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# Isolated vascularized gastric tube biliary enteric drainage: a paediatric case series experience

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## Abstract

**Background:** Despite the enormous surgical advancements in the last century, access to the biliary system is lost when a Roux-en-Y (RY) biliary drainage procedure is performed. Attempts have been made to overcome this inconvenient sequel using variations in the RY anastomosis, small bowel grafts and vascular grafts. These have been predominantly unsuccessful. An isolated vascularized gastric tube (IVGT) graft has been reported in the literature, which was successfully used for adult patients with common bile duct injuries. We have adopted the technique of using an IVGT graft for bile duct reconstruction in the paediatric patients at our institution. We reviewed our experience at our institution between January 2015 and October 2019. This was a retrospective review of all paediatric patients undergoing an IVGT graft procedure for biliary tract anatomical obstruction in the past 5 years. We looked at the indications for surgery, the demographic profile of the patients and outcomes following surgery and outlined the surgical technique used.

**Results:** IVGT bile duct reconstruction was performed on eight patients. Patients ranged from 2 months to 7 years, and there was an equal number of males and females. The diagnosis was made on clinical suspicion and confirmed with ultrasound (U/S) and magnetic resonance cholangiopancreatography (MRCP). There was an 87.5% resolution of biliary obstruction, and two patients who had bile leaks postoperatively were managed conservatively. Unfortunately, one patient died in the early postoperative period from sepsis due to pneumonia. Follow-up was for a minimum of 6 months and up to 5 years.

**Conclusion:** IVGT biliary enteric drainage is a safe, reproducible procedure that allows access to the biliary tree if required in the future. Thus, this procedure serves as an alternative, especially in limited-resource areas where interventional radiology is not available for future interventions.

**Keywords:** Choledochal cyst, Paediatric, Roux-en-Y, Bile drainage, Gastric conduit

## Background

Despite the enormous surgical advancements in the last century, access to the biliary system is lost when a Roux-en-Y biliary drainage (RYBD) procedure is performed. Attempts have been made to overcome this inconvenient sequel by using alternative techniques that have not been universally accepted for many reasons [1–5]. Although access to the biliary tree post-RYBD is possible with interventional radiology, this highly specialized service is rarely available, especially in developing countries [6, 7]. Helmy et al. published a study using an isolated vascularized gastric tube (IVGT) graft as a biliary conduit in 2011 [8]. The IVGT graft was later successfully adapted for adult patients with common bile duct injuries [9]. Given the concerns regarding RYBD, children's long life expectancy and the lack of interventional radiological services, we have adopted IVGT graft as a primary reconstructive

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procedure for our paediatric patients at our institution and review our experience.

## Method

The Biomedical Research and Ethics Committee approved the study. The study was a retrospective review of all paediatric patients treated with IVGT grafts for anatomical biliary tract obstruction at our institution between January 2015 and October 2019. Our institution is a tertiary hospital servicing area 2 of our province with 4.5 million people. Data were extracted from electronic records and patient folders, and this was annotated using an Excel worksheet. Qualified paediatric surgeons at our institution performed all the procedures.

### Procedure

All patients had a transverse supra-umbilical laparotomy to access the biliary system. The new conduit was created by tubularizing a vascularized segment of the greater curve of the antrum of the stomach, as follows.

The starting point was marked at approximately 1 cm proximal to the pylorus on the greater curve of the stomach. The endpoint (length of conduit) was marked at 3–4 cm proximal to the starting point, depending on the child's size and the conduit length required from the remaining biliary system to the duodenum. The diameter of the neo-tube was marked at approximately 5–7 mm to match the diameter of the remaining duct (Fig. 1). The right gastroepiploic vessels were accurately preserved as the vascular supply to the graft. At the proximal end of the graft (closer to the body of the stomach), the gastroepiploic vessels were ligated and divided. The gastroepiploic vessels were preserved at the distal end (closer to the pylorus) while the small branches supplying the remaining stomach were ligated and divided (Fig. 2). Thus, this allowed for increased mobility of the vascular pedicle

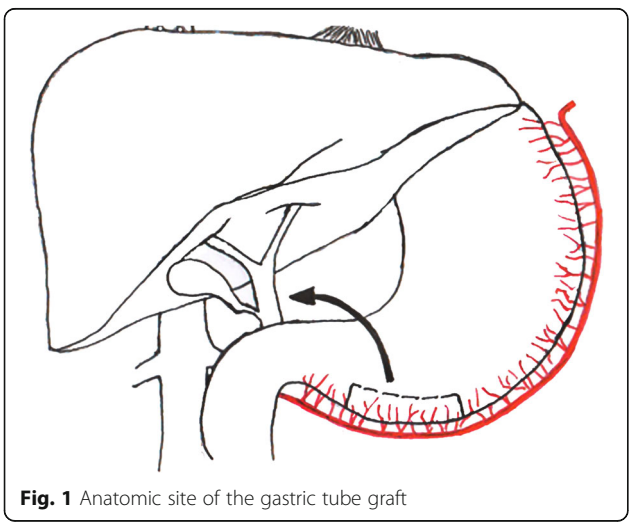

**Fig. 1** Anatomic site of the gastric tube graft

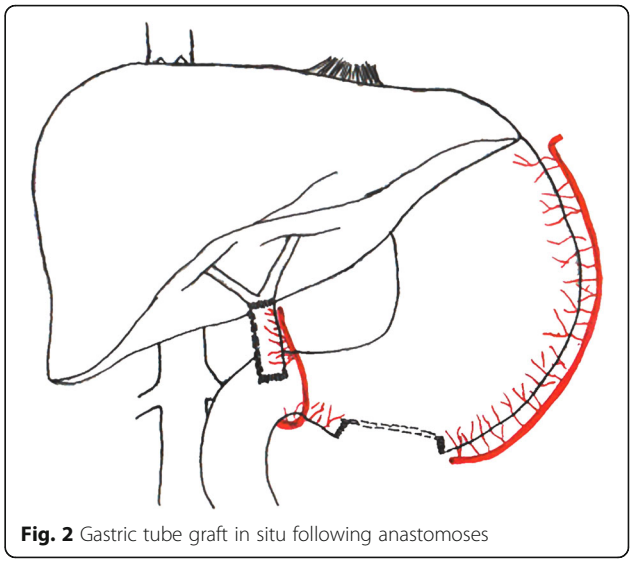

**Fig. 2** Gastric tube graft in situ following anastomoses

enabling the graft to be transferred to the biliary site without tension on its blood supply. Electro-cautery was not used because of the possibility of lateral spread and devascularization; therefore, all the vessels were ligated. The stomach was then incised at the start and end markings on both surfaces using dissecting scissors. The tube was created using a linear stapler device that was fired between the two gastric openings along the length of the intended conduit. The tube can also be made by manually suturing the edges together. The graft was then transferred to the biliary site, ensuring that the vessels were not twisted. The proximal end of the graft was anastomosed to the remaining proximal hepatic duct(s) using either 4/0 or 5/0 interrupted absorbable monofilament polydioxanone sutures. The distal end of the graft was anastomosed similarly to a defect created in the antimesenteric wall of the second part of the duodenum.

No trans-anastomotic stents were used within the graft (Fig. 3). A nasojejunal tube was passed intra-operatively for enteral feeding. A multi-lumen drain was placed behind the graft, and a nasogastric tube was placed to drain the stomach. Prophylactic antibiotics were given for 24 h, and jejunal feeds were started after 24–48 h post-surgery, depending on the postoperative course. The nasojejunal tube was removed after 1 week when oral or gastric feeds were initiated.

## Results

There were eight patients in the cohort, with equal halves being male and female. The age of presentation varied between 2 months and 7 years of age, and all patients presented with clinical and biochemical features of obstructive jaundice. Radiological investigations were U/S, followed by MRCP for all patients. The causes of the obstructed biliary systems were choledochal cysts in

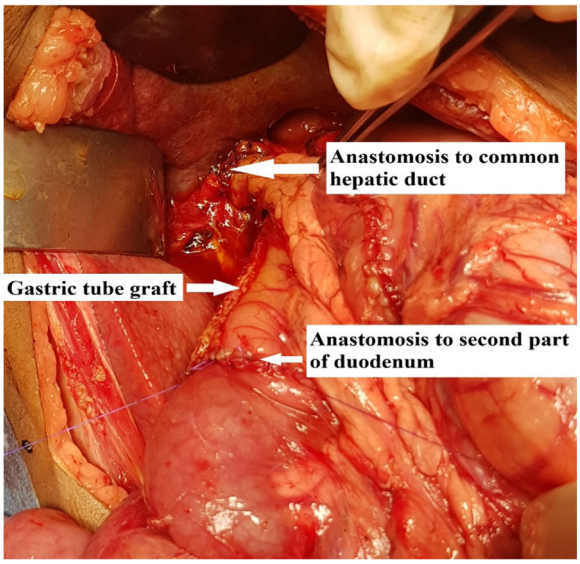


**Fig. 3** Intra-operative picture of completed graft

seven patients and a congenital biliary stricture in one patient (Table 1).

### Outcome

Seven of the eight patients (87.5%) had complete resolution of symptoms and normal liver function. One patient died in the postoperative period due to sepsis and multi-organ failure with a background of chronic liver disease. This resulted from ventilator-associated pneumonia, and the abdomen remained soft with no collections on imaging. Cirrhosis was confirmed on the intra-operative liver biopsy of this patient. Postoperative bile leak was present in two patients, of which one resolved after 10 days, and in the other patient, drainage decreased to 5 ml per day; however, this was the patient who demised. Relaparotomies were not performed for the bile leaks. None of the patients had any episodes of cholangitis. One patient required a relaparotomy for adhesive bowel obstruction 3 months after the initial surgery (Table 2). Follow-up was for a minimum of 6 months and up to 5 years.

## Discussion

RYBD is widely accepted as the procedure of choice for biliary drainage in the paediatric population, especially for choledochal cysts and biliary strictures. The jejunum is usually divided approximately 15–20 cm beyond the duodeno-jejunal. A 40-cm Roux limb is usually created, and some surgeons have used shorter Roux limbs with equivocal results [10, 11]. The 40-cm Roux limb may not impact children with standard bowel length but may be of concern in children with shorter bowel length or short bowel syndrome. IVGT does not result in bowel loss for digestion.

The long-term problems associated with RYBD are anastomotic strictures, cholangitis, gallstone formation and obstruction [12, 13]. Addressing anastomotic strictures and intrahepatic stones has been an ongoing problem. Where available, interventional radiological techniques have been used to dilate and stent anastomotic strictures [14–16]. Failed RYBD often requires major repeat laparotomies or interventional radiology procedures [17, 18]. Given the complications and the lack of advanced paediatric interventional radiology services, surgeons began exploring alternative methods to access the biliary tracts post-reconstruction. The 'access loop' was developed and has been used to access the biliary tracts together with interventional radiology [5, 19]. Endoscopic ultrasound with the creation of a hepatico-gastrostomy has also been used for biliary anastomotic strictures post-RYBD as an alternative to a major relaparotomy [16]. A modification of the 'access' loop with the end of the Roux loop anastomosed to the anterior wall of the stomach has also been attempted [2]. This allowed endoscopic access to the bilio-enteric anastomosis in the future.

Hepatico-duodenostomy is still performed in some units; however, other centres have changed to RYBD because of bile reflux and incidental malignancy [20–23]. Other alternates that have been used were the

**Table 1** Results

| Patient | Age | Gender | Clinical presentation | Investigations | Cause | Outcome |
|---|---|---|---|---|---|---|
| 1 | 7 months | Male | Obstructive jaundice, portal hypertension | U/S, CT scan, MRCP | Type 4A choledochal cyst | Died |
| 2 | 7 years | Male | Obstructive jaundice | U/S, CT scan, MRCP | Type 1 choledochal cyst | Alive |
| 3 | 14 months | Female | Obstructive jaundice | U/S, CT scan, MRCP | Type 4A choledochal cyst | Alive |
| 4 | 25 months | Female | Obstructive jaundice | U/S, CT scan, MRCP | Distal CBD stricture | Alive |
| 5 | 10 weeks | Male | Obstructive jaundice | U/S, CT scan, MRCP | Type 1 choledochal cyst | Alive |
| 6 | 18 months | Female | Obstructive jaundice | U/S, CT scan, MRCP | Type 4B choledochal cyst | Alive |
| 7 | 15 months | Male | Obstructive jaundice | U/S, CT scan, MRCP | Type 4B choledochal cyst | Alive |
| 8 | 11 months | Female | Obstructive jaundice | U/S, CT scan, MRCP | Type 4A choledochal cyst | Alive |

**Table 2** Complications

| Complications | Number |
|---|---|
| Bile leak | 2 |
| Cholangitis | 0 |
| Adhesive bowel obstruction | 1 |

gallbladder, an ileal loop between the hepatic duct and jejunum, and an isolated vascularized jejunal tube that has also been successfully used in an animal study [1, 3, 4].

Interventional radiology procedures are paramount for addressing complications of RYBD [14, 15, 24]. Paediatric interventional radiology is a scarce resource, with few specialists practising in the developing world [6, 7]. Due to the lack of interventional radiology, complications following RYBD procedures need to be managed via open surgical techniques, and therefore, the IVGT procedure may be the solution [25].

The long-life expectancy of paediatric patients is an essential factor that should be considered when we perform any surgical procedure. The risk of strictures, cholangitis and gallstone formation is increased in patients [26]. The use of an isolated gastric tube in biliary atresia was previously described by GV Datar in 1986. He achieved successful drainage and a reduction in cholangitis rates in the long term [27]. The IVGT is more anatomical and allows for physiological drainage of bile into the duodenum. The extent and duration of the surgery are reduced because of the fewer anastomoses and lesser dissection. Accompanied by using a nasojejunal tube, early feeding can be commenced in patients with IVGT grafts, which is not possible with an RYBD procedure. The IVGT procedure theoretically excludes bowel complications such as adhesive obstruction, twisting the Roux limb with obstruction and internal hernia formation. Access to the bile ducts, including the IVGT graft, can be easily achieved with endoscopic retrograde cholangiopancreatography (ERCP) (Fig. 4).

It is well documented that hepatico-duodenostomies predispose patients to bile reflux gastritis. We have not experienced any evidence of bile reflux gastritis in our series [20, 28]. All forms of bilio-enteric anastomoses have an associated risk of cholangiocarcinoma, with RYBD being lower than hepatico-duodenostomies [29]. The IVGT graft is anastomosed to the second part of the duodenum, and bile reflux should be prevented by the normal physiology of peristalsis and the intact pylorus. We have not experienced any episodes of cholangitis as well. We intend to perform ongoing surveillance to assist us with identifying long-term problems.

Helmy et al. had a cohort of 18 adult patients who mainly had IVGT grafts for bile duct injuries [9]. It is important to note that they used a trans-anastomotic stent within the graft, and one stent was blocked postoperatively

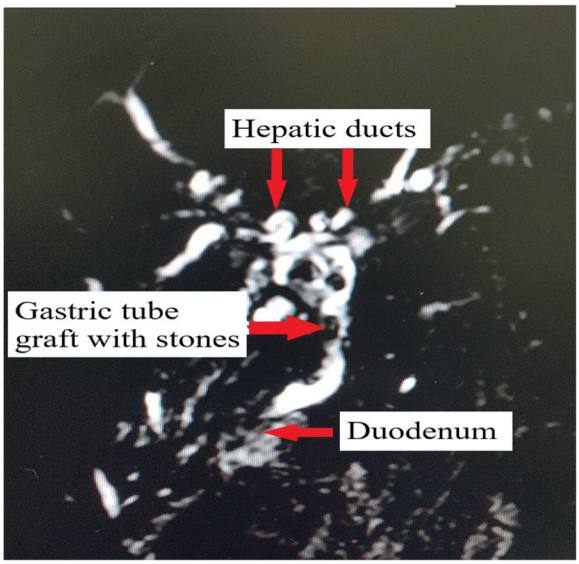


**Fig. 4** ERCP of a gastric tube graft containing stones in an adult patient

and had to be removed. We did not use trans-anastomotic tubes and had no cases of obstruction or strictures postoperatively. The other complications they experienced included three patients with bile leaks (16%), two were managed conservatively and one required converting to an RYBD procedure. Our experience was similar with two patients having minor bile leaks (25%), one resolved spontaneously after 10 days, and the other decreased to 5 ml per day when the patient died. The bile leak rate is high, but they were minor leaks that did not require a reoperation in both cases. One of our patients had a poor nutritional state with cirrhosis and sepsis that would have contributed to the leak. We will continue to be meticulous with our anastomoses and monitor our future experience.

The mortality we had resulted from pneumonia and multi-organ failure with a background of chronic liver disease. We had one child who required a relaparotomy at 3 months post-IVGT for adhesive bowel obstruction, and she recovered well post-adhesiolysis.

Although we have had good outcomes with the IVGT, there remain some concerns. Our study represents an initial experience with a small cohort of patients. We still await long-term outcomes, especially concerning bile reflux, cholangitis and malignant change. We looked into what could be the effects of bile on the gastric mucosa within the graft? De Oliveira looked at the effects of bile on gastric mucosa in dogs for up to 540 days. They noted that inflammation occurred initially; however, beyond 130 days, the gastric mucosa appeared normal because of adaptation [27]. In our cohort, no contraindications were identified, but the possibilities will include vascular anomalies that prevent maintaining a vascularized graft.

## Conclusion

Our study demonstrates that the IVGT graft in children is effective, safe and reproducible. It is an alternative option for use in developing countries where interventional radiological services are limited. The biliary tree can be easily accessed in the future via an ERCP, thereby avoiding a significant relaparotomy. Larger cohorts of patients and long-term follow-up is required to support IVGT grafts becoming an acceptable option of care in the future for biliary reconstructive surgery.

### Abbreviations

RY: Roux-en-Y; IVGT: Isolated vascularized gastric tube; MRCP: Magnetic resonance cholangiopancreatography; U/S: Ultrasound; CT scan: Computerized tomography scan

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Not applicable.

### Authors' contributions

SH, HM and SM collected, analysed and interpreted the patient data and assisted each other in the write up. FG analysed the data and assisted with the write up. All authors read and approved the final manuscript.

### Funding

None.

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

The study was approved by the Biomedical Research and Ethics Committee of the University of Kwazulu Natal (Reference BCA221/13).

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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### References

1. Hoque S. A new surgical technique of biliary drainage. Int J Clin Med. 2013; 04(09):400–4. https://doi.org/10.4236/ijcm.2013.49072.
2. de Moricz A, Azevedo OS, Campos TD, Colaiacovo R, Akiba T, Silva RA, et al. Modified "Roux en Y" hepaticojejunostomy to permit transgastric endoscopic access. Acta Cir Bras. 2014;29(suppl 3):14–6. https://doi.org/10.1590/S0102-86502014001700003.
3. Crema E, Trentini EA, Llanos JC. Proposal of a new technique for bile duct reconstruction after iatrogenic injury: study in dogs and review of the literature. Acta Cir Bras. 2007;22(3):162–7. https://doi.org/10.1590/S0102-86502007000300002.
4. Coimbra FJ, Diniz AL, Ribeiro H, Lima EN, Montagnini AL. Ileal loop interposition: an alternative biliary bypass technique. Hepatobil Pancreat Int. 2010;9(6):654–7.
5. Al-Ghnaniem R, Benjamin IS. Long-term outcome of hepaticojejunostomy with routine access loop formation following iatrogenic bile duct injury. BJS. 2002;89(9):1118–24. https://doi.org/10.1046/j.1365-2168.2002.02182.x.
6. SPIR: Society for Pediatric Interventional Radiology Official Site. spir. [cited 2019 Nov 4]. Available from: https://www.spir.org.
7. Marshall S. Comment and analysis: paediatric IR is coming of age: Interventional News; 2019. [cited 2019 Oct 27]. Available from: https://interventionalnews.com/paediatric-ir/
8. Helmy AA, Hamad MA, Aly AM, Sherif T, Hashem M, El-Sers DA, et al. Novel technique for biliary reconstruction using an isolated gastric tube with a vascularized pedicle: a live animal experimental study and the first clinical case. Ann Surg Innov Res. 2011;5(1):8. https://doi.org/10.1186/1750-1164-5-8.
9. Helmy AA, Ali AMA. Iatrogenic bile duct injury repair using isolated vascularized gastric tube: early experience in two tertiary centers. Int Surg J. 2017;4(6):1825. https://doi.org/10.18203/2349-2902.isj20172385.
10. Diao M, Li L, Zhang J-Z, Cheng W. A shorter loop in Roux-Y hepatojejunostomy reconstruction for choledochal cysts is equally effective: preliminary results of a prospective randomized study. J Pediatr Surg. 2010; 45(4):845–7. https://doi.org/10.1016/j.jpedsurg.2009.12.022.
11. Felder SI, Menon VG, Nissen NN, Margulies DR, Lo S, Colquhoun SD. Hepaticojejunostomy using short-limb Roux-en-Y reconstruction. JAMA Surg. 2013;148(3):253–7. https://doi.org/10.1001/jamasurg.2013.601.
12. AbdelRafee A, El-Shobari M, Askar W, Sultan AM, El Nakeeb A. Long-term follow-up of 120 patients after hepaticojejunostomy for treatment of post-cholecystectomy bile duct injuries: a retrospective cohort study. Int J Surg Lond Engl. 2015;18:205–10. https://doi.org/10.1016/j.ijsu.2015.05.004.
13. Yan J-Q, Peng C-H, Ding J-Z, Yang W-P, Zhou G-W, Chen Y-J, et al. Surgical management in biliary restricture after Roux-en-Y hepaticojejunostomy for bile duct injury. World J Gastroenterol. 2007;13(48):6598–602.
14. Chaudry G. Paediatric interventional radiology. SA J Radiol. 2016;20(1):1–6.
15. Kloeckner R, Dueber C, dos Santos DP, Kara L, Pitton MB. Fluoroscopy-guided hepaticoneojejunostomy in recurrent anastomotic stricture after repeated surgical hepaticojejunostomy. J Vasc Interv Radiol. 2013;24(11): 1750–2. https://doi.org/10.1016/j.jvir.2013.07.025.
16. Miranda-García P, Gonzalez J, Tellechea J, Culetto A, Barthet M. EUS hepaticogastrostomy for bilioenteric anastomotic strictures: a permanent access for repeated ambulatory dilations? Results from a pilot study. Endosc Int Open. 2016;04(04):E461–5.
17. Saidi RF, Elias N, Ko DS, Kawai T, Markmann J, Cosimi AB, et al. Biliary reconstruction and complications after living-donor liver transplantation. HPB. 2009;11(6):505–9. https://doi.org/10.1111/j.1477-2574.2009.00093.x.
18. Benkabbou A, Castaing D, Salloum C, Adam R, Azoulay D, Vibert E. Treatment of failed Roux-en-Y hepaticojejunostomy after post-cholecystectomy bile ducts injuries. Surgery. 2013;153(1):95–102. https://doi.org/10.1016/j.surg.2012.06.028.
19. Ray MS, Deepak BS. Access loop Roux-en-Y hepaticojejunostomy: revisited a study of twenty two cases over 15 years (2001-2015). Int Surg J. 2017;4(3): 1028. https://doi.org/10.18203/2349-2902.isj20170856.
20. Atkinson JJ, Davenport M. Controversies in choledochal malformation. South Afr Med J. 2014;104(11):816–9. https://doi.org/10.7196/SAMJ.8633.
21. Shimotakahara A, Yamataka A, Yanai T, Kobayashi H, Okazaki T, Lane GJ, et al. Roux-en-Y hepaticojejunostomy or hepaticoduodenostomy for biliary reconstruction during the surgical treatment of choledochal cyst: which is better? Pediatr Surg Int. 2005;21(1):5–7. https://doi.org/10.1007/s00383-004-1252-1.
22. Saxena NA, Kulkarni BK, Borwankar SS, Lahoti HN, Multani P, Oak SN. Hepaticoduodenostomy as a technique for biliary anastomosis in children with choledochal cyst: an experience with 31 cases. Ann Pediatr Surg. 2017; 13(2):78–80.
23. Narayanan SK, Chen Y, Narasimhan KL, Cohen RC. Hepaticoduodenostomy versus hepaticojejunostomy after resection of choledochal cyst: a systematic review and meta-analysis. J Pediatr Surg. 2013;48(11):2336–42. https://doi.org/10.1016/j.jpedsurg.2013.07.020.
24. McLaren C. Paediatric interventional radiology. Radiography. 2014;20(3):195–201. https://doi.org/10.1016/j.radi.2014.02.005.
25. Shah SH, Binkovitz LA, Ho ML, Trout AT, Adler BH, Andronikou S. Pediatric radiology mission work: opportunities, challenges and outcomes. Pediatr Radiol. 2018;48(12):1698–708. https://doi.org/10.1007/s00247-018-4221-x.
26. Li Z, Cui N, Chen L. Treatment experience of subsequent complications after Roux-en-Y biliojejunostomy. Eur Surg Res. 2009;43(1):34–8. https://doi.org/10.1159/000216521.
27. Datar GV. Use of isoperistaltic gastric tube in biliary atresia. Indian J Surg. 1986;48:152–6.
28. Hamada Y, Hamada H, Shirai T, Nakamura Y, Sakaguchi T, Yanagimoto H, et al. Duodenogastric regurgitation in hepaticoduodenostomy after excision

of congenital biliary dilatation (choledochal cyst). J Pediatr Surg. 2017;52(10):1621–4. https://doi.org/10.1016/j.jpedsurg.2017.03.063.
29. Tocchi A, Mazzoni G, Liotta G, Lepre L, Cassini D, Miccini M. Late development of bile duct cancer in patients who had biliary-enteric drainage for benign disease: a follow-up study of more than 1,000 patients. Ann Surg. 2001;234(2):5.

## Publisher's Note