Journal of Pediatric Gastroenterology and Nutrition
49:323–328 © 2009 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition

Hepatic Fibrosis Scan for Liver Stiffness Score Measurement: A Useful Preendoscopic Screening Test for the Detection of Varices in Postoperative Patients With Biliary Atresia

*Hye Kyung Chang, †Youn Joon Park, ‡Hong Koh, *Seong Min Kim, ‡Ki Sup Chung, *Jung Tak Oh, and *Seok Joo Han

*Department of Pediatric Surgery, Severance Children's Hospital, Yonsei University College of Medicine, Seoul, †Department of Pediatric Surgery, Dankook University, College of Medicine, Cheonan, and ‡Department of Pediatric Gastroenterology, Hepatology, and Nutrition, Severance Children's Hospital, Yonsei University College of Medicine, Seoul, Korea

ABSTRACT

Objective: Even after successful Kasai portoenterostomy, progressive hepatic fibrosis in postoperative patients with biliary atresia (BA) can be associated with portal hypertension and esophageal or gastric varices. Therefore, early diagnosis and close follow-up of varices are important. We investigated the correlation between the liver stiffness scores measured by FibroScan and the presence of esophageal or gastric varices to examine the usefulness of FibroScan as a preendoscopic screening test for varices.

Patients and Methods: A total of 49 of 81 children with BA following successful Kasai operations were enrolled in this study. FibroScan and endoscopic examination were performed prospectively.

Results: There were 22 males (44.9%) and the mean age of the patients was 3.8 ± 2.7 years. Esophageal or gastric varices were present in 30 patients (Vx group) and absent in 19 (nVx group). The mean liver stiffness score was significantly higher in the Vx group (21.35 ± 10.31 kPa in the Vx group versus 9.75 ± 8.61 kPa in the nVx group, $P < 0.001$). The optimal cutoff value of the liver stiffness score for the prediction of a varix was 9.7 kPa with a sensitivity of 0.97 and a specificity of 0.80.

Conclusions: Liver stiffness scores measured by FibroScan correlate well with the presence of esophageal or gastric varices. FibroScan is a novel, noninvasive, and useful screening method for the preendoscopic detection of varices in postoperative patients with BA. ***JPGN 49:323–328, 2009.*** **Key Words:** Biliary atresia—Esophageal varices—FibroScan—Gastric varices—Liver stiffness. © 2009 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition

Even after successful Kasai portoenterostomy with clearance of jaundice and maintenance of hepatic function, progressive hepatic fibrosis in postoperative patients with biliary atresia (BA) can be associated with ensuing portal hypertension and esophageal or gastric varices. Adequate management of esophageal or gastric varices becomes increasingly important in long-term follow-up of postoperative patients with BA because bleeding from varices is one of the most serious and potentially life-threatening complications of portal hypertension (1,2). Esophageal or gastric varices in these patients can rupture unexpectedly during febrile conditions, such as cholangitis or infection of diverse etiology, and can have devastating consequences, including death. Therefore, early diagnosis and close follow-up of esophageal or gastric varices are mandatory in the management of postoperative patients with BA. Liver fibrosis is an alternative method for predicting the actual presence of esophageal or gastric varices in postoperative patients with BA. Recent approaches to measure hepatic fibrosis in adults include the FibroTest (BioPredictive, Paris, France), Forns score, aspartate transaminase-to-platelet ratio index, and transient elastography; all of these methods have been reported to indicate the degree of hepatic fibrosis reliably (3–9). However, few studies have evaluated hepatic fibrosis parameters in pediatric patients. De Ledinghen et al (10) suggested that liver stiffness measurement with FibroScan is feasible in children and correlates well with the clinical parameters

Received May 25, 2008; accepted January 14, 2009.

Address correspondence and reprint requests to Seok Joo Han, MD, Department of Pediatric Surgery, Severance Children's Hospital, Yonsei University College of Medicine, 250 Seongsan-no, Seodaemun-gu, Seoul 120-752, Korea (e-mail: sjhan@yuhs.ac).

Youn Joon Park and Hong Koh contributed equally to this work.

The authors report no conflicts of interest.

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.

of portal hypertension, such as the presence of esophageal varices and splenomegaly, biochemical parameters, and Metavir scoring of liver fibrosis. We hypothesized that liver stiffness measurement could also be a useful noninvasive preendoscopic screening method for the detection of esophageal or gastric varices in postoperative patients with BA. To examine this hypothesis, we investigated the correlation between the degree of liver stiffness measured by FibroScan and the actual presence of esophageal or gastric varices. We also determined the optimal cutoff value of the liver stiffness score to predict the presence of esophageal or gastric varices with sufficient discriminative power.

PATIENTS AND METHODS

From April 2007 to November 2008, FibroScan and endoscopy were performed prospectively in consecutive children with BA following successful Kasai portoenterostomy at Severance Children's Hospital, Seoul, Korea. This study was approved by our institutional review board. Written informed consent was obtained from the patients' parents. Patients who could not tolerate endoscopic examination or whose liver stiffness could not be measured reliably (success rate of measurement <90%) were excluded from the study.

Liver Stiffness Measurement

The hepatic fibrosis scan (FibroScan502, Echosens, Paris, France) is a new medical device based on transient elastography that measures liver stiffness in a noninvasive, rapid, painless, and reproducible manner (11,12). Furthermore, it is reported to have good reproducibility with low variability. Intra- and interobserver agreements were analyzed using the intraclass correlation coefficient and correlated with different patient-related and liver disease–related covariates. The overall interobserver agreement intraclass correlation coefficient was 0.98 (95% confidence interval [CI] 0.977–0.987) (13).

For the FibroScan, an ultrasound transducer probe with an external diameter of 9 mm is mounted on the axis of a vibrator. Vibrations of low amplitude and low frequency (50 Hz) are transmitted by the transducer, and induce an elastic shear wave that propagates through the underlying tissues. Pulse-echo ultrasound acquisition is used to follow the propagation of the shear wave and to measure its velocity, which is directly related to tissue stiffness (the elastic modulus E expressed as $E = 3\rho V^2$, where V is the shear velocity and ρ is the mass density [constant for tissues]): the stiffer the tissue, the faster the shear wave propagates (14). Transient elastography measures liver stiffness between 25 and 65 mm below the skin surface in a volume that approximates a cylinder that is 1 cm wide and 4 cm long. This volume is at least 100 times larger than a biopsy sample and is therefore far more representative of the hepatic parenchyma (8). We measured the liver stiffness of the children in our study as reported previously (10). In brief, liver stiffness was measured quantitatively on the right lobe of liver through the intercostal spaces with the child in the supine position with maximal abduction of the right arm until 10 successful measurements were obtained. The median value of the 10 measurements of liver stiffness was calculated automatically by software on a microcomputer installed in the FibroScan; this score was expressed as the liver stiffness score in kilopascals (kPa). A success rate for measurement of at least 60% has been considered reliable (8,11). However, in our study, patients with a success rate less than 90% were excluded from the analyses in an effort to make the data even more reliable (10).

Fiberoptic Endoscopic Examination

A standard flexible gastro-fiberscope (EG-2530, Pentax, Tokyo, Japan) was used for endoscopic examinations, which were performed as soon as possible after the FibroScan examinations. The endoscopic examinations were performed by a pediatric gastroenterologist who was unaware of the liver stiffness scores of the patients (Figs. 1 and 2). Patients with a body weight less than 5 kg were excluded from the endoscopic examination because of the large diameter (7 mm) of the scope. Esophageal varices were graded based on the endoscopic criteria developed by the Japanese Research Society for Portal Hypertension in 1991 (grade 0, lesions assuming no varicose appearance; grade 1, straight, small-caliber varices; grade 2,

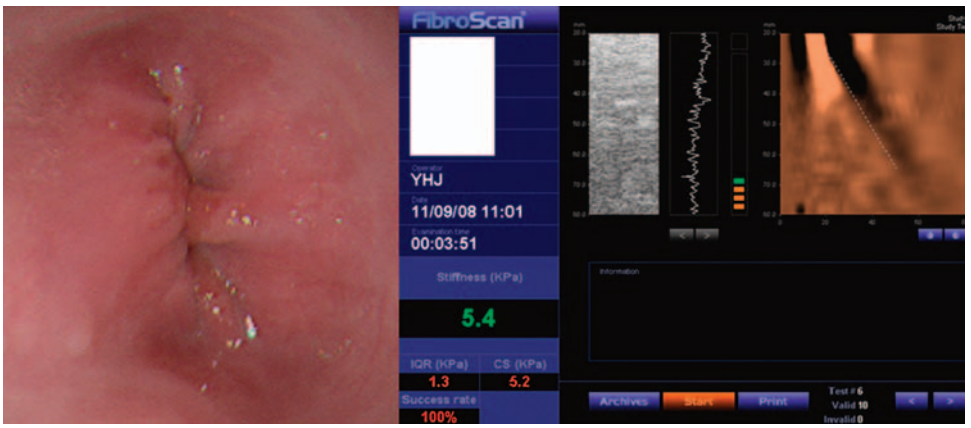

FIG. 1. Endoscopic findings of a patient (male, 225 weeks post-Kasai operation) showing a normal esophageal wall without any varices (left). The patient's liver stiffness score was 5.4 kPa (right).

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.

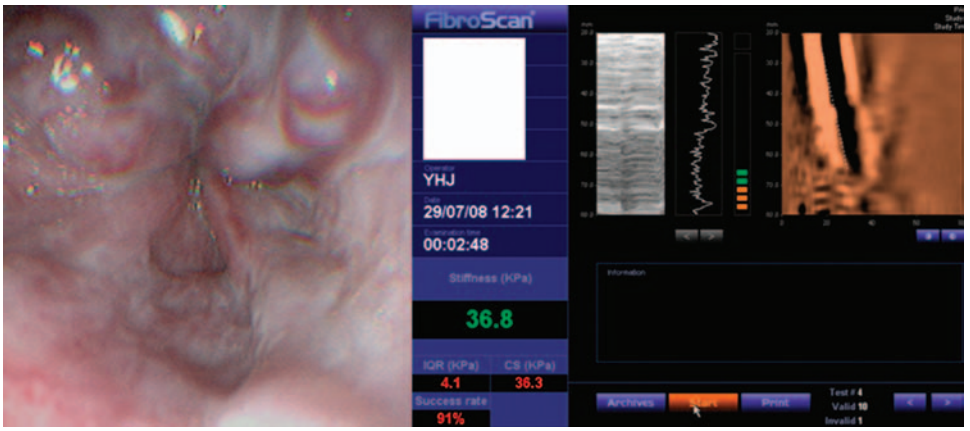

FIG. 2. Endoscopic findings of a patient (male, 131 weeks post-Kasai operation) showing grade 3 esophageal varices (left). The patient's liver stiffness score was 36.8 kPa (right).

moderately enlarged, beady varices; and grade 3, markedly enlarged, nodular, or tumor-shaped varices) (15).

Statistical Analysis

Student *t* test and the χ^2 test were used to evaluate statistical significance of differences between the 2 groups. Receiver operating characteristic (ROC) curves were used to determine the reliability of the liver stiffness score for predicting esophageal or gastric varices in postoperative patients with BA. Optimal cutoff values of the liver stiffness score for the prediction of esophageal or gastric varices were defined as the liver stiffness score at which the sum of the specificity and sensitivity was the highest. Statistical analyses were performed using SPSS version 13.0 software (SPSS, Chicago, IL). A P value less than 0.05 was considered statistically significant.

RESULTS

Patients

A total of 49 of 81 children with BA following successful Kasai operations met our inclusion criteria and were enrolled in this study. Their characteristics are summarized in Table 1. There were 22 males (44.9%) and 27 females (55.1%) with ages ranging from 5 months to 12 years (mean 3.8 ± 2.7 years) at the time of enrollment. The mean body weight and height at the time of enrollment were 21.3 ± 14.2 kg and 103.6 ± 39.7 cm, respectively. The success rate of FibroScan was $97.7\% \pm 3.9\%$. Endoscopic examination showed that esophageal or gastric varices were present in 30 patients (variceal group, Vx) and absent in 19 (nonvariceal group, nVx). There were no significant statistical differences in sex, body weight, height, mean age, or mean follow-up duration following the operation between the Vx and nVx groups. The mean age at Kasai portoenterostomy was significantly higher in the Vx group than the nVx group (9.12 ± 3.11 weeks in Vx vs 7.19 ± 3.42 weeks in nVx, $P = 0.047$). The mean liver stiffness score for all of the patients was 16.85 ± 11.17 kPa. The mean liver stiffness score of the Vx group was significantly higher than the nVx group (21.35 ± 10.31 kPa in Vx vs 9.75 ± 8.61 kPa in nVx, $P < 0.001$).

Grade and Location of Varices

Table 2 summarizes the grade and location of the varices. The results were as follows: grade 1 of esophageal varices, n = 11 (36.7%); grade 2 of esophageal varices, n = 10 (33.3%); grade 3 of esophageal varices, n = 4 (13.3%); gastric varices only, n = 5 (16.7%); and

TABLE 1. *Baseline characteristics and liver stiffness scores*

	Total (n = 49)	nVx (n = 19)	Vx (n = 30)	*P*
Male, %	22 (44.9)	8 (42.1)	14 (46.7)	>0.05
Age at operation, wk	8.37 ± 3.33	7.19 ± 3.42	9.12 ± 3.11	0.047
Age at FibroScan, wk	198.56 ± 142.84	204.02 ± 123.75	195.72 ± 155.69	>0.05
Follow-up duration, wk*	190.55 ± 143.11	196.81 ± 124.57	186.59 ± 155.65	>0.05
Liver stiffness score, kPa	16.85 ± 11.17	9.75 ± 8.61	21.35 ± 10.31	<0.001

Values are mean ± SD. kPa = kilopascals; nVx = no varices; Vx = presence of esophageal or gastric varices.
* Follow-up duration from Kasai operation to FibroScan (weeks).

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.

TABLE 2. *Grade and location of varices (n = 30)*

	No. (%)
EVx grade 1	11 (36.7)
EVx grade 2	10 (33.3)
EVx grade 3	4 (13.3)
GVx only	5 (16.7)
EGVx	9 (30.0)

EVx = esophageal varices; EGVx = presence of both esophageal and gastric varices; GVx = gastric varices.

presence of both esophageal and gastric varices, n = 9 (30.0%).

Diagnostic Accuracy of Liver Stiffness Measurement for Prediction of Varices

The subjects were divided into 4 groups for ROC curve analysis: Vx (n = 30), presence of esophageal or gastric varices; EVx (n = 25), presence of esophageal varices; GVx (n = 14), presence of gastric varices; and EGVx (n = 9), presence of both esophageal and gastric varices (Fig. 3). The areas under the ROC curves (95% CI) were 0.88 in Vx, 0.85 in EVx, 0.65 in GVx, and 0.70 in EGVx.

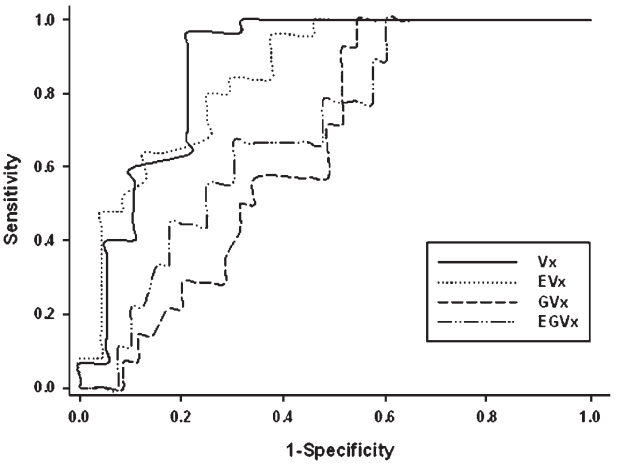

FIG. 3. Receiver operator characteristics (ROCs) curves of liver stiffness measurement for varices. The corresponding areas under the ROCs were 0.88 (95% CI) in the presence of esophageal or gastric varices (Vx, n = 30), 0.85 in esophageal varices (EVx, n = 25), 0.65 in gastric varices (GVx, n = 14), and 0.70 in the presence of both esophageal and gastric varices (EGVx, n = 9). CI = confidence interval; EVx = esophageal varices; EGVx = presence of both esophageal and gastric varices; GVx = gastric varices; Vx = presence of esophageal or gastric varices.

Determination of Liver Stiffness Score Cutoff Values

Table 3 shows the optimal liver stiffness score cutoff values obtained for all of the subjects as well as the corresponding sensitivities, specificities, and likelihood ratios. We analyzed the ROC curves using the liver stiffness scores for the diagnosis of varices. The cutoff value of the liver stiffness score for the Vx group was 9.7 kPa with a summed total sensitivity and specificity of 1.77. The negative predictive value of liver stiffness scores <9.7 kPa for the presence of varices was 94%. Thirty-three patients (67.3%) had liver stiffness scores greater than or equal to 9.7 kPa and 16 (32.7%) had liver stiffness scores <9.7 kPa. The cutoff value for esophageal varices was 9.7 kPa with a total summed sensitivity and specificity of 1.59. The clear cutoff value (35.3 kPa) was obtained for grade 3 esophageal varices with a sensitivity of 75% and a specificity of 93%.

DISCUSSION

Hepatic fibrosis is the final result of chronic liver disease and is a wound healing process similar to those observed in other organs (7). In children, BA is the most common cause of liver fibrosis, even after surgical intervention. As the postoperative survival of patients with BA following the Kasai operation on the native liver has improved, the incidence of complications from portal

TABLE 3. *Cutoff values of liver stiffness scores according to the grade of esophageal varices and the presence of gastric varices*

	Vx	EVx ≥1	EVx ≥2	EVx = 3	GVx	EGVx
Optimal cutoff	9.7	9.7	17.8	35.3	11.7	17.8
True positives	29	24	10	3	13	6
True negatives	15	15	27	42	17	29
False positives	4	9	8	3	18	11
False negatives	1	1	4	1	1	3
Sensitivity	0.97	0.96	0.71	0.75	0.93	0.67
Specificity	0.80	0.63	0.77	0.93	0.49	0.70
Likelihood ratio	4.85	2.59	3.09	10.43	1.82	2.23
Positive predictive value	0.88	0.73	0.55	0.49	0.42	0.33
Negative predictive value	0.94	0.94	0.87	0.98	0.95	0.90
AUROC	0.88	0.85	0.78	0.89	0.65	0.70

AUROC = area under the receiver operator characteristics curve of liver stiffness measurements; EVx = grade of esophageal varices; EGVx = presence of both esophageal and gastric varices; GVx = gastric varices; Vx = presence of esophageal or gastric varices.

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.

hypertension has also increased and close follow-up of postoperative patients with BA to prevent life-threatening complications, such as variceal bleeding, has become more important. Conventional parameters, such as biochemical tests or physical examinations, have been suggested for follow-up of chronic liver cirrhosis (3–9). However, none of these reflect the degree of hepatic fibrosis accurately. Endoscopic procedures to evaluate varices in young patients with BA are risky due to their small size. In this study, we evaluated the usefulness of liver stiffness score measurements as a preendoscopic screening tool for the prediction of varices in postoperative patients with BA using a new medical device, FibroScan. Our results revealed a significant difference in liver stiffness scores between the variceal and nonvariceal groups.

Our study is similar to that of Fagundes et al (16), in that both studies aimed to find reliable, convenient, and less invasive clinical predictors of esophageal varices in children with liver cirrhosis. Fagundes et al observed that splenomegaly was the only factor with adequate sensitivity (97.7%) and negative predictive value (91.7%) to be useful as a screening test to predict the presence of esophageal varices, thus reinforcing the importance of physical examination. However, the specificity of splenomegaly was relatively low (26.8%) and the ''presence'' of splenomegaly may depend on the examiner's subjective judgment. In 2006, Kazemi et al (17) showed that in adult patients with liver cirrhosis, the optimal cutoff value of the liver stiffness score for the diagnosis of esophageal varices is 13.9 kPa. This value yielded a sensitivity of 92% and a specificity of 43%. The area under the ROC curve was 0.84 with a 95% CI. We evaluated the ROC curve of liver stiffness scores for the diagnosis of varices in pediatric patients with BA. Our study demonstrated that the optimal cutoff value of the liver stiffness score for the variceal group was 9.7 kPa, with a summed total sensitivity and specificity of 1.77. Thus, FibroScan has a high degree of sensitivity and specificity for the prediction of varices in postoperative patients with BA. Furthermore, FibroScan is convenient to use and noninvasive; it is ideal for measuring liver stiffness score in a pediatric patient with BA to screen for varices postoperatively.

The correlation between liver stiffness scores and variceal size is unclear (11,17). Lim and Groszmann (18) pointed out that liver stiffness may reflect a progressive rise in portal pressure that is mainly due to an increase in hepatic vascular resistance from fibrogenesis. However, a liver stiffness measurement cannot measure the complex hemodynamic changes characteristic of clinically important portal hypertension. In a recent report, liver stiffness measurement values increased with the grade of esophageal varices (Kendall tau-$b = 0.49$, $P < 0.0001$). Furthermore, the area under the ROC curve for the diagnosis of esophageal varices grade greater than or equal to 2 according to liver stiffness measurements was 0.83 with a 95% CI (0.76–0.89). Apparent performance identified an optimal cutoff value (19 kPa) that ensured a minimal sensitivity of 91% with a specificity of 60% to identify patients with large varices (17). Our results for the postoperative patients with BA indicate that the optimal cutoff value of the liver stiffness score for esophageal varices grade greater than or equal to 2 and grade equal to 3 are 17.8 and 35.3 kPa, with sensitivities of 71% and 75% and specificities of 77% and 93%, respectively. Therefore, liver stiffness measurement is a powerful diagnostic tool for large esophageal varices.

However, it should be noted that FibroScan is not used to treat varices; rather, it is used to screen for varices in postoperative patients with BA before performing endoscopy. The mere presence of varices without any evidence of bleeding should not be an indication to treat. The presence of varices in postoperative patients with BA requires different management strategies, including close monitoring and careful follow-up, because of the risk of variceal bleeding that can be provoked by common ailments such as cholangitis or other infections. Several clinical trials have shown that prophylactic endoscopic variceal ligation (EVL) or β-blockers prevent the bleeding of esophageal varices, reduce the frequency of bleeding episodes, and improve survival in patients with esophageal varices (19–22). However, performing routine endoscopic examinations in all of the children following a Kasai portoenterostomy is not widely accepted because pediatric endoscopy and sedation carry inherent risks, such as airway obstruction or cardiovascular complications (23). Furthermore, for a large proportion of postoperative patients with BA, endoscopy is unnecessary because of the possibility of negative exploration. In our study, the negative predictive value of liver stiffness scores <9.7 kPa for the presence of varices was 94%. Thirty-three patients (67.3%) had liver stiffness scores greater than or equal to 9.7 kPa and 16 (32.7%) had liver stiffness scores <9.7 kPa. If we apply this cutoff value to our population of 49 patients, we would avoid endoscopy in 30.7% of them. FibroScan has the potential to be an effective screening tool for predicting the presence of varices, and should therefore decrease the number of negative exploration endoscopies. Furthermore, FibroScan is easy to perform at the bedside or in the outpatient clinic. The results are available immediately and are independent of the operator. This study is the first report to investigate the usefulness of hepatic fibrosis measurements (liver stiffness scores) using FibroScan to identify esophageal or gastric varices in postoperative patients with BA.

This study has several clinical implications. First, liver stiffness measurement can be performed safely and confidently for pre- and postoperative evaluation of liver fibrosis in patients with BA. Second, FibroScan can be used reliably for first-line preendoscopic evaluation of

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.

varices in pre- and postoperative patients with BA. FibroScan also has good sensitivity and an acceptable specificity, thereby allowing clinicians to avoid performing unnecessary endoscopic examinations in a significant number of patients. Third, FibroScan can be repeated as often as necessary to monitor liver disease progression and, potentially, to evaluate the effect of antifibrotic therapy on liver fibrosis in pediatric liver disease. Finally, FibroScan can identify and select patients at high risk for variceal bleeding for whom effective preemptive treatment may be necessary.

There were some limitations to this study: even though this study was performed prospectively, there was an evaluation interval between FibroScan and endoscopy (8.44 ± 8.36 weeks); the number of patients was small and evaluation of a larger series is required to confirm our results; we did not find a correlation between FibroScan and biochemical parameters of hepatic activity; and the duration of follow-up was short; long-term follow-up is necessary to standardize the results.

In conclusion, we have established that the degree of liver fibrosis measured by FibroScan correlates well with the presence of esophageal or gastric varices in postoperative patients with BA. A cutoff value of 9.7 kPa for the liver stiffness score can predict the presence of esophageal or gastric varices with a high sensitivity (97%) and an acceptable specificity (80%). Liver stiffness scores obtained using FibroScan are recommended as a novel, noninvasive screening method for the preendoscopic detection of varices in postoperative patients with BA.

REFERENCES

1. Lilly JR, Stellin G. Variceal hemorrhage in biliary atresia. *J Pediatr Surg* 1984;19:476–9.
2. Stringer MD, Howard ER, Mowat AP. Endoscopic sclerotherapy in the management of esophageal varices in 61 children with biliary atresia. *J Pediatr Surg* 1989;24:438–42.
3. Callewaert N, Van Vlierberghe H, Van Hecke A, et al. Noninvasive diagnosis of liver cirrhosis using DNA sequencer-based total serum protein glycomics. *Nat Med* 2004;10:429–34.
4. Forns X, Ampurdanes S, Llovet JM, et al. Identification of chronic hepatitis C patients without hepatic fibrosis by a simple predictive model. *Hepatology* 2002;36:986–92.
5. Hui AY, Chan HL, Wong VW, et al. Identification of chronic hepatitis B patients without significant liver fibrosis by a simple noninvasive predictive model. *Am J Gastroenterol* 2005;100:616–23.
6. Imbert-Bismut F, Ratziu V, Pieroni L, et al. Biochemical markers of liver fibrosis in patients with hepatitis C virus infection: a prospective study. *Lancet* 2001;357:1069–75.
7. Wai CT, Greenson JK, Fontana RJ, et al. A simple noninvasive index can predict both significant fibrosis and cirrhosis in patients with chronic hepatitis C. *Hepatology* 2003;38:518–26.
8. Castera L, Vergniol J, Foucher J, et al. Prospective comparison of transient elastography, fibrotest, APRI, and liver biopsy for the assessment of fibrosis in chronic hepatitis C. *Gastroenterology* 2005;128:343–50.
9. Foucher J, Chanteloup E, Vergniol J, et al. Diagnosis of cirrhosis by transient elastography (FibroScan): a prospective study. *Gut* 2006; 55:403–8.
10. de Ledinghen V, Le Bail B, Rebouissoux L, et al. Liver stiffness measurement in children using Fibroscan: feasibility study and comparison with Fibrotest, aspartate transaminase to platelets ratio index, and liver biopsy. *J Pediatr Gastroenterol Nutr* 2007;45:443–50.
11. Vizzutti F, Arena U, Romanelli RG, et al. Liver stiffness measurement predicts severe portal hypertension in patients with HCV-related cirrhosis. *Hepatology* 2007;45:1290–7.
12. Sandrin L, Fourquet B, Hasquenoph JM, et al. Transient elastography: a new noninvasive method for assessment of hepatic fibrosis. *Ultrasound Med Biol* 2003;29:1705–13.
13. Fraquelli M, Rigamonti C, Casazza G, et al. Reproducibility of transient elastography in the evaluation of liver fibrosis in patients with chronic liver disease. *Gut* 2007;56:968–73.
14. Castera L, Forns X, Alberti A. Non-invasive evaluation of liver fibrosis using transient elastography. *J Hepatol* 2008;48:835–47.
15. Idezuki Y. General rules for recording endoscopic findings of esophagogastric varices (1991). Japanese Research Society for Portal Hypertension. *World J Surg* 1995;19:420–3.
16. Fagundes ED, Ferreira AR, Roquete ML, et al. Clinical and laboratory predictors of esophageal varices in children and adolescents with portal hypertension syndrome. *J Pediatr Gastroenterol Nutr* 2008;46:178–83.
17. Kazemi F, Kettaneh A, N'kontchou G, et al. Liver stiffness measurement selects patients with cirrhosis at risk of bearing large oesophageal varices. *J Hepatol* 2006;45:230–5.
18. Lim JK, Groszmann RJ. Transient elastography for diagnosis of portal hypertension in liver cirrhosis: is there still a role for hepatic venous pressure gradient measurement? *Hepatology* 2007; 45:1087–90.
19. Sasaki T, Hasegawa T, Nakajima K, et al. Endoscopic variceal ligation in the management of gastroesophageal varices in postoperative biliary atresia. *J Pediatr Surg* 1998;33:1628–32.
20. Shashidhar H, Langhans N, Grand RJ. Propranolol in prevention of portal hypertensive hemorrhage in children: a pilot study. *J Pediatr Gastroenterol Nutr* 1999;29:12–7.
21. Celinska-Cedro D, Teisseyre M, Woynarowski M, et al. Endoscopic ligation of esophageal varices for prophylaxis of first bleeding in children and adolescents with portal hypertension: preliminary results of a prospective study. *J Pediatr Surg* 2003;38:1008–11.
22. McKiernan PJ, Beath SV, Davison SM. A prospective study of endoscopic esophageal variceal ligation using a multiband ligator. *J Pediatr Gastroenterol Nutr* 2002;34:207–11.
23. Lamireau T, Dubreuil M, Daconceicao M. Oxygen saturation during esophagogastroduodenoscopy in children: general anesthesia versus intravenous sedation. *J Pediatr Gastroenterol Nutr* 1998;27:172–5.

Copyright © 2009 by Lippincott Williams & Wilkins.Unauthorized reproduction of this article is prohibited.