Adding a spur valve to laparoscopic portoenterostomy for patients with biliary atresia can achieve a high jaundice clearance rate and lower the number of episodes of cholangitis

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Abstract

**Purpose:** This study aimed to evaluate the efficacy of adding a spur valve to laparoscopic portoenterostomy for patients with biliary atresia.

**Methods:** We retrospectively reviewed the records of all patients diagnosed with biliary atresia (BA) who underwent laparoscopic portoenterostomy (Lap-PE) between 2013 and 2021. The patients were divided into two groups: Lap-PE with a spur valve (spur group) and without it (control group). Perioperative management was the same in both groups. We compared patient backgrounds and clinical outcomes, including jaundice clearance and the number of postoperative cholangitis episodes.

**Results:** Of 63 patients reviewed, 16 received a spur valve. There were no statistically significant differences in the patient backgrounds between the groups. All patients in the spur group achieved jaundice clearance. The number of postoperative cholangitis episodes one year after surgery was significantly lower in the spur group than in the control group (1 [0–3] vs. 3 [0–9], \( p = 0.04 \)). The jaundice-free survival rate with the native liver at one year after surgery was significantly higher in the spur group (100% vs. 53%, \( p = 0.01 \)).

**Conclusions:** Adding a spur valve during Lap-PE significantly lowered the number of cholangitis episodes one year after surgery.

Introduction

Cholangitis is the most common complication of biliary atresia (BA) after Kasai portoenterostomy and has a significant negative impact on long-term prognoses [1]. Ascending infection is a possible mechanism; however, the precise mechanisms underlying cholangitis remain unclear. Several surgical modifications have been reported to improve the outcome. Among these is the intussusception antireflux valve, but its use has been controversial [2] [3] [4]. The spur valve, first reported in 1982, is another surgical technique used to prevent cholangitis [5]. However, there have only been a few reports on its effectiveness.

We have added spur valves as an anti-reflux function to laparoscopic portoenterostomy (Lap-PE) since 2020. We aimed to evaluate the efficacy of this additional surgical procedure.

Materials And Methods

This was a single-center, retrospective, case-control study. All patients who underwent laparoscopic portoenterostomy between August 2013 and December 2021 were eligible. The patients were divided into two groups: those with a spur valve (spur group) and those without (control group). Beginning in 2020, we added a spur valve to Lap-PE. Perioperative management was the same in both the groups. We compared the patient backgrounds, surgical outcomes, and clinical outcomes between the two groups. To validate the efficacy of the spur valve, we evaluated the number of postoperative cholangitis episodes,
jaundice clearance rate, and jaundice-free survival rate with the native liver one year post surgery. Postoperative cholangitis was diagnosed using a combination of two factors: fever over 38 °C with no other obvious focus, and serum levels of liver enzymes (such as aspartate aminotransferase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), and gamma-glutamyl transpeptidase (γ-GTP) levels increased above 1.5 times the normal level, serum total bilirubin (TB) levels increased above 2.0 mg/dL, or any of these five elements elevated compared to the latest results). This was based on the Tokyo Guidelines 2018 [6]. Jaundice clearance was defined as a decrease in total bilirubin levels below 1.5 mg/dL. This study was approved by the Ethics Committee of Nagoya University Hospital (Ref No. 2021-0493).

**Surgical procedure**

In Lap-PE, intraoperative cholangiography was performed to confirm the diagnosis of BA. Next, the fibrous tissue in the hilar plate was dissected just before baring the liver parenchyma [7] [8]. A Roux-en-Y anastomosis with a spur valve was then created outside the umbilical incision. It consists of an end-to-side anastomosis of the jejunum, 15 cm distal to the ligament of Treitz and 40 cm of the Roux-en-Y limb. Then we dissected a 2-cm length × 1/2 circumference width of the seromuscular layer of the Roux-en-Y limb near the anastomosis (Fig. 1a). The exposed submucosal layer of the Roux-en-Y limb was covered with the seromuscular layer of the jejunal wall (Fig. 1b) [9].

**Statistical analysis**

Continuous variables were expressed as medians (range). The Mann-Whitney U test was used to compare continuous variables. Fisher’s exact probability test was used to analyze the differences between discrete variables. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using R software version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

**Results**

**Patient characteristics**

Sixty-three BA patients underwent lap-PE: 16 in the spur group (25%) and 47 in the control group (75%). There were no significant differences between the groups for age at surgery ($p = 0.98$), weight at surgery ($p = 0.66$), preoperative AST levels ($p = 0.98$), ALT levels ($p = 0.51$), TB levels ($p = 0.68$), DB levels ($p = 0.45$), ALP levels ($p = 0.26$), or γ-GTP levels ($p = 0.22$) (Table 1).

| Table 1 |
|--------------------------------------------------|
| Comparison of patient characteristics between the two groups |
Spur (n=16) | Control (n=47) | p.value
---|---|---
**Patient characteristics**
Age at surgery (days), median (range) | 59 (23-104) | 55 (28-116) | 0.98
Weight at surgery (g), median (range) | 4345 (2560-7040) | 4236 (2244-6200) | 0.66

**Preoperative blood test median (range)**
AST (mg/dL) | 129 (25-934) | 133 (34-990) | 0.98
ALT (mg/dL) | 86 (19-419) | 84 (10-321) | 0.51
TB (mg/dL) | 7.3 (4.6-15.8) | 7.3 (2.9-14.8) | 0.68
DB (mg/dL) | 4.5 (2.6-11.3) | 4.7 (1.9-10.5) | 0.45
ALP (IU/L) | 1653 (819-6288) | 1792 (774-6231) | 0.26
γ-GTP (IU/L) | 312 (148-2400) | 490 (74-1759) | 0.22

AST = aspartate aminotransferase, ALT = alanine transaminase, TB = total bilirubin, DB = direct bilirubin, ALP = alkaline phosphatase, γ-GTP = gamma-glutamyl transpeptidase.

**Perioperative surgical outcomes**

Table 2 shows the surgical outcomes in both groups. There was no significant difference in the operative time between the two groups (p = 0.58). All patients in the spur group achieved jaundice clearance, but there was no significant difference compared with the control group (p = 0.05). The time taken for jaundice clearance did not differ significantly between the groups (35 [15–58] vs. 43 [8–158], p = 0.31). No serious adverse events such as small bowel obstruction or perforation occurred in the spur group.

### Table 2

| Comparison of perioperative surgical outcomes between the two groups |
|---|---|---|---|
| Operation time (min), median (range) | 340 (302-371) | 336 (298-390) | 0.58 |
| Blood loss (ml), median (range) | 18 (6-24) | 25 (12-45) | 0.04 |
| Jaundice-clearance ratio, n (%) | 16 (100) | 36 (77) | 0.05 |
| Time taken for jaundice clearance (days), median (range) | 35 (15-58) | 43 (8-158) | 0.31 |

Clinical Outcomes at 1 year postoperatively
Nine patients in the spur group were observed for > 1 year postoperatively. The incidence of cholangitis did not differ significantly between groups (78% vs. 85%, \( p = 0.6 \)). However, the number of postoperative cholangitis episodes was significantly lower in the spur group than that in the control group (1 [0–3] vs. 3 [0–9], \( p = 0.04 \)). The jaundice-free survival rate with native liver was significantly higher in the spur group than in the control group (100% vs. 53%, \( p = 0.01 \); Table 3).

| Table 3 |
| --- |
| Comparison of clinical outcomes at 1 year postoperatively between the two groups |

|                          | Spur (n=9) | Control (n=47) | \( p \)-value |
|--------------------------|------------|----------------|--------------|
| Incidence of postoperative cholangitis, n (%) | 7 (78)     | 40 (85)        | 0.6          |
| The number of postoperative cholangitis episodes, median (range) | 1 (0-3)    | 3 (0-9)        | 0.04*        |
| Jaundice-free survival rate with the native liver, n (%) | 9 (100)    | 25 (53)        | 0.01*        |

* Indicates statistical significance

**Discussion**

This is one of the few retrospective case-control studies to evaluate the efficacy of spur valves. To our knowledge, there has only been one study similar to ours [9]. Previous study has showed improvement in the rate of jaundice clearance and the incidence of cholangitis. However, not only spur valve but also total removal of the extrahepatic biliary remnants was added. They also included patients with BA in the past few decades; therefore, treatment protocols may have changed. In our study, patients with BA in the last eight years were enrolled; therefore, the Lap-PE procedure including the extent and depth of fibrous tissue dissection in the hilar plate and postoperative treatment (such as periods of antibiotic administration and tapering prednisone doses) have been standardized. Besides, the operator was not fixed and different surgeons have performed the Lap-PE in both groups. There were no significant differences in age at surgery or preoperative liver enzymes contributing to prognosis between the two groups [10] [11]. Thus, the difference in clinical outcomes is likely influenced by the presence or absence of a spur valve.

The spur valve, first reported in 1982, has been proven to prevent reflux of enteric contents into the Roux-en-Y limb by animal experiments; therefore, it is expected to improve ascending cholangitis [5] [12]. However, the pathogenesis of postoperative cholangitis after PE remains controversial. Bacterial infection from the enteric conduit is a possibility, but there are many other possible causative factors for cholangitis, including reduced lymph drainage at the porta hepatis, portal venous infection, hepatolithiasis, and partial bile drainage [13]. This leads us to assume that the spur valve did not significantly decrease the incidence of cholangitis compared with the control group. Chen et al. showed
that the number of cholangitis episodes was more likely to be a prognostic marker to predict liver transplantation after PE than the incidence of cholangitis [14]. Another study reported that repeated cholangitis attacks significantly decreased jaundice-free survival in the native liver [15]. In our study, the number of postoperative cholangitis episodes one year after Lap-PE was significantly lower in the spur group than in the control group. The jaundice-free survival rate with the native liver after one year was significantly higher in the spur group. These results suggest that the spur valve is effective against some types of cholangitis, mainly ascending cholangitis, and could improve native liver survival.

All patients in the spur group achieved clearance of jaundice. It is widely known that sufficient bile flow through bile capillaries is important for jaundice clearance [16]. Frequent refluxes of intestinal content into the ascending jejunal limb damage the bile capillaries and worsen bile flow. Our previous report indicated that postoperative intestinal obstruction negatively affects bile secretion, and we proposed that creating an anti-reflux valve would prevent an increase in the intraluminal pressure of the hepatic hilum and maintain good bile flow [17]. Our new findings supported this hypothesis.

This study has some limitations: the small number of patients, the retrospective design, and the shorter follow-up interval in the spur group than in the control group. Therefore, further research is required to confirm the efficacy and long-term prognosis of spur valves.

In conclusion, adding a spur valve during Lap-PE achieved a high jaundice clearance rate and significantly lowered the number of cholangitis episodes one year after surgery. This study suggests that the spur valve maintains good bile flow and has a positive effect on jaundice-free survival rate with the native liver.

**Declarations**

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**Ethics approval:** This study was conducted in line with the principles of the Declaration of Helsinki. The study was approved by the Ethics Committee of Nagoya University Hospital (Ref No. 2020-0589).

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**Figures**

**Figure 1**

a Dissection of the seromuscular layer of the Roux-en-Y limb to expose the submucosal layer.

SM, the submucosal layer; RYA, Roux-en-Y anastomosis

b Completion of the spur valve. The exposed submucosal layer of the Roux-en-Y limb is covered with the wall of the proximal jejunum by using 5-0 absorbable monofilament sutures

SV, spur valve; RY, Roux-en-Y limb; PJ, proximal jejunum