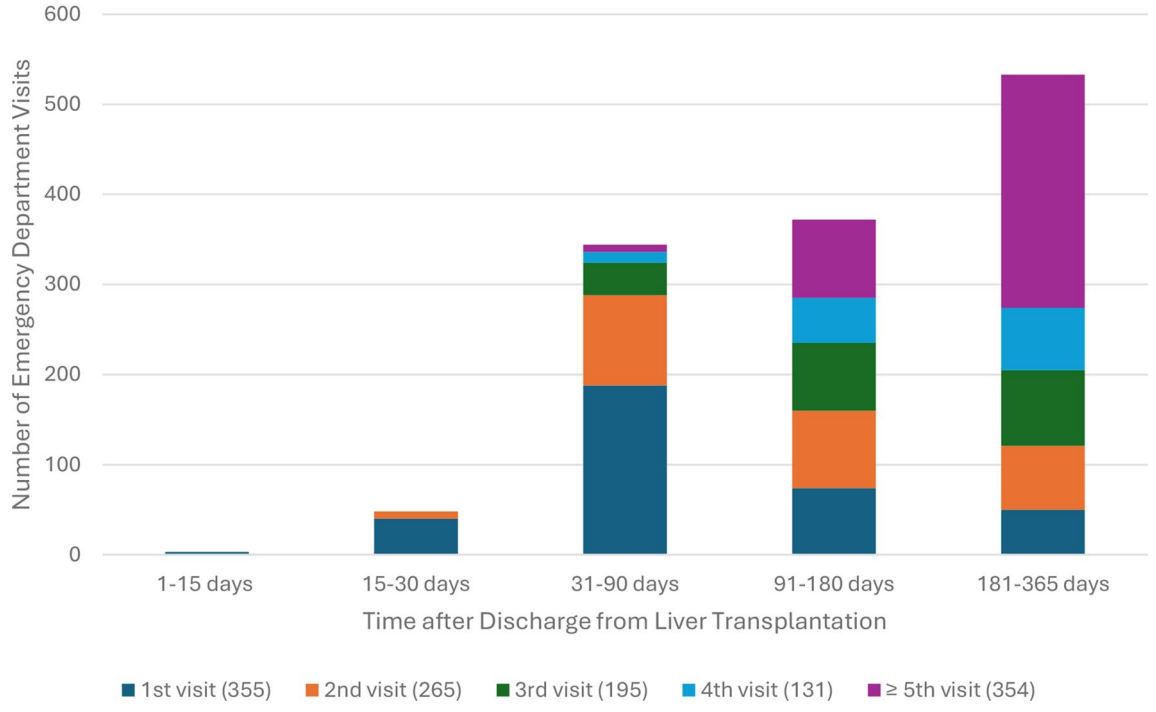

Fig. 1 Graphic visualization of frequency of emergency department visits over time

Table 5 Emergency department visit characteristics

Emergency department (ED) visit characteristics	*N* = 1297 (%)
Reason for ED Visit	
Gastrointestinal Symptoms	415 (32%)
Pulmonary Symptoms	285 (22%)
Infectious Symptoms	207 (16%)
Laboratory Abnormalities	116 (9%)
Renal Symptoms	52 (4%)
Musculoskeletal Symptoms	41 (3%)
Neurological Symptoms	38 (3%)
Cardiac Symptoms	10 (1%)
Other	133 (10%)
Admitted to Hospital	558 (43%)
Length of Stay	4 ± 10.7 days
Inpatient Diagnosis	
Respiratory Tract Infection	151 (27%)
Gastroenteritis	118 (21%)
Sepsis	67 (12%)
Clostridium Difficile Infection	23 (4%)
Urinary Tract Infection	17 (3%)
Covid-19 Infection	16 (3%)
CMV Infection	15 (3%)
Other	151 (27%)

CMV, cytomegalovirus

community-acquired infections and viral reactivations, such as cytomegalovirus (CMV) and Epstein-Barr virus (EBV). Notably, gastrointestinal symptoms ranked foremost, accounting for 32% of visits, followed by respiratory manifestations at 22% and infectious presentations at 16%. When combined, these three categories constituted 70% of all post-transplant ED encounters. Furthermore, this distribution remained remarkably stable across the different pediatric age strata examined (1–5 years, 6–12 years, and 13–17 years), underscoring the consistently high impact of gastrointestinal, pulmonary, and infection-related issues on ED utilization. These findings underscore the need for vigilant monitoring and targeted preventive strategies to mitigate the burden of these predominant clinical challenges in pediatric liver transplant recipients. Appendix A illustrates the symptoms under each organ system upon which the presenting complaint was categorized. Although tacrolimus is known to be associated with nephrotoxicity and neurotoxicity, abnormal tacrolimus levels were not significantly correlated with renal ($p = 0.26$) or neurological ($p = 0.21$) manifestations in our study. Moreover, following an ED visit, 43% ($N = 558$) of patients were admitted to the hospital with an average length of stay in the hospital of 4 ± 10.76 days. On the other hand, 56.83% ($N = 753$) of the patients were discharged. Among the admitted patients, several diagnoses were recorded. The most common diagnosis were respiratory tract infections 27% (151), gastroenteritis 21% (118), and sepsis 12% (67).

For pediatric patients presenting to the Emergency Department (ED) within the first year following a liver transplant, Fig. 2 provides a detailed visualization of the likelihood of an ED visit occurring at various intervals post-transplantation. Probabilities of the varying visits at different time periods were calculated and plotted. The graph highlights the probability of an ED visit occurring during a certain time as compared to other time periods. The figure underscores a notable decline in the probability of such visits as time progresses, with a particularly marked decrease observed after the initial 6 months. Specifically, the likelihood of ED presentation drops to below 40% by the 6-month mark and continues to decline sharply, reaching less than 10% by the 11th month. This data suggests that the most critical period for potential ED visits is within the first 6 months post-transplant. Therefore, implementing targeted interventions and ensuring more intensive follow-up during this period could significantly reduce ED visits. Such strategies might include closer monitoring of symptoms, more frequent outpatient consultations, and proactive management of potential complications. By focusing on these early months, healthcare providers can better support pediatric transplant recipients, ultimately enhancing patient outcomes and reducing the strain on emergency healthcare services.

Discussion

The body of literature concerning emergency visits by liver transplant recipients remains notably limited and heterogeneous. To date, only eight non-comprehensive observational studies have explored this topic [3, 12–16, 22, 23], with four of these studies being published over a decade ago. This gap underscores the persistent lack of targeted research that addresses the unique needs of this patient subgroup. Our study marks a significant advancement in this area, as it is the first to specifically examine emergency visits among pediatric liver transplant recipients. In contrast to previous studies, which predominantly focused on older populations with mean ages ranging from 24 years [12], to 61 years [14], our study uniquely highlights the pediatric population, with a mean patient age of 9.7 years, thus providing better understanding of the distinct healthcare challenges faced by younger liver transplant recipients. Our study evaluated a cohort of 361 pediatric patients who collectively accounted for 1,297 emergency department visits within the first year following liver transplantation. Despite focusing exclusively on a pediatric population, our study constituted the fifth largest sample size within the current body of literature. This is particularly significant given the paucity of studies in literature, especially large-scale studies. Emergency department (ED) visits were notably frequent among pediatric liver transplant recipients, with 30% of visits occurring within the first 3 months post-transplant,

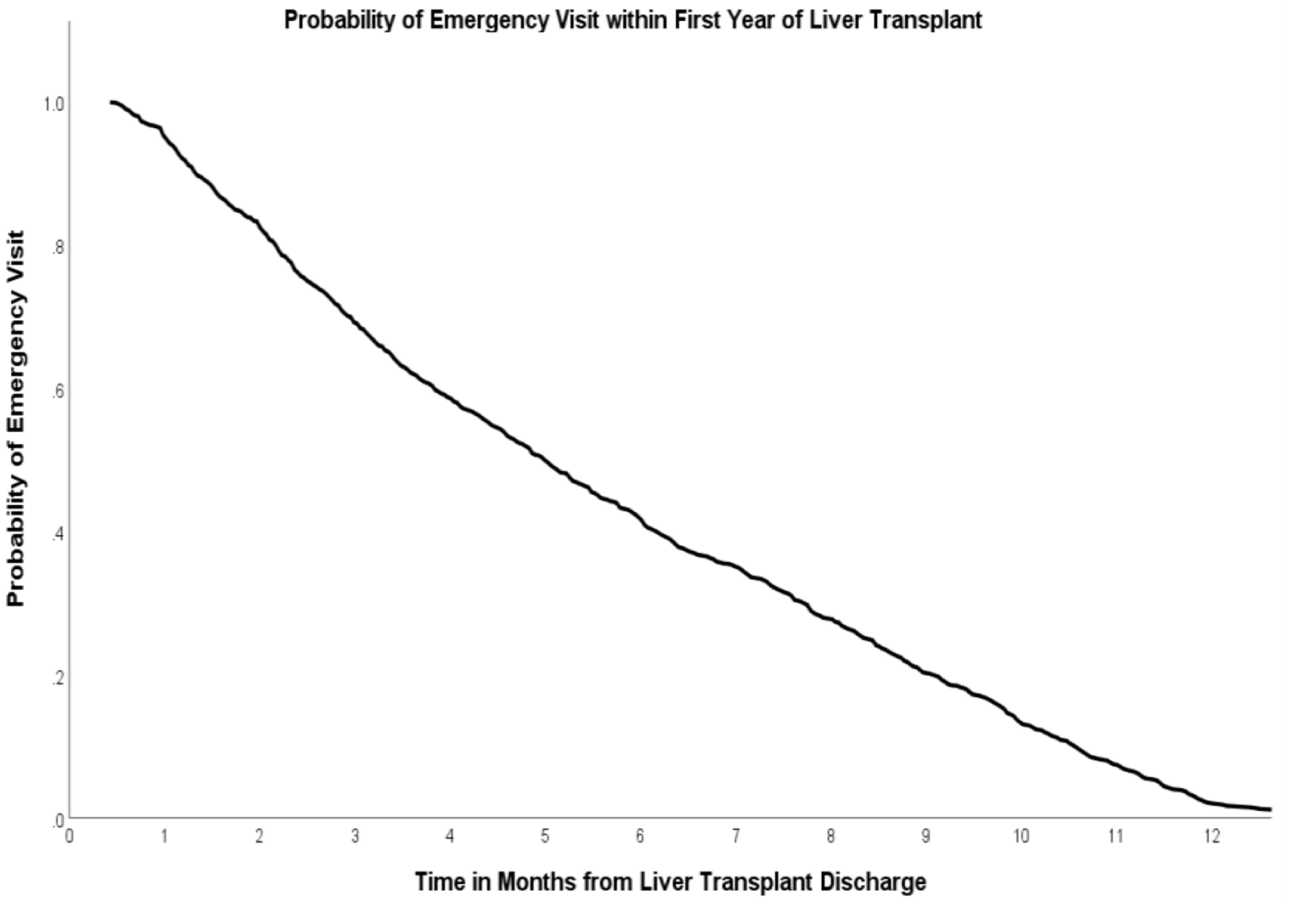

Fig. 2 Probability of emergency department Visit for patients presenting within first year of liver transplantation

escalating to 58% by the 6-month mark. This underscores the critical importance of the initial 6-month period, which accounts for nearly 60% of all ED visits, reflecting the heightened vulnerability of patients during this early phase of recovery. Although the incidence of ED visits during the first 6 months following lung transplantation varies widely in the literature, with reported rates ranging from 40 to 77% [3, 12], the findings of this study fall squarely within this spectrum. Moreover, the data illustrates the sustained need for acute care beyond the 6-month period, with approximately 40% of total ED visits occurring thereafter, emphasizing the ongoing medical complexities faced by pediatric liver transplant recipients long after the immediate postoperative phase. The study further emphasizes the period between 3- and 6-month post-transplant as particularly critical, with 55% of the total emergency department visits occurring during this window. This finding suggests that while the immediate postoperative phase is important, the mid-term period between 3 and 6 months represents a heightened phase of vulnerability for pediatric liver recipients. Of note is the low rate (4%) of ED visits within first month of transplant as compared to adult population in the literature with visit rate ranging from 13 to 52% [3, 12]. Various factors, beyond age, may account for the differences in ED visit rates observed across different countries. Interestingly, the most comparable study conducted on an adult cohort at the same center reported a 1-month visit rate of 21% and a 6-month visit rate of 67% [13]. This notable variation between adult and pediatric populations highlights a potentially significant divergence in post-transplant care needs and outcomes. This difference cannot be contributed largely to differences in outpatient follow-protocols as they are almost identical between pediatric and adult populations in our center. To better understand these differences, further research specifically targeting the pediatric population is warranted to explore the underlying factors contributing to these disparities.

Although first and second ED visits accounted for 27% and 20% of total visits respectively, patients continued to represent to the ED with third visits and more accounting for 52% of total visits. Research on the frequency of emergency department (ED) visits among patients remains limited, with only two studies in the literature addressing this issue. A study conducted by Aljumaa et al. (2023) reported findings consistent with our own, showing that

the first and second ED visits comprised 27% and 21% of total visits, respectively. Conversely, the study by Oh et al. (2018) presented divergent results, with 63% of the total visits occurring during the first visit and 22% during the second. These contrasting findings underscore the nuanced nature of ED utilization patterns among liver recipients, with Aljumaa et al.'s study reinforcing the persistent recurrence of ED visits in this population, while Oh et al.'s data suggest a decline in subsequent visit rates. Due to the scarcity of research on pediatric liver recipients, our study is the first to report the mean PELD score of 13.2 among pediatric liver recipients presenting to the emergency department. Additionally, our study is only the second in the literature to evaluate the mean MELD score, which was 16.8, aligning closely with findings from a similar study conducted in South Korea [3]. The literature on the impact of organ donation source on transplant outcomes is limited and exhibits considerable variability in findings. In our study, living donors contributed to 93% of the total transplants, a proportion significantly higher than that reported in other studies, where living donor transplants ranged from 33 to 80.5% [3, 13, 23]. Furthermore, we observed that recipients of organs from living donors experienced a mean length of stay of 7.3 ± 8.3 days, while recipients of cadaveric organs had a notably shorter mean length of stay of 3.4 ± 8.8 days. This difference was statistically significant, with a p-value of 0.00019. This association was not addressed in any of the previous studies in literature. The mean number of ED visits was 3.7 for living donor recipients and 4 for deceased donor recipients which was not statistically significant (p-value = 0.39).

The most frequent presenting complaints in the emergency department were related to gastrointestinal, pulmonary, and infectious symptoms. This aligns with most studies in literature, which consistently identify these three categories as the predominant reasons for emergency visits among this patient population [3, 13, 23]. However, one notable exception exists in the literature, where musculoskeletal symptoms were reported as one of the leading presenting complaints, diverging from the otherwise common pattern observed across studies [12]. The body of literature on emergency visits among liver recipients remains limited, and studies specifically examining comorbidities in this population are even scarcer, with only two notable studies to date. In one study, 44% of patients were found to have at least one comorbidity, with diabetes mellitus, hypertension, and coronary artery disease being the most prevalent [12]. Another study reported a higher rate, with 74% of patients having at least one comorbidity, primarily diabetes mellitus, hypertension, and chronic kidney disease [13]. In contrast to these findings, our study revealed that 35% of patients had at least one comorbidity, with hypertension, congenital heart disease, and seizure disorders emerging as the most common conditions.

This study had several limitations. The retrospective design of our study introduces inherent limitations, primarily due to missing or incomplete data. Clinical information, including symptoms, outcomes, and complications, may have been inconsistently or inadequately documented, potentially causing misclassification bias. Furthermore, reliance on electronic medical records can amplify these issues, as documentation quality varies by clinician practices and accuracy. Future studies should adopt a prospective design with standardized protocols for data collection, ensuring consistent documentation of clinical variables, outcomes, and complications. Utilizing structured data entry forms, predefined criteria, and regular training for clinical staff can significantly reduce missing or incomplete information. Second, our center is the main transplant center in Saudi Arabia with many patients residing in other cities which can lead to an underestimation of the actual ED visits of those patients. Third, the exclusion of patients who underwent transplantation at other centers or lacked follow-up at our institution may limit the generalizability of findings. Additionally, reliance on electronic records likely underestimates ED visits occurring at external facilities. The ongoing national initiative to unify healthcare records across Saudi Arabia presents an invaluable opportunity to obtain a more accurate and comprehensive understanding of emergency department utilization patterns among pediatric liver transplant recipients. Leveraging this integrated database in future studies will enable more robust follow-up analyses, facilitate longitudinal tracking of patient outcomes, and help overcome the current limitations related to fragmented or incomplete data. Lastly, this study lacks a comparison group so no comparison could be made between the characteristics of those who presented to the ED and those who did not. This calls for further studies in the future to take those limitations into account to further enhance literature.

Appendix A Presenting symptoms of different organ systems

System	Example Symptoms
Gastrointestinal	Nausea, vomiting, abdominal pain, diarrhea, constipation, hepatomegaly, gastrointestinal bleeding (e.g., hematemesis, melena)
Pulmonary	Cough, dyspnea (shortness of breath), tachypnea, wheezing, cyanosis, crackles or rales on auscultation, pleural effusion
Infectious	Fever, chills, night sweats, lymphadenopathy, localized redness or swelling, pus or discharge, systemic signs of sepsis (e.g., hypotension, tachycardia)
Laboratory Abnormalities	Anemia, leukocytosis or leukopenia, thrombocytopenia, elevated liver enzymes (ALT, AST), electrolyte imbalances (e.g., hyponatremia, hyperkalemia), elevated creatinine or BUN, coagulation abnormalities (e.g., prolonged PT/INR)
Renal	Hematuria, proteinuria, low urine output, hypertension, flank pain, or reduced GFR

Appendix A Presenting symptoms of different organ systems

System	Example Symptoms
Musculoskeletal	Joint pain, swelling or inflammation of joints, muscle pain, bone pain, or decreased range of motion
Neurological	Seizures, altered mental status (confusion, disorientation), headache, muscle weakness or paralysis, sensory deficits, ataxia, vision or speech disturbances
Cardiac	Chest pain, palpitations, tachycardia or bradycardia, dyspnea on exertion, edema (peripheral or pulmonary, due to heart failure), syncope.
Other	Fatigue, weight loss, poor appetite, skin rashes or lesions.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12873-025-01231-x.

Supplementary Material 1

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Author contributions
J.A. had full access to all the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis.R.E., A.A., J.A. and F.P. contributed to study design, acquisition of the data, data management and analysis, and preparation of the manuscript.I.A.A., M.A., M.A., H.A.B., A.M.E., N.L., and S.M.A. contributed to acquisition of the data, data management, and preparation of the manuscriptAll authors reviewed and approved the submission.

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Data availability
The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Institutional Board Review at King Faisal Specialist Hospital and Research Center and given registration number **2231461**. Informed consent was waived due to the observational nature of the study and the analysis of deidentified information.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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