Journal of Liver Transplantation 24 (2026) 100394

Contents lists available at ScienceDirect

Journal of Liver Transplantation

journal homepage: www.elsevier.com/locate/liver

Original article

Can biliary stricture development be prevented in liver transplantation involving high-risk biliary tracts?

C Reguero-Fernández [a,*], A Boscá-Robledo [a], E Montalvá-Orón [b], J Maupoey-Ibáñez [a], C Martínez-Chicote [a], A Hernando-Sanz [a], D Calatayud-Mizrahi [a], F Mingol-Navarro [a], V Ibañez-Pradas [a], R López-Andújar [b]

[a] Surgery HPB and Liver Transplant Unit, Universitary and Politecnic Hospital La Fe, Valencia, Spain
[b] Surgery HPB and Liver Transplant Unit, Instituto de Investigación Sanitaria La Fe (IIS La Fe) & CIBER-EHD, Universitary and Politecnic Hospital La Fe, Valencia, Spain

ARTICLE INFO

Keywords:
Liver transplantation
Biliary complications
Anastomotic stricture
Biliary stent
T-tube

ABSTRACT

Introduction: Biliary tract complications (especially biliary stricture) remain a significant cause of morbidity and mortality following liver transplantation. Various prophylactic intraoperative strategies have been proposed, but a gold-standard surgical technique remains unestablished. The primary objective of this study is the description of biliary anastomosis outcomes in small-caliber bile ducts categorized by the surgical technique utilized in liver transplant recipients.

Material and methods: An observational, retrospective, single-center study. A consecutive series of liver transplant recipients between January 2021 and December 2024 presenting with a small-caliber biliary tract (defined as at least one of the two bile ducts measuring ≤7 mm) was reviewed. The primary variable evaluated was anastomotic biliary stricture, defined by radiological criteria combined with laboratory evidence of cholestasis. The intraoperative management of the small bile duct was performed using three surgical techniques: T-tube placement, bioabsorbable self-expanding biliary stent placement or no additional measures.

Results: Two hundred and three patients receiving a deceased-donor liver transplant were evaluated. Small-caliber biliary tract management was performed via T-tube placement in 27 cases (13.3 %), self-expanding biliary stent placement in 20 (9.8 %) or without additional measures in 156 (76.8 %). Stricture rates of 3.7 %, 25 % and 14.7 % were observed in each respective group, with median times to stricture development of 2, 8 and 4 months, respectively. The use of a T-tube (as a protective factor), the presence of initial graft dysfunction and a biliary fistula (as risk factors) were found to be statistically significantly associated with the occurrence of biliary anastomotic stricture ($p < 0.05$).

Conclusion: Despite advancements in liver transplantation anastomotic biliary stricture remains a significant complication and currently no effective strategy is available for the prevention of its onset in high-risk biliary tracts.

Introduction

Liver transplantation is the treatment of choice for patients with end-stage liver disease [1]. Biliary complications remain a major cause of morbidity and mortality [1,2], with an estimated prevalence of 10–50 % [3], which remains high despite the improvement of overall post-transplant outcomes over time [1,2]. Among them, biliary stricture is considered one of the most frequent, with rates of 5–15 % [4,5]. The shortage of available donors, together with an increasing number of recipients on the waiting list, led several years ago to the increasingly frequent use of grafts from donors meeting expanding criteria (ECD) and to the expansion of donation after circulatory death (DCD) [6–9].

The use of these organs poses a particular challenge, as these grafts are significantly more susceptible to ischemia-reperfusion injury due to prolonged warm ischemia [6–8]. Cholangiocytes, owing to their low levels of antioxidants, are extremely vulnerable to hypoxia, resulting in

* Corresponding author.
E-mail addresses: reguero_cri@gva.es (C. Reguero-Fernández), bosca.robledo@gmail.com (A. Boscá-Robledo), montalva_eva@gva.es (E. Montalvá-Orón), maupoey_jav@gva.es (J. Maupoey-Ibáñez), crismchicote@gmail.com (C. Martínez-Chicote), hernando_ana@gva.es (A. Hernando-Sanz), davidcalatayud1975@gmail.com (D. Calatayud-Mizrahi), navarro_fer@gva.es (F. Mingol-Navarro), rafaellopezandujar@gmail.com (R. López-Andújar).

https://doi.org/10.1016/j.liver.2026.100394
Received 4 July 2026; Received in revised form 3 October 2026; Accepted 10 October 2026
Available online 12 October 2026
2666-9676/© 2026 The Authors. Published by Elsevier Masson SAS. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

profound injury to the surface epithelium, peribiliary glands and vascular plexus [6]. This ischemic ``insult´is the main trigger of ischemic cholangiopathy, characterized by the development of severe non-anastomotic biliary strictures, which may lead to graft loss and the need for retransplantation [6]. Anastomotic strictures are also linked to technical aspects of the biliary reconstruction and the bile duct diameter; considering these latter two as primary determining factors [3,4]. The most recent consensus statements consider end-to-end duct-to-duct anastomosis the preferred technique for biliary reconstruction [6,10,11].

Given the high morbidity and mortality associated with anastomotic strictures, early detection and appropriate management are deemed essential, particularly due to the associated risk of cholangitis [12–14].

Consequently, various surgical techniques have been described over time aimed at preventing strictures [4,15], such as T-tube or bioabsorbable stents. Nevertheless, the existence of an effective intraoperative strategy to prevent anastomotic biliary strictures in liver transplantation remains unresolved [3,16,17].

The primary objective of this study is the analysis of various anastomotic strategies and the description of outcomes in a single-center series of liver transplants featuring small-caliber biliary anastomoses, categorized by the surgical technique used.

Materials and methods

Study design

An observational, retrospective, single-center study was conducted out of 397 liver transplants performed between January 2021 and December 2024. Exclusion criteria include pediatric recipients, prior hepaticojejunostomy or death in the immediate postoperative period, resulting in a final cohort of 338 patients. Among these, a small-diameter biliary tract was identified in 203 cases. This condition was defined by a diameter of ≤7 mm in at least one of the two bile ducts (donor and/or recipient) [18] (Fig. 1). The small bile duct corresponded to the donor in 64 patients, the recipient in 52 patients and both bile ducts were small in 87 patients.

The primary study variable was defined as symptomatic anastomotic biliary stricture, identified by radiological criteria via magnetic resonance cholangiopancreatography in patients presenting with cholestasis laboratory alterations, with or without associated cholangitis crisis. Furthermore, demographic, medical and both intraoperative and postoperative surgical variables were included. Post-transplant hemorrhage was defined as bleeding requiring reintervention; and primary graft dysfunction was evaluated according to Olthoffs criteria. A high-risk hepatic artery was defined by the presence of severe atherosclerosis, vascular variants requiring arterial reconstruction or low intraoperative flows (below 100 mL/min). Intraoperative arterial flow measurement was performed in all cases prior to abdominal wall closure. Immediate postoperative arterial flows were assessed via hepatic Doppler ultrasound by expert radiologists on the first and 5th postoperative days. Biliary fistula was defined by the presence of biliary ascites or bile in the surgical drain.

Patients with a small biliary tract were managed intraoperatively via three distinct techniques: T-tube placement, bioabsorbable self-expanding biliary stent placement or end-to-end choledocho-choledochal anastomosis without additional measures. The T-tubes utilized in this series consisted of rubber (2.5 mm diameter) or silicone (3 mm diameter). The *X-ELLA*® 3 mm stent was employed in all cases. The anastomosis was performed in all cases using a continuous suture on the posterior wall and interrupted sutures on the anterior wall with 6/0 polydioxanone (a long-lasting absorbable monofilament suture). The selection of the surgical technique was determined by the liver transplant surgical teams criteria, primarily conditioned by a temporal factor and material availability. Initially, T-tubes were used in cases of small-caliber bile ducts. Following discontinuation of their manufacture, primary anastomoses were performed, using self-expanding absorbable biliary stents when available at the hospital.

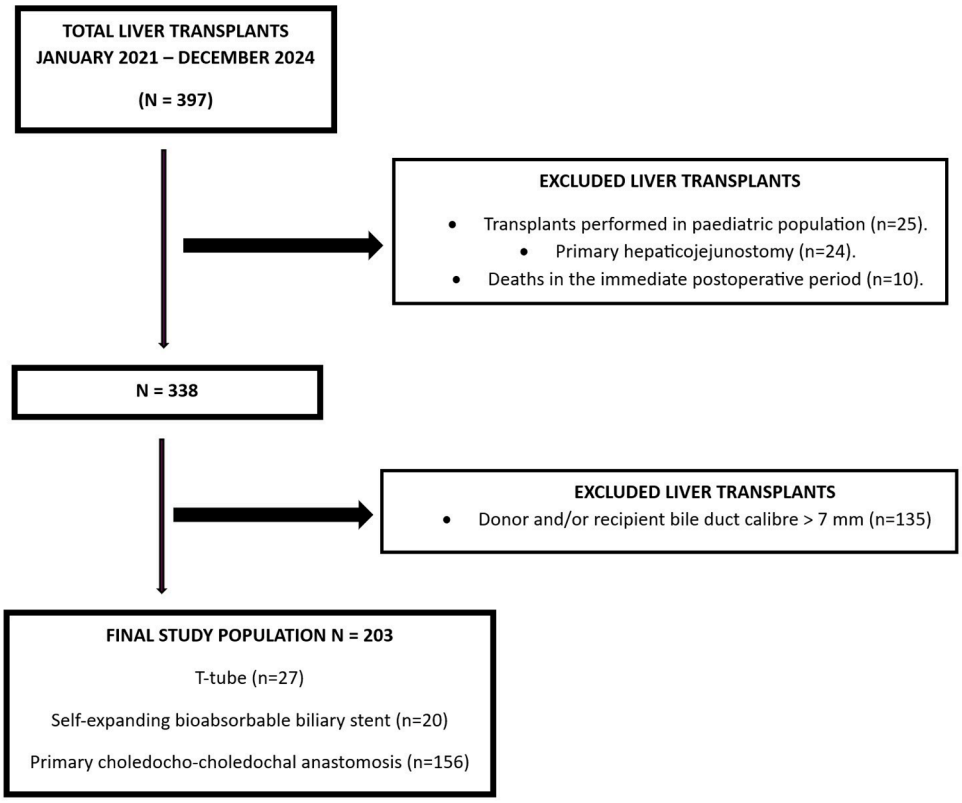


Fig. 1. Flow diagram that represents the selection process of the final study population.

Statistical analysis

Non-normally distributed quantitative variables are expressed as median and full range or interquartile range (IQR), whereas qualitative variables are presented as absolute numbers and percentages. The normality of quantitative variables was assessed using the *Shapiro-Wilk* test. To identify potential risk factors associated with biliary anastomotic strictures, a univariate analysis was first performed using the *Chi-squared* test for qualitative variables and *Student's t-test* for quantitative variables. Subsequently, variables with a p-value ≤ 0.10 were selected for multivariate analysis via logistic regression. Statistical significance was defined as a p-value < 0.05. All statistical analyses were conducted using Stata software, version 16.1 (StataCorp, College Station, TX, USA).

Results

The demographic and clinical characteristics of the 203 patients included are detailed in Table 1. The median overall patient follow-up was 16 months (Range 2–54).

T-tube placement was selected in twenty-seven patients (12.4 %), utilizing silicone in nine cases and rubber in eighteen. A biliary stent was inserted in twenty cases (9.6 %) and standard choledocho-choledochal anastomosis without additional measures was performed in one hundred and fifty-six patients (78 %). A high-risk hepatic artery was identified intraoperatively in 77 patients (37.9 %). The median intraoperative arterial flow was measured at 200 mL/min (IQR 139–300 mL/min) in the overall cohort and 165 mL/min (IQR 120–215 mL/min) in the high-risk hepatic artery group.

The median postoperative stay in the Intensive Care Unit (ICU) was 2 days (Range 1–32).

Postoperative biliary fistula was observed in 11 patients (5.4 %): four in the T-tube group and seven in the primary choledocho-choledochal anastomosis group. A total of 29 biliary strictures (14.3 %) were documented. The stricture rate was 3.7 % in the T-tube group, 25 % in the biliary stent group and 14.7 % in the group receiving no additional measures (Fig. 2). The median time to stricture development in each group was 2 months (72 days) for T-tube, 8 months (235 days) for stents and 4 months (130 days) for primary anastomosis (Fig. 3).

Table 1
Demographic and clinical characteristics of the study population. BMI, Body mass index; MELD, Model for end-stage liver disease.

Demographic characteristic	N (%) or Median (Range) $N = 203$	N (%) or Median (Range) $N = 27$ (T-tube)	N (%) or Median (Range) $N = 20$ (self-expanding bioabsorbable biliary stent)	N (%) or Median (Range) $N = 156$ (primary choledocho-choledochal anastomosis)
Male sex	158 (77.8 %)	20 (74.1 %)	13 (65 %)	125 (80.1 %)
Age	61 (21–75)	58 (43–70)	64 (43–75)	61 (21–74)
Overweight or obesity (BMI $\geq$ 25)	130 (73.9 %)	22 (81.5 %)	11 (55 %)	117 (75 %)
Functional MELD *Score*				
6–9	77 (37.9 %)	14 (51.9 %)	9 (45 %)	54 (34.6 %)
10–19	86 (42.4 %)	20 (74.1 %)	8 (40 %)	68 (43.6 %)
≥20	30 (19.7 %)	3 (11.1 %)	3 (15 %)	34 (21.8 %)
Emergency liver transplant	14 (6.9 %)	4 (14.8 %)	2 (10 %)	8 (5.1 %)
Donor type				
Circulatory death	98 (48.3 %)	9 (33.3 %)	10 (50 %)	79 (50.6 %)
Brain death	105 (51.7 %)	18 (66.7 %)	10 (50 %)	77 (49.4 %)

T-tube related complications were exhibited by three patients (11.1 %), consisting of bile peritonitis following T-tube removal in all cases. Silicone T-tubes were utilized in two of these patients (22 %) and a rubber tube was used in one (5 %). Subsequent biliary anastomotic stricture was not developed by any of these three patients. Regarding biliary stents, choledocholithiasis associated with the stent was observed in only one patient and only a single case of cholangitis was recorded. Biliary fistulas were not detected in this patient group.

The association between biliary anastomotic stricture and several potential risk factors was analyzed. In the univariate analysis, statistical significance was achieved by sex ($p = 0.0761$), MELD score ($p = 0.083$), the presence of small bile ducts in both donor and recipient ($p = 0.079$), the type of small bile duct management ($p = 0.10$), the occurrence of post-transplant hemorrhage ($p = 0.059$), initial graft dysfunction ($p = 0.027$) and biliary fistula ($p = 0.011$) (Table 2). These variables were subsequently incorporated into de multivariate analysis. The use of a T-tube (as a protective factor) ($p = 0.022$), the occurrence of initial graft dysfunction ($p = 0.007$) and biliary fistula ($p = 0.009$) were found to be statistically significantly associated with the presence of biliary anastomotic stricture (Table 3 and Fig. 4).

The management of the twenty-nine anastomotic strictures, categorized by intraoperative management of the small bile duct, was tailored individually after discussion within a multidisciplinary committee (Fig. 5). Three patients received ursodeoxycholic acid, which successfully managed the cholestatic laboratory alterations without requiring additional invasive procedures. In five cases a primary hepaticojejunostomy was performed; and one patient underwent percutaneous transhepatic cholangiography dilatation due to a history of gastric bypass.

Choledocholithiasis related to the endoscopic stent was presented by nine patients and at least one episode of cholangitis was experienced by six.

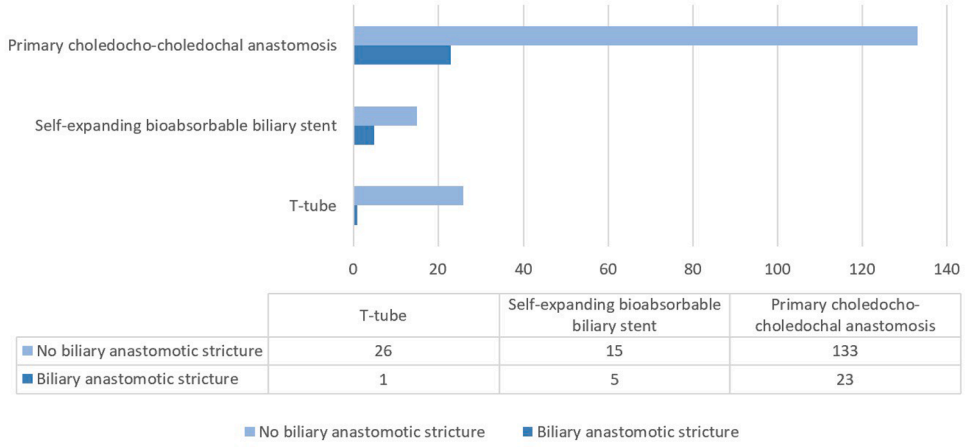
At the study's conclusion, one hundred and eighty-nine patients remained alive and without stricture (93.1 %). Death from other causes occurred in thirteen patients (6.4 %). Two deaths were attributed to severe cholangitis secondary to biliary anastomotic stricture (0.5 %).

Discussion

A gold-standard surgical technique capable of significantly reducing the rate of anastomotic biliary strictures following liver transplantation currently remains unidentified [4,5,12–14]. Various risk factors have been linked to them [4,12,19]. Notably, the small caliber of at least one of the two bile ducts is considered a primary factor [19], with the cutoff generally established at 7 mm [3,18]. In our study, multivariate analysis demonstrated a statistically significant association between the development of stricture and early graft dysfunction, as well as biliary fistula. Nevertheless, these findings must be interpreted with caution, as a direct causal relationship cannot be established due to the retrospective and observational nature of the study.

Various surgical techniques have been described over time aimed at preventing both biliary fistulas and strictures [4,15]. The placement of a T-tube was the traditionally utilized option [14,15]. In recent years, however, several authors have advocated against the routine use of T-tubes due to the inherent complication risk [20] (specially, bile peritonitis after removal). Amador et al., Vest et al. and other authors suggest their restriction to high-risk biliary anastomoses, such as those presenting significant caliber discrepancies between donor and recipient bile ducts [21,22]. Irrespective of potential associated complications, the use of rubber T-tubes – which posses greater demonstrated efficacy in reducing bile peritonitis risk post-removal – has been discontinued due to market unavailability.

In our series, the statistical model identified the use of a T-tube as an apparently protective factor against stricture, with results similar to



	T-tube	Self-expanding bioabsorbable biliary stent	Primary choledocho-choledochal anastomosis
No biliary anastomotic stricture	26	15	133
Biliary anastomotic stricture	1	5	23

Fig. 2. Distribution of anastomotic biliary strictures based on small bile duct management.

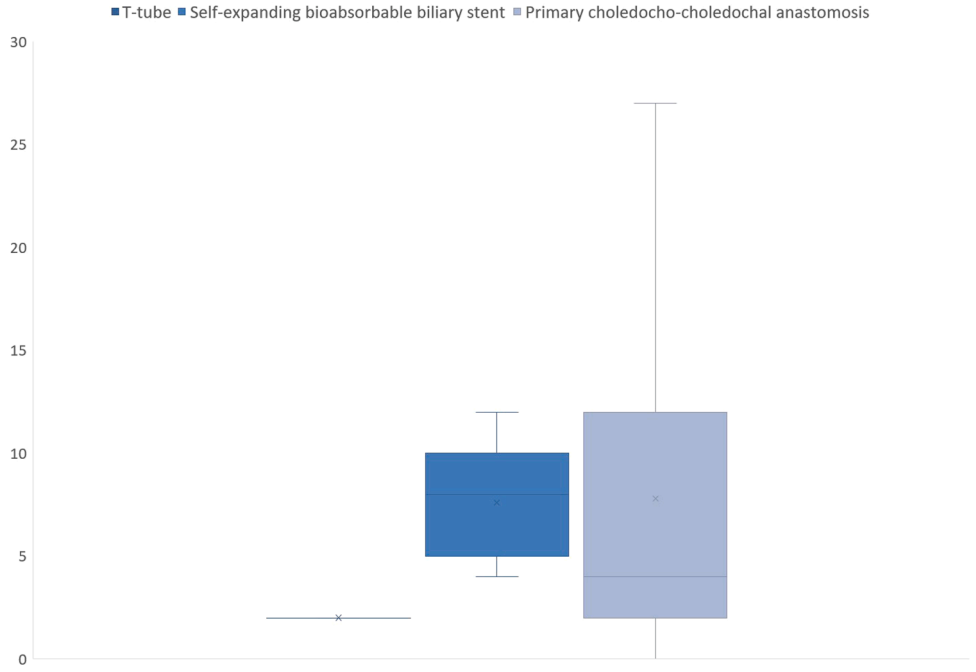


Fig. 3. Boxplot. Time to stricture (months).

those obtained in other studies with larger patient series [18,20]. However, this conclusion, if based exclusively on the data from this study, must be qualified and interpreted with extreme methodological rigor, as it is supported by a single adverse clinical event. Furthermore, this finding may be influenced by an intrinsic selection bias arising from the retrospective study design, since placement was not randomized. Nevertheless, in all cases, the bile ducts were considered high-risk. Regarding the potential associated morbidity, the influence of the t-tube material should be considered, as reflected in our study and demonstrated in previous research [18,20]. Silicone T-tubes, rather than rubber ones, have been associated with higher rates of bile peritonitis after removal. Given that they are currently the only available option, their systematic use is currently discouraged.

Consequently, bioabsorbable self-expanding covered biliary stents have gained prominence as a prophylactic alternative [4,5,19,23–26], with the main advantage of their biodegradable nature, eliminating the need for delayed endoscopic removal [5,19]. Benefit with minimal complications in treating biliary leks or strictures has been demonstrated by several studies conducted outside the context of liver transplantation [23,27,28]. Studies employing these stents in liver transplantation also exist, though yielding equivocal results [3,27]. Conversely, the safety of their insertion is supported by other publications [29]. López-López et al. advocated for their near-systematic use during biliary anastomosis in liver transplantation, justifying a lower rate of early biliary complications (or easier management of them if arise) and minimal drawbacks, although long-term stricture rates appeared undiminished. Mathur et al. and other authors have reported a lack of benefit with these stents, finding no differences in biliary complications rates, while identifying potential added adverse effects associated with their use (stent migration, biliary fistula, cholangitis) [3]. Our results are consistent with this critical view: this group had the highest incidence of anastomotic stricture (25 % versus 14.7 % for primary anastomosis). This counterproductive phenomenon is supported by solid pathophysiological hypotheses [30–33]. On the one hand, hydrolytic degradation of absorbable polymers triggers a sustained local foreign-body inflammatory response. This inflammatory stress in the biliary epithelium induces reactive mucosal hyperplasia, myointimal thickening and fibrotic scarring that narrows the lumen. Additionally,

Table 2
Univariate analysis of potential risk factors related to anastomotic biliary stricture.

Variable	No biliary anastomotic stricture N (%) or Median (Range) ($N = 174$)	Biliary anastomotic stricture N (%) or Median (Range) ($N = 29$)	*p*-value
Pre-transplant variables			
Age	61 (55–65)	61 (56–65)	0.729
Sex			**0.0761**
Male	136 (78.16 %)	22 (75.86 %)	
Female	38 (21.84 %)	7 (24.14 %)	
BMI			0.368
<18.5	1 (0.57 %)	0	
18.5–24.9	48 (27.59 %)	4 (13.79 %)	
25–29.9	95 (54.60 %)	19 (65.52 %)	
30–34.9	22 (12.64 %)	3 (10.34 %)	
35–39.9	7 (4.02 %)	3 (10.34 %)	
>40	1 (0.57 %)	0	
MELD			**0.083**
6–9	71 (40.80 %)	6 (20.69 %)	
10–19	72 (41.38 %)	14 (48.28 %)	
20–29	24 (13.79 %)	6 (20.69 %)	
30–40	7 (4.02 %)	3 (10.34 %)	
Intraoperative variables			
Emergency liver transplant	163 (93.68 %)	26 (89.66 %)	0.321
No	11 (6.32 %)	3 (10.34 %)	
Yes			
Donor type			
Brain death	89 (51.15 %)	16 (55.17 %)	0.421
Circulatory death	85 (48.85 %)	13 (44.83 %)	
Donor bile duct size (mm)	7 (6–8)	7 (6–7)	0.546
Donor bile duct ≤ 7 mm			
No	47 (27.01 %)	5 (17.24 %)	0.190
Yes	127 (72.99 %)	24 (82.76 %)	
Recipient bile duct size (mm)	7 (6–8)	7 (5–8)	0.808
Recipient bile duct ≤ 7 mm	56 (32.18 %)	8 (27.59 %)	0.622
No	118 (67.82 %)	21 (72.41 %)	
Yes			
Both bile ducts (donor & recipient) ≤ 7 mm	100 (57.47 %)	12 (41.38 %)	**0.079**
No	74 (42.53 %)	17 (58.62 %)	
Yes			
Size discrepancy between bile ducts (mm)	2 (1–4)	2 (0–5)	0.458
Intraoperative biliary anastomosis technique	133 (76.44 %)	23 (79.31 %)	**0.100**
Primary choledocho-choledochal anastomosis	26 (14.94 %)	1 (3.45 %)	
T-tube	15 (8.62 %)	5 (17.24 %)	
Self-expanding bioabsorbable biliary stent			
Arterial flow (mL/min)	202 (139–290)	200 (130–225)	0.421
High-risk hepatic artery			
No	109 (63.01 %)	16 (55.17 %)	0.273
Yes	64 (36.99 %)	13 (44.83 %)	
Post-transplant variables			
Post-transplant hemorrhage	163 (93.68 %)	24 (82.76 %)	**0.059**
No	11 (6.32 %)	5 (17.24 %)	
Yes			
Initial graft dysfunction			
No	153 (87.93 %)	21 (72.41 %)	**0.027**
Yes	21 (12.07 %)	8 (27.59 %)	
Biliary fistula			
No	168 (96.55 %)	24 (82.76 %)	**0.011**
Yes	6 (3.45 %)	5 (17.24 %)	

Table 3
Multivariate analysis of potential risk factors related to anastomotic biliary stricture.

Variable	OR	95 % CI	*p*-value
Sex	1.04	0.35–3.09	0.949
Male/Female			
MELD			
6–9	1	0.79–7.05	0.124
10–19	2.35	0.54–8.43	0.283
20–29	2.12	1.31–43.55	0.079
30–40	5.31		
Both bile ducts ≤ 7 mm	2.28	0.89–5.08	0.083
Intraoperative biliary anastomosis technique			
Primary choledocho-choledochal anastomosis	1	0.03–0.65	**0.022**
T-tube	0.05	0.63–7.31	0.223
Self-expanding bioabsorbable biliary stent	2.14		
Post-transplant hemorrhage	2.63	0.70–9.91	0.152
Initial graft dysfunction	4.43	1.51–13.06	**0.007**
Biliary fistula	8.55	1.71–42.84	**0.009**

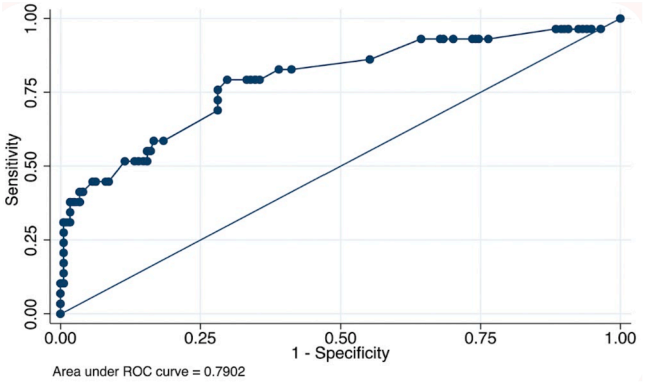


Fig. 4. ROC curve.

the loss of structural integrity during resorption us usually asymmetric. This releases solid microfragments into the biliary lumen that act as lithogenic nuclei, promoting stasis and biliary sludge formation and precipitating episodes of obstructive cholangitis [30–33]. In addition, clinically, our experience confirms that the device did not simplify subsequent management: all patients who developed strictures after stent placement required invasive procedures for resolution.

Regarding the overall postoperative management, the endoscopic (ERCP) and surgical (hepaticojejunostomy) approaches predominated in our study; invasive alternatives that may be effective [4]. In the present study is outlined the management of three strictures exclusively via pharmacological treatment and subsequent follow-up. Laboratory improvement was achieved, despite persistent imaging evidence of the biliary stricture. While this management approach may raise questions regarding whether these cases truly represented anastomotic biliary strictures, this classification resulted from the strict criteria utilized for biliary stricture definition in this study.

Limitations and perspective

Despite the substantial patient cohort, the sample size within each group is insufficient to achieve statistical significance and limits statistical power for some variables. Furthermore, the results are derived from a single-center, retrospective study, which entails a risk of bias in data collection and makes it difficult to accurately capture all the nuances and intraoperative criteria that determined the surgeons' final decision regarding the bile. Consequently, the development of prospective, multicenter clinical trials with a larger number of patients is imperative to definitively validate and consolidate these conclusions.

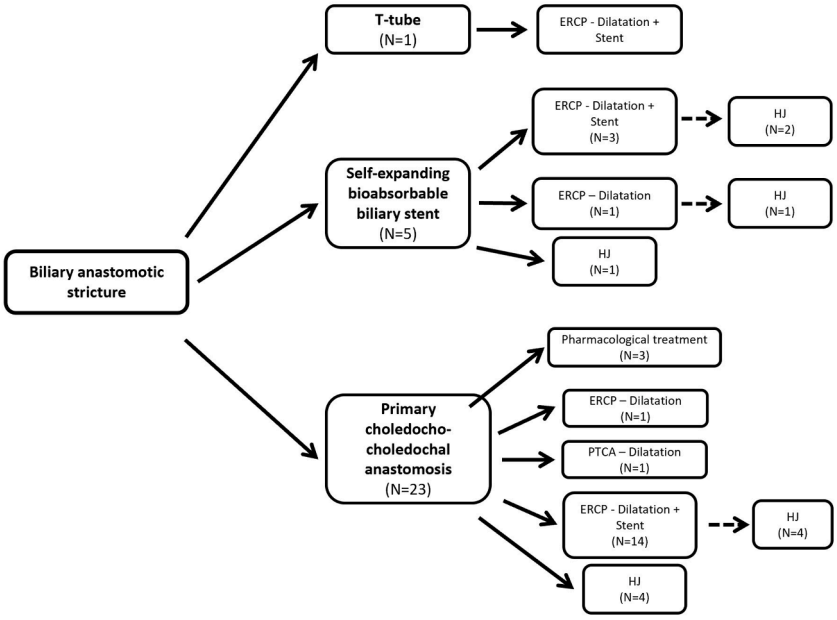


Fig. 5. Treatment of anastomotic biliary strictures. ERCP, endoscopic retrograde cholangiopancreatography; PTCA, percutaneous transhepatic cholangiography; HJ, Hepaticojejunostomy.

Conclusion

In conclusion, in light of our results and the available evidence [18, 20], reconstruction of the small bile duct after liver transplantation remains a major challenge. The theoretical protective effect of the T-tube lacks full statistical validity based exclusively on the data of this study and previous results [18,20] cannot be applied to silicone T-tubes (which have a higher rate of bile peritonitis after removal). Given these considerations and since bioabsorbable stents may exacerbate local inflammation and fibrosis, increasing the rate of stricture, our current technical recommendation and preference, in the absence of rubber T-tubes, is to perform a primary end-to-end choledocho-choledochal anastomosis using absorbable suture without additional stenting or prosthesis.

Funding

None.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (2013) and approved by the institutional ethics committee of the "Hospital Universitari i Politècnic La Fe" (Register Number 2026-0504-1). All data was collected anonymously, without patient identifiers. All actions were logged in accordance with Good Clinical Practice guidelines.

CRediT authorship contribution statement

C Reguero-Fernández: Writing – original draft, Software, Methodology, Investigation. **A Boscá-Robledo:** Writing – review & editing, Formal analysis, Conceptualization. **E Montalvá-Orón:** Writing – review & editing, Validation, Supervision, Methodology, Investigation. **J Maupoey-Ibáñez:** Writing – review & editing. **C Martínez-Chicote:** Writing – review & editing, Supervision. **A Hernando-Sanz:** Writing – review & editing. **D Calatayud-Mizrahi:** Writing – review & editing. **F Mingol-Navarro:** Writing – review & editing. **V Ibañez-Pradas:** Writing – review & editing. **R López-Andújar:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Investigation.

Declaration of competing interest

The author is an Editorial Board Member/Editor-in-Chief/Associate Editor/Guest Editor for this journal and was not involved in the editorial review or the decision to publish this article.

References

[1] Zhao JZ, Qiao LL, Du ZQ, Zhang J, Wang MZ, Wang T, et al. T-Tube vs no T-Tube for biliary tract reconstruction in adult orthotopic liver transplantation: an updated systematic review and meta-analysis. World J Gastroenterol 2021;27(14):1507–23. https://doi.org/10.3748/WJG.V27.I14.1507.
[2] Ostroff JW, Lynne A, Chair MB. Management of biliary complications in the liver transplant patient. Gastroenterol Hepatol 2010;6(4):264–72. Number.
[3] Goumard C, Boleslawski E, Brustia R, Dondero F, Herrero A, Lesurtel M, et al. Duct-to-duct biliary reconstruction with or without an intraductal removable stent in liver transplantation: the BILIDRAIN-T multicentric randomised trial. JHEP Rep 2022;4(10):100530. https://doi.org/10.1016/j.jhepr.2022.100530.
[4] Yoon YC, Etesami K, Kaur N, Emamaullee J, Kim J, Zielsdorf S, et al. Biliary internal stents and biliary complications in adult liver transplantation. Transpl Proc 2021;53(1):171–6. https://doi.org/10.1016/j.transproceed.2020.06.019.
[5] Tashiro H, Ogawa T, Itamoto T, Ushitora Y, Tanimoto Y, Oshita A, et al. Synthetic bioabsorbable stent material for duct-to-duct biliary reconstruction. J Surg Res 2009;151(1):85–8. https://doi.org/10.1016/j.jss.2008.02.056.
[6] Esser H, De Jong IEM, Roos FM, Bogensperger C, Brunner SM, Cardini B, et al. Consensus classification of biliary complications after liver transplantation: guidelines from the BileducTx meeting. Br J Surg 2025;112(5). https://doi.org/10.1093/bjs/znae321. Number.
[7] Wiederkehr HA, Nguyen MC, Moss A, Mathur AK, Nuñez-Nateras R, Wiederkehr JC, et al. Liver transplantation: embracing the future with machine perfusion. Arq Bras Cir Dig 2026;39. https://doi.org/10.1590/0102-672020260000017e1946.
[8] Magini G, Wozniak H, Schafer A, Moeckli B, Banz V, Vionnet J, et al. Abdominal normothermic regional perfusion is associated with improved graft survival in liver transplantation from circulatory death donors. Transpl Int 2026;39:39. https://doi.org/10.3389/ti.2026.16004.
[9] Ohara SY, Stevens V, Madisetty A, Arias S, Gupta A, Zhang N, et al. Revisiting futility: normothermic perfusion improves outcomes across all UK DCD risk strata. Clin Transpl 2026;40(9):40. https://doi.org/10.1111/ctr.70669.
[10] Hong SY, Hu XG, Lee HY, Won JH, Kim JW, Shen XY, et al. Longterm analysis of biliary complications after duct-to-duct biliary reconstruction in living donor liver transplantations. Liver Transpl 2018;24(8):1050–61. https://doi.org/10.1002/lt.25074.
[11] Kawachi S, Shimazu M, Wakabayashi G, Hoshino K, Tanabe M, Yoshida M, et al. Biliary complications in adult living donor liver transplantation with duct-to-duct hepaticocholedochostomy or Roux-en-Y hepaticojejunostomy biliary

reconstruction. Surgery 2002;132(1):48–56. https://doi.org/10.1067/msy.2002.125314.
[12] Lladó L, Fabregat J, Ramos E, Baliellas C, Torras J, Rafecas A. Complicaciones biliares tras el trasplante hepá tico. Cir Esp 2012;90(1):4–10. https://doi.org/10.1016/j.ciresp.2011.10.007. Number.
[13] Tingle SJ, Thompson ER, Ali SS, Figueiredo R, Hudson M, Sen G, et al. Risk factors and impact of early anastomotic biliary complications after liver transplantation: UK registry analysis. BJS Open 2021;5(2). https://doi.org/10.1093/bjsopen/zrab019.
[14] Janousek L, Maly S, Oliverius M, Kocik M, Kucera M, Fronek J. Bile duct anastomosis supplied with biodegradable stent in liver transplantation: the initial experience. Transpl Proc 2016;48(10):3312–6. https://doi.org/10.1016/j.transproceed.2016.09.039.
[15] Mathur AK, Nadig SN, Kingman S, Lee D, Kinkade K, Sonnenday CJ, et al. Internal biliary stenting during orthotopic liver transplantation: anastomotic complications, post-transplant biliary interventions, and survival. Clin Transpl 2015;29(4):327–35. https://doi.org/10.1111/ctr.12518.
[16] Taniai T, Furukawa K, Haruki K, Yanagaki M, Hamura R, Akaoka M, et al. Multimodal management for refractory biliary stricture after living donor liver transplantation. Transpl Proc 2023;55(4):940–4. https://doi.org/10.1016/j.transproceed.2023.04.001.
[17] Zeair S, Stasiuk R, Zair L, Wawrzynowicz-Syczewska M, Rybicka A, Grochans E, et al. Incidents and risk factors of biliary complications after orthotropic liver transplantation. Medicine (United States) 2021;100(34):e26994. https://doi.org/10.1097/MD.0000000000026994.
[18] López-Andújar R, Orón EM, Carregnato AF, Suárez FV, Herraiz AM, Rodríguez FSJ, et al. T-tube or no T-tube in cadaveric orthotopic liver transplantation: the eternal dilemma: results of a prospective and randomized clinical trial. Ann Surg 2013;258(1):21–9. https://doi.org/10.1097/SLA.0b013e318286e0a0.
[19] Lopez-Lopez V, Kuemmerli C, Iniesta M, Hiciano-Guillermo A, Cascales-Campos P, Baroja-Mazo A, et al. Efficacy of self-expandable absorbable stents during liver transplant to minimize early biliary complications. Ann Surg 2026;283:667–74. https://doi.org/10.1097/SLA.0000000000006502.
[20] López-Andújar R, Maupoey J, Escrig J, Granero P, Vila JJ, Ibáñez V, et al. Selective indication of T-tube in liver transplantation: prospective validation of the results of a randomized controlled trial. Transpl Proc 2019;51(1):44–9. https://doi.org/10.1016/j.transproceed.2018.03.133.
[21] Amador A, Charco R, Martí J, Navasa M, Rimola A, Calatayud D, et al. Clinical trial on the cost-effectiveness of T-tube use in an established deceased donor liver transplantation program. Clin Transpl 2007;21(4):548–53. https://doi.org/10.1111/j.1399-0012.2007.00688.x.
[22] Vest M, Ciobanu C, Nyabera A, Williams J, Marck M, Landry I, et al. Biliary anastomosis using T-tube versus No T-tube for liver transplantation in adults: a review of literature. Cureus 2022. https://doi.org/10.7759/cureus.24253.
[23] De Gregorio MA, Criado E, Guirola JA, Alvarez-Arranz E, Pérez-Lafuente M, Barrufet M, et al. Absorbable stents for treatment of benign biliary strictures: long-term follow-up in the prospective Spanish registry. Eur Radiol 2020;30(8):4486–95. https://doi.org/10.1007/s00330-020-06797-7.
[24] Sánchez-Cabús S, Calatayud D, Ferrer J, Molina V, Pavel MC, Sampson J, et al. Beneficial effect of a resorbable biliary stent in living donor liver transplantation. Eur Surg Res 2016;56(3–4):123–31. https://doi.org/10.1159/000443271.
[25] Jung SW, Kim DS, Yu YD, Suh SO. Clinical outcome of internal stent for biliary anastomosis in liver transplantation. Transpl Proc 2014;46(3):856–60. https://doi.org/10.1016/j.transproceed.2013.12.025.
[26] Ong M, Slater K, Hodgkinson P, Dunn N, Fawcett J. To stent or not to stent: the use of transanastomotic biliary stents in liver transplantation and patient outcomes. ANZ J Surg 2018;88(6):603–6. https://doi.org/10.1111/ans.14383.
[27] Xu X, Liu T, Liu S, Zhang K, Shen Z, Li Y, et al. Feasibility of biodegradable PLGA common bile duct stents: an in vitro and in vivo study. J Mater Sci: Mater Med 2009;20(5):1167–73. https://doi.org/10.1007/s10856-008-3672-2.
[28] Siiki A, Rinta-Kiikka I, Sand J, Laukkarinen J. Endoscopic biodegradable biliary stents in the treatment of benign biliary strictures: first report of clinical use in patients. Dig Endosc 2017;29(1):118–21. https://doi.org/10.1111/den.12709.
[29] Mohanka R, Rao P, Golhar A, Nikam V, Shrimal A, Shah M, et al. Archimedes absorbable internal biliary stent in liver transplants to prevent bile leak. Transpl Proc 2021;53(10):2923–8. https://doi.org/10.1016/j.transproceed.2021.09.020.
[30] Zhang L-B, Wang Y, Yang X-J. Bioresorbable biliary stents: a step forward. World J Clin Cases 2025;13(27). https://doi.org/10.12998/wjcc.v13.i27.108391.
[31] Song G, Zhao HQ, Liu Q, Fan Z. A review on biodegradable biliary stents: materials and future trends. Bio Mater 2022;17:488–95. https://doi.org/10.1016/j.bioactmat.2022.01.017.
[32] Siiki A, Sand J, Laukkarinen J. A systematic review of biodegradable biliary stents: promising biocompatibility without stent removal. Eur J Gastroenterol Hepatol 2018;30(8):813–8. https://doi.org/10.1097/MEG.0000000000001167. Number.
[33] Mauri G, Michelozzi C, Melchiorre F, Poretti D, Tramarin M, Pedicini V, et al. Biodegradable biliary stent implantation in the treatment of benign bilioplastic-refractory biliary strictures: preliminary experience. Eur Radiol 2013;23(12):3304–10. https://doi.org/10.1007/s00330-013-2947-2.