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Assessment of The Pancreas with Strain Elastography in Healthy Children: Correlates and Clinical Implications

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Summary

Background: To determine strain index (SI) values at various locations in the pancreas and to investigate the relationship between age, gender, body weight, height, body mass index (BMI), and elasticity values of the pancreas in healthy children.

Material/Methods: This cross-sectional trial was performed in 147 healthy children who underwent transabdominal ultrasonography for strain elastography of the pancreas. A convex, 3.5–5-MHz probe was used to obtain the images. Baseline descriptive data including age (months), body weight (kg), height (cm), and BMI (kg/m^2) were noted. Strain index values were calculated for the head, body, and tail of the pancreas, and a mean value was obtained. The relationship between demographic variables and SI values was assessed. Correlation between variables with normal distribution was evaluated with Pearson's correlation coefficient and Spearman's rho.

Results: The average SI values in girls and boys were 1.30±0.34 and 1.32±0.22, respectively. There was no significant difference between SI values measured in the head, trunk, and tail of the pancreas (p=0.594). The average SI value did not differ between girls and boys (p=0.751). Correlation analysis revealed that SI was positively associated with age (p=0.005), body weight (p=0.004), height (p=0.003), and BMI (p=0.005).

Conclusions: This study determined normal elasticity values of the pancreas in healthy children. SI values of pancreas change with age, body weight, height, and BMI in the pediatric population. Information obtained from healthy children can serve as a baseline against which pancreatic diseases can be examined.

MeSH Keywords: **Child • Elasticity Imaging Techniques • Pancreas**

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Background

Ultrasound elastography is a new diagnostic procedure that is based on documentation of elastic features of particular soft tissues [1]. Elastography has been utilized for the diagnosis of stiff lesions, including neoplasms that exist within normal tissues [2,3]. Ultrasound elastography demonstrates displacement and deformation of tissues induced by an external force, and it shows tissue remodeling after the external force is removed [4,5]. Strain elastography and shear wave elastography are the two principal techniques used in the procedure [1].

Although elastography of the pancreas has been recently popularized [6–10], there are scarce data on its utilization in healthy children. There is a negative correlation between the grade of strain and stiffness of target tissues. In other words, the greater is the strain, the softer the stiffness of the target tissue. Because manual compression is not very effective in the case of the pancreas, the strain is induced by aortic pulsations. For an optimal strain elastographic assessment, the target tissue must be placed in a straight line between the probe and the aorta. A fine elastogram can be obtained in the pancreatic body, except for patients with severe arteriosclerosis [6].

Our purpose was to determine SI values at various locations in the pancreas and to investigate relationships between age, gender, body weight, height, and BMI in the pediatric population

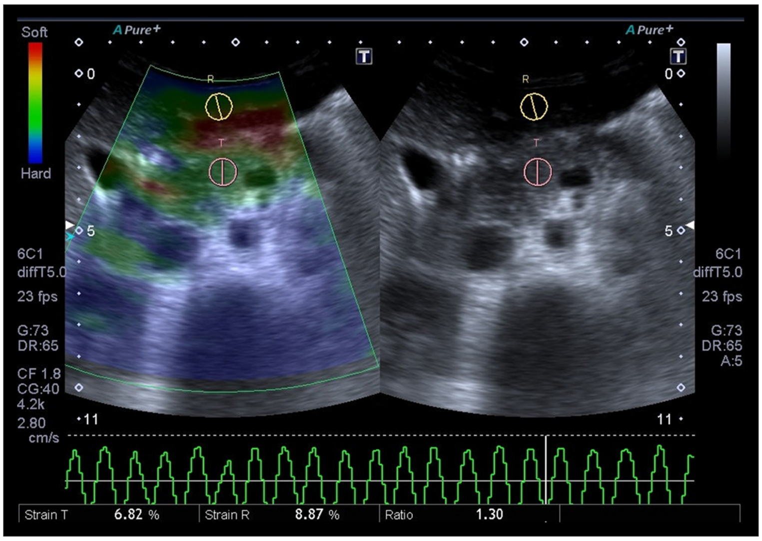

Figure 1. Elastography of the pancreas in a 102-month-old healthy boy displayed a strain index of 1.30. Region of interest (T) is set on the head of pancreas and ROI (R) is set on read area around the left lobe of liver. The strain ratio (R/T) was calculated automatically and displayed on the bottom of the screen. The numbers define the strain values, and "%" defines the strain ratio.

Material and Methods

Patients and study design

This cross-sectional, controlled trial was performed in the pediatric radiology department of our tertiary care center between June 2015 and October 2016 after approval of the local Institutional Review Board. Written informed consent was obtained from the parents of every child. Procedures were carried out in accordance with the Declaration of Helsinki and Good Clinical Practice principles. Elastography did not pose any additional risks or inconvenience for the patients except for the additional several minutes spent for exploration of the target tissue.

Data were collected from 147 healthy children (73 girls, 74 boys; average age: 126.6±45.3 months, range: 49-204 months) who underwent transabdominal ultrasonography for strain elastography of the pancreas. We calculated the average SI value for our pediatric population and investigated whether there is a difference between SI values obtained from the head, body, and tail of the pancreas. Baseline descriptive variables included age, gender, height, weight, and BMI. The correlation between descriptive variables and SI values was tested.

Exclusion criteria were history or presence of any pancreatic disease (such as inflammation, autoimmunity, infection, and neoplasm), and any systemic disease affecting the pancreas at the time of study. Because, in children under 3 years of age an appropriate elastographic examination cannot be performed, they were excluded from the trial. Healthy children were referred from the pediatrics department of our institution for elastographic examinations.

Transabdominal sonoelastography examination

Ultrasonography was performed with the Toshiba Applio 500 device (Toshiba Medical Systems, Co, Ltd., Otawara, Japan). Strain elastography was carried out using a 3.5–5 MHz convex probe. A single radiologist experienced in pediatric and abdominal radiology (M.O.) carried out all transabdominal ultrasonography procedures. Scanning was performed early in the morning after an overnight fasting period. In some cases, subjects were instructed to drink 250 ml of water during the procedure in order to improve the visibility of the pancreas. Identification of the pancreas was facilitated by using the left lobe of the liver, portal vein, superior mesenteric artery, and inferior vena cava as landmarks.

An elastography module allowed real-time elastographic assessment and recording. The method was based on the identification of small structural deformations in the B-mode image induced by compression. The strain is smaller in stiff tissues than in soft tissues. Different elasticity values are displayed with different colors, and a color-map system is used. The region of interest (ROI) was manually selected and involved the target tissue. Elastographic characteristics were determined with respect to the predominant color as well as homogeneity or heterogeneity of distribution [11].

Strain is expressed with colors superimposed on the B-mode images (color map), and reference B-mode images are also shown. If B-mode images cannot be achieved clearly, it is impossible to obtain excellent elastograms. Hence, generation of B-mode images with minimal artifacts is critical [7].

Figure 1 demonstrates elastography of the pancreas in a 102-month-old, healthy boy. A region of interest (T) is placed in the head of pancreas and another ROI (R) is placed in the area around the left lobe of the liver. The strain ratio (R/T) was calculated automatically and is shown on the bottom of the screen. In every patient, three independent measurements were made in the head, body, and tail of the pancreas. Additionally, an average strain index (SI) was calculated using the arithmetic mean of these 3 values. Since the pancreas is a retroperitoneal structure, manual compression of the pancreas should be targeted onto the left lobe of the liver, where the pancreas is in line with the aorta whose pulsations aid in compression. The intensity and duration of manual compression was adjusted by monitoring elastograms on the video screen of the ultrasound system. Movement of the

Table 1. Baseline descriptives in healthy children who underwent strain elastography. Average values are expressed as mean ± standard deviation and range is shown as minimum-maximum.

Variable		Gender			
		Girls (n=73)		Boys (n=74)	
		Average	Range	Average	Range
Age (months)		126.4±45.7	50–204	126.9±45.2	49–203
Body weight (kg)		40.3±15.9	16–66	44.5±18.8	17–82
Height (cm)		142.4±20.0	106–169	147.7±22.1	108–185
BMI (kg/m^2)		18.8±2.8	14.2–23.4	19.2±2.8	14.6–24.5
SI	Head	1.30±0.33	0.57–2.22	1.32±0.22	0.76–1.88
	Trunk	1.30±0.34	0.58–2.33	1.32±0.22	0.77–1.82
	Tail	1.31±0.35	0.56–2.42	1.32±0.22	0.77–1.78
	Average	1.30±0.34	0.57–2.32	1.32±0.22	0.77–1.83

transducer was repeated using different compression ratios, until a stable and reproducible image series was gained. The ultrasound B-mode and elastography images were recorded on the internal hard disk of the ultrasound machine.

Statistical analysis

The IBM Statistical Package for Social Sciences (SPSS), version 20, (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Normality of distribution was tested with the Kolmogorov-Smirnov test. Parametric tests were used for variables with normal distribution, while variables without normal distribution were evaluated with non-parametric tests. Correlation between variables with normal distribution was evaluated with Pearson's correlation coefficient and Spearman's rho. Comparison between groups with regard to variables with normal distribution was made with the independent samples T test. Repetitive measurements were compared by using the repeated measures ANOVA test. Quantitative data were expressed as either means and standard deviations or medians and interquartile ranges. Confidence interval was 95%, and p value smaller than 0.05 was accepted as statistically significant.

Results

Table 1 demonstrates descriptive variables and SI values in boys (n=74) and girls (n=73). The average SI values in girls and boys were 1.30±0.34 and 1.32±0.22, respectively.

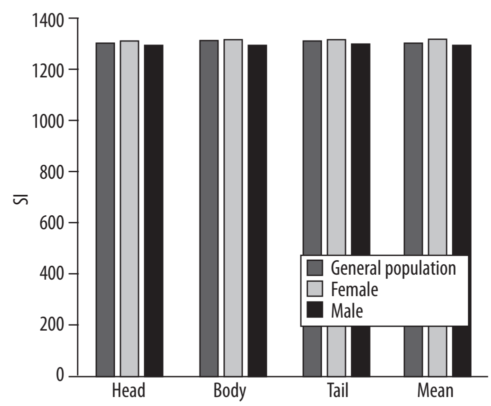

Figure 2. The average strain index values measured on the head, body, tail of pancreas in the general population, male and female subgroups.

Based on the repeated measures ANOVA test, there was no significant difference between SI values measured in the head, body, and tail of the pancreas (p=0.594). Figure 2 displays the mean SI values measured in the head, body, and tail of the pancreas in the general sample and separately in boys and girls. Importantly, the SI values did not differ between boys and girls (p=0.751).

Table 2 exhibits a comparison between three consecutive SI measurements performed in different regions of the pancreas.

Table 2. Comparison of SI measurements performed on the head, trunk and tail of pancreas.

Parameter	Site of measurement	Average value	p-value
SI	Head	1.31±0.28	0.594
	Trunk	1.31±0.28	
	Tail	1.31±0.29	

Table 3. Correlation analysis between descriptive parameters and SI.

Variable	Correlate	r-Value	p-Value
SI	Age	0.243	0.005*
	Body weight	0.250	0.004*
	Height	0.257	0.003*
	BMI	0.241	0.005*

* Statistically significant.

Correlation analysis revealed that SI was positively correlated with age (p=0.005), body weight (p=0.004), height (p=0.003), and BMI (p=0.005) (Table 3).

Discussion

The objective of the present study was to determine the average SI values in the head, trunk, and tail of the pancreas and to calculate the mean SI in healthy children. We investigated whether there was a significant difference between SI measurements performed in different locations. Furthermore, we found a positive and weak correlation between demographic variables and the mean SI strain index values. We found that the average SI values in girls and boys were 1.30±0.34 and 1.32±0.22, respectively and that this difference was statistically insignificant. Similarly, no significant difference was observed between SI values of the head, body, and tail of the pancreas. Notably, SI values were positively correlated with age, body weight, height, and BMI; gender seemed to have no effect on SI values. The current study provides baseline data from healthy children and serves as a reference for elastographic studies of the pancreas.

Although relatively novel, elastography may serve as an accurate, safe, practical, and useful diagnostic tool for assessing the pancreas in children. Because of this novelty, important information may be provided not only by studies conducted in patients with pancreatic diseases but also in healthy children. In spite of the recent popularization of this method, further trials in different populations are needed for developing guidelines and for validating the method. We hope that our data will contribute to this objective.

Elastography of the pancreas by means of transabdominal ultrasonography was initially described by Uchida et al. [12]. Placing ROIs can be made either within the target area only or within the target area and the surrounding tissue [7]. The former method is more convenient for diffuse diseases, while the later method is more commonly used for focal diseases. Since our series consisted of healthy participants, we selected the latter method since preservation of normal tissue was more likely in focal disorders.

Elastography is not only a tool for diagnosing pancreatic diseases, but it may also serve as an effective way of screening asymptomatic cases or the general population. Therefore, establishment of criteria and guidelines is required for utilization of elastography as a measure for periodical screening. Determining if elastograms accurately reflect histological structure is critical and therefore our findings are important. We observed that elastography was not influenced remarkably by gender and location of ROIs within the pancreas. Therefore, our results indicate that elastography may serve as a reliable and operator-independent method. In spite of the deep location, small size of the pancreas, and the impact of aortic pulsation, our results are promising for popularization of elastography as a non-invasive diagnostic modality for assessing the pancreas in the healthy pediatric population.

Moreover, increased awareness on the normal range of elastographic parameters will aid in early identification of pathological changes. Further studies must focus on the relationship between histopathological changes and elastographic findings in pancreatic disorders. Defining early elastographic changes in the pancreas may help detect pathologies that may otherwise present in more advanced stages [6].

Llamosa-Torres et al. [13] suggested that measurements performed in different parts of the pancreas (head, body and tail) yielded similar results in patients without chronic pancreatitis. In line with their results, we observed that location of ROIs within the pancreas seemed not to affect the elastographic measurements. Those authors suggested that morphological changes such as calcifications or dilatation of pancreatic changes associated with chronic pancreatitis were more obvious in the body of the pancreas. Introduced by Itokawa et al. [14], SI is a semi-quantitative method that reflects tissue stiffness objectively, and it is the ratio of the distortions produced by a force on two adjacent sites.

Gungor et al. [1] suggested that elasticity of the normal thyroid gland, as evidenced by SI values, was not affected by age, body weight, height, or BMI. In our study, we observed that SI values of the pancreas were positively correlated with age, body weight, height and BMI. This difference may be due to the internal characteristics of the pancreas.

Routine use of elastography may offer additional information and reinforce conventional imaging modalities. Thereby, unnecessary procedures may be avoided and cost-effectiveness will be improved. In the present study, selection bias cannot be ruled out due to the clinical setting. Moreover, the study was non-blinded and performed in a single center.

Some limitations of the present study should be mentioned. Cross-sectional design, small sample size, and data collected in a single institution by a single operator must be taken into account during interpretation of our findings and extrapolation of our results to larger populations.

Conclusions

To conclude, our results indicated that elastography of the pancreas can be used as a safe, practical, and cheap screening procedure in healthy children. Elasticity of the pancreas may be associated with age, body weight, height, and BMI in children. We hope that our data will be useful for future studies focusing on pancreatic diseases and will contribute to the improvement of diagnostic, therapeutic, and follow-up strategies.

Conflict of interest

None.

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