ORIGINAL ARTICLE

Right-heart catheterization using antecubital venous access in patients with complex congenital heart defects and Glenn anastomosis

Kompleks doğuştan kalp hastalığı olan ve Glenn anastomozu uygulanmış hastalarda antekübital venöz yol kullanılarak sağ kalp kateterizasyonu

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ABSTRACT

Objective: Right-heart catheterization using the antecubital veins has recently regained attention, and studies demonstrating the feasibility and safety of antecubital access in adults have been published. However, no changes have been observed in the preferred entrance sites in right-heart catheterizations in children with congenital heart diseases. This article is a description of the technique and features of the antecubital venous approach in pediatric patients with complex congenital heart defects and a Glenn anastomosis.

Methods: The data regarding a right cardiac catheterization through the antecubital fossa veins performed in 18 patients with various clinical indications between January 2014 and August 2017 were reviewed retrospectively and the results were assessed.

Results: Ten patients (55%) were male and 8 patients were female. All of the patients but 1 had a complex congenital heart disease with a Glenn anastomosis. One patient had been operated on for a sinus venosus atrial septal defect and an abnormal pulmonary venous return and had a total occlusion of the superior vena cava. A diagnostic catheterization was performed in all cases. Additional procedures consisted of a balloon test occlusion of the pulmonary valve in 2 patients, a superior vena cava-right pulmonary artery anastomosis dilatation in 1, and abnormal veno-venous collateral occlusion with various devices in 2 patients.

Conclusion: The antecubital venous approach technique can be performed easily and safely for diagnostic and therapeutic catheterization in patients with complex congenital heart defects. The authors advocate that the antecubital venous approach should be the first site selected for right-heart catheterization, especially in patients with a Glenn anastomosis.

ÖZET

Amaç: Bu yazıda, kompleks doğuştan kalp defekti olan ve Glenn anastomozu yapılmış çocuk hastalarda antekübital venöz yaklaşım ile sağ kalp kateterizasyonu tekniği ve özellikleri sunuldu. Günümüzde antekübital damarlar kullanılarak yapılan sağ kalp kateterizasyonunun teknik özelliklerini ve güvenliğini gösteren çalışmalar yetişkinlerde yayınlanmıştır. Ancak, doğuştan kalp hastalıkları olan çocuklarda sağ kalp kateterizasyonlarında tercih edilen giriş yerlerinde değişiklik gözlenmemiştir.

Yöntemler: Ocak 2014 - Ağustos 2017 tarihleri arasında çeşitli klinik bulgulara sahip 18 hastada yapılan antekübital fossa venleri ile sağ kalp kateterizasyonu verileri geriye dönük olarak incelendi ve sonuçlar değerlendirildi.

Bulgular: On hasta (%55) erkek, sekiz hasta kadındı. Biri hariç tüm hastalar, Glenn anastomozu yapılmış kompleks doğuştan kalp hastalığına sahipti. Bir hasta sinüs venöz tipi atriyal septal defekt ve anormal pulmoner venöz dönüş anomalisi nedeniyle ameliyat edilmiş ve superiyor vena kavası tamamen tıkanmıştı. Tüm hastalarda tanısal kateterizasyon yapıldı. Ek işlemler; iki hastada pulmoner kapağın balon oklüzyonu, bir hastada süperiyor vena kava-sağ pulmoner arter anastomoz dilatasyonu ve iki hastada çeşitli cihazlarla anormal veno-venöz kollaterallerin tıkanması idi.

Sonuç: Antekübital venöz yaklaşım tekniği, kompleks doğuştan kalp defekti olan hastalarda tanı ve tedavi amaçlı kateterizasyon için kolay ve güvenli bir şekilde uygulanabilir. Antekübital venöz yaklaşımın özellikle Glenn anastomozlu hastalarda sağ kalp kateterizasyonu için seçilen ilk bölge olabilir.

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Traditionally, the transfemoral approach has been the accepted access site for the vast majority of transcatheter congenital heart procedures. However, veins other than the femoral can be a convenient access site for selected patients. In patients who have undergone a Glenn anastomosis, the pulmonary arterial single-access pathway becomes the upper venous system if the ventricular-pulmonary artery connection is interrupted.[1] The preferred sites for entry in these cases are the internal jugular or subclavian veins. The antecubital venous approach is a technique that has been nearly forgotten nowadays, but this vein is easy to access and provides a very high level of patient and physician comfort. This report is a description of the technique and features of the antecubital venous approach in children with complex congenital heart defects and a Glenn anastomosis.

METHODS

This study was conducted in compliance with the ethical standards of the relevant national guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Technique

After sedation or general anesthesia, the usefulness of the antecubital fossa vein was evaluated by applying a tourniquet to the upper arm. If the cephalic or basilic vein was prominent, either visibly or palpably, the antecubital venous approach was considered possible. Selection of the right or left forearm was made according to the side of the Glenn anastomosis. If there was no prominent vein on the side of the Glenn anastomosis, the other side was used in the initial puncture.

After cleaning the antecubital fossa with an antiseptic solution, the most prominent antecubital fossa vein was punctured with a 21-G needle or a 22- or 24-G intravenous cannula. To start, a 0.014-in standard coronary guidewire or a 0.021 hydrophilic guidewire (Terumo Corp., Tokyo, Japan) was inserted through the needle into the vein. After feeling free movement of the wire and seeing the tip of the wire in the superior vena cava, a 4- or 5-F sheath was inserted into the antecubital vein over the guidewire.

For the initial patients, the preference was to inject contrast material through the sheath prior to catheterization to determine the diameters, anatomy, and folds of the vessels the catheter passed through (Fig. 1a, b). As we became more experienced and determined that there was no obvious problem with this technique, we did not perform the initial venous system imaging unless there was a difficulty in the catheter or guide wire manipulation.

If the superior vena cava was not reached with a smooth and comfortable trace, or if there were angulations on the way to the superior vena cava, a right Judkins catheter and coronary guidewire combination was used to reach the superior vena cava. A size 4- or 5-F right Judkins catheter was passed via the sheath

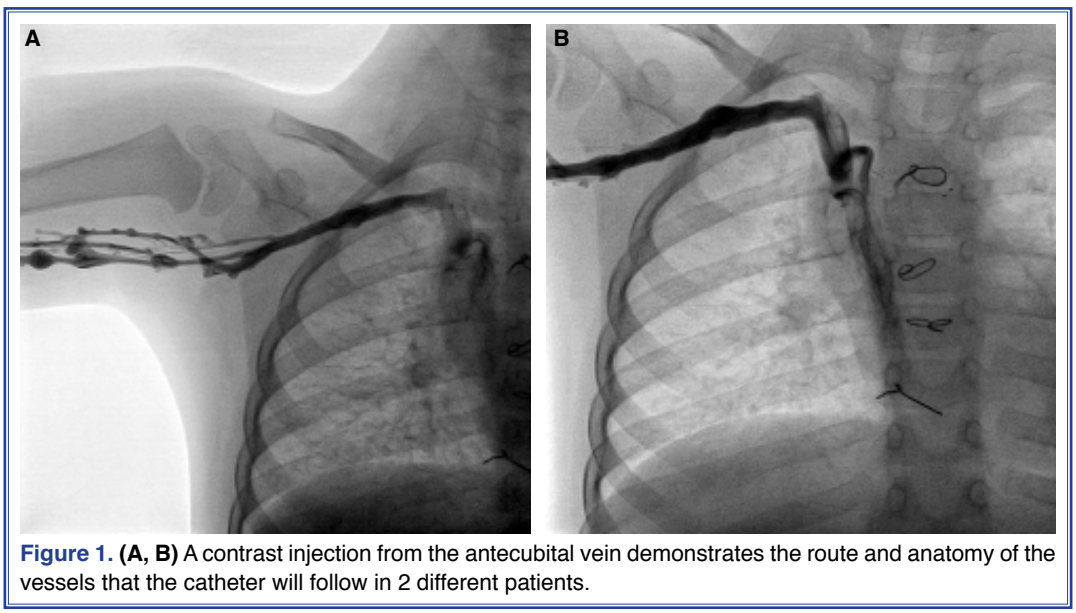

Figure 1. (A, B) A contrast injection from the antecubital vein demonstrates the route and anatomy of the vessels that the catheter will follow in 2 different patients.

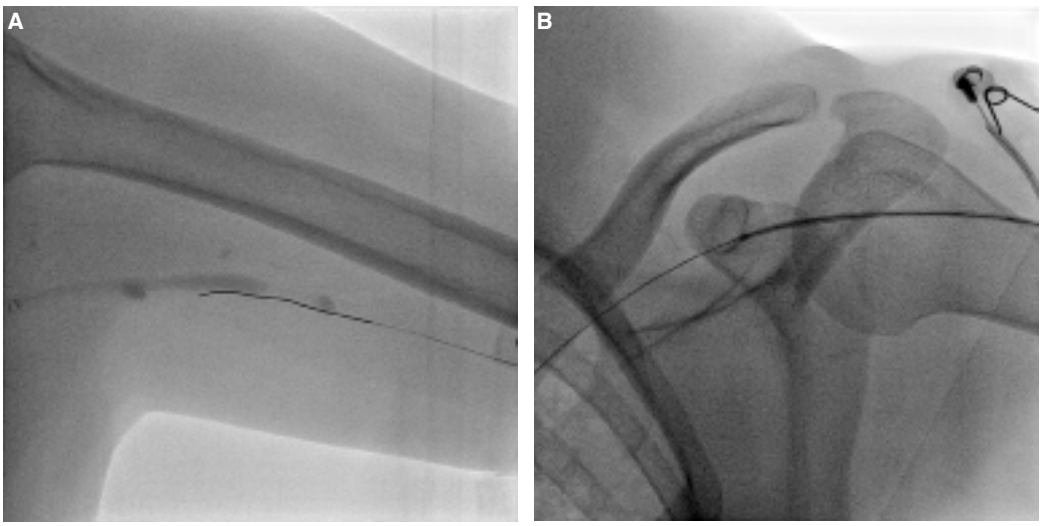

Figure 2. **(A)** A coronary guidewire is advanced through the vein; **(B)** The catheter is advanced over the guidewire.

and over the guidewire into the superior vena cava (Fig. 2a, b). After reaching the superior vena cava, the guidewire was exchanged for a 0.035-in hydrophilic wire (Terumo Corp., Tokyo, Japan), and all of the manipulations were performed using a right Judkins catheter and a 0.035-in hydrophilic wire. If needed, the right Judkins catheter was exchanged with a pigtail catheter, especially in the case of a diagnostic angiography (Fig. 3). Heparin was not routinely administered, and the sheaths were removed at the end of the procedure using manual compression to ensure homeostasis. The patients were discharged after 3 to 4 hours if no therapeutic interventional procedure had been performed.

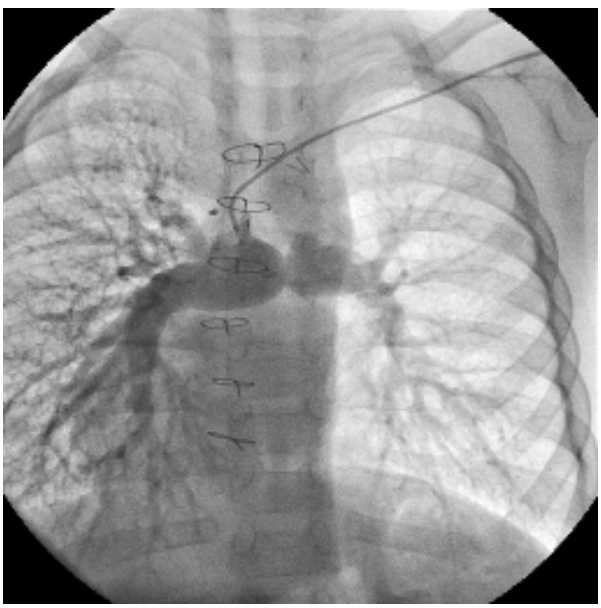

Figure 3. A superior vena cava injection demonstrating the pulmonary vascular anatomy.

RESULTS

Between January 2014 and August 2017, a right cardiac catheterization through the antecubital fossa veins was performed in 18 patients with various clinical indications. The last 10 catheterizations were performed during the last 8 months as the technique became standardized and the simplicity of this method was recognized. Ten patients (55%) were male and 8 were female. The median age was 10 years (1.5–24 years) and the median weight was 25 kg (10–80 kg). The right arm was used for 6 patients (33%), and the left arm was used for 12. All of the patients except 1 had a complex congenital heart disease with a Glenn anastomosis. One patient had been operated on for a sinus venosus atrial septal defect and an abnormal pulmonary venous return and had a total occlusion of the superior vena cava (Fig. 4).

In 5 cases, the femoral approach was used simultaneously for additional diagnostic reasons. A diagnostic catheterization was performed in all of the patients. Additional procedures consisted of a balloon test occlusion of the pulmonary valve in 2 patients, a superior vena cava-right pulmonary artery anastomosis dilatation in 1, and abnormal veno-venous collateral occlusion with various devices in 2 patients (Fig. 5a, b). The mean fluoroscopy time and the total pro-

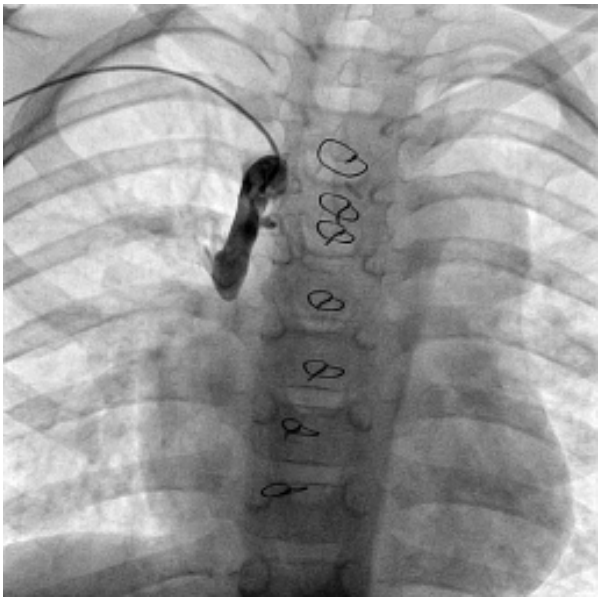

Figure 4. A superior vena cava injection demonstrating total occlusion of the superior vena cava.

cedure time was 11.5±16.9 minutes (1.1–41 minutes) and 44.4±34.8 minutes (20–105 minutes), respectively. Three patients had the longest fluoroscopy and procedure time (100.72 and 105 minutes). Patients who only had a diagnostic angiography performed through the antecubital fossa veins were discharged after 3 to 4 hours, and there were no complications. The characteristics of the patients are provided in Table 1.

DISCUSSION

The right-heart catheterization technique was initially introduced in 1929 and was performed using antecubital venous access.[2] Since that time, the preferred access site has shifted from the antecubital veins to the proximal veins, and traditionally, right-heart catheterization has been performed using proximal venous access sites, such as the common femoral, internal jugular, or subclavian veins. Over the last decade, there has been increasing interest in performing left-heart catheterization via the radial artery approach, and a complete transition from a femoral to a radial approach has occurred in adult patients. Now it is considered a safe, successful, and preferred approach for many cardiovascular procedures.[3,4] For logistical reasons, right-heart catheterization using the antecubital veins has regained attention, and many studies demonstrating the feasibility and safety of antecubital access have been published.[5–9] However, no changes have been observed in the preferred entrance sites for right-heart catheterizations in children with congenital heart diseases. Recent work on this subject has been published in the literature in 2004 by Kusa et al.[1]

In complex congenital heart disease, repeat catheterizations may lead to iliac vein thrombosis, and superior access is needed. Venous access through the superior vena cava is mandatory for studying the pulmonary arteries in patients with a Glenn anastomosis. In order to avoid an internal jugular or subcla-

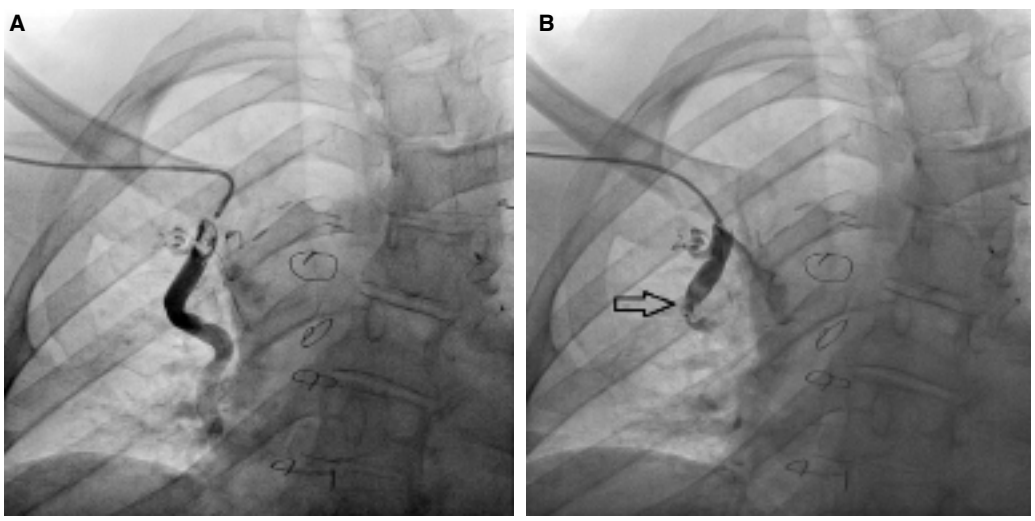

Figure 5. **(A)** A selective venous injection demonstrating an abnormal veno-venous collateral; **(B)** Total occlusion of the abnormal veno-venous collateral after device implantation (Arrow: occlusion device).

Table 1. The characteristics of the patients

No	Age (years)	Weight (kg)	Gender	Site of entry	Sheath (F)	Diagnosis	Intervention
1	10	25	M	Right	5	Absence of right AV connection, single atrium + ventricle + absence of LPA + Glenn	–
2	22	65	M	Left	5	ASI, absence of left AV connection + DORV + PS + Glenn	–
3	5	13	M	Right	4	RAI + absence of right AV connection + bilateral Glenn + pulmonary band	Pulmonary artery test occlusion
4	22	55	F	Right	5	ASD + DILV + Patr + Glenn	Transcatheter closure of veno-venous collateral
5	24	56	M	Left	6	Functional single ventricle (large VSD) + malposition of great arteries + pulmonary band+ Glenn	Transcatheter closure of veno-venous collateral
6	5.5	22	M	Right	4	Operated sinus venosus ASD + PAPVR	–
7	23	60	F	Left	5	SIT + large VSD + hypoplastic RV + PS + Glenn	–
8	17	80	M	Left	5	Dextrocardia + ASI + ASD + VSD + hypoplastic RV + PS + Glenn	Pulmonary artery test occlusion
9	3.5	12	F	Left	4	Tatr + Patr + Glenn	–
10	2	12	M	Left	4	Tatr + ASD + VSD + Glenn	–
11	2.5	12.4	M	Left	4	Dextrocardia + ASS + functional single ventricle + malposition of great arteries + Patr + Glenn	–
12	17	50	F	Right	5	RAI + KAVSD + hypo LV + DORV + PS + operated TAPVR + Glenn	Balloon angioplasty (Glenn anastomosis stenosis)
13	1.5	10	M	Left	4	HLHS Stage II + Glenn	–
14	5	15	F	Right	4	HLHS Stage II + Glenn	–
15	3	12	F	Right	4	Tatr + ASD + VSD + Glenn	–
16	22	55	F	Left	5	ASD + DILV + Patr + Glenn	–
17	17	61	M	Left	6	Dextrocardia + ASI + KAVSD + DORV + PS + Glenn	–
18	10	61	F	Left	5	Tatr + Patr + Glenn	–

AV: Atrioventricular; ASD: Atrial septal defect; ASI: Atrial situs inversus; ASS: Atrial situs solitus; CAVSD: Complete atrioventricular septal defect; DILV: Double inlet left ventricle; DORV: Double outlet right ventricle; F: Female; HLHS: Hypoplastic left heart syndrome; LPA: Left pulmonary artery; LV: Left ventricle; M: Male; PAPVR: Partial anomalous pulmonary venous return; Patr: Pulmonary atresia; PS: Pulmonary stenosis; RAI: Right atrial isomerism; RV: Right ventricle; SIT: Situs inversus totalis; TAPVR: Total anomalous pulmonary venous return; Tatr: Tricuspid atresia; VSD: Ventricular septal defect.

vian venous puncture, we have used a puncture of the antecubital vein as the elective access point. Because these antecubital veins are superficial, they are easily located visually, by palpation, or both. The internal jugular or subclavian veins are not visible, and venous access is based on the presumed location of the vessel, the identification of surface or skin anatomical landmarks, and the blind insertion of the needle until blood is aspirated. This is a less controlled procedure when compared to antecubital vein access. As a result, the internal jugular or subclavian approaches have additional established risks, such as carotid or subclavian

artery puncture, nerve injury, brachial plexus paralysis, hemothorax, or pneumothorax.[10–12] To mitigate some of these risks, ultrasound-guided central venous access has been advocated, but this is not available in all centers.[11] Antecubital access is free of all these complications and can also be performed by an experienced nurse.[13] Post-procedure bleeding control is as easy as blood collection from the elbow. The head movement of an awakening child and the risk of compressing the adjacent carotid artery make bleeding control difficult with other access methods and may result in large, undesired hematomas and pain in the neck, which has a large area of soft tissue. Since these concerns do not exist with antecubital venous access, this technique reduced the prevalence of access-site hematomas. Furthermore, antecubital venous access-based right-heart catheterization can be performed safely on anticoagulated patients without interrupting the anticoagulation process.[6,14,15]

Particularly in small or overweight children, it is not always possible to use the preferred vessel, and the most obvious vessel in the forearm is cannulated. If it is possible, however, the veins on the medial (ulnar) side of the forearm are preferred because the route to the heart is more direct through the basilic, axillary, and subclavian veins. Access via the veins on the lateral (radial) side of the forearm can be more challenging because the cephalic vein typically enters the axillary vein at a sharp angle that can be difficult to navigate (Fig. 6a).[16] Therefore, wherever possible we preferred medial side vessels. When this option was not possible and lateral vessels were cannulated, we performed a venogram through the cannula, solving the hard angle problem using a right Judkins catheter and coronary guidewire combination under the guidance of venogram imaging, as mentioned above (Fig. 6b).

Generally, one of the most important rules for cardiac catheterization is not to push if resistance is felt. This rule is even more important in the antecubital approach in small children because arm vessel diameters are smaller than with the femoral or internal jugular vessels.

Another challenge is that venous occlusion from a previous trauma, surgery, or prior instrumentation can result in collateral circulation, leading to a tortuous path. This problem may not be apparent upon physical examination because of the rich collateral circulation.[16] Based on this knowledge, we always avoided hard manipulations. When we felt resistance, even in guidewire manipulation, we performed a venogram through the cannula or sheath to determine the optimal pathway. A right Judkins catheter and coronary guidewire combination was used to reach the superior vena cava under the guidance of a venogram image. We did not experience any problems with our patients' contralateral side; however, alternative access sites may be preferred if there is difficulty reaching the superior vena cava.

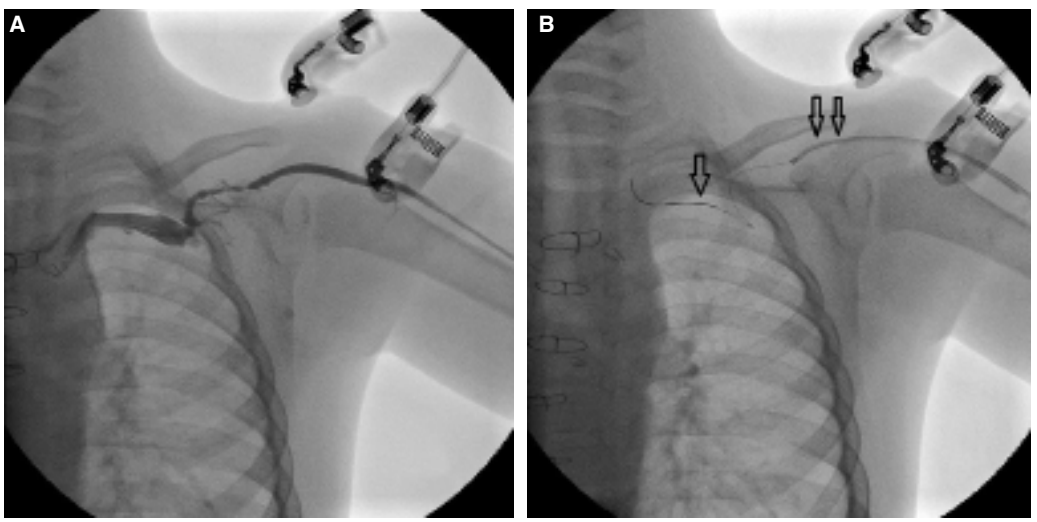

Figure 6. **(A)** A venogram demonstrating the cephalic vein, which typically enters the axillary vein at a sharp angle; **(B)** Passage through the sharp angle with a right Judkins catheter and coronary guidewire combination (Arrow: guidewire; double arrows: catheter over the guidewire).

In addition diagnostic catheterization, the antecubital approach also enables interventional procedures. In our study, we performed therapeutic procedures in 3 patients. In 2 cases, the veno-venous collaterals were closed with various devices, and the Glenn anastomosis stenosis was dilated using balloon angioplasty in 1 patient. In small children, 4-F sheaths and catheters were sufficient for diagnostic catheterization, whereas in older children and adolescents, we used up to a 6-F sheath without any trouble. Kusa et al. reported that balloon-branch angioplasty was performed in 3 of 34 patients, and the smallest patient was 3.1 years old. In their study, they saw a late thrombosis of the right brachial vein in 2 patients. Our smallest patient was 1.5 years old and weighted 10 kg, and we had no complications.

Another advantage of antecubital venous access is greater patient and family comfort. After cardiac catheterization, thick bandages covering the neck, a hematoma at the entry site, or discoloration as a result of a healing hematoma may cause the patient or family members without medical knowledge to feel very uncomfortable. This is especially important in school-age children and adolescents who may have difficulty explaining their condition. There is almost no ecchymosis with antecubital venous access. If there does happen to be a small complication, a teenager can more easily explain the situation as a complication of a simple blood sampling to schoolmates. Moreover, antecubital venous access for right-heart catheterization allows for early patient ambulation after the procedure and facilitates same-day discharge, as well as appearing to be more comfortable for the patients.[6] In our study group, patients without additional femoral access or any intervention were able to be discharged after 3 to 4 hours with no complications.

Based on our experience, the antecubital approach provides additional comfort and ease in the operator's manipulations compared with the internal jugular approach. Catheter manipulation under the image intensifier and in a very narrow space is difficult during an internal jugular approach. In contrast, the antecubital approach in the arm is far from the image intensifier, and there is wider area for catheter manipulation, which makes for easier manipulation. As a result, we believe that this convenience lowers procedure times and the amount of radiation received by the patient and the physician. In our study, the procedure time was very short in patients who did not undergo pulmonary occlusion tests or therapeutic interventions, such as collateral occlusions or balloon angioplasties. The shortest procedure time in this study was 20 minutes and the shortest fluoroscopy time was 1.1 minutes.

Limitations

This study is a retrospective review of the medical records of a small patient group. Our study is not a comparative one, and for a clear decision on the preferability of antecubital venous access, a comparative study with a much larger sample size is needed.

Conclusion

The antecubital venous approach can be performed easily and safely for diagnostic and therapeutic catheterization in patients with complex congenital heart defects. We advocate that the antecubital venous approach should be the first site selected for right-heart catheterization, especially in patients with a Glenn anastomosis.

Ethics Committee Approval: The study was approved by the Ethics Committee of İstanbul University Cerrahpaşa Faculty of Medicine (approval date: 11.07.2017 approval no.: 264319).

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Conflict-of-interest: None.

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Keywords: Antecubital venous access; children; complex congenital heart defects; diagnostic catheterization; Glenn anastomosis; right heart catheterization.

Anahtar sözcükler: Antekübital venöz yol; çocuk; kompleks doğuştan kalp hastalığı; diyagnostik kateterizasyon; Glenn anastomozu; sağ kalp kateterizasyonu.