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Application of despeckle filter local statistic mean variance (DsFlsmv) techniques towards image quality and anatomicalinformation on pancreatic ultrasound images

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ABSTRACT

Pancreatic ultrasound examination has a weakness, namely the presence of granular noise and disturbing image quality known as speckle noise. To be able to reduce speckle noise and improve the quality of pancreatic ultrasound images, this study used despeckle filter local statistic mean variance (DsFlsmv) filter technique.

This type of quasi-experimental study used a pretest posttest without control group design. The study sample was 32 volunteers. Qualitative analysis on image information begins with a visual assessment by 3 (three) radiologists then analyzed used Friedman test while quantitative analysis of image quality used Paired T-test.

Qualitative study of image quality shows differences in pancreatic ultrasound image information between pre-denoising, post-denoising size window 3x3 and post-denoising size window 5x5 images with a p-value < 0.001. The highest mean rank was obtained in the post-denoising size 3x3 images of 2.82. Quantitative study has different image quality (MSE and PSNR values) on pancreatic ultrasound post-denoising size 3x3 and post-denoising size window 5x5 images with p-value < 0.001. The lowest mean MSE value obtained in post-denoising size window 3x3 images is 5.063197 and the highest mean PSNR value in the post-denoising image size 3x3 images is 41.099753 dB.

The use of DsFlsmv technique with size window 3x3 can improve image quality and result the most optimal anatomical information on pancreatic ultrasound images.

Keywords: DsFlsmv, Speckle noise, Pancreas Ultrasound

INTRODUCTION

The pancreas is a digestive accessory gland located retroperitoneal which extends and crosses across the posterior abdominal wall [1] and is a compound gland that is connected to the digestive system that secretes secretions into the lumen of the duodenum. The pancreas is generally divided into four (or five) main parts: head, uncinate process, neck, body, and tail.[2]

In medical radiology examinations to evaluate the organs of the pancreas include CT Scan, Magnetic Resonance Imaging (MRI) and ultrasonography (USG) examinations.[2-4]

Currently, it is estimated that nearly 25% of all imaging studies conducted worldwide use ultrasonography, so medical imaging with ultrasonographic modalities is the imaging most often used.[5] Meanwhile, for the assessment of pancreatic pathology, the researchers recommend that the USG technique be used as the main method. Because ultrasound examination has many advantages.[6]

The advantages of using ultrasonography examination include: Ultrasound examination is a non-invasive examination (not using a needle or injection). Ultrasound examination is painless and easily tolerated by most patients. Ultrasound is widely available, easy to use and the cost is cheaper than other imaging methods. Ultrasound imaging is very safe and does not use ionizing radiation that is harmful to the body. Ultrasound provides real-time imaging, making it a good modality for guiding minimally invasive procedures such as biopsy needles and aspiration needles.[2, 4, 6-8]

Speckle noise is granular (multiplied) or multiplicative noise, which inherently exists and decreases ultrasonography images.[9] Speckle noise occurs because of many scattering in each image cell resolution that reflects the return of sound waves to the sensor ultrasound. Scattering of coherent waves of different phases experiences constructive and destructive interference at random.[8, 10] On visual inspection, speckle noise consists of relatively high gray level intensities, qualitatively dominated by hyperechoic (light) and hypoechoic (dark).[11]

Concerning the ultrasound image experiencing degradation due to noise, causing speckle noise to become one of the serious and major problems in image interpretation.[8, 12] The process of speckle-noise reduction is very necessary to increase the SNR value, image contrast, visualizing the anatomy of organs and increasing the accuracy of object detection without eliminating important diagnostic features from images.[8] Therefore we need a digital image processing method to reduce speckle noise, to produce high-quality image data.[12]

The DsFlsmvDenoising technique stands for Despeckle filter (DsF), local statistics (ls), mean (m) and variance (v). [13] This technique is the most appropriate filter technique to improve optical perception in the evaluation of ultrasound images and videos. Using this denoising technique reduces the number of speckle-noise variants in the image, improves the statistics and texture of feature extraction, increases the accuracy of the classification and overall image quality by increasing the edges of the image. Besides DsFlsmvsmoothes the image without damaging the details.[14, 15]

METHOD

Type and Design of Research

This study is a comparative analytic study with a quasi-experimental research design using a Pretest Posttest without control groupdesign.[16] This study aims to analyze differences in the application of Despeckle filter local statistical mean variance (DsFlsmv) techniques towards image quality and anatomical information on pancreatic ultrasound.

Population and Samples

The target population in this study were all healthy adult volunteers who were willing to take part in the study. The sampling method used in this study is nonprobability sampling by purposive sampling with certain considerations by the desired research objectives. The number of samples used in the study was 32 samples, with the normal body mass index (BMI) category.[17]

DATA ANALYSIS

Qualitative Analysis

Assessment of anatomical information on post-denoising pancreatic ultrasound image between the window size 3x3 and the window size 5x5 was performed by three respondents (radiologists). Visual assessment by observing the level of visibility of the head, body, and tail of the pancreas using 4 (four) levels of numerical grading, by giving a value of 1,2,3 or 4, with a score of 1: Not visible (Pancreas objects were assessed as invisible, very blurred, unclear boundaries and could not be analyzed), score 2: Poor (Objects of the pancreas that are judged to be vague, blurred with boundaries are still visible and difficult to analyze), score 3: Adequate (Objects of the pancreas that are judged seem quite clear, with boundaries quite clear and can be analyzed) and score 4: Good (The object of the pancreas that is assessed seems clear, with clear boundaries and is easy to analyze).[18]Then a conformity test (interobserver agreement test) is carried out using the Cohen Kappa Test at the level of "good agreement", followed by a bivariate test using the Friedman Test both overall and per anatomic criteria. The hypothesis is accepted if the p-value <α (0.05), which means there is a difference in information on the post-denoising pancreatic ultrasound image between the 3x3 window size and the 5x5 window size, while to get the most optimal image using the mean rank from the Friedman Test results.

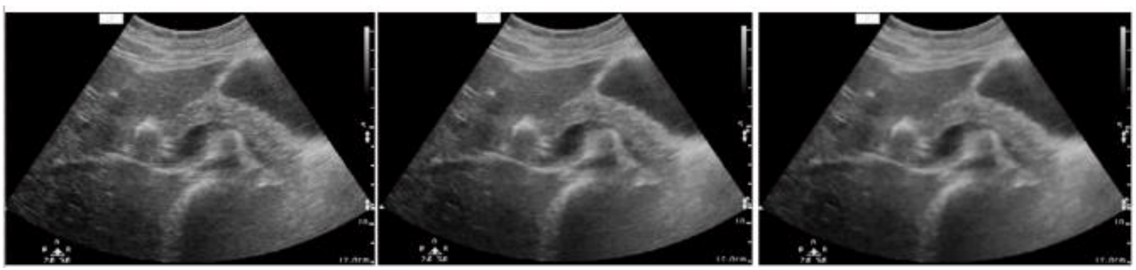
Quantitative Analysis

Quantitative data analysis was performed by comparing MSE and PSNR values on pancreatic ultrasound images between post-denoising Dsflsmv window size 3x3 and window size 5x5. The results of the MSE value are close to zero and the PSNR is more than 40dB, indicating that the Dsflsmv-degenerated image produces optimal image quality.

RESULTS

Qualitative Analysis

An assessment of differences in anatomical information on pancreatic ultrasound images between pre-denoising images, post-denoising window size 3x3 images and post-denoising window size 5x5 images is qualitatively carried out with visual assessments by radiologists, with the following results:



A B C

Figure 1.Pre-denoising and post-denoising pancreatic ultrasound image A. Pre-denoising image B. post-denoising window size 3x3 image C. Post-denoising window size 5x5 image

Assessment to determine differences in anatomic information on pancreatic ultrasound images as a whole as well as per anatomical criteria for pancreatic anatomy from pre-denoising images, post-denoising window size 3x3 images, and post-denoising window size 5x5 images was conducted by Friedman test. Friedman's test results of anatomical information on pancreatic ultrasound images as the whole anatomy are shown in the following table 1:

Table 1 Friedman Test Results in Anatomical information of pancreatic ultrasound images overall anatomy of pre-denoising images, post-denoising window sizes 3x3 and post-denoising window sizes 5x5.

Pancreatic Ultrasound Image	Mean rank	*p-value*
Pre-denoising	1,73	<0,001
Post-Denoising Size window 3x3	2,82	
Post-Denoising Size window 5x5	1,45	

Based on the Friedman test results in the above table, it can be concluded that there are significant differences in the anatomic information of the pancreatic ultrasound image as a whole, the anatomy of the pre-denoising image, the post-denoising window size 3x3 image and the post-denoising window size 5x5 image. with a p-value <α (0.05). Where the highest mean rank value is 2.82 in the post-denoising dsflsmv window size 3x3 image. Thus it can be concluded that overall the anatomy of a Post-denoising window size 3x3 pancreatic ultrasound image is the image with the most optimal anatomical information.

Furthermore, the results of the Friedman test information on the anatomy of pancreatic ultrasound images per anatomical criteria are shown in the following table 2:

Table 2. Friedman Test Results in anatomical information on pancreatic ultrasound images per anatomical criteria from pre-denoising images, post-denoising window sizes 3x3 and window sizes 5x5

No	Anatomical Criteria	Pancreatic Ultrasound Image	Mean rank	Significance
1	*Head*	*Pre-denoising*	1,64	<0,001
		Post-denoising Size window 3x3	2,75	
		Post-denoising Size window 5x5	1,61	
2	*Body*	*Pre-denoising*	1,63	<0,001
		Post-denoising Size window 3x3	2,95	
		Post-denoising Size window 5x5	1,42	
3	*Tail*	*Pre-denoising*	1,80	<0,001
		Post-denoising Size window 3x3	2,80	
		Post-denoising Size window 5x5	1,41	

Based on the Friedman test results in the above table, it can be concluded that there are significant differences in the anatomic information of pancreatic ultrasound images per anatomic criteria from pre-denoising images, post-denoising window size 3x3 images and post-denoising window size 5x5 images. with a p-value <α (0.05). Where the highest mean rank of anatomical criteria are 2.75, 2.95 and 2.80 respectively in the post-denoising dsflsmv window size 3x3 image. Thus it can be concluded that in terms of anatomical criteria, the ultrasound image of the pancreas Post-denoising window size 3x3 is the image with the most optimal anatomical information.

Quantitative Analysis

The assessment of observed image quality is the magnitude of the Mean Square Error (MSE) value and the Peak Signal to Noise Ratio (PSNR) value of the pancreatic ultrasound image after denoising the Despeckle Filter Local Statistic Mean Variance (DsFlsmv) value between window size 3x3 and window size 5x5 variations. The optimal image has a PSNR value ≥40 dB or the highest compared to the PSNR value of other images and at MSE is the image that has the lowest value compared to other images or close to 0 (zero).

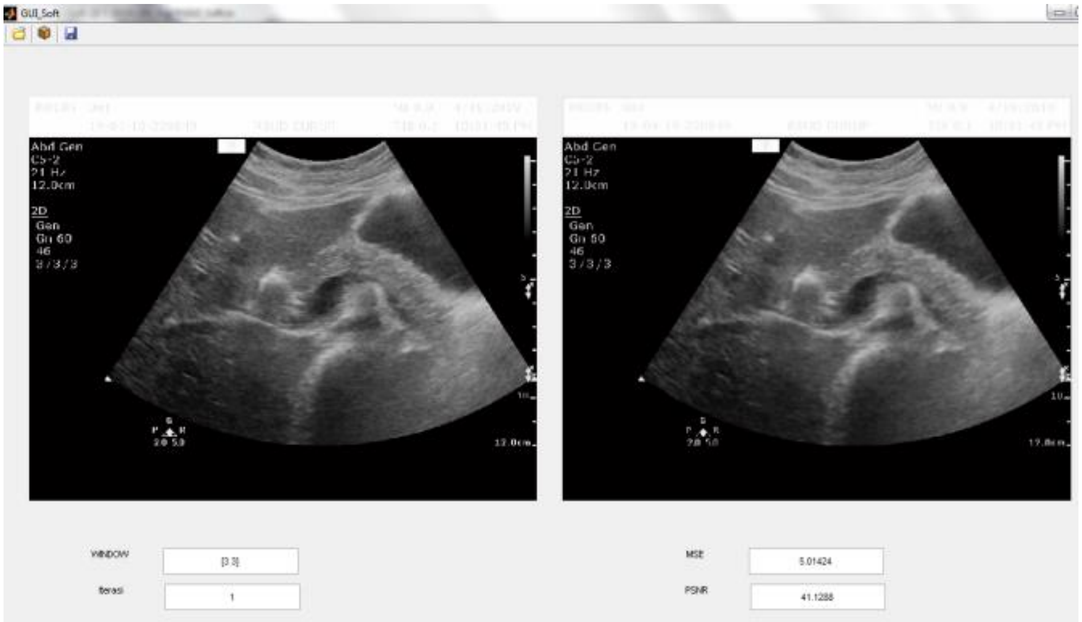


Figure 2.Display of DsFlsmv's Graphical User Interface (GUI) technique

Based on the measurement results from the Graphical User Interface (GUI) of 32 samples of pancreatic ultrasound images, the values of Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) are varied. The MSE and PSNR values of the pancreatic ultrasound image are found in the following table:

Table 5. Value of Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) on USG images of pancreas post-denoising window size 3x3 and post-denoising window size 5x5

IMAGE	MSE		PSNR	
	***Size Window* 3x3**	***Size Window* 5x5**	***Size Window* 3x3**	***Size Window* 5x5**
1	5.0142	10.4959	41.1288	37.9206
2	5.0373	10.6225	41.1088	37.8685
3	4.7430	9.5583	41.3703	38.3270
4	4.9229	10.2350	41.2086	38.0299
5	5.5252	13.2868	40.7073	36.8966
6	4.8114	10.4470	41.3081	37.9409
7	4.3673	9.1850	41.7286	38.5000
8	5.1726	11.5433	40.9937	37.5075
9	4.8845	10.7722	41.2426	37.8078
10	5.4392	11.3989	40.7755	37.5622
11	4.2727	9.0537	41.8238	38.5625
12	5.1272	10.6977	41.0320	37.8379
13	5.3236	11.0387	40.8688	37.7016
14	5.2296	10.9035	40.9461	37.7551
15	5.8018	12.4592	40.4952	37.1759
16	5.0009	10.3839	41.1403	37.9672
17	5.5831	12.1605	40.6621	37.2813
18	5.4550	11.6886	40.7628	37.4532
19	4.9591	10.4734	41.1768	37.9299
20	5.4253	11.6180	40.7865	37.4795

21	5.1119	10.9419	41.0450	37.7399
22	4.9595	10.4064	41.1764	37.9578
23	5.0838	10.4569	41.0689	37.9368
24	5.2420	10.9198	40.9358	37.7487
25	5.2850	11.4597	40.9004	37.5391
26	5.5942	12.2626	40.6534	37.2450
27	5.0398	10.6503	41.1067	37.8572
28	5.3720	11.5297	40.8295	37.5126
29	4.3633	8.9532	41.7327	38.6110
30	5.0253	10.5450	41.1191	37.9003
31	4.1761	8.6774	41.9231	38.7469
32	4.6735	9.8903	41.4344	38.1787

Tabel - 6. The results of the calculation of the MSE and PSNR values on pancreatic ultrasound images between the post-denoising dsflsmv window size 3x3 and window size 5x5.

Image	MSE		PSNR	
	Mean	***p-value***	**Mean**	***p-value***
Post-Denoising Size window 3x3	5,063197	<0,001	41,099753	<0,001
Post-Denoising Size window 5x5	10,772353		37,827472	

Based on the above table, it can be seen that there are significant differences in the MSE and PSNR pancreatic ultrasound images values between the post-denoising dsflsmv window size 3x3 and window size 5x5 with p-value <α (0.05). Where the lowest MSE mean value is 5.063197 and the highest PSNR mean value is 41.099753 on the post-denoising dsflsmv window size 3x3 image. So from these results, it can be concluded that the optimal MSE and PSNR values of pancreatic ultrasound images on post-denoising dsflsmv window size 3x3.

DISCUSSION

The Dsflsmv technique is a denoising technique that is useful in reducing noise speckles in ultrasonographic images. Based on the mean rank value in the Friedman test, the results show that the post-denoising window size 3x3 image produces the most optimal anatomic information of pancreatic ultrasound images both overall and per pancreatic anatomical criteria. This is because the process of denoising the DsFlsmv technique with a window size 3x3 can effectively and efficiently reduce the speckle noise contained in the image and not eliminate the detailed structure of the original organ. The DsFlsmv technique not only reduces noise in the organs of the pancreas but also reduces noise in other organs that are around the pancreas, such as the stomach and intestines. So that the head (head), body (body) and tail (tail) of the pancreas also look more optimal.

The results of the DsFlsmv post-denoising image window size 3x3 produce smoother images, with a level of granular spots that tend to decrease. With the reduction of granular spots, the structure of the pancreatic tissue can be seen more optimally with the edges of the organs that appear sharper and firmer. The results of this study are also following previous studies that state that the use of small size windows can improve the quality of USG images without eliminating anatomical details and structures because in the use of small size windows the values of image pixels change but do not eliminate the original image information.[14]Using this denoising technique reduces the number of speckle noise variants in the image, improves the statistics and texture of feature extraction, increases the accuracy of the classification and overall image quality by increasing the edges of the image. Besides DsFlsmvsmoothes the image without damaging the details.[14, 15]

In the ultrasound image of the pre-denoising pancreas, an image that looks more coarse is produced, with the level of granular spots that tends to increase. Granular spots spread evenly throughout the organs of the pancreas and other organs around it so that the structure of the pancreatic tissue looks not optimal and the margins of the pancreas do not look sharp.

The results of a post-denoising window size 5x5image produce an image that looks smoother than a window size 3x3image. The structure of organ tissues and the margins of the pancreas appear blurred. Increased blurring due to the process of refinement of excessive image pixels associated with the size of the window size matrix used.

The results of this study are following previous studies that stated that the despeckle noise technique has a high sensitivity to the use of window size and shape. The use of various window sizes greatly affects the quality of the image being processed. If the window size is too large, the image refinement process will occur, the image details will be lost and the edges of the edges will be blurred. On the other hand, the small window size will reduce the filter's ability to flatten (refine) noise and will not reduce speckle noise to make filter performance ineffective. In a homogeneous area the larger the window size, the more efficient the filter is in reducing noise. In heterogeneous regions, the smaller the window size, the more it is possible to keep the image smooth and the image details unchanged.[19]

In ultrasound imaging, many factors can cause a decrease in image quality. Noise in a digital image is a very common problem and is a major factor influencing the results of processing an autonomous machine. While speckle noise is the dominant type of noise found in ultrasonographic images.[20] Speckle noise appears as a granular pattern formed by constructive and destructive signal interference from ultrasound wave backscattering, substantially reducing contrast and blurring the details of an image.[21]

Pancreatic ultrasound images still have noise compositions known as speckle noise. To reduce speckle noise and improve the quality of the pancreatic ultrasound image, noise reduction techniques are needed. The method of denoising pancreatic ultrasound images used is the DsFlsmv technique. The denoising mechanism of the DsFlsmv technique begins with the mean filter, which is also known as the neighborhood average method. The principle of this method is to replace the grayscale value of the middle pixel with the average grayscale value of the environmental pixel. The DsFlsmv technique works to smooth an image, namely by reducing the intensity variation between adjacent pixels. The mean is a simple moving window spatial filter, which replaces the center window value with the average value of the environment pixel including the value of the center window. This process is implemented with a convolution mask, which is the result of a weighted number of neighboring pixel and pixel values, also called a linear filter. In this filtering technique, very similar regions (ie having similar statistics) of an image are replaced by local mean values, while regions with different characteristics do not change. Weighted statistics of an image are calculated by applying the LSMV filter with odd window sizes varying from 3 × 3 - 15 × 15.[19, 22] and frequently used 3 × 3 windows. Furthermore, the speckle model is a multiplicative noise and can use local statistics effectively in maintaining edges. This is based on the approach that if the variance in a region is low or constant, then the refinement process will not be carried out, but the refinement process is carried out if the variance is high (near the edge). If there is no smoothing, the filter only produces an average intensity value from the filter window.[20, 22]

Using this denoising technique reduces the number of speckle noise variants in the image, improves the statistics and texture of feature extraction, increases the accuracy of the classification and overall image quality by increasing the edges of the image. Besides, DsFlsmv refines images without damaging the details.[14, 15] This is following previous research also states that the application of the Dsflsmv technique is the best performing despeckle technique compared to other despeckle filter techniques. The DsFlsmv technique has also been shown to improve the accuracy of blood vessel structure and carotid atherosclerotic plaque segmentation and to improve the quality of the carotid artery (CCA) artery images. Where the results of visual evaluation by experts on the imaging of the common communist artery (CCA) DsFlsmv technique is the best technique in image denoising techniques.[14]

In addition to the visual assessment of the radiologist, the evaluation of DsFlsmvdenoising image processing performance is done by looking at the MSE and PSNR values for error sensitivity or image quality measurement measures. The lower the MSE value, the better the image produced, while the higher the PSNR value, the better image reconstruction.[23] Based on the results of the research that has been done, it can be concluded that there is a difference in the MSE values in the pancreatic ultrasound image after denoisingDsFlsmv between 3x3 window size variations and 5x5 window size. It can be concluded that there is a difference in the size of the window concerning the MSE value. Where the smaller the window size used, the lower the MSE value. In this study, the image with a window size 3x3 shows a low / near-zero the MSE value of 5.063197 compared to the MSE value of a 5x5 window size of 10.772353.

MSE is the average value of the error squared difference in the value of pixels in an image, that is, between the original image pixel and the compressed image pixel. A good image has an MSE value which is in a position close to 0 (zero).[24] A small MSE value will give a low error so that it will improve the image quality for the better.[25]

This is following the results of previous studies which state that the larger the size of the window used, the higher the average level of error of an image it has an impact on image quality deterioration. This is because the window size represents the area of the pixel matrix that is experiencing denoising. The greater the area of the matrix pixel denoising, the image will appear smoother and tend to be more blurred than the original image or the image of smaller window size.[19] In another study, it was mentioned that the use of DsFlsmvdenoising techniques in CCA examination results in the smallest MSE value so that the image is better.[14]

Meanwhile, based on the assessment of image quality on PSNR values, it is known that there are differences in PSNR values on pancreatic ultrasound images after DsFlsmv denoising between 3x3 window size variations and 5x5 window sizes, namely 41.099753 and 37.827472. Thus it can be concluded that there is an effect of window size on the magnitude of the PSNR value. Where the smaller the window size used, the higher the PSNR value.

PSNR is the ratio between the maximum possible power of the signal and the maximum possible power of noise. A higher PSNR value indicates good image quality and if the PSNR value is lower then the image is of poor quality.[24]PSNR values below 30 dB indicate relatively low image quality, where distortion caused by noise insertion is visible. However, image quality is said to be high when PSNR is> 40 dB.[26]Based on the PSNR calculation results for the two images, it shows a high PSNR value in the range of 41.099753 dB or more than 40 dB. PSNR calculation results in this study are relatively the same compared to previous studies applying DsFlsmvdenoising techniques in the examination of communis carotid artery (CCA).[14]

The use of image processing in imaging modalities is an important part of the improvement effort, especially the reduction in the effect of noise in the image. From this research, a new denoising image processing method is tried which is applied to the pancreatic ultrasound image with variations in window size, namely the DsFlsmvdenoising technique. Where this technique can efficiently reduce noise, maintain texture and detail in the image. The use of this technique can improve image quality and can be used for ultrasound examination on other organs.

CONCLUSION

Based on the results and discussion in this study, it can be concluded that the application of Despeckle filter local statistical mean variance (DsFlsmv) techniques with variations in window size 3x3 and window size 5x5 causes differences in the results of pancreatic ultrasound anatomical results both overall anatomy and per pancreatic anatomical criteria.

The application of the Despeckle filter local statistical mean variance (DsFlsmv) technique with variations in window size 3x3 and window size 5x5 causes differences in image quality results including MSE values and PSNR values of pancreatic ultrasound images.

RECOMMENDATION

The DsFlsmv technique is a computer program application that has good performance and is efficiently able to reduce speckle noise and maintain the texture of pancreatic ultrasound organ tissue images in the normal category of Body Mass Index (BMI). However, further research needs to be done on the Body Mass Index (BMI) with other categories and in patients with pancreatic pathology.

This study has limitations, namely denoising techniques carried out only focusing on the pancreatic ultrasound image of healthy volunteers, with young adult age and with the category of normal Body Mass Index (BMI). And it has not been done in patients with a history of pathology and other Body Mass Index (BMI) categories.

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