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Original Article

Estimating Reference Values of Parenchymal Stiffness of Normal Pancreatic Parenchyma by Means of Point Shear Wave Elastography

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Abstract

Introduction: There are numerous imaging modalities available to describe pancreatic parenchyma. None of the broadly accepted diagnostic methods uses elasticity as an indicator of tissue damage.

Aim: The aim of the present study was to establish reference values of parenchymal stiffness of normal pancreatic parenchyma through point shear wave elastography.

Materials and methods: The design of the study is prospective single-center cohort study. Sixty patients were included in the study. The ultrasound-based point shear wave elastography (pSWE) imaging technique was applied. The mean and median shear wave velocity values of the pancreatic parenchyma in the head, body and tail were calculated. The influence of certain variables on the shear wave velocity (SWV) values was estimated.

Results: A reference range for the entire pancreatic parenchyma of 0.66-1.62 m/s and a mean value of 1.17±0.22 m/s were calculated. Apart from age, none of the evaluated factors proved to have statistically significant influence on the obtained results. A measurement success rate of 94.5%, 97.2%, and 95.8% was established for the head, body, and tail of the pancreas, respectively.

Transabdominal pSWE could be utilized for assessment of pancreatic parenchyma with high success rate. A mean value of 1.17 m/s was measured which is consistent with the existing literature on the matter. None of the external factors examined in the study, apart from age, was found to have statistically significant influence on the SWV values.

Conclusions: The obtained results suggest that pSWE is a highly objective method for evaluating pancreatic parenchyma. Calculated reference range and mean values could be used in future studies to assess the capabilities of the method for differentiating between normal pancreatic parenchyma and diffuse and focal pancreatic disorders.

Keywords

elastography, pancreas, pSWE, shear wave, ultrasound

Abbreviations used in the study	
US: ultrasound	**SWV**: shear wave velocity
CEUS: contrast-enhanced ultrasound	**IBS**: irritable bowel syndrome
CECT: contrast-enhanced computer tomography	**IQR/M**: criterion-median interquartile range
MRCP: magnetic resonance cholangiopancreatography	**SPSS**: Statistical Package for Social Sciences
sMRCP: secretin-stimulated magnetic resonance cholangiopancreatography	**IQR**: interquartile range
pSWE: point Shear Wave Elastography	**BMI**: body mass index
ROI: region of interest	**EFSUMB**: European Federation of Societies for Ultrasound in Medicine and Biology

INTRODUCTION

Abdominal ultrasonography (US) is traditionally regarded as an introductory imaging modality for characterizing pancreatic parenchyma and for diagnosis of benign and malignant pancreatic disorders.[1] As imaging technique US is cheap, reproducible and readily available. Regrettably, even when utilized in contrast enhanced US (CEUS), the sensitivity and specificity of the technique rarely surpass 86% and 75%, respectively, rendering it inferior to both contrast enhanced computer tomography (CECT) and magnetic resonance cholangiopancreatography (MRCP).[2] On the other hand, CECT and MRCP (or Secretin-stimulated MRCP, sMRCP) have certain disadvantages including radiation exposure (CECT), duration (MRCP), cost and need of highly-trained medical personnel, all of which limit their broad application. The aforementioned underlines the necessity of a diagnostic modality that is cheap, non-invasive, and accessible on the one hand and, on the other, increases the diagnostic capability of conventional US.

Ultrasound elastography in its multiple forms is extensively utilized for evaluation of various structures in the abdominal cavity, particularly the liver.[3,4] Point shear wave elastography (pSWE) is a dynamic elastographic modality that is based on measuring the velocity of waves called 'shear waves'.[5] In pSWE, an ultrasound beam generated by standard convex transducer induces tissue displacement in a region of interest (ROI), also known as region of excitation, usually measuring 10×5 mm. Tissue displacement, in turn, generates waves in the parenchyma perpendicular to the ultrasound beam that created them, called 'shear' waves. Since the speed of the shear waves (presented in m/s) is in linear correlation with tissue stiffness, its value is in fact a direct reflection of the tissue elasticity. The physical nature of pSWE suggests that the method is much more objective and operator-independent in comparison to quasistatic elastographic techniques. It allows measurement of tissue elasticity in depths of up to 8 cm, which is a great advantage, particularly in the case of a retroperitoneal organ like the pancreas.[6-8]

The application of pSWE in various organs and structures has been extensively investigated.[4,8-10] There are few studies, though, that assess the diagnostic potential of the method in pancreatic diseases.[11-13] This fact could, at least partially, be attributed to the lack of sufficient information on the shear wave velocity (SWV) values in normal pancreatic parenchyma. Such data would undoubtedly contribute and be consequently used in future studies to assess the diagnostic capabilities of pSWE in inflammatory and neoplastic pancreatic diseases.

AIM

The aim of the present study was to establish mean and reference range values of SWV in normal pancreatic parenchyma. As a secondary endpoint, we set to establish the influence of certain variables on the obtained results.

MATERIALS AND METHODS

The study included sixty patients admitted to the Department of Gastroenterology at Kaspela University Hospital in Plovdiv, Bulgaria, from January to March 2022 for the diagnosis and/or treatment of various non-pancreatic disorders, primarily irritable bowel syndrome (IBS). IBS was defined according to the Rome IV criteria as follows: Recurrent abdominal pain on average at least 1 day/week in the last 3 months, associated with two or more of the following criteria: 1. Related to defecation, 2. Associated with a change in the frequency of stools, 3. Associated with a

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change in the form (appearance) of stools.[14] These criteria must be met for the last three months, with symptoms beginning at least six months before diagnosis.

Study design: a prospective single-center cohort study.

Inclusion criteria

Adequate visualization of all parts of the pancreas in conventional B-mode was considered a chief prerequisite for inclusion in the study. There should be neither clinical evidence or physical findings suggestive of pancreatic disease nor a family history of pancreatic disorders. All patients had normal serum levels of pancreatic enzymes – amylase <110 U/L and lipase <77 U/L. Normal ultrasonographic features of the pancreas in conventional B-mode were recorded as follows: homogeneous structure, sharp contours, iso- or slightly hyperechoic parenchyma compared to the liver, normal measurements of the gland up to 25-30 mm in the head, 18 mm in the body and 25-30 mm in the tail, non-dilated main pancreatic duct up to 2 mm in the region of the body.

Exclusion criteria

Increased alcohol consumption, defined as the intake of more than 20 g of pure alcohol per day, and the usage of medications with potential pancreatic toxicity were considered exclusion criteria.[15] We excluded from the analysis patients with diabetes, gall stone disease and surgical interventions in the upper abdomen.

Figure 1 presents the patients selection process in accordance with the described protocol.

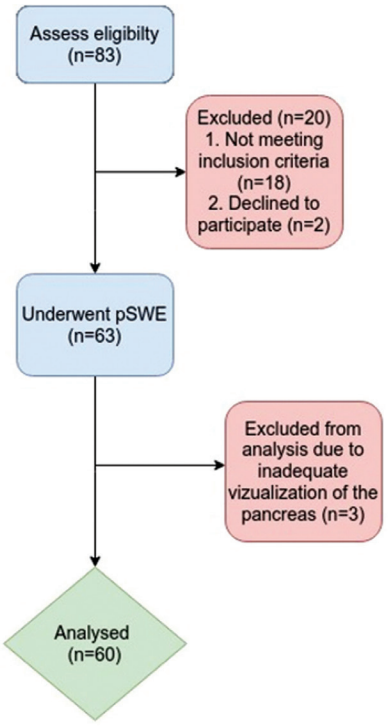

Figure 1. Patient selection process.

Examination technique

All patients had fasted at least for six hours and lain still at least 10 minutes prior to the first measurement. In the beginning, a standard B-mode evaluation of the pancreas and other abdominal tissues such as the liver, spleen, gall bladder, and arteries was conducted. A thorough search was conducted for any evidence of deviations in pancreas size and structure, as well as the presence of focal lesions, calcifications, or peri-/pancreatic fluid collections that might preclude inclusion in the study.

pSWE

pSWE was performed with the patient lying in a supine position with both hands placed overhead. The transducer was placed in the epigastric region and pointed towards the celiac trunk. The splenic vein was utilized as main anatomical landmark to aid the visualization of the pancreas and was presented by slight adjustment of the transducer direction caudally. In this position the body of the pancreas was well visualized just above the splenic vein. Subsequently, the head and the tail of the pancreas were evaluated by pointing the transducer downwards and to the right and upwards and to the left, respectively. The patient was instructed to hold his breath before every SWV measurement, even though the ultrasound machine should ideally be able to detect artefacts automatically. At least ten valid measurements of SWV were performed in every part of the gland. A validation criterion-median interquartile range (IQR/M) of less than 30% was adopted in accordance with current recommendations.[16] The depth of ROI and percentage of successful measurements were also reflected in patient cards.

Ultrasound device

pSWE was executed on Siemens Acuson S2000 ultrasound device, paired with 6C1 HD transducer 1.5-6 MHz, utilizing virtual touch quantification (VTQ) software. The maximum speed of shear waves measured by the device was 4.95 m/s. Higher SWV values or inadequate measurements are presented as X.XX m/s.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Plovdiv Medical University (No. R-3502/21.12.21) for studies involving humans. Written informed consent was obtained from each participant prior to inclusion in the study.

Statistical analysis

The obtained results were entered into a Microsoft Excel table. Statistical analysis was conducted using IBM Statistical Package for Social Sciences (SPSS, v. 24) and MedCalc v.

20.014, 2021. Metric values symmetry was checked by using the Kolmogorov-Smirnov test. In the presence of normal distribution (p>0.05), metric variables were presented with the mean value and standard deviation and were analyzed by means of parametrical statistical methods. In the absence of normal distribution (p<0.05), we utilized median values, interquartile range (IQR), and non-parametrical statistical methods. The correlation between qualitative variables was studied by means of chi-square analysis and one-way analysis of variance (ANOVA). A p value of <0.05 was regarded as statistically significant.

RESULTS

General characteristics of the studied group

Sixty patients with normal pancreatic parenchyma were prospectively included in the study, of whom 28 were male (46.70%) and 32 were female (53.30%). There was no statistically significant difference in distribution based on sex (p=0.797). Age interval was between 18 and 85 years, with mean value of 45.75±16.93 years (median, 44.50 years). Age was similar in both sexes: men – 45.61±20.30 years; women – 45.81±14.03 years, p=0.979. Detailed characteristics of the studied population are presented in **Table 1**.

Ten valid measurements were obtained from each patient. The success rate of SWV measurements in each part of the pancreas was calculated and the results are presented in **Table 2**.

Table 2. Success rate of SWV measurements in each segment of the pancreas

Segment of the pancreas	Success rate
Head	94.5%
Body	97.2%
Tail	95.8%

The mean value and standard deviation (SD) for the SWV and depth of ROI in the head, body, and tail of the pancreas were calculated. Consequently, reference values for SWV in each segment of the gland were established. The obtained results are presented in **Tables 3** and **4**, and **Fig. 2**.

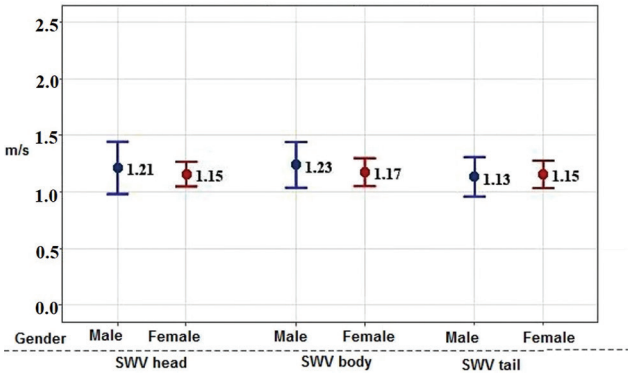

Figure 2. Mean values and 95% CI of SWV in normal pancreatic parenchyma.

Table 1. Characteristics of the studied population

Variables	Total	Male	Female	p
N (%)	60	28 (46.70%)	32 (53.30%)	0.797[f]
Age				
$\bar{X}$±SD)	45.75±16.93	45.61±20.30	45.81±14.03	
Min.–Max.	18 – 85	18 – 85	22 – 67	0.979[t]
Median (IQR)	44.50 (30)	46 (35)	44 (25)	
BMI				
Median (IQR)	22.60 (6.77)	23.45 (7.40)	22.05(6.95)	0.697[U]
Min.– Max.	17.90 – 29.40	17.90 – 29.40	18.60 – 29.40	
BMI groups				
Underweight: <18.50	2 (3.30%)	2 (7.10%)	0 (0.00%)	
Normal: 18.50 – 24.90	36 (60.00%)	14 (50.00%)	22 (68.80%)	0.396[χ^2]
Overweight: ≥25	22 (36.70%)	12 (42.90%)	10 (31.30%)	
Smoking				
Yes, n (%)	18 (30.00%)	6 (21.40%)	12 (37.50%)	0.440[f]
No, n (%)	42 (70.00%)	22 (78.60%)	20 (62.50%)	

$\bar{X}$: mean value; IQR: interquartile range; f: Fisher's test; t: t-test of independent samples; U: Mann-Whitney test; χ^2: chi-square test

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Table 3. Mean±SD values of SWV and depth of ROI

Shear Wave Velocity m/s	Total	Male	Female	*p*
Head				
$\bar{X}$ (±SD)	1.18±0.30	1.21±0.40	1.15±0.20	0.649
Min.-Max.	0.74 - 2.26	0.74 - 2.26	0.80 - 1.56	
Body				
$\bar{X}$ (±SD)	1.20±0.28	1.23±0.35	1.17±0.23	0.560
Min.–Max.	0.80-2.12	0.80 - 2.12	0.90 - 1.70	
Tail				
$\bar{X}$ (±SD)	1.14±0.26	1.13±0.30	1.15±0.22	0.821
Min.–Max.	0.76- 1.92	0.86 -1.92	0.76 -1.48	
Depth of region of interest (ROI)				
Head				
$\bar{X}$ (±SD)	5.14±0.84	5.22±0.83	5.08±0.87	0.657
Min.–Max.	3.50-6.10	4.00 - 6.10	3.50 - 6.10	
Body				
$\bar{X}$ (±SD)	4.75±0.95	4.74±0.96	4.76±0.97	0.955
Min.–Max.	3.10-6.10	3.22 - 6.10	3.10-6.10	
Tail				
$\bar{X}$ (±SD)	5.16±0.85	5.21±0.78	5.12±0.93	0.761
Min.-Max.	3.20 - 6.14	3.90 - 6.14	3.20-6.14	

$\bar{X}$: mean value; SD: standard deviation

Table 4. Reference values for SWV (m/s) in each part of the pancreas

Results	SWV Head m/s	SWV Body m/s	SWV Tail m/s
Mean value $\bar{X}$	1.18	1.20	1.14
Standard deviation	0.30	0.28	0.26
Kolmogorov-Smirnoff test for normal distribution	D=0.128, p=0.10	D=0.159, p=0.06	D=0.152, p=0.08
Anomalous values (Reed, 1971)[a]	2.26 (Patient No. 28)	None	1.92 (Patient No. 15)
Reference range (Robust method CLSI C28-A3[b])			
Lower reference limit (m/s)	0.62	0.55	0.64
90% Confidence interval (CI) of lower reference limit (m/s)	0.55 to 0.80	0.37 to 0.74	0.54 to 0.74
Upper reference limit (m/s)	1.64	1.75	1.57
90% Confidence interval of (CI) upper reference limit (m/s)	1.47 to 1.75	1.53 to 1.95	1.43 to 1.68

The lack of statistically significant difference of SWV values in different parts of the pancreas (p=0.590) justified the calculation of mean ± SD and reference range values for the pancreatic parenchyma as a whole. The results obtained are presented in **Table 5**. For the entire pancreatic parenchyma, a reference range of 0.66 m/s to 1.62 m/s was calculated.

Graphical illustration of the presented mean values and reference range limits in each part of the pancreas and the entire pancreatic parenchyma is provided in **Fig. 3**. Horizontal lines reflect the mean SWV value in the respected part of the gland. The aforementioned two anomalous val-

Table 5. SWV values for the entire pancreatic parenchyma

Descriptive statistics	SWV entire parenchyma (m/s)
The lowest value	0.86
The highest value	1.74
Mean value $\bar{X}$	1.17
Median	1.11
Standard deviation	0.22
Kolmogorov-Smirnoff test for normal distribution	D = 0.149, p =0.09
Anomalous values (Reed, 1971)	None
Reference range (Robust method CLSI C28-A3)	
Lower reference limit (m/s)	0.66
90% Confidence interval (CI) of lower reference limit	0.56 до 0.79
Upper reference limit (m/s)	1.62
90% Confidence interval (CI) of upper reference limit (m/s)	1.45 до 1.75

ues in the head and body of the pancreas are excluded.

To evaluate the influence of certain variables on the obtained results, we assessed the correlation between SWV and certain factors, in particular depth of ROI, BMI, and age.

Analysis of the correlation between SWV and depth of ROI

The connection between SWV and depth of ROI was evaluated through Spearman's rank-order correlation. No statistically significant association was found for each part and for the pancreatic gland as a whole as follows: head (p=0.170); body (p=0.653); tail (p=0.551); entire pancreas (p=0.665). Results are summarized in **Table 6**.

Table 6. Correlation between SWV and depth of ROI

Correlation between SWV and depth of ROI	Correlation coefficient (r^s)	p
Head	0.257	0.170
Body	0.860	0.653
Tail	−0.113	0.551
Entire parenchyma	0.083	0.665

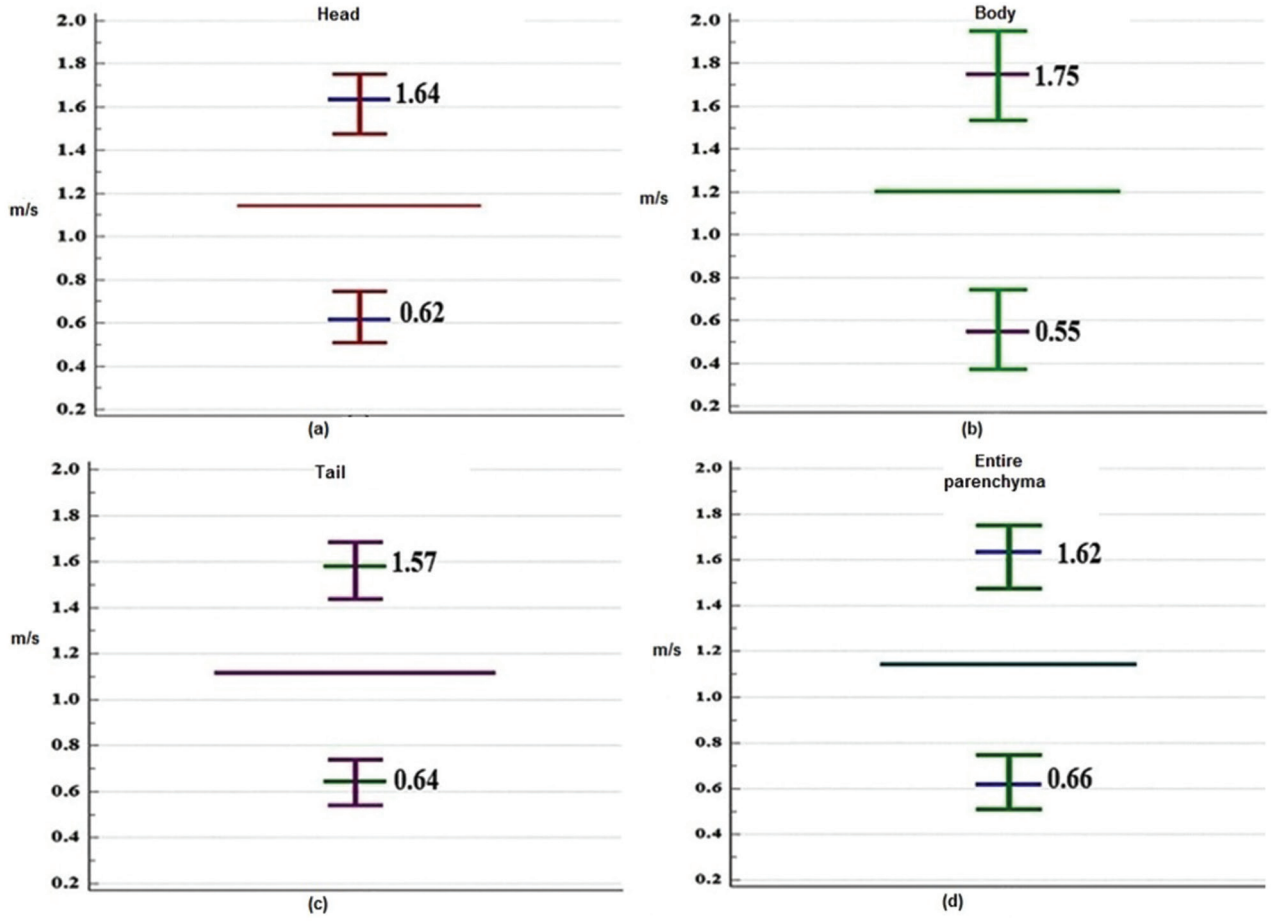

Figure 3. Reference range values of SWV in each part of the pancreas and entire pancreatic parenchyma.

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Analysis of the correlation between SWV and BMI

The potential correlation between SWV and BMI was assessed through Spearman's rank-order correlation. Again, no influence on SWV values was established: head (p=0.834); body (p=0.884); tail (p=0.214); entire pancreas (p=0.658). Results are summarized in **Table 7**.

Table 7. Correlation between SWV and BMI

Correlation between SWV and BMI	Correlation coefficient (r^s)	p
Head	0.040	0.834
Body	0.028	0.884
Tail	−0.234	0.214
Entire parenchyma	−0.084	0.658

Analysis of the correlation between SWV and age

Utilizing multiple linear regression analysis, it was found that age shows statistically significant positive correlation with SWV – higher SWV are established in older patients. The obtained results are summarized in **Table 8**.

DISCUSSION

According to recent statistics, an estimated 64,050 people in the United States in 2023 will be diagnosed with pancreatic cancer, with 50,550 deaths directly attributed to the disease. The incidence of pancreatic cancer is around 13.2/100,000 with a mortality rate of 11.1/100,000. Statistical data on chronic pancreatitis is concerning as well – the annual incidence of the disease is 5-12/100,000 with a general incidence of 50/100,000 population.

Early detection of pancreatic cancer is difficult due to the lack of early symptoms and the need for highly sophisticated and technically demanding methods for imaging diagnostics and histological confirmation. On the other hand, in chronic pancreatitis, there are no unified criteria for histological diagnosis and grading, which usually compromise and delay early recognition of the disease.

The presented data highlight the need for a non-invasive, accessible, reproducible, and inexpensive method for evaluating pancreatic parenchyma and support the idea of testing the diagnostic capability of the pSWE method on the pancreas. As a first step in this process, we investigated pSWE in patients with normal pancreatic parenchyma in order to derive mean and reference values of SWV in healthy patients.

It has been already proven that pSWE is a highly reliable method for evaluation of parenchymal stiffness of various abdominal structures and particularly for estimation of liver fibrosis.[9,10] D'Onofrio et al. were the first to investigate the application of pSWE on the pancreatic gland.[11] Utilizing pSWE, they established pancreatic cystadenoma, which was misdiagnosed as a solid lesion on CECT and conventional ultrasound. The application of the method in pancreatic diseases is questioned by a research conducted by Yashima et al., who established a very low rate of successful measurements as follows: 69% in the head, 76% in the body, and 42% in the tail of the pancreas.[17] Shaiyeri et al. also claimed that adequate visualization of the tail of the pancreas is problematic, which leads to the exclusion of this part of the gland from analysis. Of note, their study was based on 2D-SWE.[18] Subsequently, Kawada et al. have proven that pSWE is applicable on the pancreas by achieving over 80% successful measurements in virtually all parts of the pancreas: 100% of patients in the head; 100% – in the body, and 96% – in the tail.[19] In our study, we achieved 10 valid measurements in all part of the gland with a success rate in the head, body, and tail of 94.5%, 97.2%, and 95.8%, respectively. These results are similar to those reported by Zaro et al.[20] The same study claims that there is no statistically significant difference in the results obtained by five or ten measurements. The decision to use ten measurements in our study is largely determined by the recent European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) guidelines.[16]

In order to obtain results valid for larger population, we designed the study to include similar number of men and women, with no restrictions based on age (age interval 18-85 years with a mean age 45.75±16.93 years, median 44.50 years) and BMI (median 22.60 kg/m^2). Such approach is similar to the one used by Mateen et al. and differs from the study of Zaro et al.[20,21] which analyzed predominant-

Table 8. Correlation between SWV and age

	SWV			
	Head r	Body r	Tail r	Pancreas r
Age				
Correlation coefficient	0.473	0.416	0.425	0.409
p	0.004**	0.013*	0.014*	0.015*

r: correlation coefficient; **: statistical significance at p<0.01; *: statistical significance at p<0.05

ly young patients, non-smokers, with normal BMI. Such selection, in our opinion, does not reflect the influence of those factors on SWV values and calls into question the results' applicability to the general population. Shaiyeri et al. took a more lenient approach to evaluating patients with fatty liver disease, gallstone disease, and even diabetes mellitus, which may have influenced the accuracy of their results, consistently finding higher SWV values compared to previous research on the subject.[18]

In order to establish reference values of SWV in normal pancreatic parenchyma, ten valid measurements of SWV by means of pSWE were performed in each part of the pancreas. Based on the obtained SWV values we determined a reference range of 0.62 m/s–1.64 m/s in the head, 0.55 m/s–1.75 m/s in the body and 0.65 m/s–1.57 m/s in the tail of the pancreas with mean values of 1.18±0.30 m/s, 1.20±0.28 m/s, and 1.14±0.26 m/s, respectively. These findings are comparable to the ones reported by Zaro et al. (SWV – 1.224 m/s in the head, 1.227 m/s in the body, and 1.191 m/s in the tail), Yashima et al. (SWV – 1.23±0.34 m/s in the head, 1.30±0.34 m/s in the body, and 1.24±0.50 m/s in the tail), Xie et al., Stumf et al. (1.44±0.39 m/s), Nidhin et al. (1.05±0.25 m/s) and Puttmann et al. (1.2±0.2 m/s).[12,17,20,22-24]

Since there was no statistical difference between the results in each part of the gland, a reference range and a mean value for the entire pancreatic parenchyma were calculated as follows: 0.66-1.62 m/s and 1.17±0.22 m/s. In the research conducted to date, there is no defined reference range of SWV in normal pancreatic parenchyma. However, there are a few studies that estimate mean SWV values in healthy patients with results varying between 1.17 m/s and 1.30 m/s.[17,20,21,25-27] The current paper's results are largely consistent with those found in the relevant literature.

A secondary endpoint in our study was to evaluate the correlation of SWV with certain factors, namely sex, depth of ROI, BMI, and age. Of the evaluated variables, sex, depth of ROI (p=0.665), and BMI (p=0.658) showed no significant influence on SWV values. Such conclusions were derived from the studies by Zaro et al., Mateen at al., Nidhin et al. and Xie et al.[12,20,21,23] The current study suggests that there is a significant positive correlation between age and SWV, simply stated advanced age is associated with higher SWV values. Such observation could be theoretically motivated by the physiological structural changes that occur in the pancreas in the process of normal aging and is confirmed in papers by Shayieri et al. and Puttmann et al.[18,24]

The chief limitation of the current study is the lack of histological confirmation of normal pancreatic parenchyma. Biopsy was not performed since it was considered unethical to perform invasive and potentially perilous procedure on healthy individuals. The application of a reference imaging technique was considered but deemed unsuitable taking into consideration the potential radiation exposure of CECT and cost of MRCP. Similar approach, however, was adopted in all existing studies on the matter which enhances the comparability of the results. Another limitation worth mentioning is the relatively small sample size (n=60 patients). In this regard, the results and conclusions should be interpreted with caution.

CONCLUSIONS

Based on the current paper, we conclude that pSWE is a highly efficient imaging modality to characterize pancreatic parenchyma. A reference range of 0.66-1.64 m/s and a mean value of 1.17±0.22 m/s was established for the entire pancreas in healthy patients. Age is the only variable to influence the obtained results, which highlights the objectivity and reproducibility of the method. The chief restraint is the inability to adequately visualize the entire gland in every patient. Our results could be used in future research to evaluate the diagnostic potential of pSWE for differentiation between normal pancreatic parenchyma and diffuse and focal pancreatic disorders.

Author contributions

Conceptualization: D.S. and B.H.; methodology: K.D. and E.N.; investigation: B.H. and E.N.; resources: D.S. and E.N.; data curation: D.S. and M.D.; writing – original draft preparation: B.H. and K.K.; writing – review and editing: S.V. and K.K.; visualization: S.V. and E.T.; supervision: G.K. and P.U.; funding acquisition: K.D. and M.D.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee for studies involving humans.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data are available on request due to ethical restrictions.

Conflicts of Interest

The authors declare no conflict of interest.

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Оценка референтных значений паренхиматозной жёсткости нормальной паренхимы поджелудочной железы с помощью Point Shear Wave эластографии (pSWE)

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Резюме

Введение: Существует множество методов рентгенографии и радиологии для описания паренхимы поджелудочной железы. Ни один из широко распространённых методов рентгенографической и радиологической диагностики не использует эластичность в качестве индикатора повреждения тканей.

Цель: Целью настоящего исследования было установить референтные значения паренхиматозной жёсткости нормальной паренхимы поджелудочной железы с помощью Point Shear Wave эластографии (pSWE).

Материалы и методы: Методика исследования: проспективное одноцентровое когортное исследование. В исследование были включены шестьдесят пациентов. Была применена методика Point Shear Wave эластографии (pSWE) на основе ультразвука. Рассчитывали средние и медианные значения SWV паренхимы поджелудочной железы в головке, теле и хвосте. Оценено влияние некоторых переменных на значения shear wave velocity (SWV).

Результаты: Рассчитан референсный диапазон для всей паренхимы поджелудочной железы 0,66-1,62 m/s и среднее значение 1,17±0,22 m/s. За исключением возраста, ни один из оцениваемых факторов не оказал статистически значимого влияния на полученные результаты. Успешность измерения головки, тела и хвоста поджелудочной железы составила 94,5%, 97,2% и 95,8% соответственно.

Трансабдоминальная pSWE может быть использована для оценки паренхимы поджелудочной железы с высокой вероятностью успеха. Было измерено среднее значение 1,17 m/s, что соответствует существующей литературе по этому вопросу. Ни один из рассмотренных в исследовании внешних факторов, кроме возраста, не оказал статистически значимого влияния на значения SWV.

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Заключение: Полученные результаты позволяют предположить, что pSWE является высокообъективным методом оценки паренхимы поджелудочной железы. Рассчитанный референсный диапазон и средние значения могут быть использованы в будущих исследованиях для оценки возможностей метода для дифференциации нормальной паренхимы поджелудочной железы и диффузных и очаговых заболеваний поджелудочной железы.

Ключевые слова

эластография, поджелудочная железа, pSWE, shear wave, УЗИ