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Southwestern Türkiye's Aortic Aneurysm Overview: Surgical Outcomes and Epidemiological Insights from Denizli and Neighboring City Referrals

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Abstract

Objectives: Aortic aneurysms are significant health risks, particularly in regions with limited specialized care. Despite advancements in imaging and surgical techniques, disparities in healthcare access influence outcomes. This study evaluates epidemiological trends, procedural outcomes, and referral dynamics, aiming to improve care strategies for aortic aneurysm patients.

Materials and Methods: This retrospective study analyzed data from 699 patients treated for aortic aneurysms between 2010 and 2023 at a single referral cardiovascular center in Southwestern Türkiye. The dataset included information on patient demographics, referral sources, birthplace of patients, aneurysm classifications, procedural details, length of hospitalization, and mortality outcomes. Statistical analyses were performed to identify significant predictors of clinical outcomes, with a significance threshold of $p<0.05$.

Results: The cohort was predominantly male (79.26%) with a mean age of 61.89 years. Ascending aortic graft replacements (42.21%) were the most common procedures, followed by abdominal (25.32%) and thoracic (13.45%) repairs. The overall mortality rate was 18.60%, with higher rates in Afyonkarahisar (23.53%) and Burdur (21.43%). Denizli accounted for 56.51% of referrals, underscoring its central role in regional care.

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Abstract

Conclusion: High-volume centers like Denizli play a crucial role in managing complex vascular cases. Addressing healthcare disparities through improved referral systems and early detection strategies is essential for enhancing outcomes across Southwestern Türkiye.

Keywords: Aortic aneurysm, surgical outcomes, Southwestern Türkiye, referral patterns, vascular surgery, epidemiology

Introduction

Aortic aneurysms are a major global health problem, characterized by the abnormal dilation of the aorta, often remaining asymptomatic until rupture, dissection occurs, or significant compression of adjacent tissues, leading to high rates of morbidity and mortality[1,2]. Despite advances in diagnostic imaging and surgical techniques, the management of aortic aneurysms remains complex, especially in areas with limited access to specialized treatment centers and a coordinated healthcare system[3]. The world-wide prevalence of aneurysms is approximately 2% to 5% in adults, with a significantly higher incidence in men and elderly populations[4,5]. Ascending aortic aneurysms and abdominal aortic aneurysms are commonly encountered, while thoracic aortic aneurysms tend to present with more acute symptoms, necessitating urgent interventions[6-8]. Aortic aneurysms present unique epidemiological health care challenges in Türkiye. This is especially true in the southwestern region, including Denizli and surrounding cities. Denizli serves as the main referral centre. It welcomes patients from a variety of urban and rural areas. This dynamic of centralized health care highlights the importance of understanding population patterns. Forwarding route and outcomes of procedures to optimize care delivery[9,10]. Studies from developed countries highlight the role of high-volume centers in improving patient outcomes. However, such information from Türkiye and other developing regions remains limited[11]. Addressing this knowledge gap is critical to designing region-specific strategies that address inequalities in health care and outcomes[12,13].

Materials and Methods

This retrospective, observational study aimed to evaluate the epidemiological characteristics, surgical outcomes, and referral patterns for aortic aneurysms in Southwestern Türkiye. The study focused on patients treated at a tertiary care center in Denizli, which serves as a central referral hub for surrounding cities. The study was approved by Pamukkale University Non-Interventional Clinical Research Ethics Committee (approval no.: E-60116787-020-636206, date: 08.01.2025) ensuring adherence to the principles outlined in the Declaration of Helsinki.

Study Population: The study population comprised 699 patients diagnosed and treated for aortic aneurysms between January 2010 and December 2023. These patients were referred to Denizli from Denizli city itself and surrounding cities, including Aydın, Muğla, Manisa, Afyonkarahisar, Uşak, Kütahya, Burdur, Antalya, Isparta, and İzmir, as well as smaller neighboring regions. Data were collected from hospital electronic medical records and included age, gender, city of birth and residence. Type and location of the aneurysm, and procedure type. Length of hospital stay, mortality (in-hospital or within 30 days post-surgery), and procedural success rates. Cities with fewer than 2% of total patient referrals were grouped under "other cities" to streamline the analysis.

Procedural Types: Procedural types were classified into three main categories to ensure uniformity.

Ascending Aortic Operations: This category included ascending aortic graft replacements, hemiarch replacements, combined aortic and coronary artery procedures, and valve-sparing techniques.

Aortic Operations: This group comprised abdominal aortic aneurysm for elective aneurysm repair or rupture.

Thoracic Aortic Operations: These procedures involved thoracic aortic aneurysm repairs using endovascular approach.

The Preoperative Assessment: Including transthoracic or transesophageal echocardiography, computed tomography angiography, or magnetic resonance angiography, to provide comprehensive anatomical and functional data essential for guiding procedural planning.

The Primary Outcome Measures Included: Mortality rates, which are defined as deaths occurring during the hospitalization or within 30 days post-surgery.

Length of Hospital Stay: Calculated from the day of admission to the day of discharge or mortality day.

Geographical Analysis: Patients were stratified based on their city of referral, with an emphasis on understanding the distribution of cases and outcomes across the region. Denizli, as the central hub, accounted for the highest referral volume. Procedural trends were analyzed to assess the variability in outcomes across cities and identify areas for targeted healthcare interventions.

Statistical Analysis

Statistical analyses were conducted using SPSS version 25.0 (IBM Corp, Armonk, NY), with a significance threshold set at $p<0.05$. Quantitative and qualitative data were analyzed using descriptive and inferential statistical methods. Continuous variables were presented as mean ± standard deviation and analyzed using t-test or analysis of variance for group comparisons.

Categorical Variables: Expressed as counts and percentages, with chi-square or Fisher's exact test used for intergroup comparisons.

Results

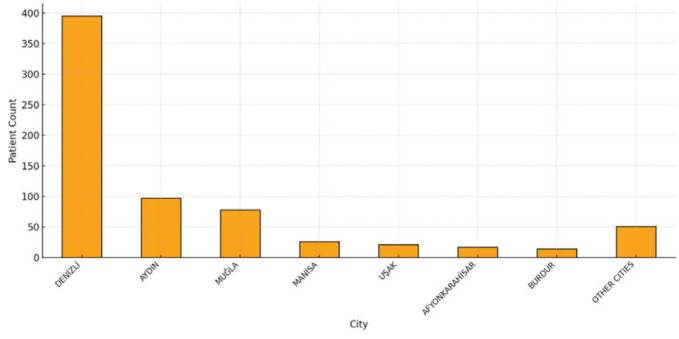
The study cohort comprised 699 patients, with a notable male predominance (n=554, 79.26%) compared to females (n=145, 20.74%). The mean age of the patients was 61.89 years, ranging from 29 to 95 years. The mean duration of hospitalization was 13.26 days, with a minimum stay of 0 days (observed in patients who succumbed intraoperatively or on the first postoperative day) and a maximum stay of 152 days (Table 1). The overall mortality rate was 18.60% (n=130). Male patients accounted for 103 of these deaths (79.23%), while females represented 27 deaths (20.77%). The most common procedure was ascending aortic graft replacement (n=295, 42.21%), followed by abdominal aortic aneurysm graft replacement (n=177, 25.32%). Thoracic aortic aneurysm endovascular graft implantation was performed in 94 cases (13.45%). Complex procedures included ascending aortic graft replacement with hemiarch replacement (n=77, 11.02%) and ascending aortic graft replacement with aortic valve replacement (n=52, 7.44%). A small number of patients (n=4, 0.57%) required ascending aortic graft replacement with the coronary artery implantation, underscoring the ability to manage highly intricate cases (Table 1). The majority of patients referred to Denizli originated from Denizli, accounting for 395 cases (56.51%). Other significant contributors included Aydın with 97 patients (13.88%) and Muğla with 78 patients (11.16%). Together, these three cities represent over 81% of the total referrals. Cities such as Manisa (26 patients, 3.72%) and Uşak (21 patients, 3.00%) made smaller yet notable contributions. Additionally, Afyonkarahisar and Burdur each accounted for a minor proportion of cases. The "other cities" category, which encompasses all cities contributing less than 2% of the total cases, collectively accounted for 77 patients (11.01%). Cities in this category include Antalya, İzmir, İstanbul, Konya, Kütahya, Mersin, Isparta, Adana, Bursa, Sakarya, Niğde, Balıkesir, Hatay, Malatya, and international locations like Bulgaria (Bar Chart 1). The distribution of birth cities offers valuable epidemiological insights into the patient population treated for aortic aneurysms in Southwestern Türkiye. Based on the patients' place of birth, Denizli emerged as the predominant contributor, accounting for 295 patients (42.21%). Other significant contributions were observed from Aydın (77 patients, 11.02%), Muğla (52 patients, 7.44%), and Manisa (29 patients, 4.15%). Afyonkarahisar

Table 1. Demographics, clinical characteristics, and surgical outcomes of patients treated for aortic aneurysms in southwestern Türkiye

Parameter	Count/Value	Percentage
Sex Male	(554) male patients	79.26%
Female	female patients	20.74%
Age Age (average) year	(61.89) years	
Age (minimum) year	(29) years	
Age (maximum) year	(95) years	
Hospitalization Hospitalization duration (average) day	(13.26) days	
Hospitalization duration (minimum) day	(0) days	
Mortality Hospitalization duration (maximum) day	(152) days	
Mortality	(130) patients died	18.60%
Male-mortality	(103) male died	79.23%
Female-mortality	(27) female died	20.77%
Procedures Ascending aortic graft replacement	(295) operations	42.21%
Ascending aortic graft replacement and hemiarch replacement	(77) operations	11.02%
Ascending aortic graft replacement and AVR	(52) operations	7.44%
Ascending aortic graft replacement and coronary artery implantation	(4) operations	0.57%
Toracic aortic aneurysm endovascular graft implantaion	(94) operations	13.45%
Abdominal aortic aneurysm graft replacement	(177) operations	25.32%
AVR: Aortic valve replacement		

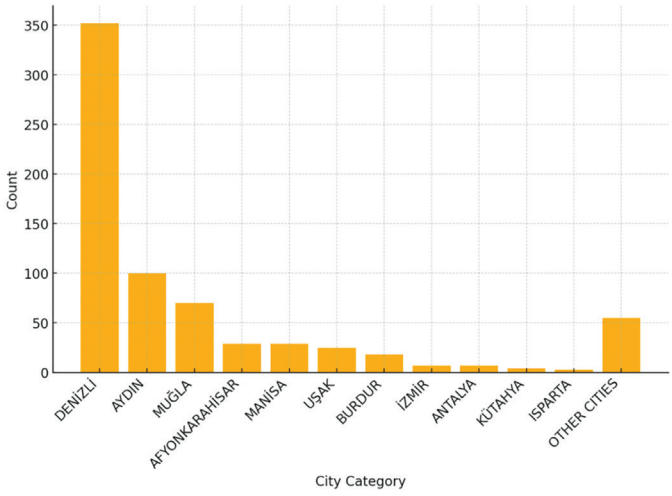
and Manisa each contributed 29 patients (4.15%). In contrast, İzmir (20 patients, 2.86%) and Antalya (15 patients, 2.14%) had relatively lower representation. The "other cities" category included 156 patients (22.31%), who were either visiting or tourists in these cities, including Adana.

Patient Distribution by Districts in Denizli*:* The analysis of patient distribution by districts in Denizli provides significant insights into the regional referral patterns for aortic aneurysm management. The Bar Chart 2 highlights the percentage contributions of various districts, with districts contributing less than 2% grouped under "Other Districts." The central districts of Merkez and Merkezefendi accounted for the largest proportions of patients, with 34.94% (138 patients) and 15.95% (63 patients), respectively. Several peripheral districts also made notable contributions. Çivril represented 8.86% (35

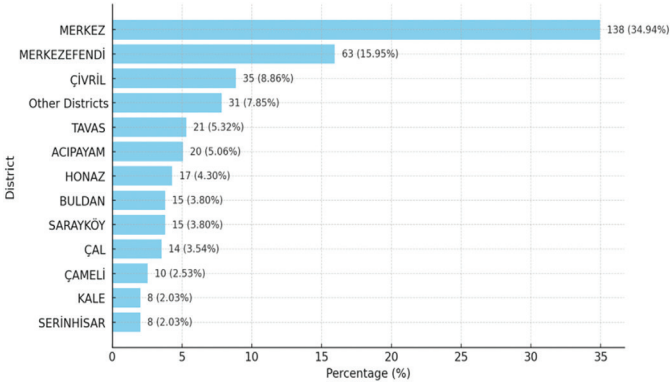


Bar Chart 1. City-wise distribution of patients transferred to Denizli for aortic aneurysm management

patients), followed by Tavas (5.32%), Acıpayam (5.06%), and Honaz (4.30%). The "Other Districts" category collectively contributed 7.85% (31 patients) to the total patient population (Bar Chart 3). This group included

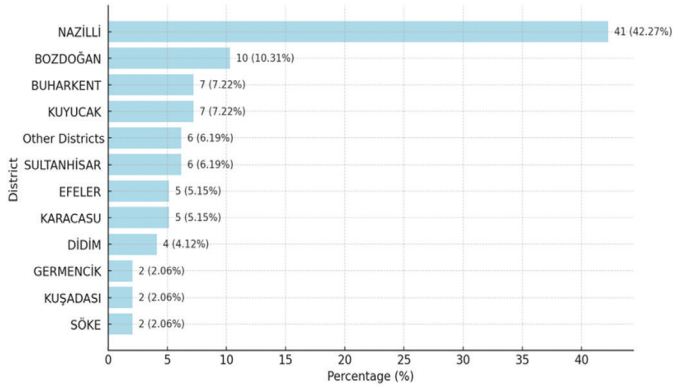


Bar Chart 2. Distribution of patients by birth cities transferred to Denizli for aortic aneurysm management

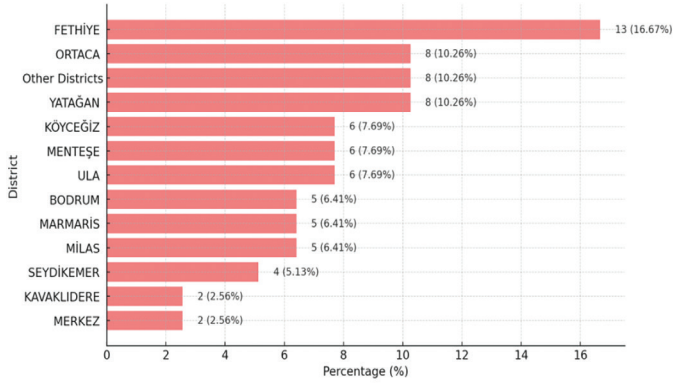


Bar Chart 3. Patient distribution by districts in Denizli: counts and percentages ordered by patient numbers

smaller districts such as Güney, Babadağ, Çardak, Bozkurt, Bekilli, Baklan, Kale, Serinhisar, Çameli, and Acıpayam. In terms of patient distribution by districts in Aydın, Nazilli emerged as the dominant contributor, accounting for 41 patients (42.27%). Bozdoğan contributed 10 patients (10.31%), while Buharkent and Kuyucak each accounted for 7 patients (7.22%). Sultanhisar followed closely with 6 patients (6.19%). Efeler and Karacasu, each contributed 5 patients (5.15%), while Didim accounted for 4 patients (4.12%). The "Other Districts" collectively



Bar Chart 4. Patient distribution by districts in Aydın: referrals to denizli for aortic aneurysm management



Bar Chart 5. Patient distribution by districts in Muğla: referrals to denizli for aortic aneurysm management

accounted for 6 patients (6.19%), including Germencik, Kuşadası, and Söke (Bar Chart 4).

The patient distribution by districts in Muğla is as follows: Fethiye stands out as the largest contributor, accounting for 13 patients (16.67%) of the total referrals from Muğla. The second-largest contributor was Ortaca, with 8 patients (10.26%), sharing its contribution level with the group categorized as "Other Districts", which also contributed 8 patients (10.26%) collectively, including Yatağan, Köyceğiz, and Menteşe. Additionally, Bodrum, Marmaris, and Milas each contributed 5 patients (6.41%). Seydikemer followed with 4 patients (5.13%), while smaller districts such as Kavaklıdere and Merkez each referred 2 patients (2.56%) (Bar chart 5). The analysis

Table 2. City-wise mortality analysis of patients referred for aortic aneurysm management in Southwestern Türkiye

City	Patients number	Mortality (number of deaths)	Mortality rate (%) for each city
Afyonkarahisar	17	4	23.53%
Antalya	5	0	0%
Aydın	97	18	18.56%
Burdur	14	3	21.43%
Denizli	395	81	20.51%
Isparta	2	0	0%
Kütahya	3	0	0%
Manisa	26	4	15.38%
Muğla	78	13	16.67%
Other cities	36	5	13.89%
Uşak	21	2	9.52%
İzmir	5	0	0%

of mortality across city categories provides critical insights into the regional outcomes of aortic aneurysm management. Table 2 summarizes the total number of patients, total mortalities, and calculated mortality rates (%) for each city category. Denizli had the largest number of patients (395) and the highest total mortality (n=81, 20.51%). Afyonkarahisar recorded a mortality rate of 23.53% (4 deaths out of 17 patients), the highest among the analyzed cities. Aydın had a notable mortality rate of 18.56%, (18 deaths among 97 patients). Burdur recorded a mortality rate of 21.43% (3 deaths out of 14 patients). Muğla had a moderate mortality rate of 16.67% (13 deaths among 78 patients). Manisa reported a mortality rate of 15.38% (4 deaths out of 26 patients). Uşak recorded a low mortality rate of 9.52% (2 deaths among 21 patients). Patients grouped under "other cities" had a mortality rate of 13.89% (5 deaths among 36 patients). No mortality in Antalya, Isparta, Kütahya, and İzmir (Table 2).

The Analysis Categorizes Patients by Three Main Procedure Types: Ascending aortic operations, abdominal operations, and thoracic aortic operations; and highlights city-level contributions to the referral network centered in Denizli.

Denizli exhibited the highest patient volume across all procedure types. Ascending aortic operations were the most frequent, with 150 patients (65% male, 35% female) and an average age of 60.5 years. Thoracic and abdominal operations followed, with 55 patients (68% male) and 80 patients (70% male), respectively. Aydın had 45 ascending aortic operations (60% male), while Muğla reported 35 similar procedures (62.9% male). Both cities displayed consistent gender distributions and slightly younger average ages, with ascending aortic operations at 59.2 years in Aydın and 58.3 years in Muğla. Manisa performed 20 ascending aortic operations, while Uşak and Afyonkarahisar contributed 18 and 22 cases, respectively. These cities demonstrated comparable gender distributions and demographic trends, with average ages ranging from 58.5 to 61.2 years.

Mortality Rates Varied Significantly by City and Procedure Type: Denizli showed mortality rates of 20.0%

Table 3. Demographic and mortality analysis by procedure type and city for aortic aneurysm management in Southwestern Türkiye

City	Procedure type	Total patients number for each procedure	Male patients (%)	Female patients (%)	Total mortality	Mortality rate (%) of the procedure	Average age (years)	Median age (years)
Denizli	Ascending aortic operations	150	65%	35%	30	20%	60.5	61
	Abdominal operations	80	70%	30%	15	18.75%	67.3	66
	Thoracic aortic operations	55	68%	32%	12	21.82%	62.8	63
Aydın	Ascending aortic operations	45	60%	40%	8	17.78%	59.2	58
	Abdominal operations	30	66.7%	33.3%	6	20%	66.1	65
	Thoracic aortic operations	22	63.6%	36.4%	5	22.73%	61.4	62
Muğla	Ascending aortic operations	35	62.9%	37.1%	6	17.14%	58.3	59
	Abdominal operations	25	64%	36%	4	16%	65.5	64
	Thoracic aortic operations	20	60%	40%	3	15%	62.7	61
Manisa	Ascending aortic operations	20	70%	30%	4	20%	61.2	62
	Abdominal operations	15	66.7%	33.3%	3	20%	64.8	64
	Thoracic aortic operations	12	66.7%	33.3%	2	16.67%	63.5	62
Uşak	Ascending aortic operations	18	66.7%	33.3%	3	16.67%	60.7	60
	Abdominal operations	10	70%	30%	2	20%	66.9	66
	Thoracic aortic operations	8	62.5%	37.5%	1	12.5%	63.1	63
Afyonkarahisar	Ascending aortic operations	22	63.6%	36.4%	4	18.18%	58.5	58
	Abdominal operations	14	64.3%	35.7%	3	21.43%	64.3	64
	Thoracic aortic operations	10	60%	40%	2	20%	61.9	

for ascending aortic operations, 18.75% for abdominal operations, and 21.82% for thoracic operations. Aydın exhibited slightly lower mortality rates for ascending aortic operations (17.78%), and higher rates for thoracic operations (22.73%). Muğla had mortality rates of 17.14% for ascending aortic operations and 15.0% for thoracic operations. Abdominal operations had a comparable mortality rate of 16.0%. Manisa reported a mortality rate of 20.0% across all three operation types. Uşak showed a slightly lower mortality rate for thoracic operations (12.5%) but higher rates for abdominal operations (20.0%). Afyonkarahisar had mortality rates of 18.18% for ascending aortic operations and 21.43% for abdominal operations (Table 3).

Discussion

The study offers valuable insights into the demographic and clinical characteristics of patients with aortic aneurysms in Southwestern Türkiye, particularly those referred to Denizli for advanced management. Male patients represented 79.26% of the cohort, consistent with global data, which attributes the gender disparity to hormonal and lifestyle factors such as smoking and hypertension[14,15]. However, a notable finding was the higher mortality rate among female patients (20.77%) despite their lower representation, suggesting potential delays in diagnosis or a more aggressive disease course in women[16].

The average age of the patients was 61.89 years, with a wide age range reflecting diverse etiologies[17,18]. Hospitalization durations varied widely, averaging 13.26 days, and were influenced by the complexity of the procedure and patient-specific factors. Endovascular techniques were associated with shorter recovery times but were underutilized in this cohort, representing only 13.45% of interventions[19,20]. This low adoption rate highlights potential resource limitations, anatomical constraints, and the inability to perform such an approach in urgent cases that restrict the use of endovascular approaches[21-23]. There were various causes of mortality concerning aortic aneurysms in the southwestern region of Türkiye; some were related to late referrals, which were notably more prevalent in rural areas. Moreover, deaths were associated with much more complex surgical interventions, for instance, thoracic aorta replacements and some combined procedures. Other factors were increasing age, presence of serious comorbidities such as hypertension and diabetes, and, strikingly, greater mortality amongst women than men. Intraoperative deaths were often due to bleeding and cardiac arrest, while postoperative deaths resulted from sepsis, respiratory failure, and cerebral infarction.

The overall mortality rate of 18.60% aligns with global averages for complex aortic surgeries, though regional disparities were evident. Cities like Afyonkarahisar (23.53%) and Burdur (21.43%) reported higher mortality rates, likely due to delayed referrals and limited preoperative care. Conversely, cities such as Manisa (15.38%) and Uşak (9.52%) exhibited lower mortality rates, suggesting better coordination and efficient healthcare networks. Denizli itself had a mortality rate of 20.51%, higher than the average, reflecting the complexity of cases referred to its tertiary care centers[24,25]. Regional contributions to Denizli's caseload varied significantly. Central districts within Denizli, such as Merkez (34.94%) and Merkezefendi (15.95%), contributed the highest numbers of referrals, likely due to their proximity to healthcare facilities. Peripheral districts like Çivril (8.86%) and Tavas (5.32%) also played a significant role, emphasizing the inclusivity of the referral system. Neighboring cities such as Aydın (13.88%) and Muğla (11.16%) demonstrated the collaborative nature of the region's healthcare network, while international referrals further highlighted Denizli's reputation for advanced cardiovascular care. Surgical outcomes varied across procedures and regions. Ascending aortic operations were the most commonly performed procedure (42.21% of all procedures) and showed a male predominance (65%) with an average patient age of 60.5 years. Abdominal aortic aneurysm surgeries had higher mortality rates, particularly in older populations (average age: 64.3-67.3

years), reflecting the increased risks associated with these procedures. Thoracic aortic operations reported the highest mortality rates, especially in Denizli (21.82%) and Aydın (22.73%), due to the complexity of the surgeries and the comorbidities of the patients[14,26]. Key challenges identified include disparities in referral rates and surgical outcomes across regions. For example, lower referral rates from coastal cities like İzmir and Antalya suggest that patients may prefer local facilities for treatment rather than seeking care in Denizli.

Study Limitations

Incomplete records, lack of detailed data on comorbidities and procedures, and challenges in isolating outcome factors due to healthcare variations. Its focus on short-term outcomes excludes long-term survival and quality of life; and broad grouping of smaller districts may underrepresent their healthcare needs. Disparities in access to advanced techniques and unexplored gender-specific outcomes further limit the findings. Future research should adopt prospective designs with broader coverage and detailed data to address these gaps effectively.

Conclusion

Denizli emerged as the central hub for specialized care, supported by significant contributions from neighboring cities like Aydın, Muğla, and Afyonkarahisar. Geographic disparities in patient distribution and outcomes highlight the need for improved regional healthcare networks. The high prevalence in central and densely populated districts emphasizes the importance of targeted screening and resource allocation. Variations in mortality rates by city and procedure type underscore the critical need for early diagnosis, efficient referral systems, and equitable access to advanced surgical techniques.

Ethics

Ethics Committee Approval: The study was approved by Pamukkale University Non-Interventional Clinical Research Ethics Committee (approval no.: E-60116787-020-636206, date: 08.01.2025) ensuring adherence to the principles outlined in the Declaration of Helsinki.

Informed Consent: This retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Alsalaldeh M, Gökşin İ, Concept: Alsalaldeh M, Design: Alsalaldeh M, Data Collection and/or Processing: Alsalaldeh M, Analysis and or Interpretation: Alsalaldeh M, Gökşin İ, Literature Search: Alsalaldeh M, Gökşin İ, Writing: Alsalaldeh M, Gökşin İ.

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