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Evaluating the Efficacy and Safety of Transbrachial Access in Iliac Endovascular Interventions: A Comprehensive Analysis

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Abstract: Background: This study evaluates the use of transbrachial artery access for endovascular treatment of iliac artery lesions, with a focus on its efficacy and safety outcomes. **Methods:** Between January 2020 and May 2023, 94 patients with iliac artery disease underwent endovascular procedures via a transbrachial access approach. The majority of patients (n = 68; 72%) presented with lifestyle-limiting claudication (Rutherford category 3). Diagnostic angiography identified Transatlantic Inter-Society Consensus II (TASC) C/D lesions in 54 patients (57%). The primary outcome was achieving technical success with transbrachial access, while secondary outcomes included secondary technical success (necessitating additional transfemoral access), access site complications, and cerebrovascular events. **Results:** The primary and secondary technical success rates were 82% and 92%, respectively. Access site-related adverse events occurred in 12 patients (12%), primarily hematomas (seven events, 7.4%; two requiring transfusion) and pseudoaneurysms (four events, 4.2%). Thrombotic occlusion was observed in one patient (1%), and brachial arterial bleeding requiring urgent surgical intervention occurred in three patients (3.2%). Neurological complications included two cerebrovascular events (2.1%), although no permanent or transient median nerve injuries were observed. **Conclusions:** The transbrachial approach represents a potential alternative to the femoral artery route in patients with iliac artery lesions. However, the relatively higher incidence of access site complications may limit its broader application in clinical practice.

Keywords: transbrachial access; iliac artery lesions; technical success; access site complications

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1. Introduction

Upper extremity access sites, particularly the radial artery, are now the most common arterial access points for percutaneous coronary procedures [1]. The radial approach is favored over femoral access in patients with acute coronary syndrome, as it has been shown to potentially reduce mortality. Several large-scale studies have linked the transradial approach with lower rates of major adverse events [2,3].

In peripheral artery interventions, combining upper extremity access with the femoral artery approach has improved the efficiency of endovascular therapies [4–8]. An antegrade approach is often required for many complex endovascular aneurysm repair procedures [9]. For iliac artery disease, brachial artery access is especially vital in cases of severe aortoiliac disease or when the lesion location precludes an inguinal approach [6–8,10–15]. Moreover, the increasing prevalence of endovascular or open procedures that use bifurcated stent grafts for abdominal aortic aneurysms frequently makes the transfemoral approach unsuitable for these peripheral interventions.

Despite the recognized supplementary benefits of the brachial to femoral artery access approach, its efficacy as a primary approach remains underexplored. This study aims to assess and document the safety and effectiveness of using the brachial artery as the primary access point in the treatment of iliac artery disease.

2. Materials and Methods

2.1. Study Design

This retrospective single-center study, approved by the institutional review board and conducted in line with the Declaration of Helsinki, evaluated patients with lower limb ischemia (Rutherford categories 2–6). These patients underwent angioplasty and stenting of an iliac artery lesion via a brachial artery route from January 2020 to May 2023. The study was sanctioned by the Human Research Ethics Committee (approval date: 28 August 2023, protocol number: 2023/398). The transbrachial artery approach was chosen for patients with compromised common femoral artery access due to severe obesity (Body mass index > 40 kg/m^2), previous groin surgeries, multiple femoral catheterizations, extensive hernias, or groin skin infections. Patients with aortic dissection, acute limb ischemia, concomitant thoracoabdominal aortic aneurysm, hematologic disorders, or intolerance to heparin, clopidogrel, and acetylsalicylic acid were excluded. Additionally, patients undergoing concurrent treatments in other areas (e.g., infrainguinal, visceral arteries), those undergoing surgical intervention for the arterial approach, and all purely diagnostic transbrachial interventions were also excluded. Those managed with hybrid procedures, such as surgical reconstruction of the common femoral artery combined with endovascular treatment of the iliac vessels, were excluded as well.

2.2. Treatment Protocol

Pre-operative imaging, including computed tomography, was utilized to assess the patency of the access vessels, subclavian artery, and carotid artery. Radiation exposure during endovascular procedures, especially in complex cases like TASC II C/D lesions and chronic total occlusions (CTOs), is a concern due to its potential long-term risks, including radiation-induced injury and increased cancer risk. However, fluoroscopic imaging is crucial for guiding catheter placement, balloon angioplasty, stent deployment, and other interventional procedures. Therefore, minimizing radiation exposure without compromising procedural success is essential. While fluoroscopy remains an essential tool for peripheral arterial interventions, there is an increasing emphasis on balancing radiation exposure with procedural outcomes. Strategies to reduce radiation exposure, such as low-dose protocols, image fusion, and real-time fluoroscopy, are vital for optimizing safety. Duplex ultrasound (DUS), when applicable, provides a radiation-free alternative for assessing vessel anatomy and post-procedural outcomes, especially in less complex cases. Combining both modalities, using fluoroscopy for the intervention and DUS for monitoring, may offer the best of both worlds, ensuring optimal procedural success while minimizing risks associated with radiation. Lesion anatomy and location were pivotal in opting for the brachial artery procedure (Figure 1a).

The left brachial artery was generally preferred to minimize catheter manipulation through the aortic arch. Right brachial artery access was reserved for patients with occlusive disease of the left subclavian artery or issues with left-sided vascular access. Ultrasound-guided insertion was employed for all patients, using an 18-G needle for vascular access. Diagnostic angiography followed the insertion of a 5-Fr arterial sheath using the Seldinger technique. Heparin (5000 units) was administered to achieve an activated clotting time of over 250 s. An ACT range of 200–220 s is a safe and effective target for anticoagulation during peripheral arterial interventions, aligned with guidelines from major vascular and cardiology societies. This range provides adequate anticoagulation to prevent thromboembolic events while minimizing the risk of bleeding. However, the use of a single heparin dose carries limitations, particularly due to patient-specific variability, and emphasizes the importance of continuous monitoring and dynamic dosing throughout the procedure. Tailoring anticoagulation to individual patient needs and adjusting doses as necessary is critical to optimize procedural outcomes and reduce the risks of complications. Using a single 5000-unit heparin bolus to achieve an ACT over 250 s is a common and effective approach for ensuring adequate anticoagulation during complex vascular procedures. This approach provides quick and predictable anticoagulation while minimizing the need for multiple doses or continuous infusion. However, ACT monitoring during the procedure is essential to ensure that the anticoagulation remains within the optimal therapeutic range. Adjusting to heparin dosing may be necessary based on the patient's response and procedural complexity.

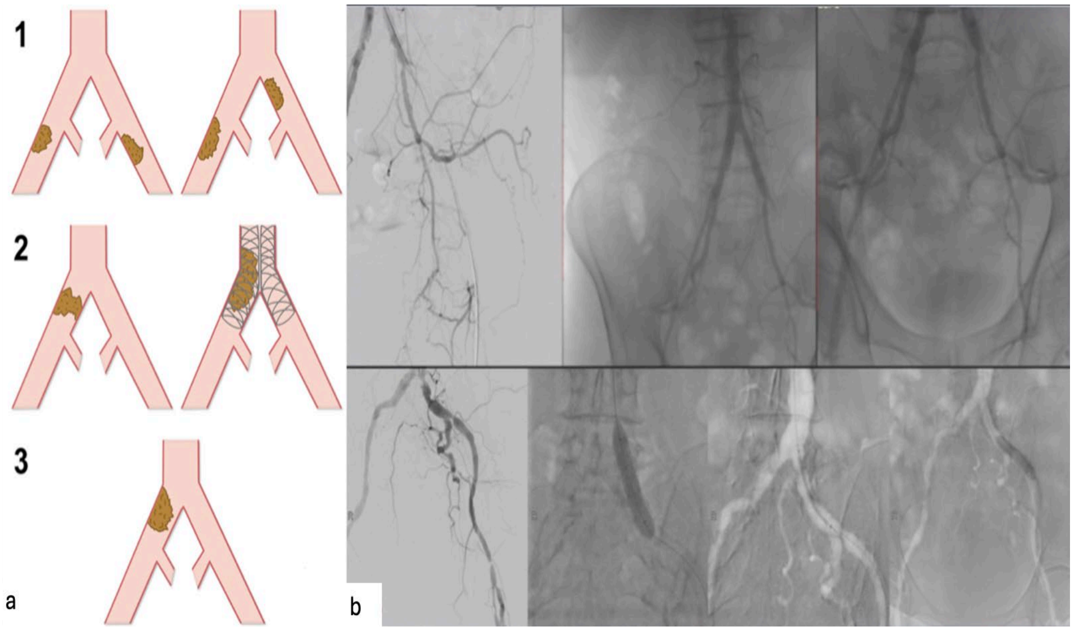

Figure 1. (**a**) Diagrammatic representation of iliac artery lesions suitable for preferential transbrachial approach: (**1**) Bilateral external iliac artery (EIA) disease, common iliac artery (CIA) disease, and concomitant contralateral EIA disease; (**2**) CIA orifice occlusion and kissing stent in-stent restenosis; and (**3**) Concomitant internal iliac artery (IIA) disease with contralateral CIA disease or acute iliac bifurcation IIA disease. (**b**) Pre-operative angiograms illustrating transbrachial stent placement in iliac artery lesions.

For enhanced stability during the procedure, the 5-Fr sheath was swapped for a longer interventional sheath (90/110 cm, ranging from 5 Fr to 7 Fr), sourced from Cook Medical, Bloomington, IN, USA. Balloon-expandable stents were used for lesions in the common iliac artery (CIA) and proximal internal iliac artery (IIA), while self-expandable stents were suited for external iliac artery (EIA) and distal IIA lesions (Figure 1b).

In practice, angioplasty or stenting of the internal iliac artery (IIA) is generally considered when symptomatic pelvic ischemia occurs, particularly when the collateral circulation is insufficient or when critical pelvic perfusion is at risk. However, when the IIA ostium is occluded, but there is adequate collateral circulation (such as flow from the contralateral IIA), intervention may often be avoided, especially in asymptomatic patients. The decision to intervene is based on the clinical severity of symptoms, the adequacy of collateral flow, and the overall risks of performing the procedure.

Post-procedure, the sheath was removed, and a brachial artery angiogram was conducted before the sheath's removal. Hemostasis was achieved by manual compression of the brachial artery for 10 to 15 min, followed by the application of a pressure bandage for 12 h, during which the ipsilateral radial artery pulse status was monitored hourly. A brachial artery duplex study was performed in cases of suspected pulse abnormalities.

Patients were prescribed acetylsalicylic acid pre-procedure, which continued upon discharge. Dual antiplatelet therapy (DAPT) with acetylsalicylic acid and clopidogrel was recommended for eight weeks following stent placement or drug-coated balloon angioplasty. Statins were also prescribed. The ESVS guidelines provide a framework for determining the optimal duration of DAPT based on the patient's risk factors, procedural complexity, and thrombotic vs. bleeding risk balance. While 1–3 months of DAPT is standard for most patients, high-risk individuals may benefit from longer durations to ensure stent patency and minimize thrombotic complications. The choice should always be tailored to the individual patient's clinical context.

2.3. Patients

Of the 452 isolated endovascular aortoiliac procedures performed in our department during the study period, 94 patients (mean age 62 ± 14.6 years; 68 male) underwent a primary transbrachial approach. Most of these patients (68; 72%) experienced lifestyle-limiting claudication (Rutherford category 3); 14 (15%) had rest pain (Rutherford category 4), and 12 (13%) suffered tissue loss (Rutherford category 5). TASC II C/D lesions were detected in 54 (57%) patients at the initial angiography. Most lesions were de novo stenoses (69; 73%); 15 (16%) were in-stent restenoses, and 10 (11%) were post-dilation restenoses. Table 1 summarizes the baseline characteristics and comorbidities of the study group, while Table 2 details procedural and radiological properties.

Table 1. Demographics and Comorbidity *.

Characteristics	Value
Age (years) (Mean ± SD)	62 ± 14.6
Gender (*n*, %)	
Male	68 (72%)
Female	26 (28%)
Rutherford Category (*n*, %)	
3	68 (72%)
4	14 (15%)
5	12 (13%)
TASC II C/D Lesions (*n*, %)	54 (57%)
Lesion Type	
De Novo Stenoses	69 (73%)
In-stent restenoses	15 (16%)
Post-dilation restenoses	10 (11%)
Comorbidities	
Hypertension	45 (48%)
Diabetes Mellitus	32 (34%)
Dyslipidemia	50 (53%)
Coronary Artery Disease	28 (30%)
Chronic Kidney Disease	10 (11%)

* Continuous data are presented as the means ± standard deviation; categorical data are given as the counts (percentage).

Table 2. Lesion Characteristics and Procedure Details *.

Characteristics	Value
Target Vessel (*n*, %)	Common Iliac artery: 68/94 (72%)
	External Iliac artery: 46/94 (49%)
	Internal Iliac artery: 22/94 (23%)
Arterial sheath (Fr) (*n*, %)	5 Fr: 16/94 (17%)
	6Fr: 57/94 (61%)
	7 Fr: 21/94 (22%)
Treatment (*n*, %)	Balloon Angioplasty: 19/77 (24%)
	Stent Deployment: 58/77 (76%)
Brachial Artery Access Side (*n*, %)	Left: 90 (96%)
	Right: 4 (4%)

Table 2. *Cont.*

Characteristics	Value
Reasons for Right-Side Access (*n*)	Left subclavian artery occlusion: 2
	Left-sided arteriovenous fistula: 2
Primary Technical Success (*n*, %)	77 (82%)
Secondary Technical Success (*n*, %)	87 (92%)
Failed Endovascular Interventions (*n*, %)	7 (7,4%)
Additional Transfemoral Access (*n*, %)	10 (11,7%)
Types of Lesions (*n*, %)	CIA Lesions: 54 (57%)
	IIA Lesions: 30 (32%)
	EIA Lesions: 10 (11%)
Access Site Related Complications (*n*, %)	Hematomas: 7 (7.4%)
	Pseudoaneurysms: 4 (4.2%)
	Bleeding from Brachial Artery: 3 (3.2%)
	Thrombotic Occlusion: 1 (1%)
Cerebrovascular Events (*n*, %)	Ischemic Stroke: 1 (1.1%)
Morbidity and Mortality (*n*, %)	Transient Ischemic Attack (TIA): 1 (1.1%)
	CIA Rupture: 1 (1.1%)
	Mortality due to Acute Coronary Syndrome: 1 (1.1%)

* Data are presented as the count/sample (percentage).

The primary outcome was technical success, defined as the restoration of vascular patency with less than 30% residual stenosis through transbrachial access alone. Secondary outcomes included the need for additional femoral artery access, access site-related complications, and cerebrovascular events. Utilization of adjunctive femoral access indicated a failure of primary technical success but was counted as a successful secondary technical success.

2.4. Statistical Analysis

Continuous variables were described as means ± standard deviation, and categorical data as counts (percentages). Continuous numeric variables were analyzed using a paired Student's *t*-test. A *p*-value of less than 0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics (version 24.0; IBM Corp., Armonk, NY, USA).

3. Results

3.1. Access Sites and Technical Success

In 90 (96%) of interventions, the left brachial artery was the preferred access site; the catheter was applied to the right side in four (4%) patients due to either occlusion of the left subclavian artery (two cases) or a left-sided arteriovenous fistula (two cases). The primary technical success rate was 82% ($n = 77$). There were 10 (11%) instances of technical failure that required additional transfemoral access to restore iliac artery patency and seven (7%) cases where endovascular interventions failed, resulting in a secondary technical success rate of 92% ($n = 87$). In three cases where transbrachial recanalization was unsuccessful, additional transfemoral access was required; in seven patients, this was necessary for performing kissing balloon angioplasty or stent deployment maneuvers. Technical success was not significantly affected by gender ($p = 0.63$) or TASC II C/D lesions

($p = 0.56$). Additionally, there was no statistical difference in technical success rates among CIA ($p = 0.62$), IIA ($p = 0.34$), and EIA ($p = 0.72$) lesions (Figure 1).

3.2. Access Site-Related Complications

There were 12 (12%) adverse events related to the puncture site, primarily consisting of hematomas (seven events, 7.4%; two required transfusion) and pseudoaneurysms (four events, 4.2%). In three patients, prolonged ultrasound compression was sufficient; one patient required surgical reintervention. There were three (3.2%) incidents of bleeding from the brachial artery and one (1%) thrombotic occlusion; all four cases required emergent surgical treatment. No median nerve damage, either temporary or permanent media, was observed.

3.3. Stroke

There were two (2.1%) cerebral events: one ischemic stroke and one transient ischemic attack (TIA), neither of which showed imaging evidence of brain injury, and both were managed conservatively. All stroke patients were male, though gender was not identified as a risk factor for stroke ($p = 0.98$). Notably, none of the stroke patients had a radiological diagnosis of previous cerebrovascular disease, and neither the presence of cerebrovascular disease ($p = 0.99$) nor the sheath size ($p = 0.41$) impacted the incidence of cerebrovascular adverse events.

While the access side (right or left) could theoretically influence stroke risk based on procedural dynamics, the evidence supporting a clear link between right-sided access and stroke is not robust. Stroke risk is more closely associated with procedural technique, embolism, and patient-related factors rather than the access site itself. Given the nature of our study, it is unlikely that we will find data supporting a direct association between right-sided access and stroke risk.

3.4. Morbidity and Mortality

Access site-related complications and acute ischemic events were the most common issues encountered. One (1.1%) incident of CIA rupture occurred during subintimal recanalization of a heavily calcified CIA/EIA occlusion; the patient underwent surgical intervention and fully recovered. One (1.1%) male patient died of acute coronary syndrome 72 h after a successful transbrachial intervention for a bilateral CIA + IIA occlusion.

4. Discussion

Our study underscores that brachial artery access for iliac artery interventions is associated with high primary success rates, even in patients with complex iliac pathologies (TASC II C/D). However, an auxiliary transfemoral approach was necessary in 11% of cases. The significant incidence of access site-related complications and cerebrovascular events underscores the limitations of the antegrade approach and warrants consideration for specific high-risk groups. We recommend this approach primarily when the transfemoral approach is challenging or impractical, such as in severely obese patients, or those with previous open or endovascular aortic interventions involving neobifurcations unsuitable for a contralateral femoral route, and in various lesions not amenable to the inguinal approach [5,8].

The reliability and effectiveness of the approach are pivotal in determining access site preference, and ensuring suitable arterial access is critical for technical success. Brachial access is increasingly utilized in endovascular procedures for various vascular regions [5,9,14]. However, these studies encompass a variety of vascular pathologies, complicating a comprehensive evaluation of this approach [4,5,16,17]. In many cases, brachial artery intervention served as a complement to the transfemoral approach or followed femoral artery access failure, indicating that the effectiveness of primary brachial artery access remains under-analyzed [6,8–10,14].

In cases of iliac artery interventions, brachial artery access is particularly valuable when severe aortoiliac disease impedes the use of the common femoral artery approach [13]. Although the common femoral artery approach is feasible, brachial artery access provides an alternative route that bypasses the technically challenging aortic bifurcation. This is especially useful after the implantation of a bifurcated endograft or kissing stent placement [7]. Moreover, addressing bilateral iliac and femoral disease through a single access point can be both practical and cost-effective [8].

In our study, brachial artery access facilitated the endovascular treatment of most iliac lesions through a single route. Despite concerns that long peripheral occlusions are difficult to manage in the transbrachial setting, our technical success rate was unaffected by TASC II C/D lesion treatment strategies [14]. Only a few cases of failed transbrachial revascularization necessitated switching to the femoral artery approach. Given the unique anatomical features of the iliac vessels, dual arterial access is often required, not only in cases for primary brachial artery access but also when femoral access is initially used, particularly for extensive disease treatment [6,11,12,18].

Experience with transbrachial settings utilizing complex endovascular devices beyond stents and balloon catheters is limited. The small diameter of the brachial artery makes it unsuitable for devices requiring sheaths larger than 6 Fr, such as atherectomy catheters and covered stents, and devices with shorter shafts due to the longer vascular route needed. In our study, we did use 7Fr sheaths in certain patients, which is applicable in select cases where the brachial artery's anatomy allows for such use. However, as mentioned in the discussion, a 6Fr sheath is generally considered the upper limit for brachial access due to the smaller diameter of the brachial artery. The use of 7Fr sheaths was limited to patients with more favorable vessel characteristics, ensuring the safety and feasibility of the procedure [16–18].

The complexity of TASC II C/D lesions, especially chronic total occlusions (CTOs), significantly impacts procedural outcomes in a variety of ways. TASC II, or the Transatlantic Inter-Society Consensus, classifies peripheral arterial disease (PAD) based on the severity and complexity of arterial lesions, with TASC C and D lesions representing the most advanced stages of the disease. These lesions are characterized by long, complex occlusions, often with severe calcification, and are frequently associated with chronic total occlusions (CTOs). The challenges posed by these lesions are multifaceted and influence procedural outcomes, including technical success, complication rates, and long-term durability. To improve outcomes in this patient population, a multidisciplinary approach is crucial, combining advanced endovascular techniques, patient selection based on anatomical considerations, and, when necessary, hybrid or open surgical interventions.

The relatively higher rate of access site-related complications remains a limitation of the transbrachial approach. The overall complication rate in our study aligns with the recent series, suggesting that these events are more related to the procedure itself rather than physician skill. Local hematomas and pseudoaneurysms were more common, while thrombotic occlusion or puncture site bleeding was relatively infrequent. Neurological adverse events can compromise the performance of upper extremity approaches [7]. However, left brachial artery catheterization reduces the risk of cerebral embolization by avoiding wire manipulation at the origin of the carotid arteries, keeping our overall stroke rate comparable to previous studies [19–21].

Access site injury and stroke are significant complications in endovascular interventions, especially when dealing with complex lesions like TASC II C/D or chronic total occlusions (CTOs). One potential solution to reduce access site injury is to cut down the access site and expose the vessel, as well as consider alternative access routes, such as the radial artery approach. Both the cut-down technique and radial artery approach offer distinct advantages in terms of reducing access site injury and stroke during peripheral arterial interventions. The cut-down technique is ideal for complex cases where percutaneous access may be difficult or failed, providing better control and reducing the risk of immediate complications. However, it comes with longer recovery times and an increased risk of infection. On the other hand, the radial artery approach offers a safer alternative with fewer complications, faster recovery, and a lower risk of stroke. However, its limitations in complex cases, such as large or calcified arteries, must be considered. Radial access has gained popularity, particularly in lower-risk patients, and is becoming more widely used in peripheral interventions. Choosing between these approaches depends on patient anatomy, lesion complexity, and procedural goals. For patients with complex TASC II C/D lesions or CTOs, a hybrid approach using both cut-down and radial access may offer the best balance of safety and technical success. A single arterial rupture (1%) occurred in our endovascular treatment series. Reported iliac rupture rates vary between 0.5% and 3%. The need for sheaths larger than 6 Fr is a significant challenge in the percutaneous brachial approach. Still, arterial ruptures are typically managed with covered stent placement and can be temporarily managed with appropriate balloons [12]. For this reason, we prepare both femoral arteries for emergency catheterization.

5. Limitations

This retrospective, non-randomized study was conducted at a high-volume center with significant experience in upper extremity access interventions. However, the absence of a control group for the femoral artery approach prevents a direct comparison between transfemoral and transbrachial interventions. Dual antiplatelet therapy is recommended for two months following stent placement or drug-coated balloon angioplasty, but there is no consensus on post-treatment antiplatelet therapy. Additionally, the lack of randomized studies limits evidence-based decision-making.

6. Conclusions

The anatomical characteristics of the iliac arteries make transbrachial access a more advantageous option compared to transfemoral artery access. Primary brachial access for iliac artery revascularization interventions demonstrated promising clinical outcomes. Nevertheless, planning a transbrachial intervention may result in relatively high rates of access site complications and potential cerebral event risks. Furthermore, the availability of advanced endovascular tools suitable for the brachial approach is limited. Large-scale prospective randomized trials are necessary to substantiate the advantages and disadvantages of brachial access compared to femoral artery access.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available at the request from the corresponding author due to privacy and ethical reasons.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

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