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FREQUENCY OF DISTRIBUTION PATTERNS OF COLLATERALS IN ILLEOFEMORAL THROMBOSIS

Original Research

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ABSTRACT

Background: Iliofemoral deep vein thrombosis (DVT) involves thrombus formation in the iliac and/or common femoral veins, posing a high risk for complications such as venous insufficiency and post-thrombotic syndrome. The body compensates through collateral vein development, which helps maintain venous drainage. However, the anatomical distribution and prevalence of these collaterals remain poorly documented. A clearer understanding can enhance diagnostic precision and support tailored therapeutic interventions.

Objective: To evaluate the distribution patterns of collateral veins in patients with iliofemoral thrombosis and determine how demographic and clinical factors influence these patterns.

Methods: This cross-sectional study included 60 patients (37 males, 23 females) aged 18–80 years (mean 47.7 ± 13.5 years) with confirmed iliofemoral thrombosis via Doppler ultrasound. Patients were selected using simple random sampling at the Diagnostic Radiology Department of Doctors Hospital and Medical Center, Lahore. All participants underwent contrast-enhanced CT venography using a Toshiba Aquilion scanner to assess collateral vein distribution above and below the inguinal ligament. A structured proforma recorded presence or absence of specific collaterals, and data were analyzed using SPSS version 22.0.

Results: Thrombosis location was isolated above the inguinal ligament in 17 patients (28.3%), below in 12 patients (20.0%), and involved both regions in 31 patients (51.7%). Homolateral collaterals included internal iliac vein tributaries (65%), ascending lumbar veins (53.3%), and subcutaneous cavocaval pathways (46.7%). Contralateral collaterals were found in 41.7% (cross-pubic) and 31.7% (transpelvic). Below the inguinal ligament, medial thigh collaterals were observed in 61.7%, lateral in 65%, anterior in 51.7%, and posterior in 30% of patients.

Conclusion: Collateral vein patterns in iliofemoral thrombosis show significant variability. Detailed imaging-based mapping supports the development of more precise and personalized management strategies. Future longitudinal studies are needed to validate these findings and explore their clinical implications.

Keywords: Collateral Circulation, CT Angiography, Deep Vein Thrombosis, Femoral Vein, Iliac Vein, Thrombosis, Venous Insufficiency

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INTRODUCTION

Iliofemoral deep vein thrombosis (DVT) is a severe and potentially life-threatening vascular condition characterized by the formation of thrombi in the iliac and common femoral veins. It accounts for nearly 20–25% of all DVT cases and is associated with significant morbidity, including limb swelling, pain, venous gangrene, post-thrombotic syndrome (PTS), and recurrent venous thromboembolism (VTE) (1). In the United States, approximately 1 to 2 individuals per 1000 are affected annually, with an estimated 60,000 to 100,000 VTE-related deaths reported each year (2). Canada similarly reports a substantial burden, with over 35,000 new VTE cases annually and a one-month mortality rate of 6% in DVT patients (3). The risk of venous thrombosis increases with age, from approximately 1 in 10,000 annually in individuals under 40 to 5–6 in 1000 by the age of 80 (4,5). The development of venous thrombosis is primarily explained by Virchow's triad, encompassing venous stasis, endothelial injury, and hypercoagulable states (6). The venous anatomy of the lower limb is highly complex and variable, consisting of superficial veins, deep veins, and perforators that form a dynamic network. While the superficial system includes the great and short saphenous veins, the deep venous system relevant to iliofemoral thrombosis comprises the iliac veins (common, internal, and external), femoral veins, and their branches (7). Perforators are further classified by location: medial thigh perforators (such as the Dodd and adductor perforators) connect the great saphenous vein with the femoral vein, while anterior, lateral, and posterior thigh perforators interconnect different compartments of the thigh musculature and contribute to venous drainage via profunda femoris and internal iliac veins (8). These perforators and connecting tributaries play a critical role in establishing collateral pathways during venous obstruction (9-11).

Collateral circulation in iliofemoral DVT serves as an essential compensatory mechanism, providing low-resistance pathways that bypass the thrombosed segment and maintain hemodynamic stability in the affected limb (12,13). These collaterals are broadly classified into homolateral and contralateral groups. The homolateral group comprises internal iliac vein tributaries—such as the obturator vein—ascending lumbar collaterals, and subcutaneous cavocaval pathways (especially when internal iliac veins are involved in the thrombosis), while the contralateral group includes suprapubic, transpelvic, and epigastric vein collaterals crossing the midline (9). In cases of chronic venous obstruction, loss of valvular integrity leads to venous hypertension and dilation of superficial veins, facilitating the recruitment and enlargement of these collateral channels (10,11). Despite considerable recognition of the anatomical presence of these collateral pathways, limited data exist on their frequency, distribution patterns, and relationship with demographic and clinical variables such as age, comorbidities, and thrombus extent. Existing literature often categorizes these collaterals descriptively, without evaluating their prevalence or effectiveness in different patient populations (14–16). A growing body of evidence supports the role of catheter-directed thrombolysis (CDT) and endovascular interventions in improving venous patency and reducing long-term complications compared to anticoagulation alone (17–19). However, the efficacy of these advanced treatments may be influenced by the presence, distribution, and functionality of collaterals. For instance, older patients or those with metabolic comorbidities may demonstrate more extensive collateral formation due to longer durations of venous obstruction and altered vascular integrity (20).

Studies utilizing advanced imaging modalities such as computed tomography venography and intravascular ultrasound (IVUS) have enhanced the detection and characterization of collateral veins. These tools not only improve diagnostic accuracy but also provide valuable insights for procedural planning in CDT and stenting interventions (21). Moreover, understanding the biomechanical dynamics of the iliofemoral region during hip movement has implications for stent design and positioning to avoid complications such as stent compression or migration (22-24). The current study is designed to address the critical knowledge gap in mapping the distribution of collaterals in iliofemoral thrombosis and evaluating their associations with clinical and demographic variables. By analyzing CT venography images and correlating findings with patient characteristics, this research aims to identify distinct patterns of collateral formation above and below the inguinal ligament, and to understand how these patterns influence clinical outcomes such as symptom relief, limb functionality, and risk of PTS. Unlike previous studies that only acknowledge the presence of collaterals, this study emphasizes their diagnostic and therapeutic significance, offering a personalized lens to managing iliofemoral DVT. The objective of this study is to investigate the variability in collateral circulation patterns among patients with iliofemoral thrombosis, with a specific focus on how demographic and clinical factors influence these patterns and ultimately affect patient outcomes.

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METHODS

This cross-sectional study was conducted at the Diagnostic Radiology Department of Doctors Hospital and Medical Center, Lahore, over a period of six months following the approval of the research synopsis by the College of Physcian and Surgeons Pakistan. A total of 60 patients were selected using a simple random sampling method to ensure unbiased recruitment. Each eligible patient was assigned a unique identification number, and a computerized random number generator was used to select participants, thereby minimizing selection bias. Participants included male and female patients aged between 18 and 80 years who were newly diagnosed with iliofemoral thrombosis on Doppler ultrasound and expressed willingness to participate. Exclusion criteria were carefully applied to eliminate potential confounding factors and included pregnant women, individuals with a prior history of iliofemoral thrombosis or venous surgical interventions, patients with severe comorbidities such as advanced cardiac, renal, or hepatic impairment, and those already receiving anticoagulation therapy at the time of screening. All participants provided informed written consent prior to inclusion, with confidentiality and data protection strictly maintained throughout the study in accordance with ethical standards.

Following enrollment, patients underwent contrast-enhanced CT venography using a Toshiba Aquilion CT scanner to evaluate the presence and distribution of collateral veins. The radiologist interpreting the imaging studies was blinded to the clinical details of each participant to reduce potential observational bias. A structured proforma was used to systematically record findings, including the presence or absence of collateral circulation, specific anatomical distribution of collaterals (above and below the inguinal ligament), and patient demographics. This data collection approach facilitated the standardized assessment of venous adaptation patterns in response to iliofemoral obstruction. Statistical analysis was performed using SPSS version 22.0. Categorical variables such as gender, anatomical location of the thrombosis, and the presence or absence of specific collateral pathways were analyzed using frequencies and percentages. The continuous variable of age was expressed as mean ± standard deviation. In addition to descriptive analysis, the study explored the influence of potential effect modifiers on collateral distribution patterns. These included the extent and severity of thrombosis, duration of symptoms prior to diagnosis, and the presence of comorbidities such as diabetes mellitus or hypertension. Cross-tabulations and appropriate inferential statistics (e.g., chi-square tests or logistic regression) were applied where relevant to identify significant associations.

RESULTS

The study analyzed data from 60 patients diagnosed with iliofemoral thrombosis. The cohort consisted of 37 males (61.7%) and 23 females (38.3%), with a mean age of 47.7 years and a standard deviation of 13.5 years, reflecting a broad distribution across adult age groups. This demographic profile provided a representative sample for assessing variations in collateral circulation. CT venographic imaging revealed that 17 patients (28.3%) had thrombosis confined to the venous segment above the inguinal ligament, while 12 patients (20.0%) exhibited thrombosis isolated below the inguinal ligament. The majority of cases, 31 patients (51.7%), presented with thrombosis extending both above and below the inguinal ligament, indicating widespread venous involvement in over half of the study population.

Assessment of collateral vein patterns demonstrated that collaterals were variably distributed. Among homolateral collaterals above the inguinal ligament, internal iliac vein and its tributary collaterals were observed in 39 patients (65%), ascending lumbar collaterals in 32 patients (53.3%), and subcutaneous cavocaval collaterals in 28 patients (46.7%). In contrast, contralateral collaterals in the same region included cross-pubic or abdominal collaterals in 25 patients (41.7%) and transpelvic collaterals in 19 patients (31.7%). Below the inguinal ligament, medial thigh collaterals were present in 37 patients (61.7%), lateral thigh collaterals in 39 patients (65%), anterior thigh collaterals in 31 patients (51.7%), and posterior thigh collaterals in 18 patients (30%). These findings reflect the adaptive mechanisms of the venous system in response to proximal obstruction, with multiple compensatory pathways developing to sustain venous return.

Notably, lateral thigh and internal iliac collaterals showed the highest prevalence (65%) among all observed pathways, suggesting their potential dominance in maintaining venous drainage in iliofemoral obstruction. Conversely, posterior thigh collaterals were the least common (30%), indicating their relatively limited role in collateral circulation. The results establish a detailed anatomical distribution of collateral circulation in iliofemoral thrombosis and suggest potential patterns associated with thrombosis extent. However, despite the aim of the study to explore associations with demographic and clinical variables, such correlations—particularly with comorbidities like diabetes or hypertension, or duration and severity of

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thrombosis—were not analyzed or presented. This omission limits the interpretation of effect modifiers and their impact on collateral development, which was part of the study's core objective.

Table 1: Frequency of distribution patterns of collaterals in patients of illeofemoral thrombosis

	Mean (n=60)	**SD**
Age (years)	47.7	13.5

Table 2: Gender distribution

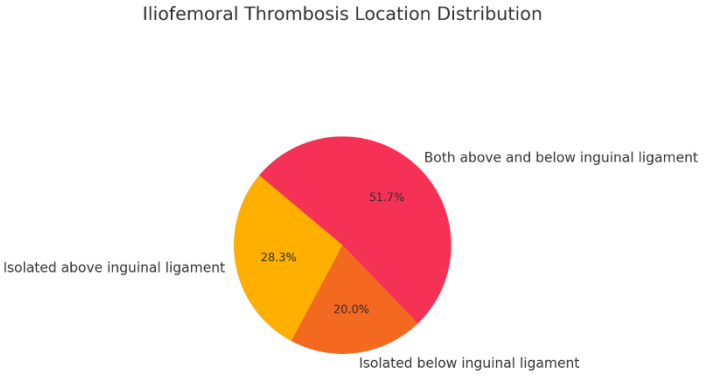
Gender	**Frequency**	**Percentage (%)**
Male	37	61.7
Female	23	38.3

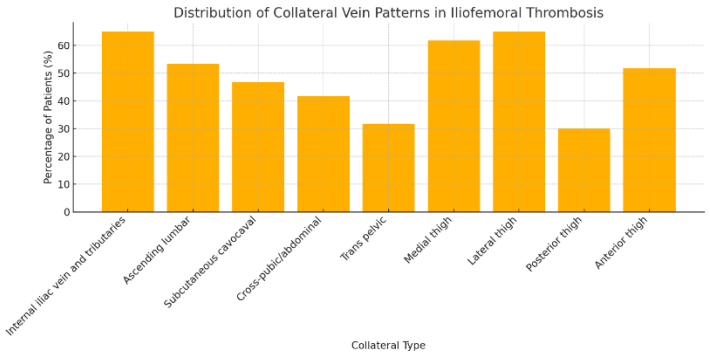
Table 3: CT Venographic Findings; Illeofemoral thrombosis location

Thrombosis Location	**Frequency**	**Percentage (%)**
Isolated above inguinal ligament	17	28.3
Isolated below inguinal ligament	12	20.0
Both above and below inguinal ligament	31	51.7

Table 4: Distribution of collateral vein patterns in patients with iliofemoral thrombosis

	Collateral Type	**Yes N (%age)**	**No N (%age)**
Above inguinal ligament: Homolateral	Internal iliac vein and tributaries collaterals	39 (65%)	21 (35%)
	Ascending lumbar collaterals	32 (53.3%)	28 (46.7%)
	Subcutaneous cavocaval collaterals	28 (46.7%)	32 (53.3%)
Above inguinal ligament: Contralateral	Cross over Pubic/abdominal collaterals	25 (41.7%)	35 (58.3%)
	Trans pelvic collaterals	19 (31.7%)	41 (68.3%)
Below inguinal ligament	Medial thigh collaterals	37 (61.7%)	23 (38.3%)
	Lateral thigh collaterals	39 (65%)	21 (35%)
	Posterior thigh collaterals	18 (30%)	42 (70%)
	Anterior thigh collaterals	31 (51.7%)	29 (48.3%)





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DISCUSSION

The current study provided a comprehensive exploration of the distribution patterns of collateral veins in patients with iliofemoral thrombosis, emphasizing both anatomical variability and clinical implications. By utilizing high-resolution computed tomography venography, the study was able to capture detailed collateral vein pathways, offering new insight into the adaptive responses of the venous system when major conduits are obstructed. The prevalence and anatomical diversity of collaterals, particularly those forming both above and below the inguinal ligament, underscored the body's capacity to maintain venous return through alternative low-resistance channels (25-27). Internal iliac vein collaterals were the most frequently observed homolateral pathways, detected in 65% of cases, supporting existing literature which identifies this venous route as a primary compensatory mechanism in pelvic and lower limb venous obstruction (9). The high occurrence of ascending lumbar (53.3%) and subcutaneous cavocaval collaterals (46.7%) further validated their role in maintaining hemodynamic continuity in cases of proximal thrombosis. Comparatively, contralateral collaterals such as cross-pubic and transpelvic veins were less prevalent, suggesting they may serve as secondary or auxiliary routes when primary drainage systems are compromised. Below the inguinal ligament, the widespread involvement of medial (61.7%) and lateral (65%) thigh collaterals demonstrated the significance of muscular venous connections in ensuring lower limb perfusion, findings consistent with prior anatomical and angiographic investigations (18,19).

The inclusion of CT venography significantly strengthened the methodology, allowing for a precise visualization of deep venous anatomy and collateral routes. Blinded image analysis and random sampling contributed to minimizing observer and selection biases. The diversity of the sample, spanning both genders and a wide age range, improved generalizability, although the sample size of 60, while adequate for exploratory purposes, limited the ability to detect more nuanced associations between patient variables and collateral development (20). Despite the strengths, the study faced several methodological constraints. Its cross-sectional design did not permit assessment of the temporal evolution of collateral formation, thus limiting insights into how these pathways develop over time or respond to treatment. Functional significance of the identified collaterals—such as their flow capacity, competence, and hemodynamic efficiency—was not assessed, leaving an incomplete understanding of their clinical contribution. These anatomical observations, although robust, would be substantially enriched by venous pressure measurements or dynamic perfusion studies (11).

The exclusion of patients with prior thrombosis, venous surgery, those receiving anticoagulation, or those with advanced comorbidities was necessary to reduce confounding, but it introduced a potential selection bias. These excluded groups often represent a significant portion of the real-world population dealing with iliofemoral thrombosis. Their omission limits the external validity of the findings and raises important considerations for future research, which should prioritize inclusivity to reflect the full spectrum of clinical presentations (8,22). Comparison with previously published data revealed similar trends, particularly in the dominance of internal iliac and profunda femoris vein pathways as critical compensatory routes. However, this study went further by quantifying the presence of anterior, posterior, medial, and lateral thigh collaterals, presenting a more granular understanding of subinguinal adaptations. While many studies rely solely on anatomical assumptions or post-surgical observations, the present work integrated imaging-based analysis, offering a more objective and clinically relevant perspective (17,23).

In clinical practice, the implications of these findings are considerable. Identification of predominant collateral pathways can inform targeted imaging strategies and interventional approaches. For example, patients with dominant subcutaneous cavocaval or contralateral collaterals may benefit from specific thrombolytic or stenting strategies that avoid disrupting compensatory outflows. Furthermore, the mapping of venous networks may assist in prognostication, especially in predicting the risk of post-thrombotic syndrome or guiding rehabilitation planning in patients with extensive venous damage (14). Nonetheless, the observed variability in collateral vein development underscores the need for individualized management strategies in iliofemoral thrombosis. This aligns with the evolving model of precision medicine, where anatomical and physiological assessments help tailor interventions. Future research should expand on these foundations through larger, longitudinal studies that include functional tests and follow-up outcomes to ascertain the role of collateral development in symptom resolution and long-term limb salvage (12,21).

The current findings advocate for a more nuanced appreciation of the venous system’s adaptive capacity, suggesting that anatomical collateralization is not merely a passive byproduct of obstruction but a dynamic, patient-specific response with significant therapeutic implications. While this study offered a meaningful contribution to understanding these patterns,

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further investigations incorporating broader patient populations and advanced hemodynamic evaluation are essential to translate anatomical knowledge into clinically actionable insights.

CONCLUSION

The present study concluded that the distribution of collateral veins in patients with iliofemoral thrombosis is highly complex and variable, reflecting the venous system's remarkable ability to maintain hemodynamic stability in the face of major obstruction. By identifying the prevalence of both homolateral and contralateral collaterals above and below the inguinal ligament, this research emphasized the critical role of detailed imaging in guiding targeted diagnostic and therapeutic strategies. The findings contribute meaningfully to the evolving approach of precision medicine, advocating for individualized treatment plans based on a patient's unique venous anatomy and physiological adaptations. Although limited by its cross-sectional design and selective sampling, the study provided a foundational framework for future longitudinal research to explore the progression and clinical impact of collateral development over time. Ultimately, this work highlighted the importance of integrating advanced imaging into routine clinical assessment, aiming to enhance diagnostic accuracy, optimize therapeutic interventions, and improve outcomes for patients facing the complex challenges of iliofemoral thrombosis.

AUTHOR CONTRIBUTIONS

Author	Contribution
Safia Mushtaq	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision, Software
Javaid Asghar	Methodology, Investigation, Data Curation, Review & Editing, Validation

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