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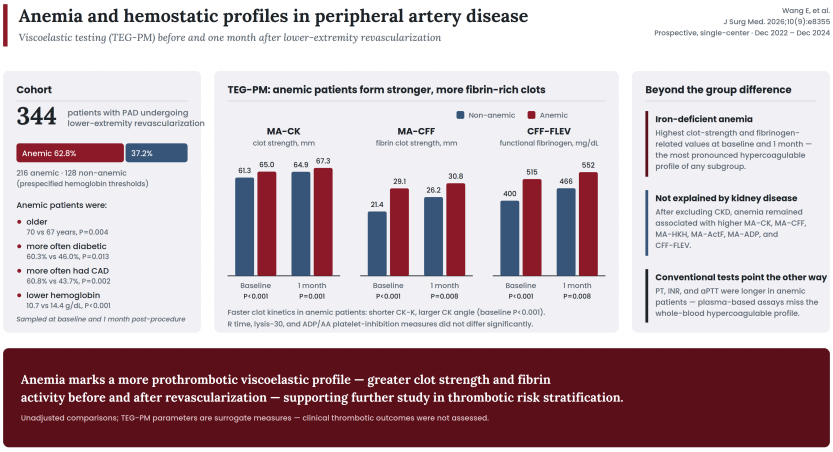

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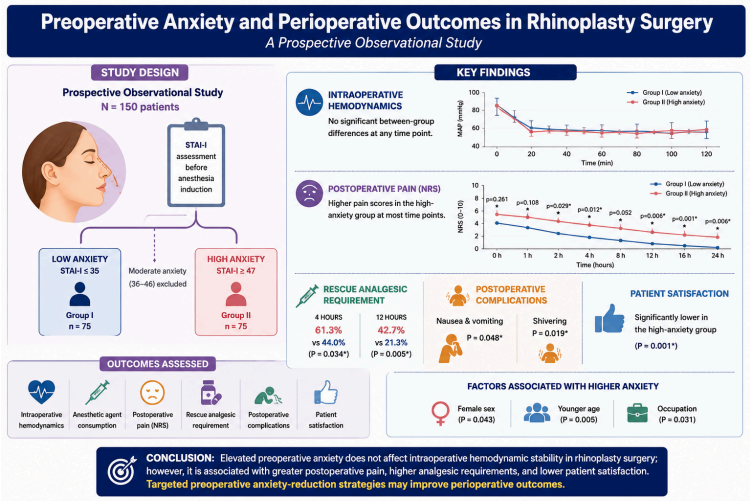

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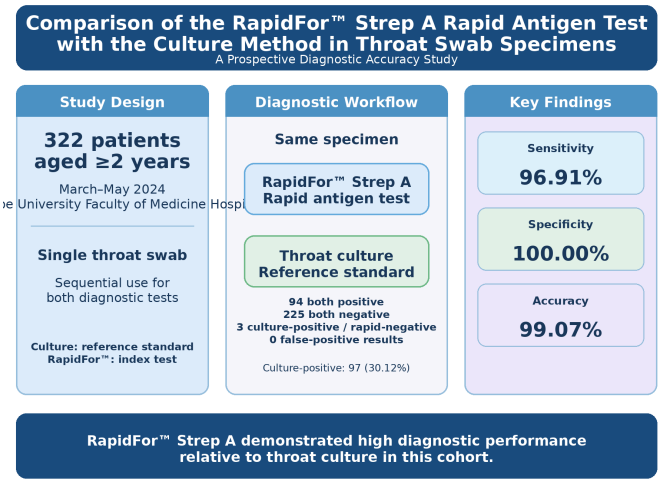

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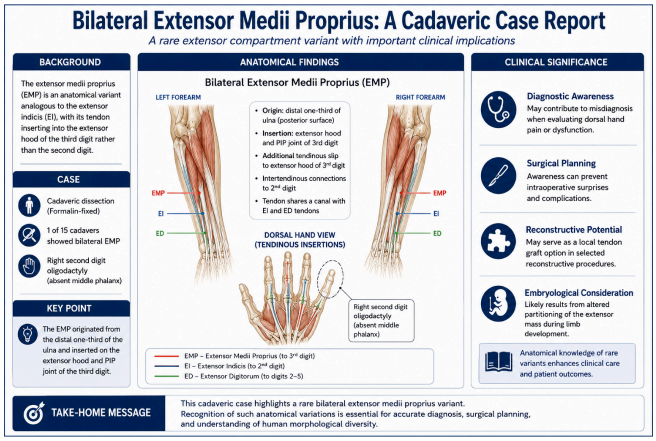

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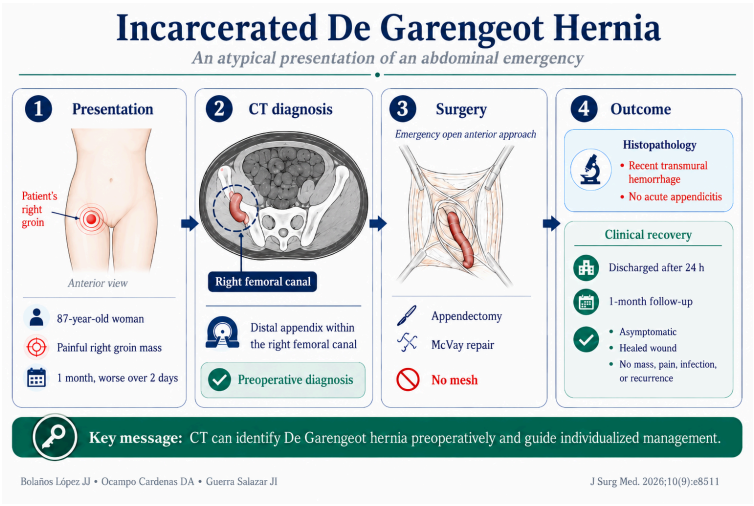

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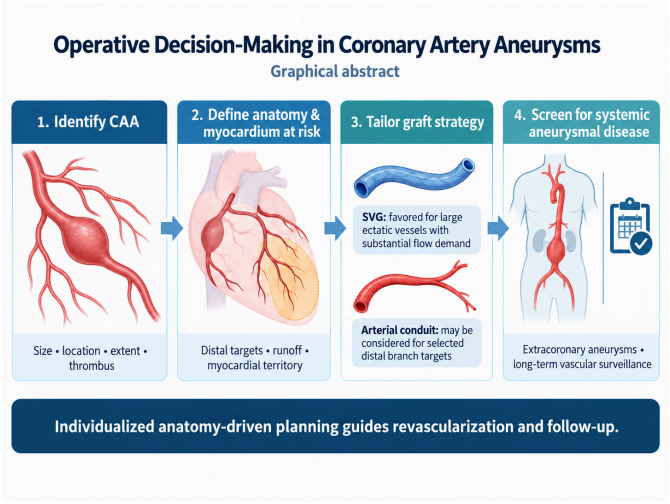

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The effect of preoperative anxiety levels on intraoperative hemodynamics and postoperative pain in rhinoplasty surgery

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Ethical Approval
The study was approved by the Non-Interventional Clinical Research Ethics Committee of Necmettin Erbakan University (Approval No. 2025/5652; March 21, 2025).

Informed Consent
Written and verbal informed consent was obtained from all participants.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Preoperative anxiety is common among surgical patients and may adversely affect perioperative outcomes; however, its influence in patients undergoing rhinoplasty remains insufficiently characterized. This study aimed to investigate the impact of preoperative anxiety levels on intraoperative hemodynamic parameters, postoperative pain intensity, analgesic consumption, postoperative complications, and patient satisfaction in patients undergoing rhinoplasty.

Methods: This single-center, prospective observational study included 150 patients aged 18–60 years with American Society of Anesthesiologists (ASA) physical status I–II who underwent rhinoplasty. Preoperative anxiety was assessed using the State-Trait Anxiety Inventory-State (STAI-I), and patients were stratified into low- and high-anxiety groups. Intraoperative hemodynamic parameters, anesthetic agent consumption, postoperative pain scores, rescue analgesic requirements, postoperative complications, and patient satisfaction were compared between groups.

Results: No significant between-group differences were observed in intraoperative hemodynamic parameters or intraoperative adverse events. Patients in the high-anxiety group had higher postoperative pain scores at most assessed time points and more frequently required rescue analgesia at 4 hours (61.3% vs 44.0%; $P = 0.034$) and 12 hours (42.7% vs 21.3%; $P = 0.005$). Postoperative nausea and vomiting ($P = 0.048$) and shivering ($P = 0.019$) were more frequent in the high-anxiety group, and patient satisfaction was lower ($P = 0.001$). Female sex ($P = 0.043$), younger age ($P = 0.005$), and occupation ($P = 0.031$) were significantly associated with anxiety group.

Conclusion: Elevated preoperative anxiety does not appear to influence intraoperative hemodynamic stability in patients undergoing rhinoplasty; however, it is associated with greater postoperative pain, higher rescue analgesic requirements, and lower patient satisfaction. These findings support the clinical value of targeted preoperative anxiety-reduction strategies to optimize perioperative outcomes.

Keywords: analgesia, anxiety, rhinoplasty

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Introduction

Preoperative anxiety is common among surgical patients and has been associated with adverse perioperative outcomes, including changes in hemodynamic parameters, increased postoperative pain, and impaired recovery [1, 2]. These effects are largely mediated through heightened sympathetic activity, which may compromise intraoperative stability. Preoperative anxiety is a multifactorial phenomenon influenced by previous surgical experiences, personality traits, and concerns related to the procedure, particularly the anticipation of postoperative pain [3]. Elevated anxiety levels have been linked to increased pain perception, greater analgesic consumption, and lower patient satisfaction [4]. Rhinoplasty is a unique surgical procedure in which psychological factors play a particularly prominent role because patients often have high aesthetic expectations and emotional investment in surgical outcomes. Despite this, the impact of preoperative anxiety on intraoperative hemodynamic stability and postoperative outcomes in patients undergoing rhinoplasty remains insufficiently characterized.

The Spielberger State-Trait Anxiety Inventory-State (STAI-I) is a validated tool that is widely used to assess situational anxiety in clinical settings [5]. Therefore, this study aimed to evaluate the effects of preoperative anxiety levels, as measured by the STAI-I, on intraoperative hemodynamic parameters, postoperative pain intensity, analgesic consumption, postoperative complications, and patient satisfaction in patients undergoing rhinoplasty. We hypothesized that higher preoperative anxiety levels would be associated with impaired intraoperative hemodynamic stability, increased postoperative pain and analgesic requirements, and lower patient satisfaction.

Materials and methods

This study was conducted between April 15, 2025, and August 15, 2025, at the Department of Anesthesiology and Reanimation, Faculty of Medicine, Necmettin Erbakan University, with patient data protected and in accordance with the principles of the Declaration of Helsinki. A total of 150 patients aged 18–60 years who were scheduled for rhinoplasty, provided written and verbal informed consent, and were classified as American Society of Anesthesiologists (ASA) physical status I–II were included. The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Necmettin Erbakan University (Approval No. 2025/5652; March 21, 2025).

Patients with ASA physical status III or higher; hypertension; renal or hepatic insufficiency; cardiovascular disease, including heart failure, coronary artery disease, or arrhythmia; malignancy; pregnancy or lactation; illiteracy; a psychiatric disorder or psychotropic medication use; chronic alcohol or opioid use; failure to respond to at least three items on the STAI questionnaire; or refusal to participate were excluded.

During the preoperative anesthesia evaluation, demographic and clinical data, including age, sex, marital status, parental status, educational level, occupational group, body mass index, ASA physical status, comorbidities, and previous anesthesia experience, were recorded. Patients were informed about the STAI-I questionnaire, the general anesthesia process, and postoperative pain assessment. To account for sociocultural differences, the questionnaires were administered by the researcher, who read the items aloud and recorded the responses.

Anxiety levels were assessed using the STAI-I immediately before general anesthesia induction. The scale scores range from 20 to 80. Scores ≤35 were classified as low anxiety, scores between 36 to 46 as moderate anxiety, and scores ≥47 as high anxiety. Patients with moderate anxiety scores (36–46) were not included in the study. Accordingly, patients with low anxiety were assigned to Group I (n=75), while those with high anxiety were assigned to Group II (n=75).

All patients received a standardized general anesthesia protocol, and open rhinoplasty procedures were performed by the same surgical team. Baseline hemodynamic parameters were recorded before induction. After peripheral venous access was established, intravenous (IV) crystalloid infusion was initiated at 10 mL/kg/h. No premedication was administered preoperatively. Anesthesia was induced with IV propofol (1–2 mg/kg), fentanyl (1 μg/kg), lidocaine (1 mg/kg), and rocuronium (0.6 mg/kg). After endotracheal intubation, tidal volume and respiratory rate were adjusted to maintain end-tidal carbon dioxide ($EtCO_2$) between 35 and 40 mmHg. Anesthesia was maintained with 50% oxygen, continuous IV remifentanil infusion (0.1 μg/kg/min), and 1 minimum alveolar concentration (MAC) of desflurane, with a fresh gas flow of 1 L/min. Hemodynamic parameters were recorded at predefined intraoperative time points. Controlled hypotension was used to improve surgical field visibility, targeting a systolic arterial pressure (SAP) of 80–90 mmHg and a mean arterial pressure (MAP) of 50–65 mmHg. Remifentanil and desflurane doses were increased by 20% as needed to achieve these targets. If MAP decreased below 50 mmHg and persisted for longer than 1–3 minutes, anesthetic doses were reduced by 20%. If no improvement was observed, crystalloid infusion was increased, and IV vasopressors were administered when necessary. Bradycardia (heart rate <40 beats/min) was treated with IV atropine (0.01 mg/kg). At the end of surgery, total remifentanil use (mg) and desflurane consumption (mL) were recorded.

For postoperative analgesia, tenoxicam (20 mg) was administered at the beginning of the operation, and tramadol (2 mg/kg) was administered as a slow IV bolus 30 minutes before the end of surgery. IV ondansetron (0.1 mg/kg) was administered as an antiemetic. At completion of the procedure, desflurane and remifentanil were discontinued. Extubation was performed after spontaneous respiration resumed. Postoperative pain was assessed using the Numeric Rating Scale (NRS), where 0 indicated no pain, 1–3 mild pain, 4–6 moderate pain, and 7–10 severe pain. Patients rated their pain from 0 to 10, and responses were recorded on the data collection form. Postoperative analgesia was evaluated using NRS scores at 0, 1, 2, 4, 8, 12, 16, and 24 hours and rescue analgesic use at 4, 12, and 24 hours. In the postoperative care unit, all patients routinely received IV paracetamol (1 g) 2 hours after arrival on the ward and every 12 hours thereafter. Patients with an NRS score ≥4 despite this regimen received IV tramadol (1 mg/kg) as rescue analgesia.

The primary outcomes were changes in intraoperative hemodynamic parameters, postoperative pain levels, and the need for rescue analgesia. Secondary outcomes included associations between anxiety and demographic and clinical characteristics and the effects of anxiety on intraoperative anesthetic consumption,

postoperative nausea and vomiting, shivering, and patient satisfaction.

Statistical analysis

The sample size was calculated using G*Power software (version 3.1.9.7; Heinrich Heine University Düsseldorf, Germany). An a priori power analysis was performed for the comparison of postoperative pain scores between two independent groups (test family: t tests; statistical test: difference between two independent means [two groups]), assuming an effect size of approximately 0.41 (Cohen's d), a significance level of 5% (α=0.05), a statistical power of 80% (1−β=0.80), and an equal allocation ratio (1:1). A one-tailed test was used because the prespecified hypothesis was directional, anticipating higher postoperative pain scores in patients with high preoperative anxiety. Based on these assumptions, approximately 75 patients per group were required.

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences), version 22.0. A *P*-value < 0.05 was considered statistically significant. The normality of continuous variables was assessed using the one-sample Kolmogorov–Smirnov test. Normally distributed data were expressed as mean (SD), whereas non-normally distributed data were presented as median (25th–75th percentile). Associations between categorical variables were analyzed using the Pearson chi-square test; Fisher's exact test was used when chi-square assumptions were not met. Continuous variables were compared between two independent groups using the independent-samples t-test when the normality assumption was met and the Mann–Whitney U test otherwise. For within-group comparisons of repeated measurements over time, the paired-samples t-test was used for normally distributed data, whereas the Wilcoxon signed-rank test was used for non-normally distributed data.

Results

Seventy-five patients with low anxiety scores were classified as Group I, and 75 patients with high anxiety scores were classified as Group II. The median STAI-I score was 30 (25–33) in Group I and 49 (46–53) in Group II. Demographic comparisons showed that female sex (*P* = 0.043), younger age (*P* = 0.005), and occupation (*P* = 0.031) were significantly associated with anxiety group, with a higher proportion of students in Group II (Table 1). Body mass index, ASA physical status, comorbidities, marital status, parental status, educational level, and previous anesthesia history were not significantly associated with anxiety group.

Regarding intraoperative adverse events, vasopressor requirement, bradycardia, and desaturation were each observed in one patient (1.3%) in Group I and in no patients (0%) in Group II. Each adverse event was analyzed separately using Fisher's exact test, and no significant between-group difference was observed for vasopressor requirement (*P* = 0.238), bradycardia (*P* = 0.238), or desaturation (*P* = 0.238).

Regarding intraoperative anesthetic consumption, the median desflurane consumption was 38 mL (range: 10–93) in Group I and 36 mL (range: 15–78) in Group II. The median remifentanil consumption was 1.4 mg (range: 1–3.2) in Group I and 1.5 mg (range: 0.8–3.0) in Group II. There were no significant differences between the groups in desflurane or remifentanil consumption (*P* = 0.523 and *P* = 0.656, respectively). Evaluation of intraoperative hemodynamic parameters revealed no significant between-group differences in MAP, heart rate (HR), or oxygen saturation (SpO_2) at any measurement time point (Figure 1).

Analysis of postoperative NRS scores over time showed significantly higher scores in Group II than in Group I at most assessed time points (*P* < 0.05) (Figure 2).

At 4 postoperative hours, 46 patients (61.3%) in Group II and 33 patients (44.0%) in Group I required rescue analgesia (*P* = 0.034). At 12 hours, rescue analgesia was required by 32 patients (42.7%) in Group II and 16 patients (21.3%) in Group I (*P* = 0.005). No significant between-group difference was observed at 24 hours. Among the 79 patients who required rescue analgesia at 4 hours, 35 continued to require rescue analgesia at 12 hours; 10 were in Group I and 25 were in Group II. Eight patients required rescue analgesia at both 12 and 24 hours, including 2 in Group I and 6 in Group II. Five patients required rescue analgesia at all assessed time points, including 2 in Group I and 3 in Group II.

Patient satisfaction differed significantly between groups (*P* = 0.001). In Group I, 62.7% of patients rated their satisfaction as excellent, whereas satisfaction in Group II was more frequently rated as good or moderate (Table 2).

Postoperative nausea and vomiting (*P* = 0.048) and shivering (*P* = 0.019) were significantly more frequent in Group II than in Group I (Table 3).

Table 1. Baseline demographic characteristics of the groups (mean (SD), n(%))

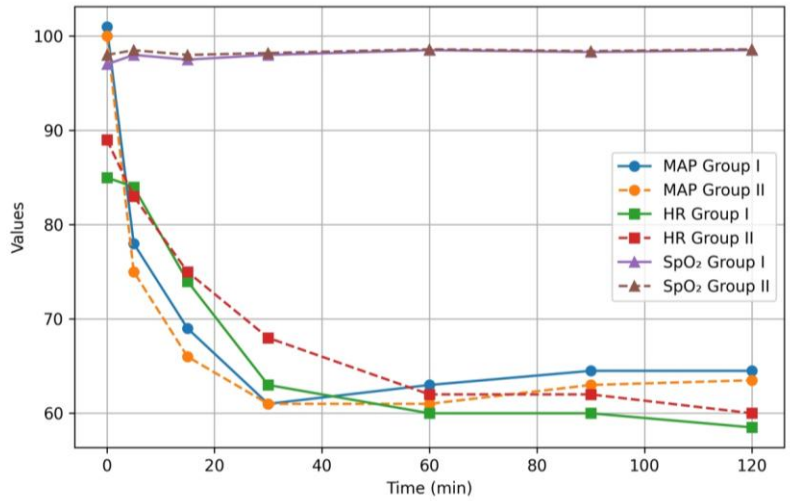
Variables	Group I (n=75)	Group II (n=75)	*P*-value
Gender (F / M)	41(54.7%) / 34(45.3%)	53(70.7%) / 22(29.3%)	**0.043**
Age (years)	27(7)	24(7)	**0.005**
BMI (kg/m²)	22.49(7)	24(7)	0.870
ASA physical status			0.414
ASA I	39 (52%)	34 (45.3%)	
ASA II	36 (48%)	41 (54.7%)	
Comorbidity			0.113
Absent	70 (93.3%)	64 (85.3%)	
Present	5 (6.7%)	11 (14.7%)	
Comorbid diseases			
Diabetes mellitus	2 (2.7%)	4 (5.4%)	0.316
Asthma/COPD	3 (4%)	7 (9.3%)	0.190
Marital status			0.193
Married	23 (30.7%)	16 (21.3%)	
Single	52 (69.3%)	59 (78.7%)	
Parental status			0.453
Has children	54 (72%)	58 (77.3%)	
No children	21(28%)	17 (22.6%)	
Educational level			0.074
Literate	1 (1.3%)	0 (0%)	
Primary education	12 (16%)	3 (4%)	
High school	37 (49.3%)	38 (50.7%)	
University	25 (33.3%)	34 (45.3%)	
Occupation			**0.031**
Retired	0 (0%)	0 (0%)	
Civil servant	10 (13.3%)	11 (14.7%)	
Worker	19 (25.3%)	11 (14.7%)	
Self-employed	27 (36%)	17 (22.7%)	
Unemployed	6 (8%)	7 (9.3%)	
Student	13 (17.3%)	29 (38.7%)	
History of general anesthesia			0.072
Yes	34 (45.3%)	45 (60%)	
No	41 (54.7%)	30 (40%)	

Abbreviations: F: female, M: male, BMI: body mass index, ASA: American Society of Anesthesiologists, COPD: chronic obstructive pulmonary disease, SD: standard deviation.

Table 2. Comparison of patient satisfaction levels between groups [n (%)]

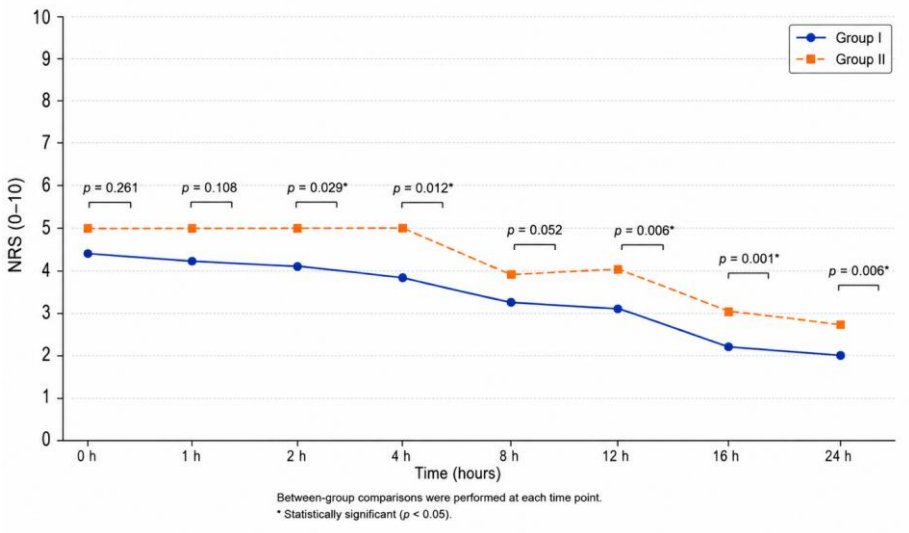
Patient satisfaction	Group I (n = 75)	Group II (n = 75)	Total (n = 150)	*P*-value
Poor	0 (0%)	3 (4.0%)	3 (2.0%)	0.001
Moderate	5 (6.7%)	12 (16.0%)	17 (11.3%)	
Good	23 (30.7%)	35 (46.7%)	58 (38.7%)	
Excellent	47 (62.6%)	25 (33.3%)	72 (48.0%)	

Figure 1. Comparison of intraoperative hemodynamic parameters between groups



Abbreviations: MAP: mean arterial pressure, HR: heart rate, SpO_2: peripheral oxygen saturation.

Figure 2. Changes in postoperative NRS scores over time between groups



Abbreviations: NRS: Numeric Rating Scale.

Table 3. Incidence of postoperative nausea and vomiting and shivering [n (%)]

Outcome	Group I (n = 75)	Group II (n = 75)	Total (n = 150)	*P*-value
Nausea and vomiting				0.048
Yes	26 (34.7%)	38 (50.7%)	64 (42.7%)	
No	49 (65.3%)	37 (49.3%)	86 (57.3%)	
Shivering				0.019
Yes	22 (29.3%)	36 (48.0%)	58 (38.7%)	
No	53 (70.7%)	39 (52.0%)	92 (61.3%)	

Discussion

This study comprehensively evaluated the effects of preoperative anxiety on intraoperative hemodynamic parameters, postoperative pain, analgesic requirements, complications, and patient satisfaction in patients undergoing rhinoplasty. The findings indicate that preoperative anxiety is particularly associated with postoperative clinical outcomes, whereas it does not appear to have a significant effect on intraoperative hemodynamic parameters.

The preoperative STAI-I scores observed in this study were consistent with those reported in the literature, supporting the representativeness of the sample [6, 7]. Compared with previously reported mean STAI-I values, the scores in this study were within a similar range, indicating that anxiety is a common and predictable phenomenon in rhinoplasty and other elective surgical procedures. This finding underscores the importance of routinely assessing preoperative anxiety.

Analysis of demographic factors revealed a notable association between younger age and higher anxiety levels, consistent with the literature [8, 9]. The higher anxiety observed in younger patients may be related to less previous surgical experience, greater uncertainty, and various psychosocial factors. Similarly, the association between female sex and higher anxiety levels is frequently reported and may be influenced by hormonal, psychosocial, and cultural factors [10]. The higher anxiety levels observed among students in the present study may reflect the influence of sociodemographic and occupational factors on preoperative anxiety [11].

No significant between-group differences were observed in intraoperative hemodynamic parameters, suggesting that preoperative anxiety alone may not determine intraoperative hemodynamic stability. In this study, the standardized anesthesia protocol and controlled hypotension strategy may have attenuated potential sympathetic responses. Although some studies have reported that preoperative anxiety may cause hemodynamic changes during induction, its effect appears to diminish during anesthesia maintenance [12, 13]. Our findings are consistent with this perspective.

The absence of a significant between-group difference in intraoperative anesthetic consumption suggests that the impact of anxiety on pharmacologic requirements may be limited. However, the literature presents conflicting findings on this issue [4, 14].

These discrepancies may reflect differences in anesthetic techniques, choice of agents, and dose-titration protocols. In particular, the stable pharmacodynamic properties of the desflurane–remifentanil combination may have attenuated or masked the effects of anxiety.

In contrast, postoperative outcomes were affected by anxiety levels. Patients with higher anxiety reported greater pain intensity, particularly later in the postoperative period, and required more rescue analgesia. These findings suggest that anxiety has a clinically relevant association with postoperative pain and analgesic needs. The higher incidence of postoperative nausea and vomiting and shivering in the high-anxiety group further supports a broader association between anxiety and postoperative recovery. Patient satisfaction was also strongly associated with anxiety level, with higher satisfaction in the low-anxiety group. These observations highlight the importance of psychological factors in the overall surgical experience and support integrating anxiety assessment into perioperative care.

This study has several limitations. First, because it was conducted at a single center, the generalizability of the findings may be limited. Second, the observational design does not permit causal inference between anxiety and clinical outcomes. Anxiety was also assessed using a self-reported scale, which may be subject to response bias. Advanced intraoperative monitoring techniques were not used. Finally, postoperative pain was evaluated using the NRS, a subjective measure that may be influenced by individual psychological factors. In particular, patients with higher anxiety may have a lower pain perception threshold, resulting in higher reported pain scores independent of actual nociceptive input or tissue trauma. Therefore, the observed association between anxiety and increased postoperative pain may partly reflect differences in pain perception and reporting rather than differences in physiologic pain generation alone.

In conclusion, high preoperative anxiety in patients undergoing rhinoplasty does not appear to affect intraoperative hemodynamic stability; however, it is associated with greater postoperative pain, higher rescue analgesic requirements, and lower patient satisfaction. Routine assessment and appropriate management of preoperative anxiety may contribute to improved perioperative outcomes.

References

1. Caumo W, Schmidt AP, Schneider CN, Bergmann J, Iwamoto CW, Adamatti LC, et al. Risk factors for postoperative anxiety in adults. Anaesthesia. 2001;56(8):720-8. doi: 10.1046/j.1365-2044.2001.01842.x.
2. Kim WS, Byeon GJ, Song BJ, Lee HJ. Availability of preoperative anxiety scale as a predictive factor for hemodynamic changes during induction of anesthesia. Korean J Anesthesiol. 2010;58(4):328-33. doi: 10.4097/kjae.2010.58.4.328.
3. Nigussie S, Belachew T, Wolancho W. Predictors of preoperative anxiety among surgical patients in Jimma University Specialized Teaching Hospital, South Western Ethiopia. BMC Surg. 2014;14:67. doi: 10.1186/1471-2482-14-67.
4. Qaddumi J, Arda AM, Alkhawaldeh A, ALBashtawy M, Abdalrahim A, ALBashtawy S, et al. Preoperative anxiety, postoperative pain tolerance and analgesia consumption: a prospective cohort study. J Perioper Pract. 2025;35(10):426-36. doi: 10.1177/17504589241253489.
5. Oh J, Lee W, Ki S, Suh J, Hwang S, Lee J. Assessment of preoperative anxiety and influencing factors in patients undergoing elective surgery: an observational cross-sectional study. Medicina (Kaunas). 2024;60(3):403. doi: 10.3390/medicina60030403.
6. Şahin C, İmer Aras H. Influence of nasal pack removal on patients' anxiety after septoplasty. Kulak Burun Bogaz Ihtis Derg. 2015;25(5):266-70. doi: 10.5606/kbbihtisas.2015.93609.
7. Çelik MR, Güneş HY. The effects of detailed preoperative information on postoperative pain and anxiety levels in rhinoplasty surgery. East J Med. 2023;28(3):471-6. doi: 10.5505/ejm.2023.34022.
8. Aloweidi A, Abu-Halaweh S, Almustafa M, Marei Z, Yaghi S, Hababeh L, et al. Preoperative anxiety among adult patients undergoing elective surgeries at a tertiary teaching hospital: a cross-sectional study during the era of COVID-19 vaccination. Healthcare (Basel). 2022;10(3):515. doi: 10.3390/healthcare10030515.
9. Erkilic E, Kesimci E, Soykut C, Doger C, Gumus T, Kanbak O. Factors associated with preoperative anxiety levels of Turkish surgical patients: from a single center in Ankara. Patient Prefer Adherence. 2017;11:291-6. doi: 10.2147/PPA.S127342.
10. Bedaso A, Mekonnen N, Duko B. Prevalence and factors associated with preoperative anxiety among patients undergoing surgery in low-income and middle-income countries: a systematic review and meta-analysis. BMJ Open. 2022;12(3):e058187. doi: 10.1136/bmjopen-2021-058187.
11. Topal Hançer A, Erturhan Türk K. Determination of Preoperative Anxiety Levels and Affecting Factors in Patients Undergoing Elective Surgery: A Descriptive and Cross-Sectional Study. Turkiye Klinikleri J Nurs Sci. 2024;16(1):35-42. doi: 10.5336/nurses.2023-100081.
12. Ahmetovic-Djug J, Hasukic S, Djug H, Hasukic B, Jahic A. Impact of preoperative anxiety in patients on hemodynamic changes and a dose of anesthetic during induction of anesthesia. Med Arch. 2017;71(5):330-3. doi: 10.5455/medarh.2017.71.330-333.
13. Bayrak A, Sagiroglu G, Copuroglu E. Effects of preoperative anxiety on intraoperative hemodynamics and postoperative pain. J Coll Physicians Surg Pak. 2019;29(9):868-73. doi: 10.29271/jcpsp.2019.09.868.
14. Chen YYK, Soens MA, Kovacheva VP. Less stress, better success: a scoping review on the effects of anxiety on anesthetic and analgesic consumption. *J Anesth.* 2022;36(4):532-53. doi: 10.1007/s00540-022-03081-4.

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Hemostatic variability among anemic peripheral artery disease patients using comprehensive viscoelastic testing

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Ethical Approval
Approval was obtained from the Mass General Brigham Institutional Review Board before study initiation (Protocol No. 2022P001918; approval date: September 19, 2022).

Informed Consent
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No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Peripheral arterial disease (PAD) often requires revascularization, but postprocedural thrombotic complications can lead to adverse limb and survival outcomes. Anemia is common among older patients with PAD and may alter coagulation, yet its association with peri-revascularization hemostatic profiles remains unclear. This study evaluated whether anemia was associated with differences in coagulation profiles before and after lower extremity revascularization.

Methods: This prospective, single-center study included patients with PAD who underwent revascularization from December 2022 to December 2024. Blood samples obtained before and one month after revascularization were analyzed using thromboelastography with platelet mapping (TEG-PM). Patients were categorized as anemic or non-anemic using prespecified hemoglobin thresholds. Continuous variables were compared using the Mann-Whitney U test, and categorical variables were analyzed using Fisher's exact test.

Results: Among 344 patients, 62.8% were anemic. Compared with non-anemic patients, anemic patients were older (70 vs. 67 years, $P = 0.004$), had higher prevalences of diabetes mellitus (60.3% vs. 46.0%, $P = 0.013$) and coronary artery disease (60.8% vs. 43.7%, $P = 0.002$), and had lower hemoglobin levels (10.7 (1.6) vs. 14.4 (1.3) g/dL, $P < 0.001$). At baseline, anemic patients had greater clot strength, including higher MA-CK (65.0 (6.7) vs. 61.3 (6.3) mm, $P < 0.001$) and MA-CFF (29.1 (10.7) vs. 21.4 (7.7) mm, $P < 0.001$), as well as higher CFF-FLEV values (515 (201) vs. 400 (145) mg/dL, $P < 0.001$). Differences in selected fibrin-related parameters persisted at one month. Longitudinally, non-anemic patients showed larger increases in MA-CFF (4.4 (8.4) vs. -0.2 (9.5) mm, $P = 0.002$) and MA-ActF (3.1 (7.4) vs. -1.6 (8.2) mm, $P < 0.001$). Iron-deficient anemic patients had the highest clot-strength and fibrinogen-related values at both time points.

Conclusion: Anemic patients with PAD demonstrated higher clot strength and fibrin activity on TEG-PM before and after revascularization. These findings identify anemia as a marker of a more prothrombotic viscoelastic profile and warrant further study of its role in thrombotic risk stratification.

Keywords: peripheral artery disease, thromboelastography, anemia, thrombosis, anticoagulants, thromboprophylaxis

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Introduction

Peripheral arterial disease (PAD) is a chronic condition affecting more than 8.5 million Americans and more than 200 million people worldwide [1, 2], yet it remains underrecognized compared with other vascular conditions [3]. PAD is often asymptomatic and is associated with increased mortality, cardiovascular events, and a substantial burden of amputation [3, 4]. These challenges underscore the need to identify additional risk factors that may worsen PAD outcomes.

Anemia is a common condition characterized by a reduced concentration of hemoglobin or red blood cells and is frequently observed in older adults and patients with chronic medical conditions. Its etiology in patients with PAD is often multifactorial and may involve chronic inflammation and comorbid conditions such as chronic kidney disease (CKD) [5]. Anemia has been independently associated with increased mortality and, among patients undergoing revascularization, with increased risks of amputation and death [6]. A better understanding of the mechanisms by which anemia contributes to these outcomes may provide clinically useful information and improve management of this high-risk population.

Thromboelastography (TEG) assesses the viscoelastic properties of whole blood and provides a dynamic representation of clot formation. Hemostatic responses measured by TEG can vary substantially among patients [7]. TEG with platelet mapping (TEG-PM) enables detailed characterization of clot strength and platelet-related pathways and therefore provides an opportunity to examine how anemia may influence coagulation in patients with PAD. The aim of this study was to evaluate whether anemia is associated with distinct coagulation profiles measured by TEG-PM. We hypothesized that anemic and non-anemic patients would differ significantly in hemostatic parameters.

Materials and methods

Study design and ethics

We conducted a prospective, single-institution study of adults aged >18 years undergoing lower extremity revascularization for PAD from December 2022 to December 2024. Approval was obtained from the Mass General Brigham Institutional Review Board before study initiation (Protocol No. 2022P001918; approved September 19, 2022), and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients before data collection.

Exclusion criteria included pregnancy, absence of atherosclerotic disease, contraindications or allergies to antiplatelet therapy, concurrent anticoagulant use, inability to provide informed consent, or inability to undergo serial blood draws.

Revascularization was considered successful when adequate blood flow was restored to the ischemic area immediately after angioplasty, stenting, or bypass surgery.

Patient data

Baseline demographics, comorbidities, medical history, and intervention-related data were collected from the electronic medical record. Variables included age at intervention, race, body mass index (BMI), hypertension, hyperlipidemia, coronary artery disease (CAD), myocardial infarction (MI), diabetes mellitus, chronic kidney disease (CKD), and deep venous thrombosis (DVT). Medication regimens, coagulation test results, and complete blood count results were also obtained from the medical record. Interventions were categorized as open surgical, endovascular, or combined procedures.

Sample collection and processing

Blood samples for TEG-PM analysis were collected in 4.0-mL non-gel sodium heparin Vacutainers at four time points: baseline (before revascularization) and one, three, and six months after the procedure. According to the manufacturer's instructions, samples underwent a mandatory 30-minute incubation period and were analyzed within two hours of collection. Only baseline and one-month postoperative time points were included in the present analysis.

Thromboelastography with platelet mapping assay

Coagulation profiles were generated using the TEG® 6s Hemostasis Analyzer (Haemonetics Corporation, Boston, MA, USA). The TEG PlateletMapping® 6s system uses PlateletMapping® cartridges to measure kinetic changes during clotting of heparinized whole-blood samples and provide a qualitative assessment of platelet function.

The PlateletMapping® cartridge evaluates maximum amplitude (MA) under four conditions: heparinized kaolin with heparinase activation (MA-HKH), which stimulates a maximal thrombin response to assess overall clot strength and stability despite antiplatelet therapy; fibrin-only activation (MA-ActF), in which reptilase converts fibrinogen to fibrin while thrombin is inhibited; adenosine diphosphate stimulation (MA-ADP); and arachidonic acid stimulation (MA-AA). Reduced MA responses to ADP or AA indicate P2Y12 inhibitor or aspirin activity, respectively, and results are calculated as the percentage of platelet aggregation or inhibition for the ADP and AA pathways.

Subgroup analysis

Patients were classified as anemic or non-anemic using prespecified hemoglobin thresholds (<13.5 g/dL for men and <12 g/dL for women). Additional analyses evaluated iron deficiency anemia (IDA) by categorizing patients as non-anemic, anemic without iron deficiency, or anemic with iron deficiency (IDA-A). A separate analysis excluded patients with CKD to assess whether coagulation differences between anemic and non-anemic patients persisted in the absence of renal impairment.

Statistical analysis

Descriptive statistics were calculated for all variables. Continuous variables are reported as mean (SD), including age, BMI, and hemoglobin A1c. Categorical variables are presented as frequencies and percentages. Groups were compared using the Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. Analyses were performed using GraphPad Prism (GraphPad Software; version 11.0.2). $P < 0.05$ was considered statistically significant.

Results

Patient characteristics and comorbidities

Of 344 patients, 216 (62.8%) were anemic. As shown in Table 1, the anemic group was older (70 (11) vs. 67 (11) years, $P = 0.004$) and had higher prevalences of diabetes mellitus (60.3% vs. 46.0%, $P = 0.013$) and coronary artery disease (60.8% vs.

43.7%, $P = 0.002$) than the non-anemic group. Anemic patients also had a lower BMI (26.6 (5.3) vs. 28.3 (6.5) kg/m², $P = 0.013$) and lower eGFR (65 (27) vs. 76 (21) mL/min/1.73 m², $P = 0.017$).

Table 1. Demographics and medical history of anemic and non-anemic patients.

Variable	Non-anemic	Anemic	*P*-value
Demographics	n = 124	n = 211	
Age (years)	67 (11)	70 (11)	**0.004**
Male (%)	57.3	73.4	**0.003**
White (%)	78.2	64.0	**0.007**
Comorbidities	n = 126	n = 209	
Body mass index (BMI) (kg/m²)	28.3 (6.5)	26.6 (5.3)	**0.013**
eGFR (mL/min/1.73 m²)	76 (21)	65 (27)	**0.017**
Diabetes mellitus (%)	46.0	60.3	**0.013**
Hypertension (%)	84.1	88.5	0.249
Hyperlipidemia (%)	81.8	88.5	0.104
Current smoker (%)	33.3	19.6	**0.006**
Coronary artery disease (%)	43.7	60.8	**0.002**
Previous myocardial infarction (%)	23.2	31.1	0.135

Data are presented as mean (SD) or percentage, as applicable. Abbreviations: BMI: body mass index, eGFR: estimated glomerular filtration rate. $P < 0.05$ was considered statistically significant.

Laboratory and coagulation profiles

As shown in Table S1, anemic patients had lower red blood cell counts (3.69 (0.6) vs. 4.75 (0.5) million/mcL, $P < 0.001$), hemoglobin levels (10.7 (1.6) vs. 14.4 (1.3) g/dL, $P < 0.001$), and hematocrit values (33.1 (5.1)% vs. 43.4 (3.7)%, $P < 0.001$). Mean corpuscular volume ($P = 0.697$), white blood cell count ($P = 0.787$), and platelet count ($P = 0.451$) did not differ significantly between groups. Conventional coagulation tests showed longer values in anemic patients, including PT (16.0 (7.7) vs. 15.3 (5.7) seconds, $P = 0.002$), INR (1.28 (0.42) vs. 1.19 (0.49), $P < 0.001$), and aPTT (50 (27) vs. 35 (14) seconds, $P < 0.001$).

Table S1. Baseline laboratory values in anemic and non-anemic patients.

CBC and clotting laboratory values	Non-anemic (n = 128)	Anemic (n = 216)	*P*-value
White blood cell count (k/mcL)	8.9 (5.7)	8.3 (2.7)	0.787
Red blood cell count (million/mcL)	4.75 (0.5)	3.69 (0.6)	**<0.001**
Hematocrit (%)	43.4 (3.7)	33.1 (5.1)	**<0.001**
Hemoglobin (g/dL)	14.4 (1.3)	10.7 (1.6)	**<0.001**
Mean corpuscular volume (fL)	91.4 (5.0)	91.9 (8.0)	0.697
Platelet count (k/mcL)	249 (91)	265 (129)	0.451
INR	1.19 (0.49)	1.28 (0.42)	**<0.001**
PT (seconds)	15.3 (5.7)	16.0 (7.7)	**0.002**
aPTT (seconds)	35 (14)	50 (27)	**<0.001**

Data are presented as mean (SD). Abbreviations: CBC: complete blood count, INR: international normalized ratio, PT: prothrombin time, aPTT: activated partial thromboplastin time. $P < 0.05$ was considered statistically significant.

TEG-PM findings at baseline and 1-month follow-up

At baseline (Table 2), anemic patients had higher MA-CK (65.0 (6.7) vs. 61.3 (6.3) mm, $P < 0.001$), MA-CFF (29.1 (10.7) vs. 21.4 (7.7) mm, $P < 0.001$), MA-HKH (62.9 (8.2) vs. 58.2 (7.3) mm, $P < 0.001$), MA-ActF (16.1 (7.5) vs. 10.3 (5.4) mm, $P < 0.001$), MA-ADP (52.8 (15.0) vs. 44.6 (15.4) mm, $P < 0.001$), and MA-AA (41.4 (19.7) vs. 35.3 (17.0) mm, $P = 0.007$). Anemic patients also had shorter CK-K times (1.32 (0.70) vs. 1.61 (0.63) minutes, $P < 0.001$), larger CK angles (71.0 (10.5)° vs. 68.6 (8.9)°, $P < 0.001$), and higher CFF-FLEV values (515 (201) vs. 400 (145) mg/dL, $P < 0.001$). R time ($P = 0.199$), lysis-30 ($P = 0.207$), ADP inhibition ($P = 0.395$), and AA inhibition ($P = 0.313$) were not significantly different.

At one month (Table 2), anemic patients continued to have higher MA-CK (67.3 (5.2) vs. 64.9 (5.7) mm, $P = 0.001$), MA-CFF (30.8 (10.8) vs. 26.2 (8.1) mm, $P = 0.008$), CK angle (72.1 (9.6)° vs. 69.8 (9.7)°, $P = 0.016$), and CFF-FLEV (552 (213) vs. 466 (145) mg/dL, $P = 0.008$), as well as a shorter CK-K time (1.34 (0.76) vs. 1.48 (0.74) minutes, $P = 0.047$). No significant differences were observed for R time ($P = 0.182$), lysis-30 ($P = 0.154$), MA-HKH ($P = 0.203$), MA-ActF ($P = 0.177$), MA-ADP ($P = 0.257$), MA-AA ($P = 0.252$), ADP inhibition ($P = 0.660$), or AA inhibition ($P = 0.516$).

Longitudinal changes in TEG-PM

Longitudinal comparisons (Table S2) showed larger changes in non-anemic patients for MA-CK (3.5 (5.2) vs. 2.0 (6.2) mm, $P = 0.012$), MA-CFF (4.4 (8.4) vs. -0.2 (9.5) mm, $P = 0.002$), MA-HKH (4.2 (10.2) vs. -2.0 (6.8) mm, $P < 0.001$), and MA-ActF (3.1 (7.4) vs. -1.6 (8.2) mm, $P < 0.001$). The change in CK-K also differed between groups (-0.14 (0.90) vs. 0.05 (0.81) minutes, $P = 0.010$).

Table 2. Preoperative and 1-month postoperative TEG-PM values in non-anemic and anemic patients.

Variable	Non-anemic (n = 108)	Anemic (n = 180)	*P*-value
Preoperative			
R time (minutes)	6.4 (2.5)	6.9 (4.6)	0.199
Lysis-30 (minutes)	0.48 (0.92)	0.65 (1.52)	0.207
MA-CK (mm)	61.3 (6.3)	65.0 (6.7)	**<0.001**
MA-CFF (mm)	21.4 (7.7)	29.1 (10.7)	**<0.001**
MA-HKH (mm)	58.2 (7.3)	62.9 (8.2)	**<0.001**
MA-ActF (mm)	10.3 (5.4)	16.1 (7.5)	**<0.001**
MA-ADP (mm)	44.6 (15.4)	52.8 (15.0)	**<0.001**
MA-AA (mm)	35.3 (17.0)	41.4 (19.7)	**0.007**
ADP inhibition (%)	21.9 (26.4)	20.4 (21.0)	0.395
AA inhibition (%)	43.7 (36.0)	49.5 (37.5)	0.313
CK-K (minutes)	1.61 (0.63)	1.32 (0.70)	**<0.001**
CK angle (degrees)	68.6 (8.9)	71.0 (10.5)	**<0.001**
CFF-FLEV (mg/dL)	400 (145)	515 (201)	**<0.001**
1-month postoperative			
R time (minutes)	6.8 (1.7)	7.4 (2.3)	0.182
Lysis-30 (minutes)	0.72 (0.89)	0.84 (2.31)	0.154
MA-CK (mm)	64.9 (5.7)	67.3 (5.2)	**0.001**
MA-CFF (mm)	26.2 (8.1)	30.8 (10.8)	**0.008**
MA-HKH (mm)	61.3 (7.2)	62.5 (7.5)	0.203
MA-ActF (mm)	13.8 (6.7)	15.3 (7.2)	0.177
MA-ADP (mm)	41.4 (17.9)	44.0 (18.5)	0.257
MA-AA (mm)	34.9 (18.8)	37.5 (19.2)	0.252
ADP inhibition (%)	44 (36)	40 (34)	0.660
AA inhibition (%)	56 (40)	59 (39)	0.516
CK-K (minutes)	1.48 (0.74)	1.34 (0.76)	**0.047**
CK angle (degrees)	69.8 (9.7)	72.1 (9.6)	**0.016**
CFF-FLEV (mg/dL)	466 (145)	552 (213)	**0.008**

Data are presented as mean (SD). Abbreviations: TEG-PM: thromboelastography with platelet mapping, MA: maximum amplitude, CK: citrated kaolin, CFF: citrated functional fibrinogen, HKH: heparinized kaolin with heparinase, ActF: activator F, ADP: adenosine diphosphate, AA: arachidonic acid, FLEV: functional fibrinogen level. $P < 0.05$ was considered statistically significant.

Table S2. Changes in TEG-PM values between preoperative and postoperative time points (paired differences).

Variable	Non-anemic (n = 54)	Anemic (n = 95)	*P*-value
R time (minutes)	0.3 (2.6)	0.2 (6.1)	0.297
Lysis-30 (minutes)	0.04 (1.06)	0.22 (2.55)	0.243
MA (mm)	3.5 (5.2)	2.0 (6.2)	**0.012**
MA-CFF (mm)	4.4 (8.4)	-0.2 (9.5)	**0.002**
MA-HKH (mm)	4.2 (10.2)	-2.0 (6.8)	**<0.001**
MA-ActF (mm)	3.1 (7.4)	-1.6 (8.2)	**<0.001**
MA-ADP (mm)	-4.7 (21.5)	-11.2 (19.2)	0.113
MA-AA (mm)	1.0 (22.0)	-7.5 (21.6)	0.131
ADP inhibition (%)	25 (39)	21 (35)	0.305
AA inhibition (%)	17 (41)	14 (46)	0.488
CK-K (minutes)	-0.14 (0.90)	0.05 (0.81)	**0.010**
CK angle (degrees)	1.8 (11.6)	1.2 (11.7)	0.547
CFF-FLEV (mg/dL)	53 (157)	4 (213)	0.135

Data are presented as mean (SD). Abbreviations: TEG-PM: thromboelastography with platelet mapping, MA: maximum amplitude, CK: citrated kaolin, CFF: citrated functional fibrinogen, HKH: heparinized kaolin with heparinase, ActF: activator F, ADP: adenosine diphosphate, AA: arachidonic acid, FLEV: functional fibrinogen level. $P < 0.05$ was considered statistically significant.

Subgroup analysis: iron deficiency and CKD status

Among anemic patients, those with iron deficiency had the most pronounced hypercoagulable profile (Table 3). At baseline, IDA-A patients had higher MA-CK, MA-CFF, MA-HKH, MA-ActF, MA-ADP, and MA-AA values than non-anemic patients (all $P < 0.001$), as well as a shorter CK-K time ($P < 0.001$), a larger CK angle ($P = 0.002$), and a higher CFF-FLEV value ($P < 0.001$). At one month, IDA-A patients continued to have higher MA-CK ($P < 0.001$), MA-CFF ($P < 0.001$), MA-ActF ($P = 0.025$), MA-AA ($P = 0.033$), CK angle ($P = 0.011$), and CFF-FLEV ($P = 0.005$), with a longer R time ($P = 0.004$).

Among patients without CKD (Table 4), anemia remained associated with higher MA-CK (64.1 (5.5) vs. 62.0 (6.6) mm, P = 0.017), MA-CFF (26.4 (9.4) vs. 22.0 (9.1) mm, P < 0.001), MA-HKH (62.8 (5.9) vs. 59.2 (7.1) mm, P < 0.001), MA-ActF (14.1 (7.3) vs. 10.2 (5.2) mm, P < 0.001), MA-ADP (51.5 (15.6) vs. 45.3 (15.8) mm, P = 0.003), and CFF-FLEV (447 (194) vs. 391 (164) mg/dL, P = 0.017).

Table 3. TEG-PM values in iron-deficient anemic and non-anemic patients.

Variable	Non-anemic (n = 124)	Iron-deficient anemic (n = 73)	*P*-value
Baseline			
R time (minutes)	6.3 (2.4)	7.0 (2.8)	0.148
Lysis-30 (minutes)	0.47 (0.90)	0.91 (2.25)	0.100
MA (mm)	61.4 (6.2)	65.9 (7.4)	**<0.001**
MA-CFF (mm)	21.5 (7.7)	31.8 (11.1)	**<0.001**
MA-HKH (mm)	58.6 (7.3)	64.7 (7.7)	**<0.001**
MA-ActF (mm)	10.4 (5.4)	16.7 (7.8)	**<0.001**
MA-ADP (mm)	45.4 (15.4)	53.1 (17.9)	**<0.001**
MA-AA (mm)	35.6 (17.1)	47.7 (18.6)	**<0.001**
ADP inhibition (%)	21.0 (25.8)	23.7 (26.8)	0.432
AA inhibition (%)	43.5 (36.2)	37.4 (36.2)	0.520
CK-K (minutes)	1.58 (0.62)	1.30 (0.81)	**<0.001**
CK angle (degrees)	68.9 (8.8)	70.3 (12.3)	**0.002**
CFF-FLEV (mg/dL)	401 (143)	555 (218)	**<0.001**
1-month postoperative			
R time (minutes)	6.8 (1.7)	8.3 (2.8)	**0.004**
Lysis-30 (minutes)	0.72 (0.89)	1.47 (3.80)	0.400
MA (mm)	64.9 (5.7)	68.8 (5.1)	**<0.001**
MA-CFF (mm)	26.2 (8.1)	34.8 (11.3)	**<0.001**
MA-HKH (mm)	61.3 (7.2)	64.1 (6.7)	0.056
MA-ActF (mm)	13.8 (6.7)	16.9 (7.4)	**0.025**
MA-ADP (mm)	41.4 (17.9)	47.0 (18.6)	0.078
MA-AA (mm)	34.9 (18.8)	42.3 (19.7)	**0.033**
ADP inhibition (%)	43.9 (36.4)	38.1 (29.8)	0.564
AA inhibition (%)	59.1 (38.6)	52.1 (39.9)	0.221
CK-K (minutes)	1.48 (0.74)	1.46 (1.10)	0.051
CK angle (degrees)	69.8 (9.7)	72.3 (11.3)	**0.011**
CFF-FLEV (mg/dL)	466 (145)	607 (239)	**0.005**

Data are presented as mean (SD). Abbreviations: IDA: iron deficiency anemia, TEG-PM: thromboelastography with platelet mapping, MA: maximum amplitude, CK: citrated kaolin, CFF: citrated functional fibrinogen, HKH: heparinized kaolin with heparinase, ActF: activator F, ADP: adenosine diphosphate, AA: arachidonic acid, FLEV: functional fibrinogen level. P < 0.05 was considered statistically significant.

Table 4. TEG-PM assay results in non-anemic and anemic patients without chronic kidney disease.

Variable	Non-anemic, no CKD (n = 55)	Anemic, no CKD (n = 58)	*P*-value
R time (minutes)	6.0 (2.4)	6.6 (1.7)	0.058
Lysis-30 (minutes)	0.48 (0.97)	0.547 (0.88)	0.589
MA (mm)	62.0 (6.6)	64.1 (5.5)	**0.017**
MA-CFF (mm)	22.0 (9.1)	26.4 (9.4)	**<0.001**
MA-HKH (mm)	59.2 (7.1)	62.8 (5.9)	**<0.001**
MA-ActF (mm)	10.2 (5.2)	14.1 (7.3)	**<0.001**
MA-ADP (mm)	45.3 (15.8)	51.5 (15.6)	**0.003**
MA-AA (mm)	36.6 (17.2)	39.8 (22.4)	0.210
ADP inhibition (%)	23.1 (29.0)	21.3 (23.0)	0.616
AA inhibition (%)	23.1 (36.0)	21.3 (42.6)	0.616
CK-K (minutes)	1.53 (0.63)	1.40 (0.72)	0.142
CK angle (degrees)	68.8 (9.6)	68.6 (12.0)	0.853
CFF-FLEV (mg/dL)	391 (164)	447 (194)	**0.017**

Data are presented as mean (SD). Abbreviations: CKD: chronic kidney disease, TEG-PM: thromboelastography with platelet mapping, MA: maximum amplitude, CK: citrated kaolin, CFF: citrated functional fibrinogen, HKH: heparinized kaolin with heparinase, ActF: activator F, ADP: adenosine diphosphate, AA: arachidonic acid, FLEV: functional fibrinogen level. P < 0.05 was considered statistically significant.

Discussion

Fibrin-driven hypercoagulability

This study identified distinct TEG-PM profiles in anemic and non-anemic patients with PAD. Anemic patients were older and had a greater burden of comorbidity, consistent with previous reports [8-11]. The most notable differences involved clot-strength and fibrin-related measures, suggesting that anemia is associated with a more procoagulant whole-blood phenotype in this population.

Longitudinal changes after revascularization

Before revascularization, anemic patients demonstrated greater clot strength and fibrin activity, reflected by higher MA-CK and MA-CFF values, faster clot propagation, and higher CFF-FLEV values. Because platelet-specific inhibition measures were not consistently different between groups, the higher overall clot strength may reflect a larger fibrin contribution rather than platelet function alone. After revascularization, coagulation parameters changed in both groups; non-anemic patients showed larger increases in several clot-strength measures, whereas anemic patients maintained higher absolute values for selected fibrin-related parameters. This pattern supports persistent between-group differences rather than uniformly greater postoperative increases in anemic patients.

Contrast with conventional coagulation tests

Conventional coagulation tests (INR, PT, and aPTT) showed longer clotting times in anemic patients, in contrast to the more hypercoagulable TEG-PM profile. This discrepancy highlights the limitations of standard plasma-based assays and the complementary information provided by whole-blood viscoelastic testing [12]. TEG-PM evaluates clot formation under conditions that incorporate cellular and fibrin components and may therefore characterize hemostatic function more comprehensively than conventional clotting times alone.

The pathophysiology of anemia in PAD is often multifactorial, with chronic inflammation contributing through hepcidin-mediated iron sequestration and impaired erythropoiesis. White blood cell counts were similar between groups, although this finding alone does not exclude differences in systemic inflammation. Platelet counts were numerically higher in anemic patients but were not significantly different, making an erythropoietin-mediated effect on platelet production a possible but unproven mechanism [13].

Iron deficiency anemia subgroup

The IDA-A subgroup demonstrated a particularly pronounced hypercoagulable profile. These observations suggest that iron deficiency may accentuate the coagulation abnormalities associated with anemia and warrant further investigation. Excluding patients with CKD did not eliminate most of the observed TEG-PM differences, suggesting that renal dysfunction alone does not explain the association. These findings extend previous reports of altered hemostasis in anemia [14, 15] by applying detailed TEG-PM measurements in patients with PAD. The observed fibrin activity and clot strength may be relevant to thrombotic risk, although clinical thrombotic outcomes were not evaluated in the presented analyses. The findings also remain compatible with proposed interactions between erythropoiesis and platelet biology [13].

Limitations

This single-center study included a predominantly male and White population, limiting generalizability across sex and racial groups. Sample availability varied across analyses and follow-up time points, which may introduce selection bias and should be considered when interpreting between-group comparisons. The analyses were primarily unadjusted and therefore do not establish anemia as an independent causal determinant of the observed TEG-PM differences. In addition, TEG-PM parameters are surrogate hemostatic measures, and clinical thrombotic outcomes were not reported. Further studies should assess whether anemia correction, including treatment of

iron deficiency, modifies viscoelastic profiles and clinically relevant thrombotic outcomes.

Conclusion

TEG-PM findings indicate that anemia is associated with increased clot strength and fibrin activity before and after revascularization in patients with PAD, consistent with a more prothrombotic laboratory profile. These findings support further investigation of anemia as a factor in thrombotic risk stratification and individualized antithrombotic management.

References

1. Criqui MH, Aboyans V. Epidemiology of peripheral artery disease. Circ Res. 2015;116(9):1509-26. doi: 10.1161/CIRCRESAHA.116.303849.
2. Song P, Rudan D, Zhu Y, Fowkes FJI, Rahimi K, Fowkes FGR, et al. Global, regional, and national prevalence and risk factors for peripheral artery disease in 2015: an updated systematic review and analysis. Lancet Glob Health. 2019;7(8):e1020-30. doi: 10.1016/S2214-109X(19)30255-4.
3. Shamaki GR, Markson F, Soji-Ayoade D, Agwuegbo CC, Bamgbose MO, Tamunoinemi BM. Peripheral artery disease: a comprehensive updated review. Curr Probl Cardiol. 2022;47(11):101082. doi: 10.1016/j.cpcardiol.2021.101082.
4. Heald CL, Fowkes FGR, Murray GD, Price JF, Ankle Brachial Index Collaboration. Risk of mortality and cardiovascular disease associated with the ankle-brachial index: systematic review. Atherosclerosis. 2006;189(1):61-9. doi: 10.1016/j.atherosclerosis.2006.03.011.
5. Sankaran VG, Weiss MJ. Anemia: progress in molecular mechanisms and therapies. Nat Med. 2015;21(3):221-30. doi: 10.1038/nm.3814.
6. Desormais I, Aboyans V, Bura A, Constans J, Cambou JP, Messas E, et al. Anemia, an independent predictive factor for amputation and mortality in patients hospitalized for peripheral artery disease. Eur J Vasc Endovasc Surg. 2014;48(2):202-7. doi: 10.1016/j.ejvs.2014.04.005.
7. Majumdar M, Waller D, Poyant J, McElroy I, Lella S, Feldman ZM, et al. Variability of antiplatelet response in patients with peripheral artery disease. J Vasc Surg. 2023;77(1):208-15.e3. doi: 10.1016/j.jvs.2022.08.015.
8. Lanser L, Fuchs D, Scharnagl H, Grammer T, Kleber ME, März W, et al. Anemia of chronic disease in patients with cardiovascular disease. Front Cardiovasc Med. 2021;8:666638. doi: 10.3389/fcvm.2021.666638.
9. Michalak SS, Wolny-Rokicka E, Nowakowska E, Michalak M, Gil L. Clinical implications of the coexistence of anemia and diabetes mellitus in the elderly population. J Diabetes Res. 2021;2021:8745968. doi: 10.1155/2021/8745968.
10. Gandhi SJ, Hagans I, Nathan K, Hunter K, Roy S. Prevalence, comorbidity and investigation of anemia in the primary care office. J Clin Med Res. 2017;9(12):970-80. doi: 10.14740/jocmr3221w.
11. Michalak SS, Rupa-Matysek J, Gil L. Comorbidities, repeated hospitalizations, and age ≥80 years as indicators of anemia development in the older population. Ann Hematol. 2018;97(8):1337-47. doi: 10.1007/s00277-018-3321-x.
12. Hartmann J, Mason D, Achneck H. Thromboelastography (TEG) point-of-care diagnostic for hemostasis management. Point Care. 2018;17(1):15-22. doi: 10.1097/POC.0000000000000156.
13. Stohlawetz PJ, Dzirlo L, Hergovich N, Lackner E, Mensik C, Eichler HG, et al. Effects of erythropoietin on platelet reactivity and thrombopoiesis in humans. Blood. 2000;95(9):2983-9. doi: 10.1182/blood.V95.9.2983.009k27_2983_2989.
14. Scharbert G, Wetzel L, Berlinger L, Kozek-Langenecker S. Effect of anemia on coagulation and platelet function: a whole blood in vitro study. Crit Care. 2011;15(Suppl 1):P445. doi: 10.1186/cc9865.
15. Antwi-Baffour S, Kyeremeh R, Annison L. Severity of anaemia has corresponding effects on coagulation parameters of sickle cell disease patients. Diseases. 2019;7(4):59. doi: 10.3390/diseases7040059.

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Comparison of the RapidFor™ Strep A Rapid Antigen Test with the Culture Method in Throat Swab Specimens: A Prospective Diagnostic Accuracy Study

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Ethical Approval
This study was approved by the Ümraniye Training and Research Hospital Scientific Research Ethics Committee, February 27, 2024; Decision No. 81.
All research procedures were conducted in accordance with the Declaration of Helsinki.

Conflict of Interest
No conflict of interest was declared by the authors.

Financial Disclosure
The RapidFor™ Strep A Rapid Test Kits were provided free of charge by Vitrosens. The company had no role in study design, data analysis, interpretation of results, manuscript preparation, or the decision to submit the manuscript for publication.

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Abstract

Background/Aim: Group A beta-hemolytic streptococci (GAS) are among the most common bacterial causes of pharyngitis. Throat culture is the reference diagnostic method, whereas rapid antigen tests offer faster results. This study aimed to evaluate the diagnostic performance of the RapidFor™ Strep A Rapid Antigen Test compared with throat culture in throat swab specimens.
Methods: Throat culture and rapid antigen testing were performed on specimens from 322 patients aged 2 years or older who presented to Maltepe University Faculty of Medicine Hospital between March and May 2024 with suspected upper respiratory tract infection and for whom GAS testing was planned. A single throat swab was used sequentially for culture and rapid antigen testing. Demographic information was recorded, and sensitivity, specificity, and accuracy were calculated using throat culture as the reference method.
Results: Among the 322 patients evaluated, 74.84% were younger than 18 years. GAS was detected by culture in 97 patients (30.12%). Both tests were positive in 94 patients, both tests were negative in 225 patients, and culture was positive but the rapid antigen test was negative in 3 patients. No false-positive results were observed. Sensitivity, specificity, and accuracy were 96.91%, 100%, and 99.07%, respectively.
Conclusion: The RapidFor™ Strep A Rapid Antigen Test demonstrated high diagnostic performance relative to throat culture in this cohort and provided a rapid testing option.

Keywords: rapid antigen test, throat culture, group A streptococci

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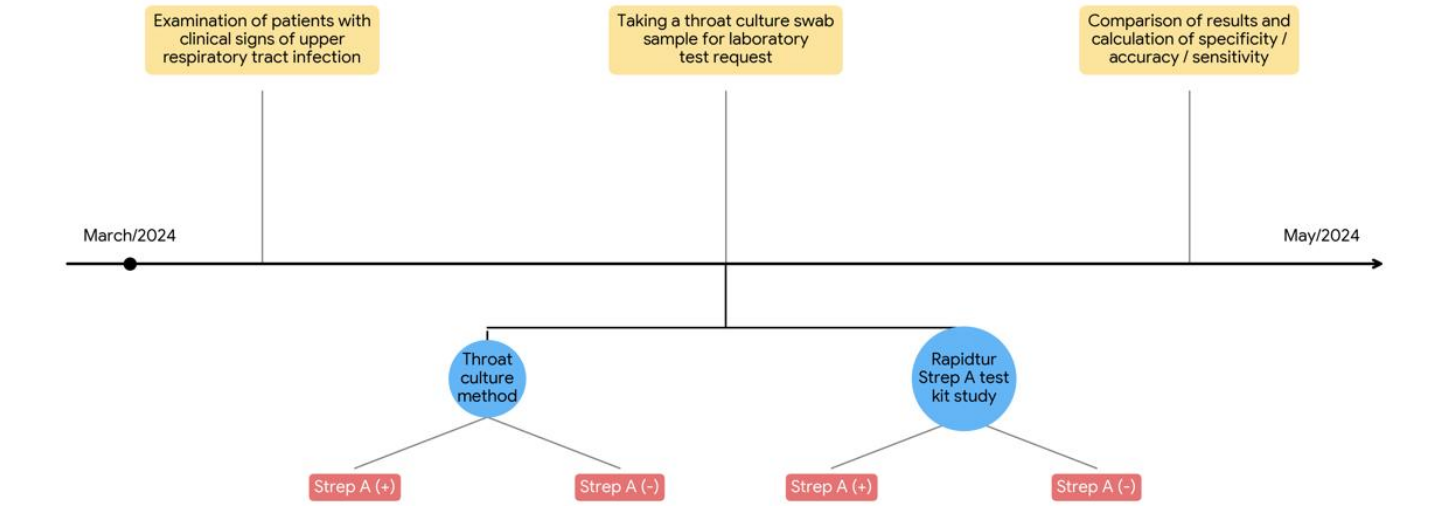
Figure 1. Study Flowchart



Abbreviations: GAS: group A streptococci.

Introduction

Streptococcus pyogenes is a Gram-positive, nonmotile organism belonging to the group A beta-hemolytic streptococci (GAS). The organism commonly colonizes the throat, nose, and skin and represents a major bacterial cause of pharyngitis [1, 2]. Streptococcal pharyngitis commonly manifests with fever above 38 °C and sore throat and may be associated with cryptic tonsils. In the absence of treatment, symptoms generally resolve within 4–5 days. GAS accounts for approximately 5–15% of acute pharyngitis cases in adults and 20–30% of cases in children [2, 3].

Throat culture performed on blood agar is widely used as the reference method for diagnosing streptococcal pharyngitis. Although culture permits identification of non-streptococcal organisms and subsequent antimicrobial susceptibility testing, obtaining a result generally requires 24–48 hours. Rapid diagnostic assays, in contrast, can detect GAS antigens within approximately 5–10 minutes and therefore provide faster diagnostic information. Despite their generally high specificity, the sensitivity of these assays may vary; consequently, negative rapid test results may require confirmation with throat culture [4]. The RapidFor™ Strep A Rapid Test Kit is an immunochromatographic assay intended for the qualitative detection of GAS antigens in throat swab specimens. This study aimed to compare the performance of the RapidFor™ Strep A Rapid Test Kit with that of throat culture, the reference method for detecting GAS in throat swab specimens, in accordance with the CLSI EP12-A2 guideline [5].

Materials and methods

Study Design, Participants, and Ethics

This prospective diagnostic accuracy study was conducted at Maltepe University Faculty of Medicine Hospital between March and May 2024 and is reported in compliance with the Standards for Reporting Diagnostic Accuracy Studies (STARD) 2015 guidelines [6].

Patients aged 2 years or older who presented consecutively to the outpatient clinics or emergency department with clinical features suggestive of an upper respiratory tract infection, including fever >38 °C, sore throat, tonsillitis, or pharyngitis, were assessed for study eligibility. Demographic characteristics, including age and sex, and the results of the rapid antigen test and throat culture were recorded. Eligibility for inclusion required clinical suspicion of GAS infection by the attending physician and a request for diagnostic testing as part of routine patient evaluation. To fully reflect real-world outpatient clinical practice, no exclusion criteria were applied based on disease severity, clinical presentation, or prior medication history (including antibiotic use). No formal prospective sample-size calculation was performed. All 322 enrolled participants underwent both diagnostic evaluations, allowing a paired comparison of the index rapid test and the reference culture method.

The study protocol was approved by the Ethics Committee of Ümraniye Training and Research Hospital (February 27, 2024; Decision No. 81). Written informed consent was obtained from all adult participants, or from the parents or legal guardians of the pediatric patients, before enrollment and data collection, with assent additionally obtained from children where developmentally appropriate in accordance with the approved protocol. The participant pathway is summarized in Figure 1.

Specimen Collection and Diagnostic Workflow

The decision to perform GAS testing was made by the attending physician as part of routine clinical evaluation. A single throat swab was collected from each participant and used sequentially for the two diagnostic procedures. The specimen was initially inoculated onto blood agar and was subsequently used for the RapidFor™ Strep A Rapid Antigen Test. This standardized sequence was followed for all participants to avoid repeated specimen collection and minimize patient discomfort. Rapid antigen testing was performed after culture inoculation in every case. The results of the two tests were recorded independently, and the personnel performing each procedure were blinded to the result of the other test.

Reference Standard: Throat Culture

For the reference standard, the throat swab was inoculated onto blood agar and incubated at 37°C for 24–48 hours. Beta-hemolytic colonies with Gram-positive and catalase-negative characteristics were further evaluated for streptococcal group identification using the Prolex™ Streptococcal Grouping Latex Kit. GAS infection was considered culture-positive when the organism was identified according to these procedures. Samples in which GAS was not detected were classified as

culture-negative. No contaminated, equivocal, unreadable, or otherwise indeterminate culture results occurred during the study period.

Index Test: RapidFor™ Strep A Rapid Antigen Test

The RapidFor™ Strep A Rapid Test Kit is an immunochromatographic assay for the qualitative detection of GAS antigen in throat swab specimens. The test was performed in accordance with the manufacturer's instructions. Results were interpreted at 5 minutes; readings obtained after 15 minutes were considered invalid. No invalid rapid antigen test results were recorded during the study period.

Statistical Analysis

Diagnostic performance was evaluated using throat culture as the reference standard. Results were classified as true positive (TP), false positive (FP), true negative (TN), or false negative (FN). Sensitivity, specificity, overall accuracy, positive predictive value (PPV), and negative predictive value (NPV) and their 95% confidence intervals (CIs) were calculated in accordance with Clinical and Laboratory Standards Institute (CLSI) guideline EP12-A2 [5]. The primary diagnostic metrics were calculated using standard formulas:

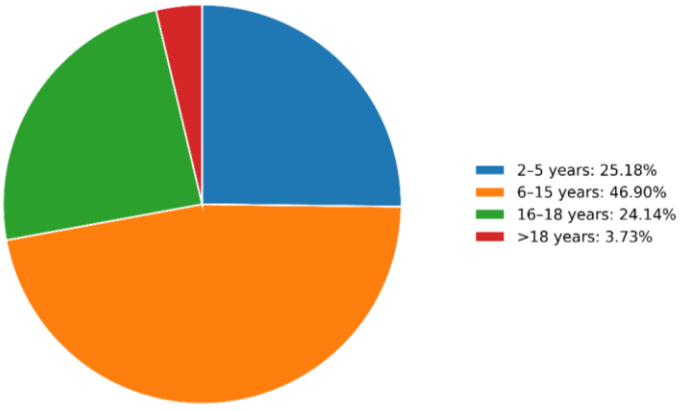
Sensitivity = TP / (TP + FN); specificity = TN / (TN + FP); accuracy = (TP + TN) / (TP + TN + FP + FN).

PPV was defined as the proportion of patients with positive rapid test results who were culture-positive [TP / (TP + FP)]; NPV was defined as the proportion of patients with negative rapid test results who were culture-negative [TN / (TN + FN)]. Statistical analyses and 95% confidence intervals were calculated using MedCalc Statistical Software version 20.0 (MedCalc Software Ltd, Ostend, Belgium) via the Clopper-Pearson exact binomial method.

Results

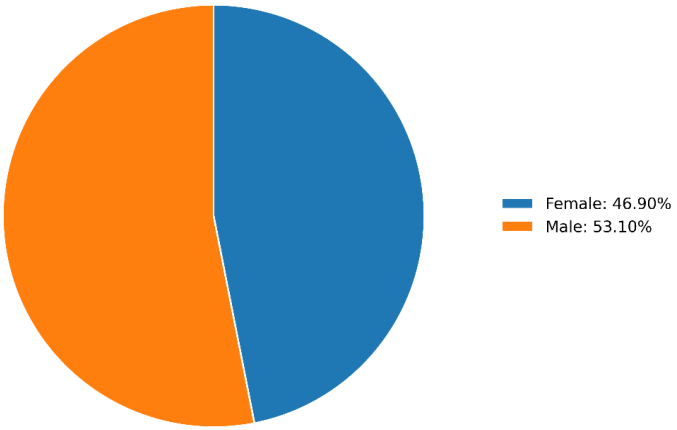
Among the 322 patients with clinically suspected GAS infection, 97 (30.12%) were culture-positive. Patients younger than 18 years accounted for 74.84% of the cohort, and 85.10% of culture-positive cases occurred in patients younger than 18 years. The distributions by age and sex are shown in Figures 2 and 3, respectively.

Figure 2. Distribution of Patients by Age Group



Note: 18-year-olds are included in the 16–18 group, making the pediatric proportion <18 years clear.

Figure 3. Distribution of Patients by Sex



Of the 322 patients, 94 tested positive for GAS by both culture and the rapid antigen test, and 225 tested negative by both methods. The remaining 3 patients were culture-positive but rapid antigen test-negative, representing the only discordant results. No false-positive results were documented. The paired test results and the derived diagnostic performance metrics are summarized in Tables 1 and 2, respectively.

Table 1. Paired Throat Culture and Rapid Antigen Test Results

Rapid Antigen Test Result	Culture Positive	Culture Negative	Total
Positive	94	0	94
Negative	3	225	228
Total	97	225	322

Abbreviations: GAS: group A streptococci.

Table 2. Diagnostic Performance of the RapidFor™ Strep A Rapid Antigen Test

Diagnostic Metric	Value	95% Confidence Interval
Sensitivity	96.91%	91.23%–99.36%
Specificity	100.00%	98.37%–100.00%
Accuracy	99.07%	97.30%–99.81%
Positive Predictive Value (PPV)	100.00%	96.15%–100.00%
Negative Predictive Value (NPV)	98.68%	96.19%–99.73%

Abbreviations: CI: confidence interval, PPV: positive predictive value, NPV: negative predictive value.

Discussion

The diagnostic performance of commercially available Strep A test kits has been evaluated in several studies. In a 2018 study using a double-swab method, the test demonstrated a sensitivity of 92.1%, specificity of approximately 99% (based on the reported data counts), and accuracy of 98.8% [7]. Another study employing double swabs reported sensitivity, specificity, and accuracy values of 84.1%, 100%, and 98.2%, respectively, compared with culture [8]. In a study using a single-swab method, sensitivity was 52% and specificity was 100% [9]. Another investigation evaluated three rapid antigen test kits using dual throat swab samples and reported sensitivities of 92.5% (95% CI, 83.4–97.5), 71.6% (95% CI, 59.3–81.9), and 74.6% (95% CI, 62.5–84.4), respectively. The corresponding specificity values were 97.0% (95% CI, 93.1–99.0), 94.6% (95% CI, 90.1–97.5), and 92.9% (95% CI, 87.8–96.2), with the highest overall accuracy being 95.7% [10].

In comparison to these literature findings, the RapidFor™ Strep A Rapid Test Kit showed sensitivity, specificity, and accuracy relative to culture of 96.91%, 100%, and 99.07%, respectively. These findings indicate that the RapidFor™ Strep A Rapid Test Kit demonstrated high diagnostic performance in the present study, despite the use of a single throat swab specimen.

The small number of discordant results is noteworthy. Three patients had positive culture results but negative rapid

antigen test results, while no false-positive results were observed. However, this study was not designed to determine the reasons for these false-negative findings. Factors such as specimen collection quality and bacterial burden may represent possible pre-analytical explanations, but these cannot be established from the available data. Several studies have addressed unnecessary antibiotic use. One study conducted in Turkey reported that antibiotics are frequently prescribed in primary care at inappropriate doses or durations or without a valid medical indication [11]. Factors contributing to this practice may include the use of findings such as fever, abnormal lung sounds, or visible tonsillar crypts as sufficient grounds for antibiotic prescribing, particularly when physicians have limited time for detailed assessments. In addition, clinicians may choose this less time-consuming approach when faced with patients or relatives who insist on medication. Higher rates of antibiotic prescribing have also been reported in primary care settings with high patient volumes [12, 13].

Rapid antigen testing provided results substantially faster than throat culture while demonstrating high diagnostic performance in this cohort. Therefore, incorporating rapid antigen tests into appropriate clinical diagnostic algorithms may support timely, evidence-based clinical decision-making and may have potential value for antibiotic stewardship. Furthermore, the utilization of a single swab offers an important practical benefit, as it simplifies the collection procedure, optimizes the clinical workflow, and may reduce the need for repeated specimen collection and associated patient discomfort compared with dual-swab approaches. However, because antibiotic prescribing behaviors and longitudinal patient management outcomes were not assessed in this study, a direct reduction in antibiotic utilization cannot be concluded from our findings.

Limitations

This study was conducted at a single center with a relatively short recruitment period (March–May 2024), which may limit the generalizability of the findings. The study population was predominantly pediatric, and no age-specific or subgroup analyses of diagnostic performance were performed. A single throat swab was used sequentially for culture and rapid antigen testing, with culture performed first; although this standardized approach was applied to all participants, a potential effect of the testing sequence on antigen detection cannot be completely excluded. Only three false-negative results were observed, limiting the assessment of factors associated with discordant results. Diagnostic performance may also vary according to GAS prevalence and the clinical spectrum of the study population. Pre-enrollment antibiotic use was not documented; although prior antibiotic therapy may produce false-negative results in both culture and rapid testing, the inclusion of consecutive patients reflects the unselected nature of clinical practice in this outpatient setting.

Conclusion

In individuals with suspected GAS infection, rapid antigen testing provided results considerably faster than throat culture and demonstrated high diagnostic performance in this cohort. These findings suggest that rapid antigen testing may support timely clinical decision-making and may contribute to appropriate antibiotic use when incorporated into an appropriate diagnostic algorithm; however, antibiotic prescribing was not directly assessed in this study.

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References

1. Ekşi Alp E, Dalgıç N, Kına N, Bayraktar B, Öncül A, Aktaş Sepetci E. The importance of rapid antigen testing for group A streptococcal tonsillopharyngitis: a single center experience. J Pediatr Inf. 2018;12(3):e93-8. doi: 10.5578/ced.201829.
2. Ashurst JV, Weiss E, Tristram D, Edgerley-Gibb L. Streptococcal pharyngitis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 [updated February 15, 2025; accessed September 8, 2026]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK525997/.
3. Sauve L, Forrester AM, Top KA. Group A streptococcal pharyngitis: a practical guide to diagnosis and treatment. Paediatr Child Health. 2021;26(5):319-20. doi: 10.1093/pch/pxab025.
4. Centers for Disease Control and Prevention. Clinical guidance for group A streptococcal pharyngitis. November 18, 2025. Accessed September 8, 2026. Available from: https://www.cdc.gov/group-a-strep/hcp/clinical-guidance/strep-throat.html.
5. Clinical and Laboratory Standards Institute. User protocol for evaluation of qualitative test performance; approved guideline. 2nd ed. Wayne (PA): Clinical and Laboratory Standards Institute; 2008. CLSI document EP12-A2.
6. Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. BMJ. 2015;351:h5527. doi: 10.1136/bmj.h5527.
7. Yücel S. A Grubu Beta Hemolitik Streptokokların 1. Basamak Sağlık Kuruluşlarında Tanısı ve Gereksiz Antibiyotik Kullanımı. STED. 2018;27(3):205-8. Available from: https://izlik.org/JA85BZ72LP.
8. Sayğılı N, Bulut E, Deniz R, Dalgıç N, Aktaş E. Use of Bionexia Strep A Plus rapid antigen test in the identification of group A beta-hemolytic streptococci in throat swab samples. Turk Mikrobiyol Cem Derg. 2017;47(3):138-45. doi: 10.5222/TMCD.2017.138.
9. Avcıoğlu F, Behçet M, Afşar Y, Özdemir B, Kurtoğlu MG. Evaluation of group A beta-hemolytic streptococcus diagnosis by culture and rapid antigen test. Dicle Med J. 2020;47(2):411-6. doi: 10.5798/dicletip.755759.
10. Kim HN, Kim J, Jang WS, Nam J, Lim CS. Performance evaluation of three rapid antigen tests for the diagnosis of group A streptococci. BMJ Open. 2019;9(8):e025438. doi: 10.1136/bmjopen-2018-025438.
11. Karabay O. Birinci basamakta antibiyotik kullanımında Türkiye'de durum. ANKEM Derg. 2007;21(Suppl 2):252-6.
12. Hosoglu S, Classen AY, Akturk Z. Antibiotic prescription in primary care from the perspective of family physicians: a qualitative study. J Infect Dev Ctries. 2021;15(8):1117-23. doi: 10.3855/jidc.13924.
13. Öztürk GZ, Toprak D, Sağsöz O, Ardıç C. Knowledge, attitude and practice of family physicians on antimicrobial therapy for acute respiratory tract infections: a study from Istanbul, Turkey. Euras J Fam Med. 2021;10(2):49-55. doi: 10.33880/ejfm.2021100202.

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Incarcerated De Garengeot Hernia: An Atypical Presentation of an Abdominal Emergency: A Case Report

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Ethics Committee Approval
Ethics committee approval was not required for this single case report according to institutional policy.

Informed Consent
Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

De Garengeot hernia is an uncommon form of femoral hernia in which the vermiform appendix is located within the hernia sac. Because its clinical presentation is usually nonspecific, the diagnosis is often difficult before surgery. An 87-year-old woman was evaluated for a painful right groin mass that had been present for one month and had worsened during the preceding two days. Ultrasonography suggested incarcerated hernia contents, and contrast-enhanced abdominopelvic computed tomography identified the distal appendix within the right femoral canal. Emergency surgery was performed through an anterior open approach. An incarcerated femoral hernia containing the appendix and hemorrhagic fluid was found, with ischemic-appearing changes in the distal third of the appendix. Appendectomy and tissue-based femoral hernia repair using the McVay technique were performed without mesh because of the potentially contaminated operative field. Histopathology showed recent transmural hemorrhage without acute appendicitis, supporting incarceration-related vascular compromise rather than primary inflammatory appendicitis. The patient had an uncomplicated postoperative course and was discharged 24 hours after surgery. This case emphasizes the value of preoperative imaging in selected patients and supports tailoring surgical management according to intraoperative findings.

Keywords: femoral hernia, de Garengeot hernia, appendix, appendectomy, McVay repair

Introduction

Femoral hernias are uncommon compared with other abdominal wall hernias, but they are clinically important because they have a greater tendency toward incarceration or strangulation. This behavior is explained in part by the anatomy of the femoral canal, a narrow space bounded by rigid structures such as the inguinal ligament, lacunar ligament, and femoral vein. Reported incarceration rates range from 14% to 56%, making prompt diagnosis and surgical treatment important in suspected cases [1, 2].

De Garengeot hernia refers to the presence of the vermiform appendix within a femoral hernia sac. It was first described in 1731 by René Jacques Croissant de Garengeot. Although femoral hernias account for approximately 3% of all hernias and are more frequent in women, appendiceal involvement is rare, with reported frequencies ranging from 0.5% to 5% of femoral hernias [3].

The diagnosis is usually difficult before surgery. Most patients present with a painful groin mass and nonspecific clinical or laboratory findings, so the condition may be indistinguishable from an incarcerated femoral hernia. In this setting, imaging can be useful. Ultrasonography may suggest incarcerated hernia contents, whereas computed tomography can identify the appendix within the femoral canal and help guide the operative approach [4-7].

There is no single accepted surgical strategy for this condition. Management depends on the patient's condition, the macroscopic appearance of the appendix, the presence of appendicitis or perforation, and the degree of contamination. These findings also influence the decision to perform appendectomy and whether prosthetic material can be safely used for hernia repair [5, 7, 8].

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We present the case of an 87-year-old woman with an incarcerated femoral hernia in whom preoperative imaging suggested de Garengeot hernia, later confirmed during emergency surgery. The appendix showed ischemic-appearing changes, and hemorrhagic fluid was found within the hernia sac; however, histopathology showed recent transmural hemorrhage without acute appendicitis. This case report was prepared in accordance with the CARE guidelines and SCARE 2025 criteria [9, 10].

Case presentation

An 87-year-old woman with no significant medical history was evaluated in the emergency department for a painful right inguinofemoral mass that had been present for approximately one month, with worsening pain during the preceding two days. She had taken analgesics without improvement. On admission, localized inflammatory changes were present over the right groin, without clinical or laboratory evidence of a systemic inflammatory response.

Soft-tissue ultrasonography showed increased echogenicity of the skin and subcutaneous tissue and a 36 × 30 mm ovoid lesion with fluid content and a hyperechoic tubular structure within it, suggesting incarcerated hernia contents. Contrast-enhanced abdominopelvic computed tomography showed a right femoral hernia containing fat, free fluid, and the distal portion of the vermiform appendix, consistent with de Garengeot hernia (Figure 1).

Emergency surgery was performed through an anterior open approach. An incarcerated right femoral hernia was identified, and after opening the hernia sac, hemorrhagic fluid and the vermiform appendix were found. The distal third of the appendix showed vascular congestion and ischemic-appearing changes (Figure 2).

Appendectomy was performed, followed by femoral herniorrhaphy using the McVay technique without mesh because of the potentially contaminated operative field. The procedure was completed without complications, and the patient was discharged

Figure 1. Contrast-enhanced abdominopelvic computed tomography findings.

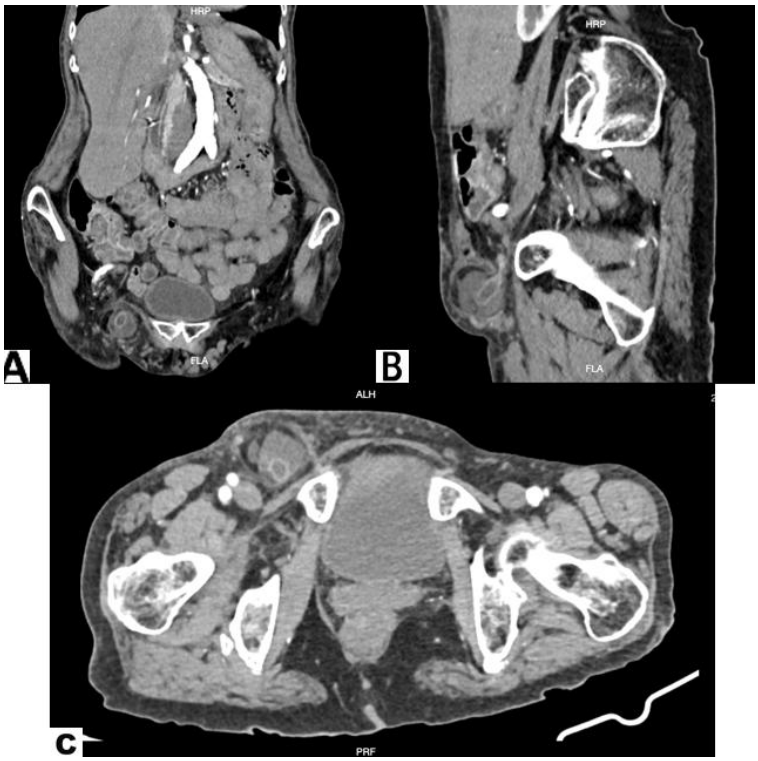

Image A: Coronal view showing a right femoral hernia containing the distal appendix, with wall enhancement, periappendiceal inflammatory changes, and free fluid within the hernia sac. **Image B:** Sagittal view demonstrating the appendix within the right femoral canal, consistent with de Garengeot hernia. **Image C:** Axial view showing the appendix in the right femoral region.

Figure 2. Clinical and intraoperative findings.

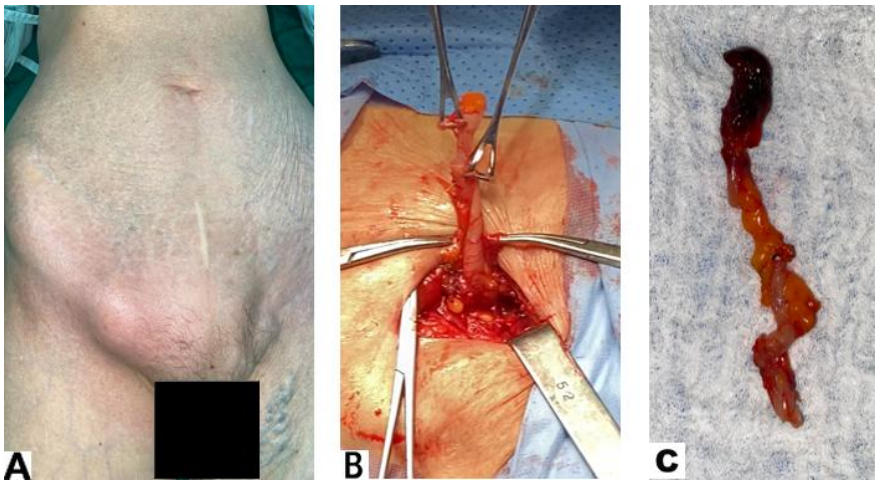

Image A: Preoperative photograph showing a bulge in the right inguinofemoral region below the inguinal ligament, consistent with an incarcerated femoral hernia. **Image B:** Intraoperative view showing protrusion of the vermiform appendix through the femoral ring. **Image C:** Resected vermiform appendix showing vascular congestion and ischemic-appearing changes after removal from the incarcerated femoral hernia sac.

24 hours after surgery. At one-month postoperative follow-up, the patient remained clinically well, with an appropriately healed surgical wound and no signs of infection, recurrent inguinofemoral mass, local pain, or clinical evidence of hernia recurrence. Histopathology showed recent transmural hemorrhage without acute appendicitis.

Discussion

The clinical diagnosis of de Garengeot hernia is difficult because its presentation overlaps with that of other complicated groin hernias. Patients usually present with painful inguinofemoral swelling, whereas laboratory findings may be normal or nonspecific. For this reason, many cases are still diagnosed during surgery rather than before the operation [3, 5].

In the present case, imaging was useful for surgical planning. Ultrasonography suggested incarcerated hernia contents, and contrast-enhanced computed tomography identified the appendix within the right femoral canal. Although the diagnosis may be made intraoperatively, computed tomography can provide relevant information about the hernia contents, appendiceal involvement, and possible inflammatory or ischemic changes [4, 7].

There is no standardized operative approach for de Garengeot hernia. The choice of technique depends on the patient's condition, the viability of the appendix, the presence of appendicitis or perforation, and the degree of contamination. Open anterior, open abdominal, laparoscopic, and combined approaches have been described; treatment should therefore be adapted to each case [5, 7, 8].

In this patient, an anterior open approach was chosen because the findings were localized to the groin and emergency repair of the incarcerated femoral hernia was required. Appendectomy was performed because the distal appendix showed vascular congestion and ischemic-appearing changes, and hemorrhagic fluid was present within the hernia sac. However, histopathology showed recent transmural hemorrhage without acute appendicitis. This discrepancy suggests that incarceration within the narrow femoral canal may produce venous congestion and hemorrhagic compromise without established inflammatory appendicitis.

The femoral defect was repaired using the McVay technique, a tissue-based repair that allows closure of the femoral defect through fixation to Cooper's ligament. This repair was preferred over other non-mesh tissue repairs because it provides direct reinforcement of the femoral canal through Cooper's ligament fixation, which was suitable for the localized femoral defect identified in this patient. Mesh was avoided because the operative field was considered potentially contaminated because of appendiceal involvement and the presence of hemorrhagic fluid. Although mesh use may be considered in selected cases without appendicitis or contamination, tissue repair remains a reasonable option when contamination is suspected [5, 7, 8].

This case provides two practical considerations. First, de Garengeot hernia should be considered in elderly women with painful inguinofemoral swelling, particularly when imaging suggests an incarcerated femoral hernia. Second, surgical management should not be based only on the presence of the appendix within the hernia sac but also on macroscopic findings, contamination risk, and histopathological correlation.

In conclusion, de Garengeot hernia is an uncommon condition that may be difficult to diagnose before surgery because of its nonspecific presentation. In this case, ultrasonography raised the initial suspicion, and computed tomography confirmed the presence of the appendix within the femoral canal, allowing appropriate operative planning. Appendectomy and tissue-based femoral hernia repair were performed without mesh because of macroscopic appendiceal compromise and concern for possible contamination. Histopathology showed recent transmural hemorrhage without acute appendicitis, supporting incarceration-related vascular compromise. Surgical management should be individualized according to clinical, radiological, and intraoperative findings.

References

1. Salawu A, Sarsam M, Butcher K. A case report and literature review of De Garengeot hernia. J Surg Case Rep. 2025;2025(1):rjae673. doi: 10.1093/jscr/rjae673.
2. Águila Gómez MV. Hernia de Garengeot, de la teoría a la práctica: a propósito de un caso. Rev Med La Paz. 2024;30(1):41-6. Available from: http://www.scielo.org.bo/scielo.php?script=sci_arttext&pid=S1726-89582024000100041.
3. Quach L, Biel A, Todd B. De Garengeot hernia with acute gangrenous appendicitis case report. Clin Pract Cases Emerg Med. 2025;9(2):165-8. doi: 10.5811/cpcem.35386.
4. Donovan EJ, Cruser JC, Macey RE, Kalan MMH. De Garengeot hernia: a rare presentation of a femoral hernia. Consultant. 2023;63(4):e6. doi: 10.25270/con.2022.08.000007.
5. Linder S, Linder G, Månsson C. Treatment of de Garengeot's hernia: a meta-analysis. Hernia. 2019;23(1):131-41. doi: 10.1007/s10029-018-1862-5.
6. Sutedja B, Rudiman R, Susanto N, Siswanto AY. De Garengeot hernia: a case report and classification. Int J Abdom Wall Hernia Surg. 2023;6(3):197-9. doi: 10.4103/ijawhs.ijawhs_28_23.
7. Guenther TM, Theodorou CM, Grace NL, Rinderknecht TN, Wiedeman JE. De Garengeot hernia: a systematic review. Surg Endosc. 2021;35(2):503-13. doi: 10.1007/s00464-020-07934-5.
8. Tiwana S, Kabir SA. De Garengeot hernia: a case report of an incidental finding. Cureus. 2024;16(11):e73817. doi: 10.7759/cureus.73817.
9. Gagnier JJ, Kienle G, Altman DG, Moher D, Sox H, Riley D, et al. The CARE guidelines: consensus-based clinical case reporting guideline development. J Med Case Rep. 2013;7:223. doi: 10.1186/1752-1947-7-223.
10. Kerwan A, Al-Jabir A, Mathew G, Sohrabi C, Rashid R, Franchi T, et al. Revised Surgical CAse REport (SCARE) guideline: an update for the age of artificial intelligence. Premier J Sci. 2025;10:100079. doi: 10.70389/PJS.100079.

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Bilateral extensor medii proprius: A cadaveric case report

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Ethics
This cadaveric case report was conducted in accordance with established ethical standards for the use of human anatomical specimens. Institutional review determination/approval was obtained under IRB number 2024-179. The cadaver was obtained through a legitimate body donation program for medical education and research. All identifying information was excluded to preserve donor anonymity and confidentiality in accordance with accepted ethical guidelines. The specimen was handled with respect and professionalism throughout the dissection and documentation process.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

During dissection of a formalin-fixed cadaver in the upper-limb unit of a gross anatomy laboratory, bilateral anomalous muscle bellies and tendons, identified as the extensor medii proprius (EMP), were observed in the posterior compartments of the forearms. The muscle originated from the distal one-third of the ulna and inserted on the extensor hood and proximal interphalangeal joint of the third digit, with an additional tendinous slip connecting to the extensor hood of the third digit and intertendinous connections to the second digit. Both tendons shared a canal with the extensor indicis (EI) and extensor digitorum (ED) tendons. The EMP was distinguished from the EI and ED by its insertion on the third digit and by a separate muscle belly, unlike the ED, which has a common origin and multiple tendons to digits two through five, and the EI, which inserts on the second digit. Although anomalies of the extensor forearm muscles are not uncommon, the literature documenting these variants remains limited. Recognition of these variants is clinically relevant because they can contribute to misdiagnosis when evaluating dorsal hand pain, affect surgical planning, or provide potential graft sources during reconstructive procedures. This report describes the bilateral EMP variant and discusses its prevalence, clinical significance, and possible embryological origin.

Keywords: extensor medii proprius, extensor indicis, forearm anatomical variation, embryology, cadaveric dissection

Introduction

The normal anatomy of the extensor compartment of the forearm includes the extensor indicis (EI) muscle, with its tendon inserting into the extensor hood of the second digit, and the extensor digitorum (ED) muscle, with its tendons inserting into the extensor hoods of digits two through five. The proximal attachment of the EI is on the distal one-third of the posterior surface of the ulna and the interosseous membrane, whereas the ED originates from the lateral epicondyle of the humerus. The EMP is an anatomical variant analogous to the EI, with its tendon inserting at the base of the third digit rather than the second digit [1]. The cadaver presented with oligodactyly involving the right second digit, although the EMP was present bilaterally. The anomalous muscle and tendon were identified in one of 15 cadavers during dissection of the deep extensor forearm muscles in a first-year anatomy course at Rocky Vista University College of Osteopathic Medicine.

The prevalence of variant muscles in the flexor compartment of the arm that may entrap neurovascular structures has been reported as 2.68% [2]. Although extensor compartment variants such as the EMP are less frequently reported, their presence has been documented in anatomical studies [3]. Recognition and investigation of these anomalies remain important because awareness can improve diagnostic accuracy and guide surgical intervention. This report describes the variant EMP muscle and tendon, its possible effects on functional use of the hand, and potential embryological origins.

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Case presentation

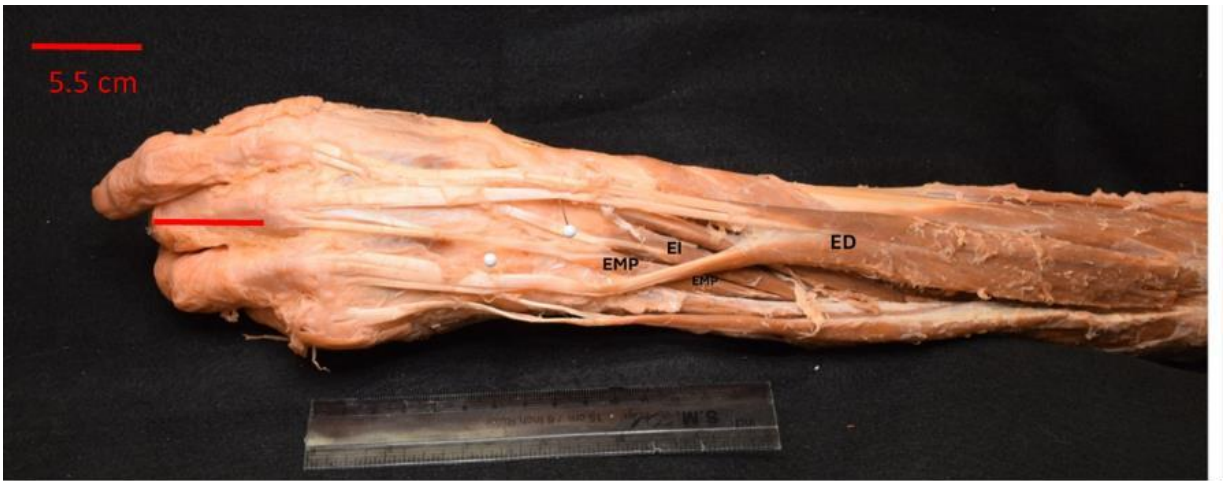
The muscle belly of the EMP originated from the distal one-third of the ulna, just distal to the EI muscle, without connections to the interosseous membrane (Figure 1). The thickest tendon slip traversed the dorsum of the hand to reach the extensor hood of the third digit on the ulnar side and then continued past the metacarpophalangeal joint to insert on the ulnar side of the proximal interphalangeal joint of the third digit. An additional tendinous slip arose from the EMP muscle belly, inserted into the extensor hood of the third digit, and provided intertendinous connections to the second digit. Both tendons traversed the wrist through a shared canal with the EI and ED tendons. The relationship of the EMP muscle belly and tendon to the ED and EI is shown in Figure 2. The deep aspect of the muscle belly was supplied by the anterior interosseous artery after it perforated the interosseous membrane and reached the posterior forearm compartment, with additional superficial supply from the posterior interosseous artery. Although the nerve supply was not visually confirmed, the EMP was presumed to be innervated by the posterior interosseous nerve (PIN) because of its proximity to the PIN and other muscles supplied by this nerve.

Discussion

The origin of the EMP is incompletely understood; however, several hypotheses have been proposed regarding possible embryological or evolutionary origins. During limb development, muscle progenitor cells derived from the hypaxial portion of the somites migrate into the limb bud and are organized into dorsal and ventral muscle masses [4]. These masses subsequently undergo differentiation and splitting to form individual muscles, a process that is not yet fully understood [5]. Anomalies such as the EMP may arise from incomplete or altered separation of these muscle groups, resulting in accessory muscle bellies or tendons. Similar explanations have been proposed for other forearm anomalies, supporting the concept that disruptions in normal muscle development can lead to anatomical variations [6, 7].

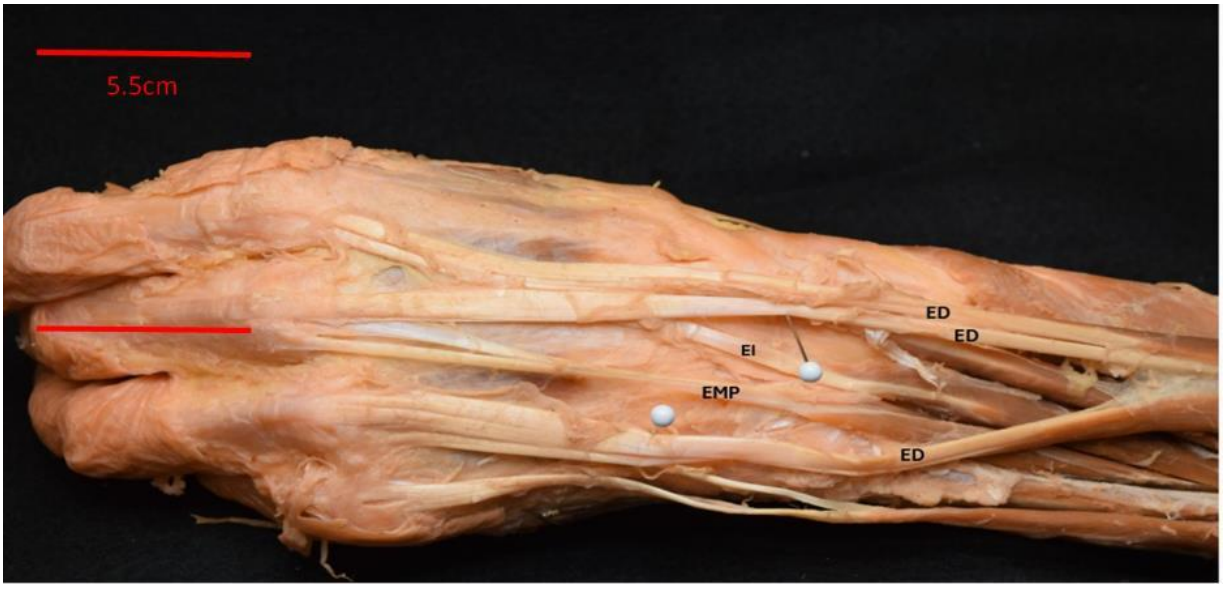
In addition to embryological explanations, anatomical studies have suggested a possible evolutionary origin for these variants. The presence of muscles such as the EMP, extensor indicis proprius (EIP), and extensor indicis et medii communis (EIMC) in nonhuman primates supports the hypothesis that these structures may represent phylogenetic remnants rather than

Figure 1. Extensor medii proprius with the muscle belly originating from the distal one-third of the ulna and the tendon inserting into the extensor hood of the third digit.



Abbreviations: ED: extensor digitorum, EI: extensor indicis, EMP: extensor medii proprius.

Figure 2. Extensor medii proprius with a distinct muscle belly and tendon located deep to the ED and medial to the EI.



Abbreviations: ED: extensor digitorum, EI: extensor indicis, EMP: extensor medii proprius.

developmental variations of the normal arrangement [8]. Although these studies provide insight into the possible origin of the EMP, further research is needed to determine whether variants such as the EMP are primarily evolutionary or embryological in origin.

Understanding the anatomy and incidence of anomalous tendons and muscles of the extremities is clinically relevant because some variants may require surgical intervention. Additional musculature in the extensor compartments may contribute to crowding beneath the extensor retinaculum, leading to pain and nerve entrapment. These presentations may be misdiagnosed as more common conditions such as ganglion cysts, tenosynovitis, or soft-tissue tumors [9]. Prior reports have shown that anomalous tendons can directly contribute to symptomatic presentations requiring surgical intervention, further emphasizing the need for accurate identification and diagnosis to improve patient outcomes [10].

Anomalous tendons and muscles can also provide resources for surgical reconstruction. Although the current literature does not provide specific statistics, EI tendons are commonly used in graft and tendon transfer procedures, suggesting that variant tendons may also be useful for surgical reconstruction [9]. In addition, accessory slips may produce clinical symptoms or complicate identification of normal tendon anatomy during surgical procedures. Preoperative awareness and careful intraoperative assessment are therefore essential to ensure accurate identification and minimize the risk of surgical complications [11].

In summary, this case report highlights the bilateral presentation of the EMP and emphasizes the importance of recognizing anatomical variations within the forearm. Although these variations are not routinely emphasized in medical education, their recognition is important for improving diagnostic accuracy and informing surgical planning, ultimately contributing to optimal patient outcomes.

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References

1. Baker C, Swartz G, Garcia J, Hernandez Perez F, McIntosh LP. Extensor medii proprius: a cadaveric case report. Cureus. 2023;15(9):e46018. doi: 10.7759/cureus.46018.
2. Paraskevas G, Natsis K, Ioannidis O, Papaziogas B, Kitsoulis P, Spanidou S. Accessory muscles in the lower part of the anterior compartment of the arm that may entrap neurovascular elements. Clin Anat. 2008;21(3):246-51. doi: 10.1002/ca.20608.
3. Yammine K. The prevalence of the extensor indicis tendon and its variants: a systematic review and meta-analysis. Surg Radiol Anat. 2015;37(3):247-54. doi: 10.1007/s00276-014-1352-0.
4. Buckingham M, Bajard L, Chang T, Daubas P, Hadchouel J, Meilhac S, et al. The formation of skeletal muscle: from somite to limb. J Anat. 2003;202(1):59-68. doi: 10.1046/j.1469-7580.2003.00139.x.
5. Wilde S, Feneck EM, Mohun TJ, Logan MPO. 4D formation of human embryonic forelimb musculature. Development. 2021;148(4):dev194746. doi: 10.1242/dev.194746.
6. Gabríková K, Kachlík D, Belbl M, Kunc V. An accessory muscle belly or an accessory muscle head? An unusual arrangement of muscles in the anterior compartment of the forearm. Surg Radiol Anat. 2023;45(3):271-5. doi: 10.1007/s00276-023-03084-0.
7. Tan ST, Smith PJ. Anomalous extensor muscles of the hand: a review. J Hand Surg Am. 1999;24(3):449-55. doi: 10.1053/jhsu.1999.0449.
8. von Schroeder HP, Botte MJ. The extensor medii proprius and anomalous extensor tendons to the long finger. J Hand Surg Am. 1991;16(6):1141-5. doi: 10.1016/s0363-5023(10)80081-4.
9. Kumka M. A variant extensor indicis muscle and the branching pattern of the deep radial nerve could explain hand functionality and clinical symptoms in the living patient. J Can Chiropr Assoc. 2015;59(1):64-71.
10. Khazzam M, Patillo D, Gainor BJ. Extensor tendon triggering by impingement on the extensor retinaculum: a report of 5 cases. J Hand Surg Am. 2008;33(8):1397-400. doi: 10.1016/j.jhsa.2008.04.007.
11. Yaşar YK, Anıl A, Anıl F, Kastamoni M, Peker TV. Anatomic variations of the hand extensor muscle tendons. Gazi Med J. 2017;28(3):206-7. doi: 10.12996/gmj.2017.60.

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Operative Decision-Making in Coronary Artery Aneurysms: A Case Series

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Ethics
This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Institutional review board approval was not required for this retrospective case series in accordance with local policy.

Patient Consent
Written informed consent was obtained from both patients for publication of their clinical details and accompanying imaging.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Coronary artery aneurysms (CAAs) are uncommon, and management recommendations remain limited because of variability in underlying etiology and clinical presentation. This case series describes two patients with right coronary artery (RCA) aneurysms managed surgically within a 2-month period. The first patient was a 69-year-old man with RCA aneurysms and obstructive coronary artery disease who underwent off-pump coronary artery bypass grafting using a saphenous vein graft to the posterior descending artery with aneurysm ligation. The second patient was a 68-year-old man with large thrombotic RCA aneurysmal disease and a concurrent abdominal aortic aneurysm, raising concern for broader vascular involvement. He underwent off-pump coronary artery bypass grafting using saphenous vein grafts to the right ventricular, posterior descending, and posterolateral branches, along with aneurysm ligation. These cases emphasize the need for an individualized, anatomy-driven framework for CAA repair and long-term surveillance and provide a practical reference for operative planning.

Keywords: right coronary artery aneurysm, off-pump CABG, aneurysm ligation, aneurysmal vascular disease, postoperative surveillance

Introduction

Coronary artery aneurysms (CAAs) are uncommon, with a reported incidence ranging from 0.3% to 5% in angiographic studies [1]. They are defined as focal coronary dilations measuring at least 1.5 times the diameter of the adjacent normal vessel [2]. The right coronary artery is most frequently involved, and larger aneurysms carry increased risks of thrombosis, distal embolization, myocardial ischemia, and, rarely, rupture [3, 4].

In adults, atherosclerosis is the most common underlying cause, although inflammatory disorders, prior coronary intervention, trauma, and connective tissue disease may also contribute [5]. Despite increasing recognition, management remains challenging because CAAs are uncommon and evidence-based treatment recommendations are limited.

Medical therapy may reduce thrombotic risk but does not address progressive enlargement or future ischemic events. Percutaneous exclusion with covered stents may be limited by thrombus burden, inadequate landing zones, restenosis, or loss of branch vessels. Surgical treatment is therefore often favored for large or symptomatic aneurysms, particularly when reliable distal revascularization is required [6, 7].

In addition, preoperative screening of other vascular beds may identify multisite aneurysmal disease that can influence operative planning and long-term postoperative surveillance. Two cases of surgically managed RCA aneurysms are presented to demonstrate how aneurysm anatomy, distal myocardial territory at risk, and associated systemic aneurysmal disease may guide individualized operative decision-making.

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Case presentation

Case 1

A 69-year-old man with a history of coronary artery disease, previous angioplasty and stenting of the circumflex and left anterior descending arteries, hyperlipidemia, morbid obesity, diabetes mellitus, and end-stage renal disease presented for surgical management of two right coronary artery (RCA) aneurysms and severe mid-RCA stenosis identified on angiography (Figure 1). Preoperative echocardiography demonstrated a left ventricular ejection fraction of 45%, concentric left ventricular hypertrophy, and no significant valvular abnormality.

At surgery, two large RCA aneurysms were noted, one proximally near the origin and one more distally near the bifurcation; both were heavily calcified. The posterior descending artery (PDA) measured 3 mm in diameter and was free of distal disease, providing a suitable target for grafting. The patient underwent single-vessel off-pump coronary artery bypass grafting (CABG) using a reverse saphenous vein graft from the right leg to the PDA, with ligation of the RCA aneurysms. Cardiopulmonary bypass was not used. The patient tolerated the procedure well and was transferred to the intensive care unit in stable condition. Postoperative management included standard hemodynamic monitoring, antiplatelet and statin therapy, glycemic control, and renal supportive care for end-stage renal disease. There were no intraoperative or postoperative complications. This case illustrates the feasibility of off-pump management of multiple calcified RCA aneurysms in a high-risk patient.

Case 2

A 68-year-old man with a history of coronary artery disease, ST-elevation myocardial infarction, hypertension, dyslipidemia, cerebrovascular accident with residual facial numbness, and an infrarenal abdominal aortic aneurysm was evaluated for a newly identified right coronary artery aneurysm. He had previously been followed for right bundle branch block and cardiomyopathy and was asymptomatic at presentation. Preoperative computed tomography angiography of the chest, abdomen, and pelvis demonstrated marked aneurysmal dilation of the RCA, measuring up to 25 mm in outer diameter, with partial mural thrombus. Additional aneurysmal changes were noted in the mid left anterior descending artery (maximum diameter, 12 mm), infrarenal abdominal aorta (4.2 × 4.0 cm), and bilateral internal iliac arteries (right, 4.9 cm; left, 4.2 cm), consistent with multisite aneurysmal disease (Figures 2-4). Transthoracic echocardiography revealed a left ventricular ejection fraction of 30%, trace mitral regurgitation, and inferior hypokinesis.

The patient underwent off-pump CABG × 3 using left saphenous vein grafts to the right ventricular branch, posterior descending artery, and posterolateral artery, together with ligation of the RCA aneurysm and excision of a mediastinal lymph node. The aneurysmal RCA segment extended from just beyond the ostium to the bifurcation of the posterior descending and posterolateral arteries. After completion of the distal anastomoses, two proximal anastomoses were constructed at the aortic root to restore flow. Cardiopulmonary bypass was not used. The postoperative recovery was uneventful.

Figure 1. Coronary angiography demonstrating large aneurysmal dilation of the proximal and distal right coronary artery with single-vessel runoff in Case 1

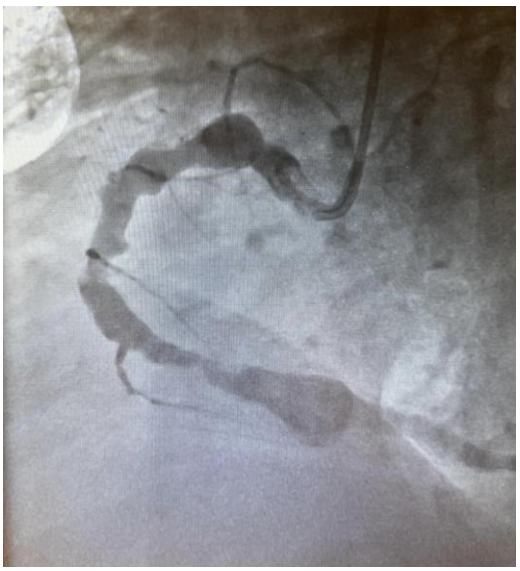


Figure 2. Coronary angiography demonstrating diffuse aneurysmal dilation and ectasia of the right coronary artery extending into the distal branches

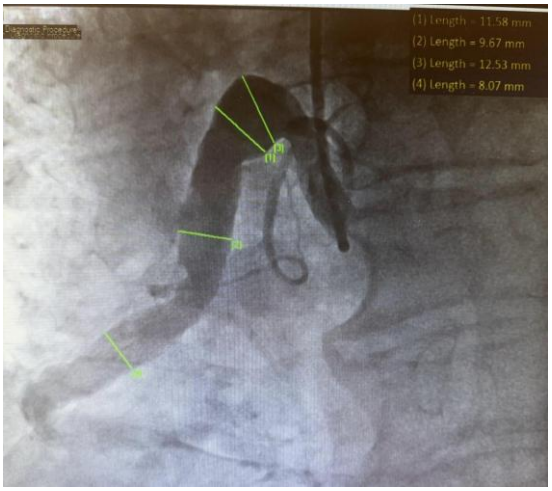


Figure 3. Cardiac computed tomography demonstrating aneurysmal dilation of the right coronary artery with additional aneurysmal involvement of the mid left anterior descending artery (maximum diameter, 12 mm), consistent with multisite coronary aneurysmal disease

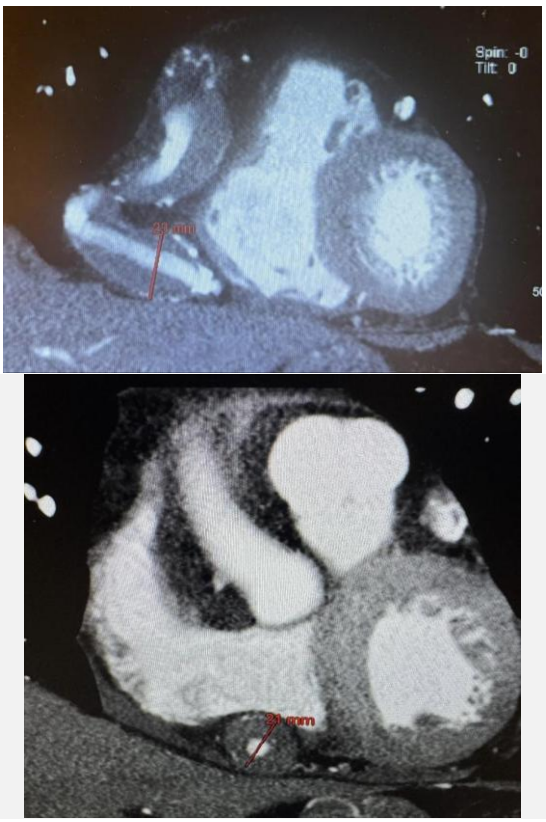
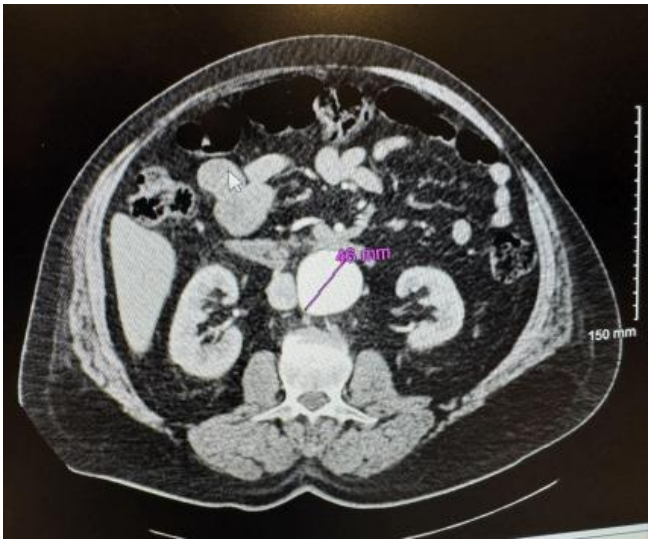


Figure 4. Computed tomography of the abdomen demonstrating an infrarenal abdominal aortic aneurysm measuring approximately 4.2 × 4.0 cm, supporting the presence of systemic aneurysmal disease

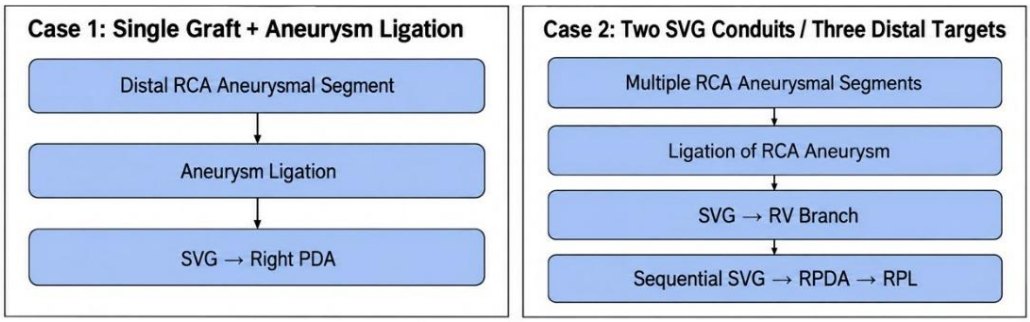


Discussion

In both patients, the operative strategy was guided by two principal objectives: exclusion of the aneurysmal coronary segment and preservation of reliable myocardial perfusion to distal coronary territories. The amount of myocardium at risk and the available distal runoff determined the number and configuration of bypass grafts required.

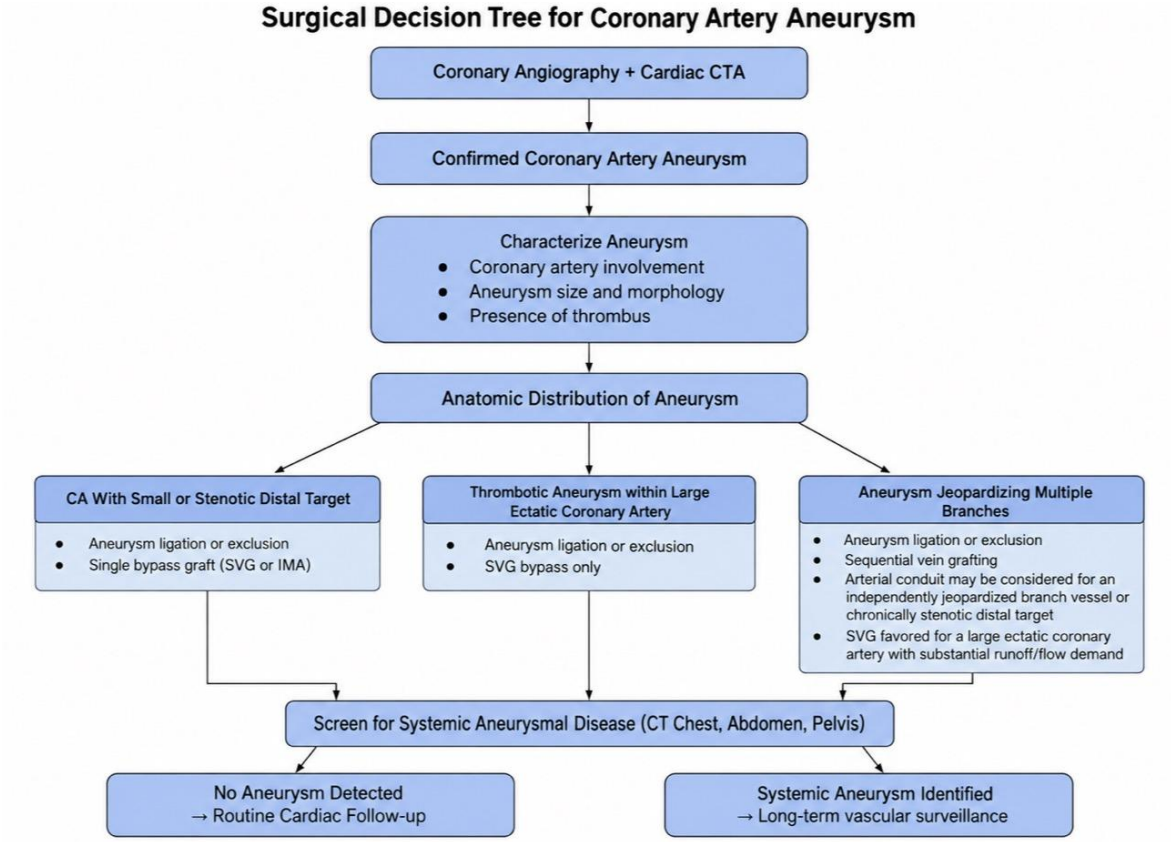
Although both patients had RCA aneurysms, the anatomic patterns differed substantially. In Case 1, preserved distal targets allowed aneurysm ligation with single-vessel bypass to the posterior descending artery. In Case 2, aneurysmal disease extended from the proximal RCA to the bifurcation of the posterior descending and posterolateral branches, requiring multivessel revascularization to maintain perfusion of multiple distal territories. These differing graft configurations, illustrated in Figure 5, demonstrate that aneurysm location alone does not determine operative strategy; distal branch involvement and the myocardial territory at risk are equally important considerations.

Figure 5. Graft configuration strategies in the surgical repair of right coronary artery aneurysms. Left: Case 1, in which a discrete distal target allowed single-vessel saphenous vein grafting after aneurysm ligation. Right: Case 2, in which two saphenous vein graft conduits provided revascularization to three distal coronary targets: one SVG to the right ventricular branch and a second sequential SVG to the right posterior descending and right posterolateral branches following RCA aneurysm ligation



Abbreviations: RCA: right coronary artery, RV: right ventricular, PDA/RPDA: (right) posterior descending artery, RPL: right posterolateral branch, SVG: saphenous vein graft.

Figure 6. Operative decision pathway for coronary artery aneurysm repair. The algorithm outlines surgical management according to aneurysm characteristics and the number of distal coronary branches at risk, guiding selection between single bypass grafting for isolated distal targets and sequential saphenous vein grafting for aneurysms jeopardizing multiple branches. The pathway also emphasizes screening for systemic aneurysmal disease to inform long-term vascular surveillance



Abbreviations: CA: coronary artery, CTA: computed tomography angiography, IMA: internal mammary artery, SVG: saphenous vein graft.

Both procedures were performed without cardiopulmonary bypass to reduce perioperative hemodynamic stress in patients with impaired ventricular function. Off-pump coronary artery bypass may be performed safely in selected patients with reduced ejection fraction when graft targets are accessible and intraoperative monitoring is carefully maintained [8]. Following completion of grafting, figure-of-eight 4-0 polypropylene sutures were placed proximally and distally around the aneurysmal segment and temporarily tightened with snares while electrocardiographic (ECG) and transesophageal echocardiographic monitoring were used to assess for ischemic change. The sutures were maintained under temporary occlusion for approximately 10 minutes. In the absence of new ischemic ECG changes, deterioration in myocardial function, or hemodynamic compromise, definitive ligation was completed. If acute ischemic ECG changes or deterioration in myocardial function were observed, the sutures would be released and the aneurysm left unligated to thrombose over time. This approach permits functional confirmation of adequate graft-dependent myocardial perfusion before permanent aneurysm exclusion and supports performing the procedure on a beating heart to allow real-time assessment.

Conduit selection also requires consideration of anticipated flow demand. In large ectatic coronary arteries with substantial runoff requirements, an internal mammary artery (IMA) graft alone may provide insufficient early flow after aneurysm ligation. In such settings, saphenous vein grafts (SVGs) may offer greater immediate conduit capacity, whereas arterial conduits may remain appropriate for independently jeopardized branch vessels or chronically stenotic distal targets.

The presence of abdominal and iliac aneurysmal disease in Case 2 highlights that coronary artery aneurysms may, in some patients, reflect broader systemic arteriopathy. Identification of aneurysmal disease in other vascular beds may influence operative planning and supports consideration of postoperative vascular surveillance. Based on this experience, the authors recommend that preoperative evaluation include computed tomography angiography of the chest, abdomen, and pelvis to assess for aneurysms in other vascular beds. Taken together, these cases support an individualized operative approach based on aneurysm anatomy, distal myocardial territory at risk, conduit flow requirements, and evidence of multisite aneurysmal disease. A simplified decision pathway derived from these operative principles is summarized in Figure 6.

In conclusion, coronary artery aneurysms lack standardized management and require individualized operative judgment. These cases suggest that off-pump aneurysm ligation with tailored saphenous vein grafting may provide an adaptable approach across differing anatomic and systemic contexts. This strategy is intended to preserve distal perfusion while limiting the need for cardiopulmonary bypass; however, broader evidence is required before its safety or generalizability can be established.

References

1. Pahlavan PS, Niroomand F. Coronary artery aneurysm: a review. Clin Cardiol. 2006;29(10):439-43. doi: 10.1002/clc.4960291005.
2. Nichols L, Lagana SM, Parwani AV. Coronary artery aneurysm: a review and hypothesis regarding etiology. Arch Pathol Lab Med. 2008;132(5):823-8. doi: 10.5858/2008-132-823-CAAARA.
3. Swaye PS, Fisher LD, Litwin P, Vignola PA, Judkins MP, Kemp HG Jr, et al. Aneurysmal coronary artery disease. Circulation. 1983;67(1):134-8. doi: 10.1161/01.CIR.67.1.134.
4. Syed M, Lesch M. Coronary artery aneurysm: a review. Prog Cardiovasc Dis. 1997;40(1):77-84. doi: 10.1016/S0033-0620(97)80024-2.
5. Abou Sherif S, Ozden Tok O, Taşköylü Ö, Goktekin O, Kilic ID. Coronary artery aneurysms: a review of the epidemiology, pathophysiology, diagnosis, and treatment. Front Cardiovasc Med. 2017;4:24. doi: 10.3389/fcvm.2017.00024.
6. Kawsara A, Núñez Gil IJ, Alqahtani F, Moreland J, Rihal CS, Alkhouli M. Management of coronary artery aneurysms. JACC Cardiovasc Interv. 2018;11(13):1211-23. doi: 10.1016/j.jcin.2018.02.041.
7. Keyser A, Hilker MK, Husser O, Diez C, Schmid C. Giant coronary aneurysms exceeding 5 cm in size. Interact Cardiovasc Thorac Surg. 2012;15(1):33-6. doi: 10.1093/icvts/ivs111.
8. Emmert MY, Emmert LS, Martinez EC, Lee CN, Kofidis T. Off-pump coronary bypass surgery is safe in patients with a low ejection fraction (≤25%). Heart Surg Forum. 2010;13(3):E136-42. doi: 10.1532/HSF98.20091178.