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Research Article

FACTORS THAT ARE DETERMINANT IN THE PREPARATION OF EFFECTIVE AND RELIABLE COLONOSCOPY: A PROSPECTIVE CLINICAL STUDY FROM A SINGLE CENTER

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ABSTRACT

Objective: Adequate bowel preparation is crucial for the effective diagnosis and treatment of colorectal diseases prior to undergoing a colonoscopy. This study aims to assess the significance of preparation for colonoscopy and to identify factors that influence its effectiveness positively or negatively.

Materials and Methods: The study included all patients who underwent colonoscopy at the Endoscopy Unit of the Gastroenterology Clinic at Aydın Adnan Menderes University Hospital from January 2021 to January 2022.

Results: A total of 303 patients participated in the study, comprised of 155 females and 148 males. It was found that Laxeno/Sennozid A+B Calcium (Ca)-based preparations were the most commonly used (55.4%) for bowel cleansing. Evaluation of drug-related side effects revealed that nausea and vomiting were the most frequently reported issues, occurring in 45.6% of patients. The Boston bowel readiness scale assessment indicated that patients most often received scores of 2 and 3 across all colon segments. Statistically significant differences were observed in the parameters of creatinine and phosphorus between pre- and post-procedure assessments for those using Lax phosphosode/sodium phosphate. Similar differences were noted for the Ca parameter in patients using pegdine/polyethylene glycol (PEG).

Conclusion: This study concluded that neither age nor gender significantly influenced the quality of bowel cleansing. Furthermore, when comparing the cleaning efficacy and side effects of various agents, no particular agent demonstrated superiority. Additionally, the potential for renal damage and electrolyte imbalances resulting from these agents was examined; post-usage evaluations indicated no impact following PEG use, while elevated phosphate levels were noted after sodium phosphate and senna usage, with creatinine levels rising after senna administration.

Key words: Bowel cleansing efficacy, Boston bowel preparation scale, Renal impairment

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INTRODUCTION

Colonoscopy is one of the endoscopic procedures performed for screening, diagnosis, and interventional purposes today. The purpose of colonoscopy is to visualize the colon up to the terminal ileum. For the diagnosis and treatment of colorectal diseases, it is very important that bowel preparation is sufficient before the colonoscopy procedure. Complete cleanliness of the intestine during the procedure increases the success of the examination and prevents the procedure from being performed again. If bowel preparation is not sufficient, this situation causes overlooking pathological lesions, if any, repetition of the procedure, loss of labor and time, cost increase and decrease in patient satisfaction (1).

Today, there are proven standard practices for adequate colon cleansing. Despite standard practices, adequate colon cleansing cannot be achieved in some patients. In studies investigating the reasons for this; A significant correlation was found between the time of initiation of the procedure, compliance with the preparation instructions, hospitalization, presence of constipation, male gender, history of comorbid diseases, and inadequate bowel preparation (2). In general, a low-fiber diet that avoids foods containing grains and other hard-to-digest substances is recommended for a few days before the procedure day, and this diet has been shown to be at least as effective as the clear liquid diet and has been associated with an increase in patient satisfaction (3). Nowadays, drugs used in bowel preparation include:

Polyethylene glycol (PEG), an isosmotic preparation containing a balanced electrolyte solution, is a high-molecular-weight polymer that is not absorbed in the intestinal mucosa. It minimizes fluid exchange in the colon membrane, helping to retain the electrolytes present in the solution and preventing their absorption. This prevents the development of systemic electrolyte imbalance. The patient is instructed to start PEG administration the evening before the procedure. A total of 4 liters of PEG solution should be consumed in divided doses. The first 2 liters should be consumed the night before, and the remaining 2 liters on the morning of the procedure, finishing at least 4 hours before the colonoscopy. Patients should also avoid solid food for at least 24 hours prior to the procedure (4).

Sodium phosphates are hyperosmotic preparations based on PEG and they are similar to intestinal preparations with magnesium citrate (5). It is generally well tolerated in healthy individuals (6). However, its

use is limited due to the potential for renal damage, even in patients with normal renal function. Acute phosphate nephropathy has been reported (7). Patients with heart failure, kidney damage, liver failure, electrolyte imbalance, or those taking diuretics are advised against using sodium phosphate. The recommended dose for sodium phosphate is two 45 mL doses. The first dose is taken the evening before the procedure, and the second dose is taken 4-6 hours before the procedure. Patients should drink plenty of water following each dose and remain hydrated throughout the preparation (8, 9).

Senna laxatives are containing anthraquinone derivatives, senna increases colonic motility and transit by acting on the intestinal mucosa. It also inhibits water and electrolyte secretion. Senna is often combined with PEG to enhance its effectiveness and reduce the amount of PEG used (10). Patients are instructed to take 2 tablets of Senna (15 mg) the evening before the procedure, followed by at least 2 liters of clear liquids. Additional hydration is recommended, and patients are advised to drink water or clear fluids up to 2 hours before the procedure (11).

Recording the quality of bowel preparation in colonoscopy reports is essential. The U.S. Colorectal Cancer Task Group describes a thorough examination as one in which residual colonic contents do not obscure lesions, except for small polyps (5 mm or less) (12). Various scoring systems have been developed to assess the quality of clinical colonoscopy preparations. The Aronchick Scale, Ottawa Bowel Preparation Scale, and Boston Bowel Preparation Scale (BBPS) are commonly used to evaluate bowel cleansing quality. The BBPS is a 10-point scoring system (ranging from 0 to 9) that assesses bowel preparation quality across three segments of the colon following all cleansing steps during colonoscopy and has been validated for both reliability and accuracy (13).

This study aimed to assess the significance of colonoscopy preparation and to identify factors that positively or negatively impact its effectiveness. With the results to be obtained in this study, we believe that identifying an optimal colonoscopy preparation method tailored to each patient can reduce the number of unnecessary procedures, enhance the procedure's success rate, and ultimately yield positive outcomes for both patient satisfaction and cost-effectiveness.

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MATERIALS AND METHODS

This study was approved by Aydın Adnan Menderes University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee's decision dated 24.03.2022, number 12 and protocol number 2022/30, and was carried out in Aydın Adnan Menderes University Practice and Research Hospital Gastroenterology Clinic Endoscopy Unit. It is a descriptive and analytical-cross-sectional type research. The research was conducted between January 2021 and January 2022. All patients who underwent colonoscopy between January 2021 and January 2022 were included in the study.

All colonoscopies in this study were performed by the same experienced endoscopist to ensure consistency in the procedure and minimize variability in outcomes.

As data collection tools, a survey form prepared by the researcher, developed in line with the relevant literature, and the Boston colonoscopy preparation evaluation scale will be used. Data will be obtained by scanning patient files. Patients' age, gender, height, weight, body mass index (BMI), comorbid disease history (diabetes mellitus, coronary artery disease, Parkinson's disease, cerebrovascular accident, Alzheimer disease, etc.), number of medications used, indication for colonoscopy, family history, side effects due to medications (nausea, vomiting, abdominal pain/bloating, weakness, dizziness/lightheadedness), enema use status and the colonoscopy preparation method they used will be recorded. Changes in the balance of urea, creatinine, sodium, potassium, calcium, and phosphorus will be evaluated in patients before and after colonoscopy. After the colonoscopy procedure, colonoscopy reports will be examined and the adequacy of colonoscopy cleaning will be recorded using the Boston colonoscopy preparation evaluation scale. In the study, the relationship between colonoscopy preparation and age, gender, height, weight, BMI, comorbid disease history, number of medications used, and preparation method applied will be evaluated. In addition, changes in electrolyte, renal functions, and phosphorus balance after colonoscopy will be evaluated and their relationship with age, gender, height, weight, BMI, comorbid disease history, number of medications used, and preparation method applied will be examined.

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Research data were analyzed using the SPSS 21.0 statistical software. The normality of continuous variables was assessed through visual methods (histograms and probability plots) as well as analytical tests (Kolmogorov-Smirnov and Shapiro-Wilk). For the descriptive statistics, the mean and standard deviation were used for data following a normal distribution, while the median and range (minimum-maximum) were applied to data that did not follow a normal distribution. The Chi-square test was employed to examine differences between categorical variables. The Student's t-test or One-Way ANOVA was used to compare continuous variables with parametric properties across independent groups, while the Mann-Whitney U test or Kruskal-Wallis ANOVA was used for non-parametric continuous variables. Pearson's test was applied for correlations involving parametric continuous variables, and Spearman's test was used for non-parametric continuous variables. A p-value of less than 0.05 was considered statistically significant.

Scoring in the BBPS score is as follows: 0 (inadequate), unprepared colon segment where the mucosa cannot be evaluated due to solid stool that cannot be cleared; 1 (poor), some of the mucosa in the colon segment is visible, but other areas of the colon segment are poorly visible due to staining, residual stool, and/or opaque fluid; 2 (good), good visualization of the colonic mucosa but few debris, small pieces of stool and/or opaque fluid; and 3 (excellent), good visualization of the entire mucosa of the colon segment, no debris, small pieces of stool or opaque fluid (Fig. 1).

RESULTS

A total of 303 patients, 155 women and 148 men, were included in this study. The average age of the patients was 59.5±14.7 years and the average BMI was 27.6±4.5. When the education and income status was evaluated, the rate of those with high school education or higher was found to be 37.0%, and the rate of those whose income was less than the expenses was 29.7%. It was determined that 70.3% of the patients used medication constantly, 70.3% had a comorbid disease, and 10.2% had a family history of colon cancer (Table 1).

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Table 1. Demographic and Clinical Characteristics of the Patients

		n	Mean ± SD
Age (min=21.0, max=97.0)		303	59.5±14.7
BMI (min=10.7, max=45.7)		303	27.6±4.5
		n	**%**
Gender	**Female**	155	51.2
	Male	148	48.8
Education level	**Below high school level education**	191	63.0
	High school and above education level	112	37.0
Income level	**Income less than expenses**	90	29.7
	Income equal to or greater than expenses	213	70.3

History of colonoscopy was evaluated in the patients. It was determined that 41.3% of the patients had previously undergone colonoscopy. The medications administered to patients for intestinal cleansing were evaluated. It was determined that laxeno/sennozid A+B calcium-containing preparations, pegdin/PEG (23.1%) and lax phosphosoda/sodium phosphate (21.5%) were most frequently used for intestinal cleansing (55.4%).

Table 2. Bowel Cleansing Medications and Associated Side Effects

		Bowel cleansing medication						**p**
		Lax Phosphosoda/Sodium Phosphate		**Laxeno/Sennozid A+B Calcium**		**Pegdin/PEG**		
		n	**%**	**n**	**%**	**n**	**%**	
Drug side effect	**No**	23	35.4	76	45.2	32	45.7	0.353
	Yes	42	64.6	92	54.8	38	54.3	
Side effects associated with bowel cleansing medication	**Abdominal pain**	18	42.9	38	41.3	11	28.9	0.334
	Nausea and vomiting	18	42.9	43	46.7	18	47.4	
	Dizziness	3	7.1	5	5.4	7	18.4	
	Other	3	7.1	6	6.5	2	5.3	

PEG: Polyethylene glycol

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When drug-related side effects were evaluated, it was observed that the patients most frequently experienced nausea and vomiting (45.6%). Side effects were detected at a rate of 64.6% in those using lax phosphosoda/sodium phosphate for bowel cleansing, in 54.8% in those using laxeno/sennozid A+B calcium drug, and in 54.3% in those using pegdin/PEG drug. However, no statistical significance was found between the groups. Among the side effects, nausea and vomiting were observed to be the most common side effects in all three drugs (Table 2).

Table 3. Biochemistry Changes Before and After Colonoscopy

			Before the procedure				After the procedure				p
		n	Avarage	SS	Min	Max	Avarage	SS	Min	Max	
Lax Phosphosoda/Sodium Phosphate	Urea	28	30.33	14.64	7.,00	71.00	30.57	18.33	8.00	110.00	0.799
	Creatinine	28	0.87	0.32	0.47	1.99	0.94	0.42	0.57	2.60	0.389
	Sodium	27	139.66	1.96	135.00	143.00	138.81	2.90	133.00	143.00	0.072
	Potassium	27	4.35	0.55	3.40	5.20	4.12	0.54	2.90	5.10	0.086
	Phosphorus	7	3.41	0.64	2.50	4.50	4.98	2.22	3.80	10.00	**0.027**
	Calcium	20	9.27	0.39	8.20	9.90	9.16	0.65	7.60	10.30	0.344
	Magnesium	12	1.87	0.14	1.49	2.03	2.23	0.86	1.73	4.70	0.450
Laxeno/Sennozid A+B Calcium	Urea	56	30.17	13.09	8.90	59.00	29.14	14.54	9.00	107.00	0.658
	Creatinine	63	0.84	0.19	0.53	1.50	0.89	0.26	0.58	2.05	**0.013**
	Sodium	56	138.85	2.52	133.00	144.00	138.17	2.87	125.00	143.00	0.081
	Potassium	56	4.36	0.51	1.97	5.10	4.33	0.50	3.10	5.80	0.310
	Phosphorus	26	3.36	0.85	1.20	4.70	4.16	1.44	2.00	10.00	**0.008**
	Calcium	46	9.18	0.52	8.00	10.90	9.31	0.52	8.30	10.40	0.069
	Magnesium	28	1.86	0.22	1.47	2.28	1.88	0.20	1.47	2.20	0.493
Pegdin/PEG	Urea	25	36.56	21.97	7.00	107.00	41.00	44.66	10.00	227.00	0.819
	Creatinine	28	0.96	0.40	0.44	1.83	0.99	0.44	0.56	2.23	0.316
	Sodium	25	139.92	2.88	132.00	144.00	139.68	4.32	130.00	148.00	0.635
	Potassium	25	4.50	0.47	3.70	5.80	4.42	0.50	3.50	5.50	0.240
	Phosphorus	12	3.72	1.27	2.00	6.30	3.55	0.71	2.10	4.50	0.666
	Calcium	21	8.85	0.72	6.70	9.80	9.15	0.72	7.10	10.20	**0.016**
	Magnesium	8	1.96	0.13	1.78	2.18	1.85	0.36	1.06	2.24	0.362

PEG: Polyethylene glycol

The BBPS applied to the patients was evaluated. It was observed that patients most frequently received scores of 2 and 3 from all colon segments. Additionally, biochemistry parameters were evaluated before and after the colonoscopy procedure. A statistically significant difference was detected between before and after the procedure in terms of creatinine, Na, K, P and Ca parameters. Biochemistry parameters were evaluated before and after colonoscopy according to the drugs used for bowel cleansing. There was a statistically

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significant difference in terms of P parameter between before and after the procedure in those using the drug Lax phosphosoda/sodium phosphate, creatinine and P parameters between before and after the procedure in those using the calcium drug laxeno/sennozidA+B, and Ca parameter between before and after the procedure in those using the drug pegdin/PEG. A difference was detected (Table 3).

Table 4. BBPS Scores and Associated Factors

		n	%
Left colon	**A part of the intestine cannot be visualized in the colonoscopy due to solid stool (0 point).**	15	5.0
	Presence of liquid or semi-solid stool in a part of the intestine (1 point).	62	20.5
	The inner surface of the intestine (mucosa) is clearly visible and there is a small amount of stool (2 points).	133	43.9
	The inner surface of the intestine (mucosa) is excellently visualized and there is no liquid (3 points)	93	30.7
Transverse colon	**A part of the intestine cannot be visualized in the colonoscopy due to solid stool (0 point).**	8	2.6
	Presence of liquid or semi-solid stool in a part of the intestine (1 point).	58	19.1
	The inner surface of the intestine (mucosa) is clearly visible and there is a small amount of stool (2 points).	140	46.2
	The inner surface of the intestine (mucosa) is excellently visualized and there is no liquid (3 points)	97	32.0
Right colon	**A part of the intestine cannot be visualized in the colonoscopy due to solid stool (0 point).**	22	7.3
	Presence of liquid or semi-solid stool in a part of the intestine (1 point).	81	26.7
	The inner surface of the intestine (mucosa) is clearly visible and there is a small amount of stool (2 points).	118	38.9
	The inner surface of the intestine (mucosa) is excellently visualized and there is no liquid (3 points)	82	27.1

According to age; BBPS scores were evaluated according to body mass index (over or below 65 years of age), according to education level, income level, presence of comorbid diseases, family history of colon cancer, and colonoscopy history. No statistically significant difference was detected in terms of BBPS scores of these parameters. BBPS scores were evaluated according to the medications used for bowel cleansing. No statistically significant difference was detected in terms of BBPS scores between those using lax

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phosphosoda/sodium phosphate, laxeno/sennozide A+B calcium and pegdin/PEG drugs for bowel cleansing. Demographic data, presence of comorbid disease, family history of colon cancer, and colonoscopy history were evaluated among those with adequate and inadequate bowel cleansing according to BBPS. There was no statistically significant difference between those with adequate and inadequate bowel cleansing in terms of demographic data, presence of comorbid diseases, family history of colon cancer and colonoscopy history (Table 4).

DISCUSSION

Colonoscopy is the gold standard method in the diagnosis and treatment of the lower gastrointestinal system. Intestinal preparation has an important place to increase the success of the procedure and prevent repeat procedures. In this study, we evaluated the factors affecting the effectiveness and reliability of bowel preparation and investigated what needs to be done for optimal preparation. The goals of ideal bowel preparation are: the fecal content should be safely evacuated from the colon, the appearance and histology of the colon mucosa should not be affected, cleaning should be achieved in a short period of time, cleaning should be comfortable, and cleaning should not cause significant changes in the fluid and electrolyte balance (14).

It has been shown in the literature that the success of the colonoscopy procedure is affected by many factors such as age, gender, comorbid disease, the agent used in preparation, and the patient's compliance with the procedure (15). Due to insufficient cleaning during the colonoscopy procedure, the procedure cannot be performed optimally and the procedure may need to be repeated. In the study conducted by Ness et al., an inadequate colon cleansing was reported in 21.7% of colonoscopies (16). In their study, Kaplan et al. reported that among all colonoscopy procedures, the excellent cleaning rate was 38%, the good cleaning rate was 17%, the average cleaning rate was 26%, and the poor cleaning rate was 19% (17). When the colonoscopy procedures in our study were evaluated, it was found that there was inadequate bowel cleansing at a rate of 25.4%. In different studies, it has been found that the rates of bowel cleansing in procedures are different. We think that this difference in the literature may depend on the sociocultural and socioeconomic characteristics of the society in the regions where the studies were conducted, as well as the difference in the agents used before the

procedure in the center where the procedure was performed, and the experience of the team following the procedures.

It is thought that age and gender differences of the patients may also be factors in inadequate bowel cleansing. Özkan et al. reported in their study that they found that bowel preparation worsened as age increased (18). In their study evaluating gastrointestinal endoscopic interventions in elderly patients, Kandemir et al. reported that bowel preparation worsened with age, and that this deterioration was especially significant in individuals over the age of 80 (19). Unlike these studies, there are also studies in the literature reporting that there is no relationship between age and bowel cleansing (20). Regarding the relationship between gender and bowel cleansing; there are also studies reporting that there is no difference between genders, while there are studies stating that male gender is significant in insufficient bowel cleansing (21). In our study, we found that there was no statistically significant difference when bowel cleansing rates were compared between age and gender groups. When the effect of education level on bowel cleansing was evaluated, Karayel et al. reported that they did not detect a statistically significant difference (22). In our study, consistent with the literature, no statistically significant difference was detected between bowel cleansing quality and educational status.

When comorbidities in patients undergoing the procedure were evaluated, no statistically significant relationship was found between the presence of comorbidities and the quality of bowel cleansing. Görücü et al. (20) reported that there was no statistically significant difference between the presence of comorbid disease and the quality of bowel cleansing. Unlike other studies, Karayel et al. only evaluated the relationship between the presence of diabetes mellitus (DM) and the quality of bowel cleansing and reported that the presence of DM negatively affected the quality of bowel cleansing, regardless of the agent used (21). In our study, no statistically significant difference was found between the presence of comorbid disease and the quality of bowel cleansing.

It is thought that the agents used for bowel cleansing may affect the quality. The aim of the studies is to reveal the advantages and disadvantages of the agents used. In their study comparing the quality of intestinal cleansing with the use of sodium phosphate and sennozide, Sücüllü et al. reported that adequate cleansing

quality was achieved with both agents and that sodium phosphate was more easily tolerated by patients (15). In another study comparing sodium phosphate, sennoside and PEG, it was reported that all three were similar in terms of effectiveness and reliability (22). In our study, consistent with the literature, no statistically significant difference was detected between the agents in terms of bowel cleansing quality.

When the side effects in the patients were evaluated in our study, an average of 56.8% side effects was found. The most common side effects were nausea and vomiting in 45.9% and abdominal pain in 39%. When they compared the sodium phosphate and sennoside groups in terms of side effects, Sücüllü et al. reported that the sodium phosphate group was more easily tolerated (15). In our study, it was determined that there was no statistically significant difference when the side effects recorded and the agents used were compared.

There are many studies on the effects of agents used in colonoscopy preparation on fluid electrolyte balance. The advantages of PEG solutions are that they do not damage the colon mucosa and do not cause electrolyte imbalance. There are studies reporting that PEG can be used safely in patients with a history of heart failure, renal disease, decompensated cirrhosis and electrolyte imbalance (23). There are publications and case reports indicating that sodium phosphate application may cause renal parenchymal damage, which may progress to renal function decline, acute kidney injury and even end-stage renal failure, in addition to electrolyte disturbances, although the mechanism is not fully understood, and this situation is called "phosphate nephropathy" (24). There is no evidence that senna group agents cause electrolyte imbalance. Due to the high sugar content it contains, careful use is recommended in patients with impaired blood sugar regulation (12). In our study, there were sodium phosphate, PEG and sennozide usage groups, and kidney function values and electrolytes were evaluated. In the sodium phosphate group, phosphorus was found to increase significantly ($p=0.02$) in the post-procedure period. On the other hand, no significant change was detected in urea-creatinine values. These data support the view that nephrotoxicity may be associated with an increase in the dose used. In the group that underwent bowel cleansing with senna, a statistically significant increase in creatinine and phosphorus values was detected after the procedure. In the PEG group, no statistically significant changes were detected in kidney function tests and electrolytes.

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CONCLUSION

Colonoscopy is a gold standard method in diagnostic and therapeutic fields, and a successful intervention is possible with optimal colonoscopy preparation. For this reason, the endoscopy team's detailed evaluation of the patient's condition and choosing the most appropriate colonoscopy preparation method for the patient will increase the success rate of the procedure and reduce the rate of unnecessary repeat procedures. As a result, in this study, we found that age and gender have no effect on the quality of bowel cleansing. We found that there was no correlation between the increase in educational status and the quality of bowel cleansing. When the effects of the presence of comorbidities in patients were examined, we found that it had no effect on the preparation quality. However, in our study, no additional evaluation was made regarding specific comorbidities and whether these comorbid conditions were under control. When the difference in cleaning quality and the presence of side effects were evaluated between the agents used, no superiority over each other was determined. When renal damage and electrolyte imbalance that may develop due to the agents used were evaluated, it was determined that there was no effect after the use of PEG, phosphate was high after the use of sodium phosphate and senna, and creatinine was high after the use of senna. However, how long this imbalance that developed after the use of sodium phosphate and senna continued and the status of permanent damage were not evaluated. And the dose of the agents was not adjusted according to the characteristics of the patient group. We believe that clearer data on this subject can be obtained through studies with longer follow-up and different dosage adjustments.

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Authorship contributions

SI, AK and MHY designed the study; SI, YBT and İT collected the data and carried out statistical analysis; YBT performed the literature search; AK and MHY supervised the study; SI, YBT, İT and AK prepared and revised the manuscript. All authors gave the final approval of the version to be published.

Data availibity statement

Data availibity statement here

Declaration of competing interest

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics

This study received ethics committee approval from the non-invasive clinical research ethics committee of Aydın Adnan Menderes University Faculty of Medicine with protocol number 2022/30.

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