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Case Reports

Robotic-assisted Kasai portoenterostomy in biliary atresia: A case report and technical considerations

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ABSTRACT

Biliary atresia is a rare and fatal cholestatic disorder characterized by progressive obliteration of the extrahepatic and intrahepatic bile ducts, typically presenting during the neonatal period. Ethology remains uncertain, although immune-mediated injury, viral triggers, and developmental anomalies have been implicated.

Kasai portoenterostomy is the primary treatment for biliary atresia, with optimal outcomes achieved when performed within the first 60 days of life. Despite early intervention, many patients experience progressive cirrhosis and portal hypertension. Liver transplantation remains the definitive therapeutic option.

The timing of liver transplantation in early infancy remains controversial. A primary concern is increased mortality associated with the inability to administer live childhood vaccines to infants transplanted before six months of age, thereby elevating the risk of subsequent life-threatening infections.

A 6-kg infant was diagnosed with biliary atresia and underwent surgery 84 days of age. Robotic-assisted Kasai portoenterostomy was performed to maintain bile flow until transplantation and to minimize adhesion formation, both of which are beneficial for subsequent transplantation. This report presents the technical aspects of the procedure.

Keywords: Biliary atresia, child, jaundice, portoenterostomy, robotic-assisted surgery, Kasai procedure

Introduction

Biliary atresia is a congenital cholangiopathy characterized by the progressive obliteration of both extrahepatic and intrahepatic bile ducts (1,2). Although there are various forms of disease, their etiopathogenesis is heterogeneous. While the exact mechanisms are not known, it is hypothesized that immune-mediated damage, perinatal viral infections, and developmental abnormalities each contribute to the development of these diseases (2,3). Clinically, this condition presents in the neonatal period with persistent jaundice, acholic stools, and hepatomegaly. In the absence of treatment, cholestatic injury initiated during the first months of life progresses rapidly to fibrosis, resulting in cirrhosis and ultimately end-stage liver failure (1). Untreated patients typically experience mortality within one year.

Kasai portoenterostomy (KPE) is the standard treatment for biliary atresia. This procedure excises the fibrous remnant of the bile ducts at the porta hepatis and facilitates drainage of the microscopic bile ducts through a jejunal portoenterostomy (4). The success of the procedure is closely linked to early surgical intervention, as delays increase the risk of complications. Furthermore, the precision of porta hepatis dissection is critical, since meticulous technique reduces the likelihood of injury to vital structures and improves patient outcomes (1). Nevertheless, a significant proportion of patients experience progressive liver failure, ultimately necessitating liver transplantation (5). The primary factors determining the success of Kasai portoenterostomy, ranked by significance, are age at initial surgery, restoration of postoperative bile flow, presence of microscopic ductal structures in the hepatic portal, degree of hepatic parenchymal disease at diagnosis, and the specific techniques employed in portoenterostomy anastomosis. Among these, age at operation is most frequently identified as the key prognostic variable. Surgical intervention before 60 days of age is associated with a favorable outcome, whereas delayed surgery typically results in the development of cirrhosis within three to four months.

Robotic surgery provides enhanced control in confined and deep anatomical regions through the use of three-dimensional imaging, tremor suppression, and articulated instruments (6,7). Recent studies indicate that robot-assisted Kasai portoenterostomy is associated with reduced blood loss, decreased transfusion requirements, improved jaundice resolution in select cases, and fewer adhesions during subsequent liver transplantation compared to open or laparoscopic approaches (8,9).

This case report describes the short- and medium-term outcomes of robot-assisted laparoscopic Kasai portoenterostomy, performed for the first time in Türkiye in a pediatric patient, and includes a review of the relevant literature.

Case Report

A male infant was initially evaluated at an external facility on day 45 for persistent jaundice, pale stools, and dark urine. He was subsequently admitted to our hospital on day 84 with a preliminary diagnosis of biliary atresia. On physical examination, hepatomegaly was observed. Laboratory evaluation demonstrated direct hyperbilirubinemia, with total bilirubin 8.8 mg/dL and direct bilirubin 8.1 mg/dL.

Liver function tests showed elevated transaminases (AST: 369 U/L; ALT: 550 U/L) and increased gamma-glutamyl transferase (GGT: 767 U/L). The coagulation profile revealed an international normalized ratio (INR) of 1, and serum albumin was 4.1 g/dL. Abdominal ultrasound showed an atrophic gallbladder, visualized as a thin line without a discernible lumen. No evidence of ascites was present, and neither clinical nor radiological findings suggested portal hypertension at the initial evaluation. Nutritional assessment showed the patient's weight was at the sixth percentile for age. Upon referral to our center at 84 days of age, the infant weighed 6 kg and had a preliminary diagnosis of biliary atresia. After multidisciplinary evaluation, surgical intervention was recommended. In the absence of clinical or radiological evidence of portal hypertension or ascites, and with no overt liver failure observed at the time of consultation, Kasai portoenterostomy was deemed an appropriate initial intervention, despite the patient's relatively advanced age.

Furthermore, limited access to immediate liver transplantation and challenges with donor availability necessitated a bridging strategy to maintain clinical stability. A robot-assisted laparoscopic approach was selected to enhance surgical precision and potentially reduce intra-abdominal adhesions, thereby facilitating a future liver transplant.

A 12 mm incision was created 2 cm below the umbilicus using a 12 mm camera trocar. The patient, aged 85 days, underwent the procedure. Under direct visualization, two 8 mm robotic arms were inserted at the level of the navel through the lateral rectus muscles, and a 10 mm auxiliary port was placed at the anterior axillary line in the upper left quadrant (Figure 1). Prior to robotic docking, the liver was suspended from the abdominal wall with 0 silk suture, guided by the camera, beginning at the falciform ligament. The liver appeared brownish-green, oedematous, and slightly nodular.

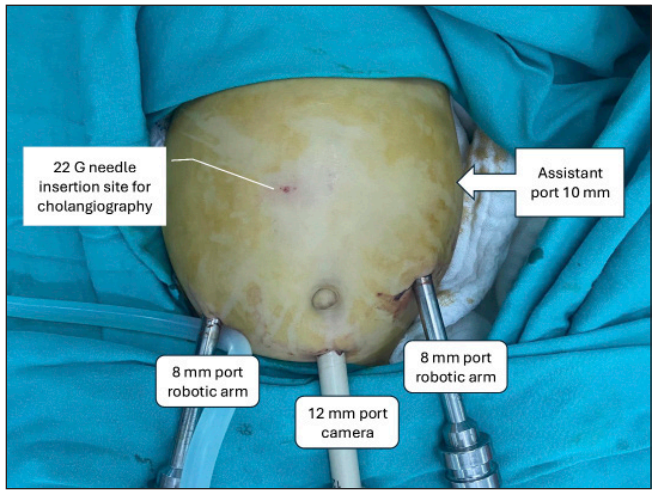

Figure 1: The patient was positioned in the reverse Trendelenburg position, and the robot approached from the cranial side. A 12-mm camera trocar was inserted below the umbilicus prior to the robot's approach. Under camera visualization, a 22G needle was inserted and placed into the gallbladder, and a cholangiogram was performed after administering a contrast agent. An 8 mm working trocar was inserted through both lateral rectus muscles, and a 10 mm assistant trocar was inserted through the left upper quadrant.

The atrophic gallbladder remnant was fibrotic and notably small. It was grasped with a dissector, and intraoperative cholangiography was performed under fluoroscopy following insertion of a 22-G needle through the abdominal wall. Intraoperative cholangiography demonstrated no opacification of the intrahepatic ducts and no passage of contrast to the duodenum, consistent with biliary atresia with obliteration at the porta hepatis (Kasai type III). After completion of the diagnostic phase, the robotic system was docked (Figure 2). The procedure was performed using the da Vinci Si robotic system (Intuitive Surgical, Sunnyvale, CA, USA). The patient was placed in the supine position, and a pneumoperitoneum was created at 10 mmHg. Adhesions were removed, and to enhance visualization, the gallbladder was fixed to the abdominal wall with 0 silk suture at its most fibrous point. The gallbladder was separated from the hepatic beds using both sharp and blunt dissection. The Lund's lymph node was excised. The common bile duct (choledochus) was exposed and ligated to the duodenum with 4/0 Vicryl. Fibrous structures corresponding to the gallbladder, choledochus, and common duct toward the portal region of the liver were cleared using sharp and blunt dissection (Figure 3). These structures were traced and excised up to the portal region, just above the portal vein and hepatic artery. No bile flow was observed. The portal plate (hepatic hilum) was exposed, and fibrotic tissue was carefully cleared. Under magnification, fine, diffuse canalicular structures were identified above the hepatic artery. The hepatic hilum was fully exposed. The extrahepatic bile ducts were dissected while preserving the hepatic artery and portal vein. Atretic bile ducts were excised after tracing their course proximally to the hepatic hilum. No significant bile flow was observed. The residual biliary ducts and adjacent liver tissue were excised, revealing minimal bile flow. The jejunum was transected 20 cm distal to the ligament of Treitz using a blue stapler. A window was

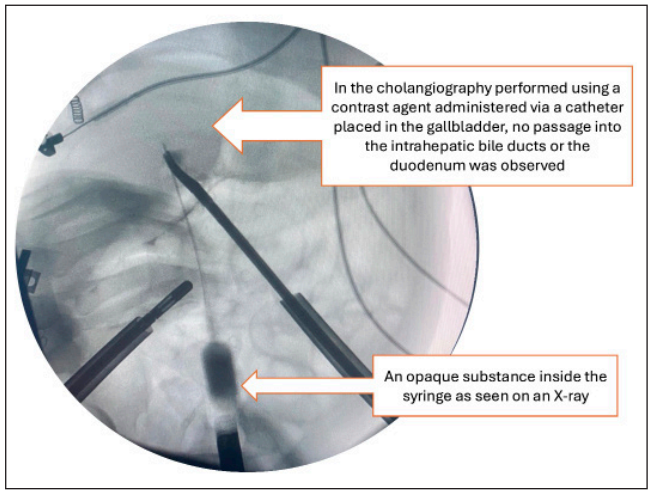

Figure 2: A 22G needle was inserted into the gallbladder, and a contrast agent was injected. No passage of the contrast agent into the intrahepatic bile ducts or the duodenum was observed. The gallbladder, held in place with a laparoscopic dissector to prevent leakage of the contrast agent, is visible under fluoroscopy.

created in the mesocolon, and with the distal end positioned laterally, a single-layer anastomosis was performed between the seromuscular edge of the Roux limb and the portal plate using 6/0 and 5/0 Vicryl sutures. The anastomosis was completed as a single layer at the lower edge, due to proximity to the hepatic artery, and as a double layer at the upper wall. A Jackson-Pratt drain was placed. Wedge and core liver biopsies were obtained; the wedge biopsy was performed with scissors, and the core biopsy was obtained via an abdominal wall incision. The jejunojejunostomy was exteriorized through the camera trocar and sutured end-to-end in two layers using Connell and Lambert sutures with 5/0 Vicryl. The abdominal cavity was inspected. The fascia was closed in layers with 2/0 Vicryl, and the skin with 5/0 Rapid Vicryl. No bleeding or complications were observed. The total duration of the procedure was 480 minutes, with 257 minutes allocated to console operation (except during laparoscopic cholangiography). Estimated blood loss was minimal, and no intraoperative transfusion was necessary.

Early oral feeding was initiated during the postoperative period. In the initial follow-up, jaundice levels decreased and no complications were observed. Total bilirubin levels decreased by 6.75 mg/dL three weeks after the operation. Histopathological analysis of wedge and core liver biopsies revealed bile duct proliferation, portal fibrosis, and cholestasis, which are consistent with a diagnosis of biliary atresia. The patient was enrolled in a follow-up program to provide bridging treatment until liver transplantation. Twenty days postoperatively, a port-side hernia developed at the trocar insertion sites due to ascites. In the absence of obstruction and given the risk of surgical adhesions, continued monitoring was chosen In the second postoperative month, the patient was hospitalized for cholangitis treatment. In the third postoperative month (day 77), excessive ascites necessitated placement of an intra-abdominal drain and initiation of intermittent drainage. At the six-month follow-up, live vaccines were administered. Currently, in the sixth

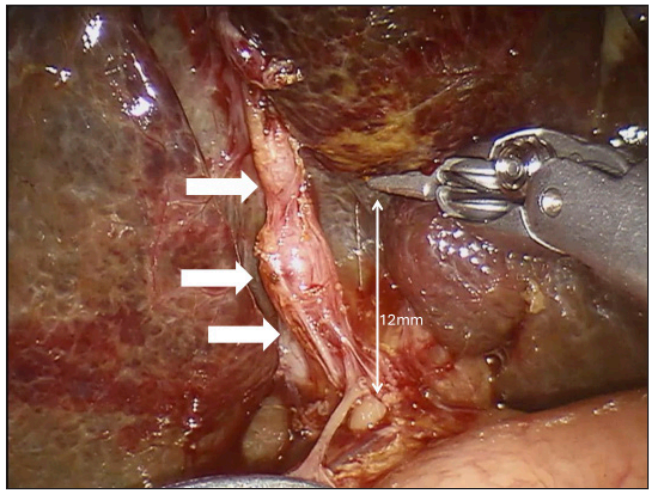

Figure 3: A nodular and cirrhotic-appearing liver is observed. The gallbladder is fibrotic and notably small, measuring approximately 15 mm in length.

postoperative month (ninth postnatal month), the patient experienced another episode of cholangitis. The patient remains on the waiting list for liver transplantation.

Discussion

Kasai portoenterostomy is the primary surgical intervention for biliary atresia, including in infants with advanced-stage disease, as it aims to preserve native liver function prior to liver transplantation. The success of this procedure depends largely on the preservation of microscopic bile ducts at the porta hepatis, which contributes to the significant technical complexity of the surgery (4).

Robotic surgery may provide more controlled and stable dissection in anatomically challenging areas. Experimental studies also indicate that robotic systems support complex hepatobiliary anastomoses using minimally invasive techniques (6). Clinical trials indicate that robotic Kasai portoenterostomy reduces blood loss and accelerates post-operative recovery compared to open surgery (8). Furthermore, the robotic approach delivers better technical outcomes than laparoscopic surgery and results in higher rates of early-stage jaundice resolution (9). Studies indicate that robotic surgery requires more time than laparoscopic or open procedures (8). The results obtained in this study were consistent with those reported in the literature.

Liver transplantation is generally considered inevitable in cases of biliary atresia; however, determining the optimal timing, particularly for patients younger than six months, remains challenging due to the inability to administer live vaccines and the increased risk of infection (3,5). A successful Kasai portoenterostomy is essential to maintain patient health until transplantation becomes feasible. In this case, a robot-assisted laparoscopic Kasai portoenterostomy was performed to provide sufficient time for live vaccine administration and to facilitate subsequent liver transplantation by minimizing adhesion formation.

In biliary atresia, the initial treatment is typically Kasai portoenterostomy (open, laparoscopic, or robotic). However,

its ability to cure is limited; many will ultimately require a liver transplant. Thus, Kasai serves mainly as a temporary, first-line intervention rather than a definitive cure (10,11). Recent studies provide information on surgical and short- to medium-term outcomes for robotic Kasai surgery, but there is limited data on transplant outcomes. Although robot-assisted Kasai portoenterostomy may provide benefits such as improved visualization and reduced adhesions, these advantages are largely unproven and based on a single case.

In 2007, Dutta and colleagues reported three successful robotic portoenterostomies. Meehan and colleagues demonstrated feasibility in two additional cases. Between 2002 and 2005, Dutta's group performed 10 minimally invasive Kasai procedures, using robotic techniques in three cases and standard laparoscopy in seven.

This is the first reported robot-assisted laparoscopic Kasai portoenterostomy from Türkiye. Minimally invasive approaches may reduce intra-abdominal adhesions, but we could not evaluate this benefit as this initial report lacks long-term follow-up (12,13).

Conclusion

This study is limited to a single case, and long-term outcomes have not been reported. Robot-assisted Kasai surgery, when performed prior to liver transplantation, appears to be safe and feasible. In comparison to open and laparoscopic techniques, the robotic approach may reduce intraoperative blood loss and facilitate faster bowel recovery. Although some studies report improved jaundice resolution with the robotic method, these results remain inconsistent. There is currently no demonstrated benefit in long-term liver survival. Most available evidence is derived from small, retrospective studies. The literature suggests that the robotic approach may be a viable option in experienced centers, although surgeon expertise, technical resources, and associated costs require careful consideration.

Contribution of the authors
Concept or design: SEUB GBB; Acquisition of data: OMÇ FBŞ; Analysis or interpretation of data: BG MBÇ ; Drafting of the article: SEUB GBB; Critical revision for important intellectual content: SD

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