ORIGINAL ARTICLE

Evaluation of Pediatric Patients with Biliary Tract Dysfunction using Ultrasound Techniques

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Abstract

Introduction: Despite advancements in surgical methods and post-transplant care, liver and kidney transplants still pose significant risks of complications such as graft rejection, infection, and severe consequences. These complications may emerge shortly after surgery or several months to years later. Early detection of complications in transplant recipients is crucial. Ultrasound (US) is the key technique for visually assessing transplanted organs and delivering diagnostic information on blood vessel opening and blood flow to organs. This study aimed to explore the potential of US techniques for evaluating pediatric patients with biliary tract dysfunction. **Materials and Methods:** The study included 128 children aged 7–14 years, with 100 children in the experimental group and 28 in the control group. The experimental group was divided into two subgroups: Group 1 consisted of 57 children with hypokinetic biliary dyskinesia and Group 2 consisted of 43 children with hypermotor dyskinesia of the biliary tract. **Results:** In cases of hypokinetic biliary dyskinesia, the motor function indicator significantly decreased below that of the control group ($P < 0.01$) and was twice as low as that of the hypermotor type ($P < 0.001$). In contrast, in group 2, this value exceeded that of the control group ($P < 0.01$). The study demonstrated that dynamic US indicators for functional disorders of the gallbladder (GB) have relatively high sensitivity (91%) and specificity (87%). **Conclusion:** This study identified variations in biliary tract function during US examinations in children with different forms of dyskinesia. Alterations in GB function affect the overall performance of the hepatobiliary system in pediatric patients.

Key words: Children, complications, hypermotor dyskinesia of the biliary tract, hypokinetic biliary dyskinesia, ultrasound

INTRODUCTION

Although significant progress has been made in surgical techniques and post-transplant care, liver and kidney transplants still carry a significant risk of complications including graft rejection, infection, and potentially life-threatening consequences. These complications can be classified as vascular or non-vascular. Vascular problems include hemorrhage, thrombosis, vascular anastomosis stenosis, pseudoaneurysms, and arteriovenous fistulas, while non-vascular complications involve fluid accumulation around the transplant, such as cytomegalovirus, chylous ascites, and acromegaly.[1-3] Other issues include restricted blood flow, infections, and localized abnormalities in organ tissues, such as secondary transplantation or the growth of malignant tumors.[3-5] Complications can occur shortly after surgery or several months to years later.[1,4,6-11]

The early detection of complications after liver and kidney donation is critical. Ultrasound (US) is the primary technique used to visually evaluate the state of transplanted organs, providing diagnostic information on blood vessel opening and blood supply to organs. Skilled practitioners may rely on this technique alone for examination. This study aimed

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to investigate the potential of US techniques for evaluating pediatric patients with biliary tract dysfunction.

MATERIALS AND METHODS

This study was conducted between 2014 and 2017 at the Department of Faculty Pediatrics, Kyrgyz State Medical Academy named after I. K. Akhunbaev, and the Advisory and Diagnostic Department of the National Center for Maternity and Child Health. A total of 128 children aged 7–14 years were recruited for this study. The average age of the patients was 10.2 ± 3.4 years. The experimental group comprised 100 children with functional abnormalities in the biliary system, whereas the control group consisted of 28 healthy children without any indications or symptoms of biliary tract dysfunction.

The patients in the experimental group were divided into two subgroups: Group 1 consisted of 57 children diagnosed with hypokinetic biliary dyskinesia, whereas Group 2 consisted of 43 children diagnosed with hypermotor dyskinesia of the biliary tract. The diagnosis of the participants was confirmed using the dynamic US of the biliary system with a Medison SonoAce 8000 (MedWrench LLC, United States). This study revealed multiple forms of dysfunction in the coordination of the sphincter apparatus of the biliary tract and the muscular layer of the gallbladder (GB) wall. The examination was conducted after the participants had consumed a choleretic breakfast, which included two uncooked egg yolks, approximately 40–50 min after the meal.

This method was used to assess the motor function of the GB.

$$IMF = \frac{d2 \times L1}{d1 \times L2}$$

where IMF is the indicator of motor function,

d_1 is the diameter of the GB before choleretic breakfast,

L_1 is the GB length before breakfast,

d_2 is the GB diameter after breakfast,

L_2 is the GB length after breakfast.

Statistical analysis of the study data was performed using Statistica v8.0 (StatSoft Inc., Tulsa, USA). Data are presented as the mean ± standard deviation. The Student's *t*-test was used to assess any intergroup differences in characteristics that followed a continuous distribution. Confidence intervals were calculated as follows: $P = 95\%$ or $P < 0.05$ (*), $P = 99\%$ or $P < 0.01$ (**), $P = 99.9\%$, or $P < 0.001$ (***). In addition, sensitivity (Se) and specificity (Sp) were determined. The study was conducted with the full consent of the patients' parents and was approved by the bioethics committee of the I.K. Akhunbaev Kyrgyz State Medical Academy (Protocol No. 33, dated April 12, 2022).

RESULTS

To determine the type of GB dyskinesia, we used a motor function indicator [Figure 1]. Our findings showed that in cases of hypokinetic biliary dyskinesia, the indicator significantly decreased below that of the control group ($P < 0.01$) and was twice as low as that of the hypermotor type ($P < 0.001$). In contrast, in group 2, this value exceeded that of the control group ($P < 0.01$).

According to the dynamic US examination in children, GB reduction was over 60% in cases of hypermotor dyskinesia after 30 min of the study, whereas it was <40% in cases of hypomotor dyskinesia. As shown in Figure 2, there were notable differences in biliary tract function during US examinations in children, depending on the type of dyskinesia.

The occurrence of hepatomegaly was higher in group 1 (47.3%) than in group 2 (23.3%). Increased parenchymal

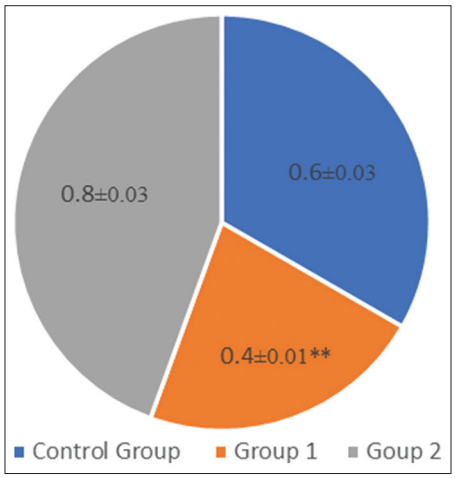

Figure 1: Indicators of gallbladder motor function in children

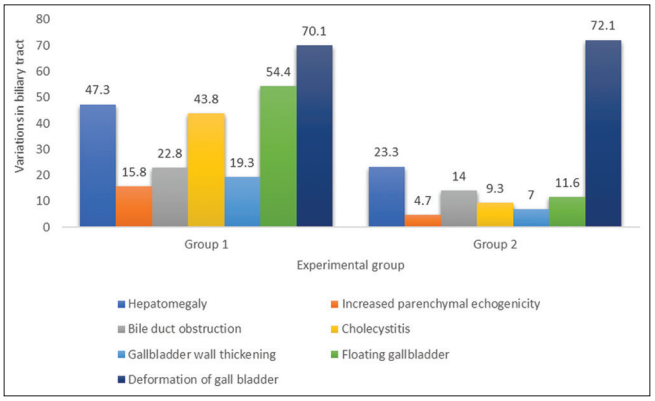

Figure 2: Ultrasound indicators of functional disorders of the biliary tract in children

Table 1: Indicators of bilirubin and its fractions in the blood serum of examined children

Examined groups	Total bilirubin, mmol/L	Direct bilirubin, mmol/L	Indirect bilirubin, mmol/L
Control group (*n*=28)			
M±m	9.1±0.5	1.0±0.1	6.2±0.4
Group 1 (*n*=57)			
M±m	26.3±2.7	7.2±0.7	19.1±0.8
P2-1	<0.01**	<0.001***	<0.01**
Group 2 (*n*=43)			
M±m	15.7±0.9	6.6±0.6	9.1±0.8
P3-1	<0.05*	<0.001***	<0.05*
P3-2	<0.01**	>0.05	<0.01**

Values are presented as the mean±standard deviation. *P<0.05, **P<0.01, ***P<0.001

echogenicity was 14.8% higher in GB hypokinesia than that in hyperkinesia (4.7%). The proportion of patients with bile duct obstruction was 22.8% in group 1 and 14% in group 2. Cholecystitis was 4.5 times greater in group 1 (43.8%) than in group 2 (9.3%). GB wall thickening was 2.5 times higher in group 1 (19.3%) than in group 2 (7%). The prevalence of floating GB was nearly 5 times higher in group 1 (54.4%) than in group 2 (11 %). Deformation of GB was observed in 70.1% and 72.1% of the children in both examination groups. This study demonstrated that dynamic US indicators for functional disorders of the GB have a relatively high sensitivity (Se = 91%) and specificity (Sp = 87%).

GB motor activity affects bilirubin metabolism indicators [Table 1]. In group 1, both the total and indirect bilirubin concentrations were significantly higher than those in the control group ($P < 0.01$) and group 2 ($P < 0.01$). The direct bilirubin level was found to be 7 times higher than the control value ($P < 0.001$) but was not significantly different from that in group 2 ($P > 0.05$). Similarly, in children with hyperkinesia of the biliary tract, bilirubin and its fractions were significantly higher than in healthy children ($P < 0.05$ – $P < 0.001$).

The manner in which GB function changes, as assessed using the US, affects the overall performance of the hepatobiliary system in children.

DISCUSSION

In recent years, there has been a significant increase in the incidence of childhood GB diseases.[12] The US is the preferred method for assessing the biliary system because of its accessibility, non-invasive nature, affordability, and lack of ionizing radiation. It is easier to evaluate adolescent patients with the US than adults because of their smaller body size and lower amount of abdominal fat.

When examining infants and toddlers with suspected biliary disease, it is critical to thoroughly inspect the liver, bile ducts, GB, pancreas, and portal vein.[13] However, diagnosing microlithiasis or gallstones smaller than 3 mm in individuals displaying biliary colic symptoms using ultrasound sonography can be challenging.

When additional visualization is necessary due to uncertainty, computed tomography or magnetic resonance tomography scans can be employed. However, it is crucial to consider the additional expenses associated with sedation, ionizing radiation exposure, and the potential risks of nephrotoxicity from iodinated contrast agents or gadolinium deposition.[5,8,9]

In recent years, contrast-enhanced US (CEUS) has gained widespread use as an auxiliary tool in complex or challenging cases following transplantation. Similar to traditional US, CEUS offers the advantages of ease of access and the ability to be performed both intraoperatively and postoperatively. CEUS is primarily used to evaluate vascular and parenchymal complications in patients who have undergone transplantations. The use of CEUS within the liver graft is also common in the early post-operative period to assess the condition of the biliary tracts of the transplanted liver, such as bile duct stricture, bile leaks, intraluminal stones, or the urinary tract of the kidney transplant, including obstruction of the urinary tract, urine leaks, and vesicoureteral reflux.[14-17] In addition, the quantitative analysis of the kinetic intensity of the contrast agent using CEUS is used for the diagnosis of acute rejection although the effectiveness of this method has not yet been proven.[18,19]

CONCLUSION

In children with hypokinetic biliary dyskinesia, the degree of functional, metabolic, and structural changes in the hepatobiliary system is significantly greater than in cases of hyperkinesia.

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AUTHOR CONTRIBUTIONS

Conception, design of the work, manuscript preparation, and data acquisition: Valeria Malevannaya, Tejaswi Vadde, and Rithwik Goud Burri. Clinical management: Valeria Malevannaya.

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