International Journal of Healthcare Sciences ISSN 2348-5728 (Online)
Vol. 4, Issue 2, pp: (1060-1066), Month: October 2016 - March 2017, Available at: www.researchpublish.com

Diagnosis and Proper Treatment Approaches for Biliary Atresia in Newborns: Review

Yusra Mohammed Abdullah Alahmari

Abstract: **Biliary atresia (BA) is the most common pediatric cause of cirrhosis, end-stage liver disease, and sign for liver transplantation in children. It takes place in 1 in 5000 to 1 in 18,000 live births. The aim of this review was to overview and discuss the evidence of diagnosis and treatment options for Biliary atresia (BA) in pediatric, we intended to discuss the etiological factors associated with this disease. Relevant studies were identified by a search of electronic databases, including MEDLINE, EMBASE, for all these articles published from time of instance up to December 2016, in English language and discussing Biliary atresia (BA) in pediatric management and diagnostic approaches, containing human subjects only. Early diagnosis is plainly connected with better results for infants with biliary atresia. Outcomes after the Kasai operation in the United States could possibly be enhanced with early diagnosis. Stool color cards distributed to mothers on discharge would not just operate as a screening tool but likewise for educating primary care physicians and moms and dads, engendering awareness that there is an irregular color to infant stool. Newborn screening for conjugated hyperbilirubinemia requires additional analysis.**

Keywords: **Biliary atresia (BA), disease, pediatric, diagnostic approaches, biliary atresia.**

1. INTRODUCTION

Biliary atresia (BA) is the most common pediatric cause of cirrhosis, end-stage liver disease, and sign for liver transplantation in children. It takes place in 1 in 5000 to 1 in 18,000 live births and is identified by consistent jaundice and progressive cholestasis establishing within weeks of birth, which are triggered by a progressive fibro-obliterated blockage of intrahepatic and extrahepatic bile ducts [(1,2,3)]. The disease affects both intra and additional hepatic ducts with progressive destruction leading to cholestasis, fibrosis and cirrhosis. Infants with biliary atresia develop jaundice and pale, acholic stools within the first couple of weeks after birth, secondary to fibro-inflammatory obstruction of the extrahepatic bile ducts that drain pipes bile from the liver into the intestinal tracts. Early diagnosis and successful surgical drainage of bile (the Kasai hepatic portoenterostomy) are associated with higher survival with the child's native liver. Lack of effective drainage undoubtedly leads to liver failure within a year and death within 2 years without transplant. Successful surgical drainage can, in many instances, delay the requirement or prevent for liver hair transplant, which is related to significant morbidities from requisite lifelong immunosuppression [(4,5,6)].

The pathogenesis of BA is incompletely comprehended but appears to be multifactorial. Between 10 and 20 percent of patients with Bachelor's Degree have actually associated congenital malformations, such as abdominal and thoracic heterotaxia, polysplenia, asplenia, intestinal malrotation, and preduodenal portal vein. The association of BA with these abnormalities recommends a developmental problem in ductal plate formation.4 BA has actually likewise been connected with prenatal direct exposure to infections such as reovirus, rotavirus, and cytomegalovirus [(7,8)]. Additionally, environmental contaminants and neonatal immune dysregulation have been linked in the pathogenesis of Bachelor's Degree [(1,9)]. Bachelor's Degree might represent a last typical path of bile duct injury in action to a combination of these factors [(1,10)].

In 1959, Kasai first reported the surgical strategy of portoenterostomy for the treatment of Bachelor's Degree [(11)]. In the Kasai treatment, the eliminated biliary remnant is excised and the portal plate is drained with a Roux-en-Y hepatojejunostomy. Successful drainage of the biliary tree is vital for transplant-free survival. However, successful drain does not necessarily forecast transplant-free survival as irreparable or progressive liver injury can occur in spite of sufficient drainage. Over the past several years, various clinical, surgical, and pathologic factors predictive of an effective

portoenterostomy and/or transplant-free survival have actually been specified [12,13]. Early diagnosis, absence of associated congenital malformations, specific anatomic versions of Bachelor's Degree, and freedom from postoperative rising cholangitis are factors that are predictive of drain and survival [14].

The aim of this review was to overview and discuss the evidence of diagnosis and treatment options for Biliary atresia (BA) in pediatric, we intended to discuss the etiological factors associated with this disease.

2. METHODOLOGY

Relevant studies were identified by a search of electronic databases, including MEDLINE, EMBASE, for all these articles published from time of instance up to December 2016, in English language and discussing Biliary atresia (BA) in pediatric management and diagnostic approaches, containing human subjects only. Search terms were used to identified articles as following: *"biliary atresia" and "cystic fibrosis" and "Kasai" and "infants" newborn" and "diagnosis", and treatment.* Search terms were combined using Boolean logic, while studies, publications. furthermore, references list of identified studies were searched for more relevant identical studies.

3. RESULTS

- **Anatomical types of BA:**

Two various kinds of BA have been determined [15]; **A)** Syndromic BA (~ 10%), related to various congenital anomalies such as polysplenia, asplenia, intra-abdominal or heart defects (situs inversus, pre-duodenal portal vein, absence of retro-hepatic inferior vena cava, intestinal malrotation). **B)** Non-syndromic Bachelor's Degree (~ 90%), where Bachelor's Degree is an isolated abnormality. Several surgical classifications of BA have actually been proposed. The French classification is based upon the anatomical pattern of the extrahepatic biliary system residue (**Table 1**) [16,17].

Table 1: Anatomical types of biliary atresia (BA) [16,17]

French classification	Frequency	Description	Upper level of obstruction of the extrahepatic bile ducts	US/UK/Japanese classification
Type 1	~3%	Atresia limited to the common bile duct	Common bile duct	Type 1
Type 2	~6%	Cyst in the liver hilum communicating with dystrophic intrahepatic bile ducts	Hepatic duct	Type 2
Type 3	19%	Gallbladder, cystic duct and common bile duct patent	Porta hepatis	Type 3
Type 4	72%	Complete extrahepatic BA	Porta hepatis	Type 3

- **Causes of BA in newborns:**

The etiology of Bachelor's Degree remains unknown. Some cases appear to be connected to irregular morphogenesis of bile ducts occurring early in pregnancy, while others appear to occur from later damage to generally establishing bile ducts [18]. There are several strands of evidence to recommend that even in non-syndromic Bachelor's Degree, the beginning happens early in gestation. Antenatal ultrasonography enables detection of those forms of Bachelor's Degree that show cystic modifications [18]. In a series of 10 infants detected antenatally, most were non-syndromic and the first irregular scans were observed at about 20 weeks of gestation [19]. In one research study on serial gastrointestinal enzyme sampling in amniotic fluid, gamma-glutamyl transpeptidase (gamma-GTs) levels were found considerably low as early as 18 weeks of gestation in infants born with non-syndromic BA, offering strong proof of biliary obstruction at this term of gestation [20].

Human embryo studies have actually also exposed similarities between the appearance of establishing bile ducts during the first trimester of pregnancy and the residual ductules seen at porta hepatis level in BA patients; thus, it was suggested that some cases of BA may result from alteration of the renovation process of the bile ducts stemming from the ductal

plate membrane [21]. The perseverance of primitive foetal-type bile ducts that leakage bile into surrounding tissues and induce a secondary inflammatory reaction in utero has actually likewise been suggested. Recent research studies have focused on transformed and regular bile duct morphogenesis [22] and the initiation of hepatic fibrosis [23].

The role of viruses as causative agents for BA in newborns has been extensively studied. An association of Bachelor's Degree with cytomegalovirus [24], breathing syncitial infection [25], Epstein-Barr virus [26] and human papilloma virus [27] has been reported. On the other hand, no association with liver disease B, A and C viruses has actually been found [27].

- ***Diagnostic methods of Biliary atresia:***

Universal screening for raised normal direct/conjugated bilirubin (DB/CB) levels might resolve a number of these problems and has a number of extra benefits. Universal testing is readily available, quickly interpretable, and supported by experts in the field [28,29]. DB/CB screening bypasses limitations of other proposed BA screening tests, such as measuring conjugated bile acids on newborn spot cards (overlap in between Bachelor's Degree and control worths), or spotting acholic stools using an "infant stool color card" (which needs moms and dads to make subjective choices on the basis of exactly what they view as stool color) [30,31,32]. Essential is that universal DB/CB level screening is an exceptionally sensitive early test for Bachelor's Degree. In this research study, all 84 DB or CB levels determined in between 0 and 96 hours of life (HoL) rose in subjects who were ultimately identified with BA [32].

Screening test (A) Serum conjugated or direct bilirubin concentrations and stool color cards. Due to the fact that the earliest sign of problem in biliary atresia is an increased conjugated bilirubin concentration, this is a sensible test to examine for universal screening, and numerous studies have actually discovered appealing results. In 2003, Powell et al [28] studied a big community-based program in the United Kingdom where conjugated bilirubin concentrations were measured from blood samples in neonates below 28 days. Of 23 415 samples, conjugated bilirubin concentrations exceeded 18 μmol/ L (1.05 mg/dL) in 3.8% of samples. The portion of conjugated bilirubin relative to overall bilirubin went beyond 20% in 16% of samples, and 107 samples (0.46%) surpassed both cutoffs. No infant with a regular test outcome had liver disease. Therefore, this test had a level of sensitivity of 100%, a specificity of 99.59%, and a positive predictive value of 10%, which is low because of the rarity of clinical liver disease in neonates. Eventually, 11 of 12 infants with abnormal results on repeat testing were identified with liver disease, 2 of whom had biliary atresia. The authors concluded that serum conjugated bilirubin concentration might be a reliable marker for neonatal liver disease, the level of sensitivity and uniqueness of screening for biliary atresia might not be accurate, given that just 2 infants would be anticipated to have biliary atresia in the sample size used. Extra larger studies are, for that reason, needed to verify these findings [28].

Harpavat et al [33] retrospectively studied whether raised conjugated bilirubin concentration can be used as an early screening test for infants with biliary atresia. Of 61 infants with biliary atresia, 34 had actually had serum direct or conjugated bilirubin concentration measured within 96 hours of life, and all demonstrated elevated concentrations, which increased over the very first 96 hours. The authors hypothesized that a raised conjugated bilirubin concentration might be present in all infants with biliary atresia in the instant postnatal period. In subsequent follow-up, the authors have actually verified this observation by recognizing raised conjugated bilirubin concentration soon after birth in 32 of 32 infants cared for at their institution who were later identified with biliary atresia [33]. Therefore, serum conjugated or direct bilirubin concentration might prove an important screening test for biliary atresia. Cutoffs for the ceiling of normal in young infants would have to be validated in each health center laboratory. The test would also have to be accompanied by an aggressive educational program for healthcare suppliers for an understanding of age-related regular values, as the infants in the Harpavat et al [33] research study who had an early abnormal conjugated bilirubin concentration did not pertain to medical attention any quicker than those who did not have actually neonatal conjugated or direct bilirubin checked. These observations, in conjunction with those of Powell et al, [28] show terrific possible for serum bilirubin determinations as a screening tool for biliary atresia.

The second potential screening test (B) is the use of stool color cards. The very first universal nationwide screening program was implemented in Taiwan, where there is a relatively high occurrence of biliary atresia (37/100 000 live births) and, for that reason, fantastic inspiration to recognize infants with biliary atresia early [32]. Parents of all newborn infants were offered color cards that revealed examples of acholic and normal stools and were asked to report the color of their infant's stool to their pediatrician. In this research study, cards were returned for 65% of 119 973 infants. Ninety-four of these infants had acholic stools, and 29 (31%) were eventually diagnosed with biliary atresia, 90% of whom were diagnosed before 60 days of age.

Ultrasonography of the liver is performed after 12 hours of fasting (with an IV dextrose infusion). Bachelor's Degree is presumed when the gallbladder is diminished despite fasting, when the liver hilum appears hyperechogenic ("triangular cord indication") or when there is a cyst at the liver hilum. There ought to be no evidence of bile duct dilatation. Syndromic Bachelor's Degree infants might reveal other functions such as numerous spleens, preduodenal portal vein, lack of retrohepatic vena cava or abdominal situs inversus [(16)].

Cholangiography, When the gallbladder appears normal on ultrasonography scans, cholangiography is had to assess the morphology and patency of the biliary tree. A cholangiogram can be obtained percutaneously (leak of the gallbladder), endoscopically (ERCP) or at operation [(16)].

Liver biopsy, the main histological functions suggestive of Bachelor's Degree are bile plugs, ductular proliferation, portal oedema and/or fibrosis. Just like other cause of neonatal cholestasis, huge cell improvement may be observed (**Figure 1**) [(16)].

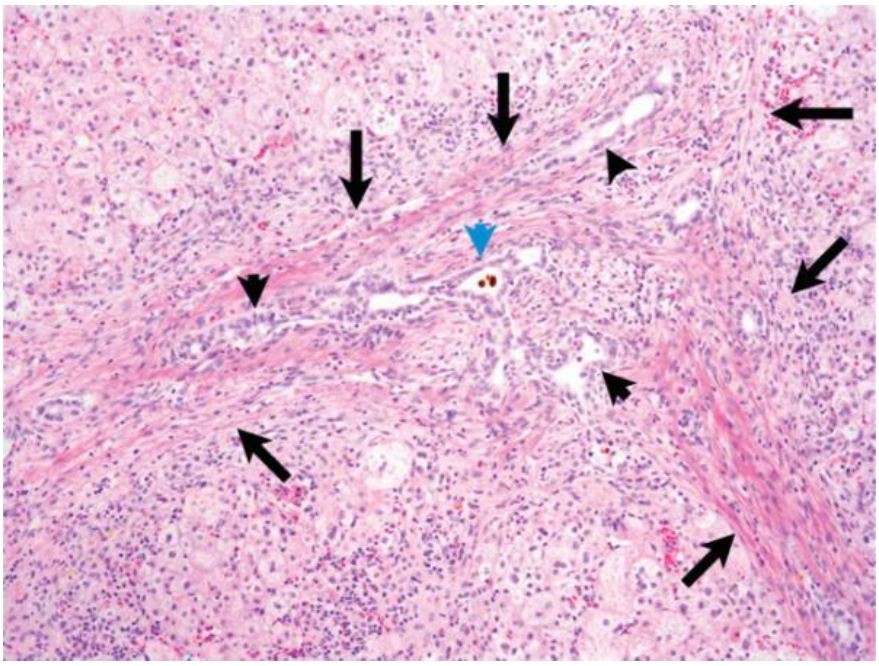

Figure1: Liver histology of a patient with biliary atresia at 8 weeks of age. The biopsy shows an expanded and fibrotic portal tract (outlined by the arrows), with inflammation, biliary proliferation (outlined by the black arrowheads), and bilirubinostasis within a ductal structure (indicated by a blue arrowhead). Hematoxylin and eosin were used; the original magnification was ×100. [(16)]

- ***Significant of early diagnosis of BA:***

The outcome of patients with biliary atresia is straight impacted by the speed with which healthcare companies come to the medical diagnosis. The CPHRG recently discovered that 10-year native liver survival rates declined with increasing age at the time of portoenterostomy; 49% of infants who underwent surgical treatment in Canada at 30 days of age were coping with their own liver 10 years later, compared to 25% of those whose operations happened at 31 to 90 days of age and 15% of those treated after 90 days of age [(35)]. This finding is consistent with other research studies, [(36)] although an American retrospective associate research study was not able to show whether age at the time of portoenterostomy affected native liver survival, most likely owing to small numbers of study subjects and a short (2 year) follow-up [(37)]. A current research study from France showed the advantage of earlier intervention 15-year survival with native liver [(38)]. The consensus that more youthful age at the time of portoenterostomy results in improved results has led professional companies to recommend measurement of direct responding bilirubin levels in infants with continuing jaundice at 2 to 3 weeks of age [(39)].

- **Treatment of biliary atresia:**

If left untreated, biliary atresia is evenly deadly within 1 to 2 years. Initial management is surgical (portoenterostomy, or Kasai operation), involving excision of the atretic biliary tree and fibrous plate and Roux-en-Y anastomosis of jejunum to the remaining ducts to permit biliary drain [(40)]. North and european American research studies have actually revealed

medium-term survival rates (2 to 10 years' follow-up) without liver hair transplant in 25% to 60% of patients who went through portoenterostomy [41,42,43]. The Canadian experience with biliary atresia reveals a 10-year total survival rate of 77% after portoenterostomy and native liver survival rates of 46% at 2 years, 36% at 4 years, and 26% at 10 years [36]. Any intervention that enhances native liver and total survival rates could affect the lifestyle of these children in addition to the accessibility of transplant organs.

The treatment of biliary atresia is the hepatic portoenterostomy, as initially explained by Kasai in 1959. The operation involves excision of the extrahepatic biliary tree, with reestablishment of bile flow through a Roux-en-Y sector of intestine stitched straight to the liver at the portal plate [44]. Whereas all infants with biliary atresia not receiving the Kasai operation will need liver hair transplant in the very first 1 to 2 years of life, infants getting the Kasai operation gain substantial benefit, and some prevent liver transplantation entirely. Eventually, however, around 80% of all patients with biliary atresia will need liver hair transplant by 10 years of age [44]. Patients with effective biliary drainage may establish cirrhosis more gradually, which can delay the need for liver transplant into youth or early adult life. This group of patients is typically much healthier before the hair transplant, has a bigger swimming pool of liver donors for the liver transplant, and has a much better postoperative course after liver transplant. The most substantial factor associating with success of the Kasai operation is the infant's age at the time of surgery, with younger infants receiving the best benefit. The degree of intrahepatic fibrosis at the time of medical diagnosis is a crucial pathologic finding that associates adversely with prognosis with treatment [44]. Medical proof of cirrhosis at diagnosis (ie, existence of ascites) associates with poorer outcome after portoenterostomy [44]. Proof of associated splenic malformations, such as asplenia or polysplenia, also is related to poorer results [44].

4. CONCLUSION

The natural history of biliary atresia is sufficiently well established. Early diagnosis is plainly connected with better results for infants with biliary atresia. Outcomes after the Kasai operation in the United States could possibly be enhanced with early diagnosis. Stool color cards distributed to mothers on discharge would not just operate as a screening tool but likewise for educating primary care physicians and moms and dads, engendering awareness that there is an irregular color to infant stool. Newborn screening for conjugated hyperbilirubinemia requires additional analysis. The American Academy of Pediatrics already suggests newborn screening for hyperbilirubinemia. Many nurseries, nevertheless, utilize transcutaneous bilirubin measurements in lieu of serum bilirubin decisions, however so far, only newborn serum conjugated hyperbilirubinemia has actually been correlated with the eventual medical diagnosis of biliary atresia, and the utility of newborn serum conjugated bilirubin screening for biliary atresia stays unidentified.

REFERENCES

[1] Mack CL, Sokol RJ. Unraveling the pathogenesis and etiology of biliary atresia. Pediatr Res. 2005;57:R87–R94.

[2] Kahn E. Biliary atresia revisited. Pediatr Dev Pathol. 2004;7:109–124.

[3] Perlmutter DH, Shepherd RW. Extrahepatic biliary atresia: a disease or a phenotype? HEPATOLOGY. 2002;35:1297–1304.

[4] Petersen C. Pathogenesis and treatment opportunities for biliary atresia. Clin Liver Dis. 2006;10:73–88, vi.

[5] Sokol RJ, Mack C, Narkewicz MR, Karrer FM. Pathogenesis and outcome of biliary atresia: current concepts. J Pediatr Gastroenterol Nutr. 2003;37(1):4–21.

[6] Marchetti P. New-onset diabetes after liver transplantation: from pathogenesis to management. Liver Transpl. 2005;11(6):612–620.

[7] Shivakumar P, Campbell KM, Sabla GE, et al. Obstruction of extrahepatic bile ducts by lymphocytes is regulated by IFN-gamma in experimental biliary atresia. J Clin Invest. 2004;114(3):322–329.

[8] Tyler KL, Sokol RJ, Oberhaus SM, et al. Detection of reovirus RNA in hepatobiliary tissues from patients with extrahepatic biliary atresia and choledochal cysts. Hepatology. 1998;27(6):1475–1482.

[9] Harper P, Plant JW, Unger DB. Congenital biliary atresia and jaundice in lambs and calves. Aust Vet J. 1990;67(1):18–22.

[10] Caponcelli E, Knisely AS, Davenport M. Cystic biliary atresia: an etiologic and prognostic subgroup. J Pediatr Surg. 2008;43(9):1619–1624.

[11] Kasai M, Suzuki SA. A new operation for "non-correctable" biliary atresia-Portoenterostomy. Shijitsu. 1959;13:733–739.

[12] Altman RP, Lilly JR, Greenfeld J, et al. A multivariable risk factor analysis of the portoenterostomy (Kasai) procedure for biliary atresia: twenty-five years of experience from two centers. Ann Surg. 1997;226(3):348–353. discussion 353–5.

[13] Davenport M, Kerkar N, Mieli-Vergani G, et al. Biliary atresia: the King's College Hospital experience (1974–1995) J Pediatr Surg. 1997;32(3):479–485.

[14] Chardot C, Carton M, Spire-Bendelac N, et al. Epidemiology of biliary atresia in France: a national study 1986–96. J Hepatol. 1999;31(6):1006–1013.

[15] Howard ER. Biliary atresia. In: Stringer MD, Oldham KT, Mouriquand PDE, Howard ER, editor. Pediatric surgery and urology: long term outcomes. London: WB Saunders; 1998. pp. 402–416.

[16] Chardot C. Biliary atresia. *Orphanet Journal of Rare Diseases*. 2006;1:28. doi:10.1186/1750-1172-1-28.

[17] Gauthier F, Luciani JL, Chardot C, Branchereau S, de Dreuzy O, Lababidi A, Montupet P, Dubousset AM, Huault G, Bernard O, Valayer J. Determinants of life span after Kasai operation at the era of liver transplantation. Tohoku J Exp Med. 1997;181:97–107. doi: 10.1620/tjem.181.97.

[18] Brunero M, De Dreuzy O, Herrera JM, Gauthier F, Valayer L. Prenatal detection of a cyst in the liver hilum. Interpretation for an adequate treatment. Minerva Pediatr. 1996;48:485–494.

[19] Hinds R, Davenport M, Mieli-Vergani G, Hadzic N. Antenatal presentation of biliary atresia. J Pediatr. 2004;144:43–46. doi: 10.1016/j.jpeds.2003.09.027.

[20] Muller F, Oury JF, Dumez Y, Boue J, Boue A. Microvillar enzyme assays in amniotic fluid and fetal tissues at different stages of development. Prenat Diagn. 1988;8:189–198.

[21] Tan CE, Driver M, Howard ER, Moscoso GJ. Extrahepatic biliary atresia: a first-trimester event? Clues from light microscopy and immunohistochemistry. J Pediatr Surg. 1994;29:808–814.

[22] Desmet VJ. Ludwig symposium on biliary disorders-part I. Pathogenesis of ductal plate abnormalities. Mayo Clin Proc. 1998;73:80–89.

[23] Ramm GA, Nair VG, Bridle KR, Shepherd RW, Crawford DH. Contribution of hepatic parenchymal and nonparenchymal cells to hepatic fibrogenesis in biliary atresia. Am J Pathol. 1998;153:527–535.

[24] Fischler B, Ehrnst A, Forsgren M, Orvell C, Nemeth A. The viral association of neonatal cholestasis in Sweden: a possible link between cytomegalovirus infection and extrahepatic biliary atresia. J Pediatr Gastroenterol Nutr. 1998;27:57–64.

[25] Nadal D, Wunderli W, Meurmann O, Briner J, Hirsig J. Isolation of respiratory syncytial virus from liver tissue and extrahepatic biliary atresia material. Scand J Infect Dis. 1990;22:91–93.

[26] Weaver LT, Nelson R, Bell TM. The association of extrahepatic bile duct atresia and neonatal Epstein-Barr virus infection. Acta Paediatr Scand. 1984;73:155–157.

[27] Drut R, Drut RM, Gomez MA, Cueto Rua E, Lojo MM. Presence of human papillomavirus in extrahepatic biliary atresia. J Pediatr Gastroenterol Nutr. 1998;27:530–535.

[28] Powell JE, Keffler S, Kelly DA, Green A. Population screening for neonatal liver disease: potential for a community-based programme. J Med Screen. 2003;10(3):112–116.

[29] Trikalinos TA, Chung M, Lau J, Ip S. Systematic review of screening for bilirubin encephalopathy in neonates. Pediatrics. 2009;124(4):1162–1171.

[30] Mills KA, Mushtaq I, Johnson AW, Whitfield PD, Clayton PT. A method for the quantitation of conjugated bile acids in dried blood spots using electrospray ionization-mass spectrometry. Pediatr Res. 1998;43(3):361–368.

[31] Mushtaq I, Logan S, Morris M, et al. Screening of newborn infants for cholestatic hepatobiliary disease with tandem mass spectrometry. BMJ. 1999;319(7208):471–477.

[32] Chen SM, Chang MH, Du JC, et al.; Taiwan Infant Stool Color Card Study Group Screening for biliary atresia by infant stool color card in Taiwan. Pediatrics. 2006;117(4):1147–1154.

[33] Harpavat S, Finegold MJ, Karpen SJ. Patients with biliary atresia have elevated direct/conjugated bilirubin levels shortly after birth. Pediatrics. 2011;128(6).

[34] Moyer V, Freese DK, Whitington PF, Olson AD, Brewer F, Colletti RB, et al. Guideline for the evaluation of cholestatic jaundice in infants: recommendations of the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. J Pediatr Gastroenterol Nutr. 2004;39:115–128.

[35] Schreiber RA, Barker CC, Roberts EA, Martin SR, Alvarez F, Smith L, et al. Biliary atresia: the Canadian experience. J Pediatr . 2007;151(6):659–65. 665.e1. Epub 2007 Oct 22.

[36] Sokol RJ, Shepherd RW, Superina R, Bezerra JA, Robuck P, Hoofnagle JH. Screening and outcomes in biliary atresia: summary of a National Institutes of Health workshop. Hepatology. 2007;46(2):566–81.

[37] Shneider BL, Brown MB, Haber B, Whitington PF, Schwarz K, Squires R, et al. A multicenter study of the outcome of biliary atresia in the United States, 1997 to 2000. J Pediatr. 2006;148(4):467–74.

[38] Serinet MO, Wildhaber BE, Broué P, Lachaux A, Sarles J, Jacquemin E, et al. Impact of age at Kasai operation on its results in late childhood and adolescence: a rational basis for biliary atresia screening. Pediatrics. 2009;123(5):1280–6.

[39] Guidelines for detection, management and prevention of hyperbilirubinemia in term and late preterm newborn infants (35 or more weeks' gestation)—summary. Paediatr Child Health. 2007;12(5):401–18.

[40] Ohi R. Surgery for biliary atresia. Liver. 2001;21(3):175–82.

[41] McKiernan PJ, Baker AJ, Kelly DA. The frequency and outcome of biliary atresia in the UK and Ireland. Lancet. 2000;355(9197):25–9.

[42] Nio M, Ohi R, Miyano T, Saeki M, Shiraki K, Tanaka K. Five- and 10-year survival rates after surgery for biliary atresia: a report from the Japanese Biliary Atresia Registry. J Pediatr Surg. 2003;38(7):997–1000.

[43] Yoon PW, Bresee JS, Olney RS, James LM, Khoury MJ. Epidemiology of biliary atresia: a population-based study. Pediatrics. 1997;99(3):376–82.

[44] Superina R, Magee JC, Brandt ML, et al. Childhood Liver Disease Research and Education Network. The anatomic pattern of biliary atresia identified at time of Kasai hepatoportoenterostomy and early postoperative clearance of jaundice are significant predictors of transplant-free survival. Ann Surg. 2011;254(4):577–585.