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Research Article

Complications of Ultrasound-Guided vs. Conventional Radial or Femoral Puncture in the Cardiac Catheterization Laboratory and Electrophysiology Laboratory of a Tertiary Care Hospital Performed by Residents

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Abstract

Introduction: Ultrasound (US) is increasingly used in interventional cardiology and electrophysiology when arterial or venous puncture is required for diagnostic and/or therapeutic purposes. Clinicians must look for ways to reduce procedural risks while maximizing success. Therefore, the US offers significant advantages in guidance during vascular access.

Objective: To describe the prevalence of complications from vascular punctures (venous and/or arterial) performed with and without US. Secondly, to compare the complications between the groups.

Methods: This was a retrospective and analytic study to determine if the intervention with US guidance reduced complication rates. We evaluated patients who underwent US-guided puncture for diagnostic or therapeutic purposes in June 2024.

Results: A total of 54 patients were included, 27 in the US-guided group and 27 in the conventional group. Demographic characteristics, comorbidities, pharmacological treatment, laboratory findings, and indications for puncture were similar between the groups. The number of attempts was similar (p = 0.776), as well as to achieve a successful puncture (p = 0.639). In the US-guided group, ecchymosis was observed in 6 cases (22.2%) *vs.* 7 cases (25.9%) in the conventional group (p = 0.750). For some outcomes (hematomas' appearance and hematoma severity), the results favored the use of US-guided punctures to reduce complications. Hematomas occurred in 2 cases (7.4%) in the US group *vs.* 7 cases (25.9%) in the conventional group (p = 0.068). Hematoma severity, measured using the EASY scale, showed a trend favoring US guidance (p = 0.087).

Conclusions: In our study, the use of US-guided interventional and electrophysiological procedures was associated with a trend to reduce hematoma occurrence and its severity with comparable success and attempt rates.

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Introduction

Modern medicine evolves constantly, and many specialties have incorporated novel diagnostic and/or therapeutic tools that aim to improve diagnostic accuracy, the quality of care, and short- and long-term outcomes while reducing the risks of interventions. Ultrasound (US) is currently widely used given its high availability in emergency departments, hospital wards, operating rooms, etc. In addition, the US is a relatively low-cost study, and there are already pocket-sized devices that make it easy to carry and use in different scenarios.

There are clinical contexts, such as trivascular coronary artery disease with high anatomical complexity, in which the standard of care requires major surgical intervention. However, over the years, less invasive therapeutic strategies have emerged. In the treatment of univascular coronary artery disease or those with low anatomical complexity, a less invasive procedure is preferred. In some valvular diseases, such as aortic stenosis in a context of high prohibitive pre-surgical risk, and even in the treatment of certain arrhythmias, minimally invasive alternatives are also an option. The performance of these procedures by interventional and electrophysiology cardiologists requires puncture of the upper or lower extremities (radial artery, ulnar artery, femoral artery, subclavian vein, brachial vein, axillary vein, or femoral vein) to subsequently proceed with the treatment of the underlying disease.

Even though complications with minimal invasive procedures are fewer compared to major surgeries, they can always occur.

Traditionally, vascular punctures rely on palpation, fluoroscopic guidance, venography, or arteriography to determine the right puncture site. International guidelines recommend the use of fluoroscopic or US guidance to perform vascular punctures [1]. In clinical, interventional, or electrophysiology cardiology, and even in vascular surgery, studies have shown that US guidance allows faster vascular access and may reduce complication rates [2,3].

US-guided punctures have been used in various circumstances, including radial artery puncture for arterial blood gas sampling, where first-attempt success increased up to 300% [4], particularly after training or in patients with complicated anatomy. Although the use of US proves to be useful, it requires prior knowledge of vascular anatomy since the approach can be performed under the short and long axis of the vessel [5].

Vascular complications vary in severity, ranging from the formation of a hematoma to fistulas, vascular perforations, aneurysms or pseudoaneurysms, and even significant bleeding or shock [6,7].

Ultrasound or fluoroscopy-guided radial or femoral punctures offer several significant benefits:

- **Increased safety:** Ultrasound facilitates access to the radial and femoral arteries, reducing the risk of complications such as hematomas and pseudoaneurysms [8,9].
- **Higher first-attempt success rate:** US-guided puncture significantly improves the first-attempt success rate, especially compared to blind puncture. This is because the artery and needle can be directly visualized in real time [2,8-11].
- **Reduced procedure time:** US-guided radial artery puncture is faster than other techniques, as ultrasound enables more accurate identification of the artery and reduces the number of failed attempts.
- **Lower bleeding and vascular complications:** US-guided femoral puncture significantly reduces bleeding and vascular complications compared to the conventional technique.
- **Cost savings:** The use of ultrasound or fluoroscopy in arterial and central venous puncture reduces costs associated with hospitalization and medical procedures [1,9].

Technological advances and medical progress have made radial catheterization more frequent in the last decade rather than femoral catheterization, even though it provides a more direct route to the heart [2,12].

Radial access is usually preferred [13,14] for coronary angiography or interventions as it has been associated with fewer complications compared to femoral access. There is evidence suggesting that radial access reduces mortality in ST-segment elevation myocardial infarction [10,15], supporting the status of "radial first" in interventional cardiology. Failure to cannulate the radial artery accounts for 57% of all failed percutaneous coronary interventions [10]. For that reason, the guidance with US or fluoroscopy increases the efficacy of vascular punctures. Nonetheless, femoral access, both venous and arterial, still has its specific indications, such as structural interventions [1,2,16,17].

According to the evidence available to date, the use of US decreases the number of puncture attempts from 3.05 to 1.65, $p < 0.0001$, and increases the success rates from 43.9% to 64.9%, $p < 0.0001$, based on 2015 studies [10]. Other studies have demonstrated a small benefit in favor of ultrasound, but with similar success rates compared to fluoroscopy [2], which supports the recommendation to guide punctures with any method available.

Complication rates for a femoral puncture are 1.4% when ultrasound is used compared to 3.8% with the traditional method [18].

There is literature that provides the necessary methodology to perform an arterial or venous puncture in the form of clinical practice guidelines [2,12,13,19,20] regardless of the indication for the procedure. For the development of this study, we took into consideration this literature, intending to address the required training and periprocedural preparation.

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A recent study published in 2022 concluded that the use of US for radial catheterization increased first-attempt success rates (90.8% *vs.* 80.8%, $p = 0.026$) and reduced the incidence of hematoma (9.2 *vs.* 28.2%, $p < 0.001$) when compared to the conventional puncture method [21].

It should be noted that the success of an intervention is also determined by the clinician's experience, and it has been demonstrated that experienced clinicians can achieve a success rate with conventional techniques comparable to that obtained with US-guided techniques [22].

Despite all the available evidence on the use of US in the catheterization laboratories, it still remains underutilized [2]. This situation is no exception in our country and in our medical center. Even though the authors are aware that it is used sporadically in some medical centers, no national literature has been published on the subject.

Based on the information presented, it is necessary for centers where minimally invasive cardiovascular interventions are performed to be familiar with the technique and the benefits derived from the use of ultrasound, regardless of the preferred access route, to increase puncture success while simultaneously reducing potential complications.

The objective of this study is to compare the complications derived from punctures performed with US-guidance in hemodynamic and electrophysiology procedures at the Central South High-Specialty Hospital (HCSAE) with those resulting from punctures using the conventional technique (classic palpatory Seldinger technique, fluoroscopy, or arteriography-guided).

Methods

A retrospective, cross-sectional, descriptive case-control study was conducted to evaluate complications arising from punctures performed in the hemodynamics and electrophysiology laboratories in two groups of patients. In the first group, punctures were performed under ultrasound guidance, while in the control group, outcomes were assessed following conventional techniques. The punctures were performed by interventional or clinical cardiology residents in training.

For vascular puncture, the Butterfly IQ+ ultrasound device was used in the hemodynamics and electrophysiology laboratories for the US-guided group. In the conventional puncture group, the procedure was assisted using palpation, anatomical sites, fluoroscopy, and/or arteriography.

Study population

The study included all hospitalized patients under the care of the cardiology department at HCSAE during June 2024.

The intervention group (cases) included patients who underwent a procedure made by interventional cardiology or electrophysiology in which vascular puncture was performed with US guidance. The control group included patients whose punctures were made without the assistance of US.

Complications in all the included patients were evaluated through the review of the electronic medical record.

Sample size

To answer the research question, the sample size was estimated using the formula for the difference in proportions between two independent populations. The calculation aimed to detect a difference in the prevalence of complications of 9% *vs.* 28% for the groups of patients undergoing puncture with US-guidance and conventional puncture, respectively. The estimation was based on data reported by Wu X-L and colleagues regarding the prevalence of hematomas in both types of interventions. It was determined that a sample of 51 patients would be sufficient. A 95% confidence level and a statistical power of 80% were considered.

Selection criteria

- **Inclusion criteria:** Adult patients hospitalized at HCSAE under the care of clinical cardiology considered candidates for interventional or electrophysiological procedures requiring radial, ulnar, or femoral (arterial or venous) puncture.
- **Exclusion criteria:** Patients under 18 years; hospitalized patients not eligible for interventional or electrophysiological cardiology procedures; patients in whom puncture was performed via subclavian or jugular access.
- **Elimination criteria:** Patients who withdrew consent for the predetermined procedure by the interventional and/or electrophysiology cardiologist attending.

Statistical analysis

Statistical analysis was performed using SPSS software, version 27.

To describe the characteristics of the study population, a descriptive analysis of the main variables of interest was performed, using frequencies and percentages for nominal variables and medians (25^{th}–75^{th} percentile) for continuous quantitative variables.

The characteristics of patients who underwent puncture with US-guidance and conventional technique were analyzed using the chi-square test for categorical variables and the Mann-Whitney U test for continuous variables. A two-tailed p-value ≤ 0.05 was considered statistically significant.

Results

Population characteristics

A total of 54 patients were included in the study: 27 in the intervention group (ultrasound-guided puncture) and 27 in the control group (conventional puncture). The mean age in the intervention group was 65.37 years (p25–p75: 62–71), while in the control group it was 67.11 years (p25-p75: 58–74). Regarding sex distribution, overall, more male patients were

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included: 20 men (74.07%) in the ultrasound group *vs*. 19 men (70.37%) in the conventional puncture group.

The demographic characteristics of our study population are presented in Table 1.

Comorbidities

Patients with heart disease often present with conditions that contribute to elevated cardiovascular risk, and the study population was no exception. In the US-guided puncture group, 74.07% [20] had known type 2 diabetes mellitus, 74.07% [20] had hypertension, 22.2% [6] had established coronary artery disease, 18.5% [5] had dyslipidemia, 55.5% [15] were smokers, and 77.7% [21] were sedentary. In the conventional puncture group, the distribution of comorbidities did not differ substantially from that of the US-guided group: 44% [12] had diabetes mellitus, 77.7% [21] had hypertension, 22.2% [6] had established coronary artery disease, 7.4% [2] had dyslipidemia, 62.9% [17] were smokers, and 88.8% [24] were sedentary. Figure 1 displays the distribution of comorbidities in each group, while Table 2 presents the frequencies of comorbidities in both populations (with and without US-guidance).

An important finding in our cohort was the higher prevalence of diabetes mellitus in one of the study groups. Since diabetes is independently associated with increased cardiovascular risk, peri-procedural complications, and worse long-term prognosis, this imbalance should be considered as a potential confounding factor in the interpretation of our results.

Table 1: Demographic characteristics.

	Total population		US-guided puncture		Conventional puncture	
Female[1]	15 (27.8%)		7 (25.9%)		8 (29.6%)	
Male[1]	39 (72.2%)		20 (74.1%)		19 (70.4%)	
Total[1]	54 (100%)		27 (50%)		27 (50%)	
	p50	p25-p75	p50	p25-p75	p50	p25-p75
Age	67.5	59.5-73.0	64	62-71	70	58-74
Weight (Kg)	73.4	65.4-84.6	72.6	67-86	74	64.7-81.4
Height (m)	1.7	1.63-1.75	1.7	1.63-1.75	1.69	1.63-1.75
BMI	27	23.9-28.4	27.1	24.4-28.7	26.9	23.2-28.1

The study population was characterized by a predominance of male patients in both groups, a median age of approximately 67 years, and an overweight status.
[1]N (%), p50: 50th percentile, p25–p75: 25th–75th percentile

Figure 1: Comorbidities of the study population. The vertical axis shows the percentage of occurrence, while the horizontal axis displays the different comorbidities identified. An important presence of diabetes, hypertension, smoking, and a sedentary lifestyle can be observed, as is commonly the case in patients with heart disease. DM: diabetes mellitus; HAS: Hipertensión arterial sistémica; EAC: Enfermedad arterial coronaria; Dislip: Dislipidemia; Tab: Tabaquismo; Sedent: Sedentarismo.

Table 2: Frequency of comorbidities.

	Total (54)	US-guided puncture (27)	Conventional puncture (27)	*p* value
DM[1]	32 (59.3%)	20 (74.1%)	12 (44.4%)	0.027
HTN[1]	41 (75.9%)	20 (74.1%)	21 (77.8%)	0.75
CAD[1]	12 (22.2%)	6 (22.2%)	6 (22.2%)	1.000
Dyslipidemia[1]	7 (13%)	5 (18.5%)	2 (7.4%)	0.224
Smoking[1]	32 (59.3%)	15 (55.6%)	17 (63%)	0.580
Sedentary lifestyle[1]	45 (83.3%)	21 (77.8%)	24 (88.9%)	0.273

The predominant conditions in the total population and by groups were diabetes mellitus, hypertension, smoking, and sedentary lifestyle. This finding is consistent with what is commonly observed in patients with heart disease, as these are major cardiovascular risk factors. [1]N (%).

Although statistical analyses accounted for this variable, it cannot be entirely excluded that the greater prevalence of diabetes may have influenced the magnitude of the outcomes observed. This limitation should be acknowledged when interpreting the external validity of our findings and highlights the need for studies with more homogeneous populations or more robust multivariable adjustments.

Treatment at admission

The medications patients were receiving at the time of the interventional or electrophysiological procedure were related to their comorbidities, reason for admission, and indication for the procedure. Table 3 describes the main medications received by our study population.

Reason for admission and indication for the procedure

In the analyzed population, ischemic pathology predominated, as is commonly observed in cardiology services.

Regarding the indications for interventional or electrophysiological procedures, in the US-guided group the reason for admission was chronic coronary syndrome group 1 (CCS G1) in 4 patients (14.81%), CCS group 2 (CCS G2) in 2 patients (7.4%), CCS group 3 (CCS G3) in 6 patients (22.22%), CCS group 4 (CCS G4) in 1 patient (3.7%), CCS group 6 (CCS G6) in 1 patient (3.7%), unstable angina (UA) in 3 patients (11.1%), NSTEMI in 2 patients (7.4%), STEMI in 4 patients (14.81%), atrial fibrillation or flutter in 2 patients (7.4%), aortic stenosis (AS) in 1 patient (3.7%), and evaluation of nonsustained ventricular tachycardia (NSVT) in 1 patient (3.7%).

In contrast, in the conventional puncture group, the indications were CCS group 1 in 6 patients (22.22%), CCS group 2 in 3 patients (11.11%), CCS group 3 in 1 patient (3.7%), CCS group 4 in 2 patients (7.4%), CCS group 6 in 1 patient (3.7%), UA in 2 patients (7.4%), NSTEMI in 6 patients (22.22%), STEMI in 4 patients (14.81%), atrial fibrillation in 1 patient (3.7%), and AS in 1 patient (3.7%). The indications for invasive studies are summarized in Figures 2,3.

Access approach

Regarding the access approach performed in each group, in the US-guided group, 20 punctures were radial arterial (74.1%), 5 were femoral arterial (18.5%), and 2 were femoral venous

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(7.4%). In the conventional puncture group, 21 procedures were performed with radial arterial access (77.8%), 5 with femoral arterial access (18.5%), and 1 with femoral venous access (3.7%). Table 4 shows the distribution of puncture access approaches.

In the present cohort, both radial and femoral access routes were employed. As consistently reported in international literature, the radial approach is associated with a lower incidence of vascular and bleeding complications compared with the femoral approach. In our analysis, hemorrhagic and vascular adverse events were predominantly observed in patients who underwent femoral access, whereas those treated via the radial approach experienced a considerably lower frequency of such complications. These findings reinforce previously published evidence and suggest that the choice of vascular access may have influenced the overall safety profile observed in this study.

Performance of hemodynamic and electrophysiology studies

Interventional cardiology procedures were performed through arterial punctures, either radial or femoral, by residents in training. On the other hand, electrophysiology procedures were carried out by a senior specialist in that field. It is important to note that all punctures related to interventional cardiology procedures (52 punctures) were performed by residents in training, while only those related to electrophysiological procedures (2 punctures) were performed by the senior specialist. Bias was controlled by comparing procedures performed with and without ultrasound guidance by the same physician, thereby ensuring that the comparison was not influenced by differences in physician experience and/or skill.

Table 3: Pharmacological treatment.

	Total		US-guided puncture (*N* = 27)		Conventional puncture (*N* = 27)		
	No. of patients	%	No. of patients	%	No. of patients	%	*p* value
Insulin	8	14.8%	5	18.5%	3	11.1%	0.444
Oral hypoglycemic	26	48.1%	16	59.25%	10	37.03%	0.102
ASA	37	68.5%	20	74.07%	17	62.96%	0.379
P2Y12 inhibitor	31	57.4%	16	59.25%	15	55.5%	0.783
Statin	39	72.2%	22	81.48%	17	62.9%	0.129
ACEI/ARB	35	64.8%	17	62.96%	18	66.6%	0.776
BB	22	40.7%	11	40.7%	11	40.7%	1.0
ARNI	3	5.6%	1	3.7%	2	7.4%	0.552
MRA	6	11.1%	2	7.4%	4	14.8%	0.386
SGLT2 inhibitor	18	33.3%	10	37.03%	8	29.6%	0.564

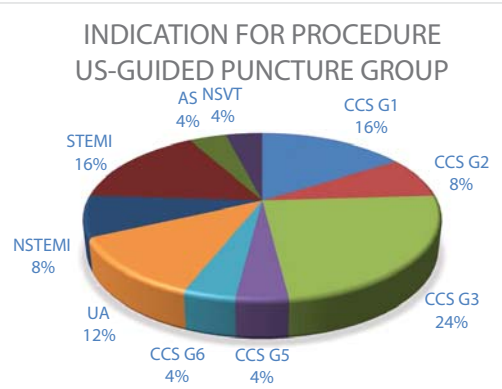

Figure 2: Reason for admission/Indication for the procedure. CCS: Chronic coronary syndrome; G1: Group 1; G2: Group 2; G3: Group 3; G4: Group 4; G6: Group 6; UA: Unstable angina; NSTEMI: Non–ST-segment elevation myocardial infarction; STEMI: ST-segment elevation myocardial infarction; AS: Aortic stenosis; NSVT: Nonsustained ventricular tachycardia

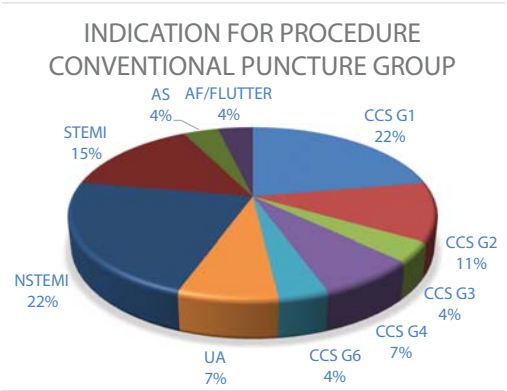

Figure 3: CCS: Chronic coronary syndrome; G1: Group 1; G2: Group 2; G3: Group 3; G4: Group 4; G6: Group 6; UA: Unstable angina; NSTEMI: Non–ST-segment elevation myocardial infarction; STEMI: ST-segment elevation myocardial infarction; AS: Aortic stenosis; AF: Atrial fibrillation.

Table 4: Distribution of puncture access approaches.

	US-guided puncture group		Conventional puncture group	
	N	%	N	%
Radial arterial	20	74.1%	21	77.8%
Femoral arterial	5	18.5%	5	18.5%
Femoral venous	2	7.4%	1	3.7%

p = 0.836.

Number of attempts to achieve a successful puncture

Previous evidence shows that the number of attempts required for a successful puncture decreases with the use of ultrasound. The results of the statistical analysis are consistent with the findings reported to date. The mean number of attempts was lower in the ultrasound group, with 1.56 attempts (SD 0.934), compared to 1.74 (SD 1.403) in the conventional puncture group.

Defining a successful puncture as one in which the guidewire and subsequently the introducer could be advanced to proceed with the studies and/or procedures, our study demonstrated a success rate of 92.59% in the ultrasound group compared with 88.8% in the conventional puncture group. In 3 cases in the ultrasound group, crossover to femoral access was required compared with 5 cases in the conventional puncture group.

For both groups, the pulse was perceived as good or adequate for the chosen puncture site (arterial) in >90% of

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cases. The previously mentioned characteristics are detailed in Table 5.

Complications between the two study groups

No major complications (need for transfusion, neurovascular compromise, vascular injury, or death as a consequence of the procedure) were observed after punctures in any of the cases. Only the presence of ecchymosis and hematoma was noted in some patients, distributed as follows: in the ultrasound group, ecchymosis occurred in 6 cases (22.2%) and hematoma in only 2 cases (7.4%), while in the conventional puncture group, these complications were observed in 7 cases (25.9%) for ecchymosis and 7 cases (25.9%) for hematoma. In the study population, 13 patients (24.1%) presented with ecchymosis and 9 patients (16.7%) with hematoma. One of the most important findings was a *p* - value of 0.068 showing a clear trend toward statistical significance when comparing hematoma occurrence between groups, highlighting the benefit of using this tool. Table 6 illustrates the complications observed in our population.

Among the hematomas, their severity was assessed according to the EASY scale. In the US group, one event was classified as EASY 1 and another as EASY 3, while in the non-US group, 3 events were classified as EASY 1 and 4 events as EASY 2 ($p = 0.087$). It should be noted that the most severe hematoma (EASY 3) occurred in the US-guided puncture group. Based on these findings, although the p-value did not reach < 0.05, the trend clearly favors the use of ultrasound. Table 7 describes the severity of hematomas according to the EASY scale.

Discussion

In this study, conducted in patients under the care of the cardiology department during a defined period at HCSAE, we describe the outcomes following different types of punctures related to interventional cardiology and electrophysiology procedures.

The findings of this investigation are consistent with those reported in previous studies, demonstrating that the use of ultrasound in the catheterization and electrophysiology laboratories has the capacity to reduce complications [2].

When compared with previously published studies [3,8,9], our work, despite including a small number of patients (a characteristic of major importance), showed results aligned with prior literature: a similar number of attempts required to obtain vascular access, a comparable success rate, and a lower frequency of complications (ecchymosis, hematoma, and hematoma severity). It is important to notice that only the latter complications demonstrated a trend toward statistical significance.

Previous evidence has reported a frequency of hematoma occurrence of up to 28% in radial punctures [20]. In our study, we observed a similar frequency in the conventional puncture group (25.9%) and a 3.5-fold reduction when ultrasound was used (7.4%).

Distinctive features of our study include the fact that most punctures were performed by first-year interventional cardiology residents. This situation, described in the first lines of our study, gives additional relevance to our work, as the use of ultrasound at the early stages of training not only decreases adverse outcomes but also enables residents to acquire a skill that is often underutilized in our country. Also, ultrasound guidance allows the early detection of patients in whom the vascular access may need to be modified before potentially causing harm.

Considering both the strengths and limitations of our clinical trial, the results are encouraging. We can conclude that US-guided punctures showed a trend toward reduced adverse outcomes aligned with our initial hypothesis.

Conclusion

In a tertiary care center where punctures are predominantly performed by physicians in training, the use of ultrasound resulted in fewer complications (ecchymosis, hematomas, and hematoma severity), with a similar number of attempts required to achieve successful puncture. This was observed with a *p* - value showing a trend toward statistical significance.

Table 5: Outcomes assessed after puncture.

	US-guided puncture group		Conventional puncture group		*p* value
Successful puncture (N)	25[1]	92.6%	24[1]	88.9%	0.639
Number of attempts	1.0[2]	1.0-2.0[3]	1.0[2]	1.0-2.0[3]	0.776
	1.56 (SD 0.934)		1.74 (SD 1.403)		-
Crossover	3[1]	11.1%	5[1]	19.2%	0.409
Good pulse quality	24[1]	96%	25[1]	96 .2%	0.997

Importantly, the ultrasound group showed a higher puncture success rate, a lower number of attempts, less need for crossover to femoral puncture, and a similar pulse quality in both groups.
[1]N, [2]p50, [3]p25–p75, SD: standard deviation.

Table 6: Complications after US-guided and conventional punctures.

	US-guided puncture group (N=27)		Conventional puncture group (*N* = 27)		*p* value
	N	%	N	%	
Ecchymosis	6	22.2%	7	25.9%	0.750
Hematoma	2	7.4%	7	25.9%	0.068

The findings show that the occurrence of ecchymosis was similar in both groups; however, regarding the presence of hematoma, there was a significant trend favoring the use of US, with only 2 patients presenting this complication in the US-guided group versus 7 in the group without US.

Table 7: Severity of hematomas (EASY scale).

	US-guided puncture group (*N* = 25)		Conventional puncture group (*N* = 26)		*p* value
	N	%	N	%	
EASY 1	1	3.7%	3	11.1%	0.087
EASY 2	0	0%	4	14.8%	
EASY 3	1	3.7%	0	0%	
EASY 4	0	0%	0	0%	

The severity of hematomas was lower in the US group, with a *p* - value showing a trend toward statistical significance. It is worth noting that the most severe hematoma occurred in the US group, probably because of the patient's adverse anatomical characteristics.

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Although we are aware that ultrasound is already used in some catheterization and electrophysiology laboratories to guide punctures, no similar study has been published in our setting to scientifically demonstrate its advantages. We believe that our results will encourage both specialists and residents to use ultrasound more frequently, and, in cases where the equipment is not available, to intensify efforts to obtain it. Without doubt, given the compelling evidence supporting puncture guidance, both physicians and residents should acquire the necessary skills and perform punctures under ultrasound guidance whenever possible.

It is important to reiterate the retrospective nature of our study and to emphasize that further prospective or multicenter studies are needed to validate and strengthen the relevance of our findings.

Ethical considerations

The study was approved by the ethics and research committees (Folio RMI-2418). In addition, before the procedures, informed consent was obtained from all patients and/or legal guardians.

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