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Original Research Paper

Contribution of Ultrasound Guidance in the Placement of Hemodialysis Catheters

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ABSTRACT:
Ultrasound has revolutionized the placement of hemodialysis catheters by offering a precise and secure method. Our prospective randomized study conducted at the nephrology department of CHU Bab el Oued between November 2016 and November 2018 compared the use of ultrasound guidance to anatomical landmarks for catheter placement. Among the 285 patients included, divided into two groups (anatomical and ultrasound-guided), ultrasound guidance showed significantly higher overall success rates and success rates at first puncture compared to anatomical landmarks (90.1% vs 52.4% and 53.52% vs 24.47% respectively, $p < 0.0006$). This trend persisted among experienced operators, with higher success rates for ultrasound guidance (94.7% vs 80.4%, $p = 0.01$). Furthermore, the use of ultrasound significantly reduced the incidence of complications related to catheter insertion. These results confirm the crucial importance of ultrasound guidance in the placement of hemodialysis catheters, regardless of the insertion site and the operator's level of experience, while emphasizing the need for an alternative in case of unavailability of the ultrasound machine or in extreme emergency situations.

Keywords: Hemodialysis catheter, Ultrasound, Renal failure, Venous access.

PATIENTS AND METHODS:

This is a prospective randomized study conducted at the nephrology department of CHU Bab el Oued between November 2016 and November 2018. The study population consisted of patients with acute or end-stage renal failure requiring the placement of a hemodialysis catheter for extrarenal clearance. Patients were randomized into two groups: the anatomical landmarks group (AL) and the ultrasound-guided group (UG). Collected data, in addition to demographic information, included the localization technique, insertion site, overall success rate, first puncture success rate, and complications.

RESULTS:

Our study included 285 patients randomized into 2 groups: the anatomical landmarks group: 143 patients (50.2%) and the ultrasound-guided group: 142 patients (49.8%). The mean age was 56.21 ± 2.17 years, with a slight male predominance and a sex ratio of 1.37. Hypertension and diabetes were the most common medical histories among our patients, with respective percentages of 65.6% and 37.5%. The vast majority of our patients (80%) had end-stage renal failure, while acute renal failures accounted for only 20%. Regarding the puncture site, 158 patients (55.4%) underwent jugular catheter placement, and 127 patients (44.6%) underwent femoral catheter placement. The success rate was higher in the ultrasound-guided group (90.1%) compared to the anatomical landmarks group (52.4%) (Figure 1), with a very significant difference ($p < 10$ -6). The first puncture success rate was also higher in the ultrasound-guided group (53.52%) vs (24.47%) in the anatomical landmarks group, with a significant difference ($p = 0.0002$). Among experienced operators (> 50 procedures), the success rate during ultrasound-guided localization (94.7%) was higher than that of anatomical landmarks localization (80.4%) (Figure 2) with a significant difference ($p = 0.01$).

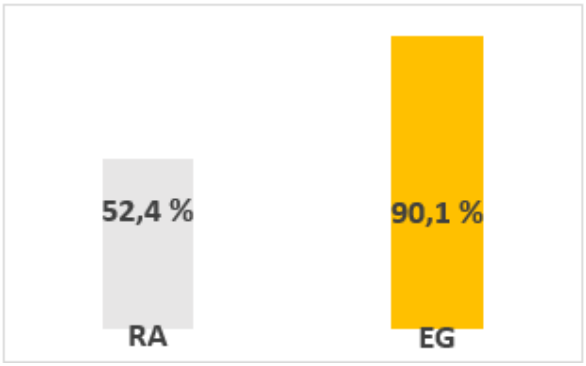

Figure 1: Overall success rate.

For inexperienced operators (<50 procedures), there is a higher success rate during ultrasound-guided localization (84.8%) compared to anatomical localization (37%) (Figure 3) with a highly significant difference ($p < 10^{-6}$). This is noteworthy as in ultrasound-guided procedures, inexperienced operators surpass the success rate of experienced operators in anatomical localization, thereby compensating for their lack of experience. The average venous return time is 42 sec ± 0.10 min for the ultrasound-guided group, whereas it is 91 sec ± 0.16 min for the anatomical group (Figure 4) with a significant difference ($p = 0.000002$), which could be explained by a higher number of puncture attempts in the anatomical group.

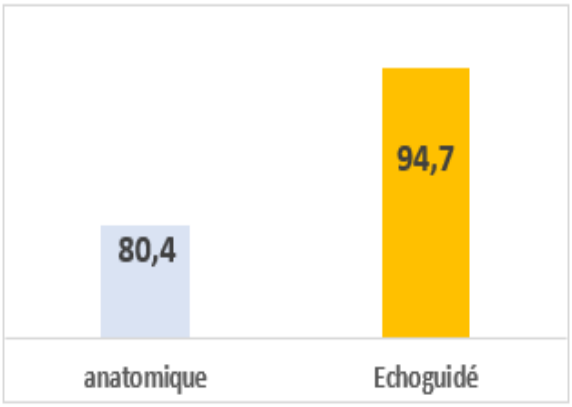

Figure 2: Success Rate in Experienced Operators

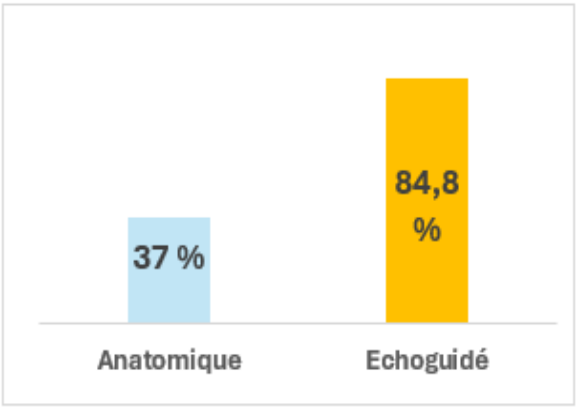

Figure 3: Success Rate in Inexperienced Operators

There are fewer immediate complications in the ultrasound-guided group (19.7%) compared to the anatomical group (45.5%) with a highly significant difference ($p < 10^{-6}$) (Figure 5). We observed that medium-term complications were not influenced by comorbidities such as diabetes or hypertension, despite higher complication rates among diabetics (55.1%) and hypertensive patients (51.9%), which were statistically not significant with respective p-values of 0.2 and 0.6. There are more infections in the anatomical group (18.2%) than in the ultrasound-guided group (14.1%), with no significant difference ($p = 0.34$), which could be explained by the higher number of punctures and longer procedure times in the anatomical group. Infections occur at both sites, with a slight predominance at the femoral site (56.5%). Thromboses occur at both sites, with a predominance at the jugular site (58.2%), possibly explained by a longer catheter presence duration in the jugular compared to the femoral site (14.74 days vs. 8.96 days).

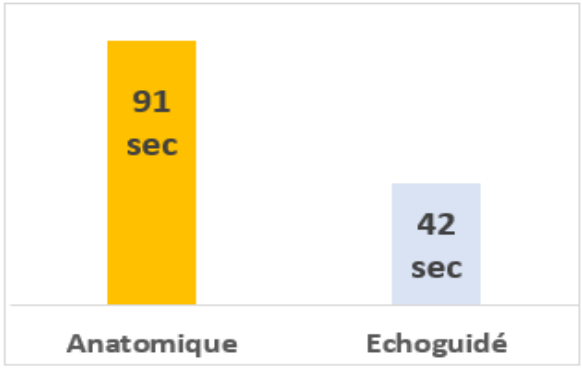

Figure 4: Venous return in experienced operators

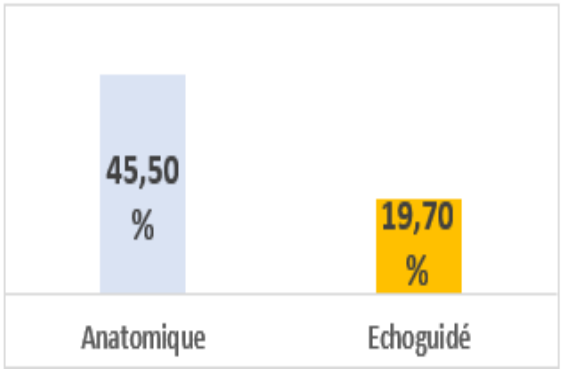

Figure 5: Complication rate

DISCUSSION:

Most of the central venous pathways currently used were first described in the 1950s-1960s. The first central venous pathway was described in 1952 by Robert Aubaniac, a surgeon born in Sidi Bel-Abbes in 1914, and a graduate of the Faculty of Medicine of Algiers [1]. Hemodialysis catheters are dual-lumen, immediately usable, temporary catheters, allowing a blood flow rate of at least 200 ml/min [2]. Three sites are accessible for catheterization: the subclavian veins, the jugular veins, and the femoral veins. However, current recommendations advise against the use of subclavian veins [3] due to the observed venous stenosis rates of 42% to 50% after inserting an EER catheter into a subclavian vein, compared to 0 to 10% for a jugular vein [4]. These subclavian stenoses significantly limit the possibilities of subsequent arteriovenous fistula creation in the event of progression to chronic renal failure. The catheter placement must be performed under surgical aseptic conditions, by a trained operator, on an informed and perfectly immobilized patient under local anesthesia using the Seldinger technique [5]. For catheterizing the internal jugular vein, the patient must be in the supine position, with the head turned to the opposite side of the puncture, in the Trendelenburg position to avoid gas embolism associated with the negative pressure in this vein, especially during inspiration, and also to improve vascular filling. Most authors preferentially choose the right internal jugular vein whose axis coincides with that of the superior vena cava, facilitating catheter descent. In our department, we use the Daily approach, puncturing at the center of the Sédillot triangle, with the needle directed downward, in a parasagittal plane, at a 30° angle to the skin plane. During femoral vein access, the patient is placed in the supine position with moderate head elevation, the lower limb in abduction and external rotation. The operator's free hand locates the femoral artery, and the puncture is performed just inside the artery, 10-15 mm from its axis, usually 20 mm below the inguinal ligament [6], with the needle making an angle of approximately 30° with the skin and oriented in the axis of the limb. The first recommendations on the subject were issued by the National Institute for Clinical Excellence (NICE) in 2002 [7]. Since then, other recommendations have been published, advocating for the use of ultrasound guidance for all central venous accesses [8,9]. French recommendations on the subject were published in 2015, recommending ultrasound guidance for all central venous accesses (Grade 1+) [10]. By visualizing the position of the vein and artery, ultrasound allows for the detection of anatomical variations, vein thrombosis when the vein does not compress, and a virtual vein < 5 mm in diameter [11] (Figure 6,7). The use of ultrasound enables visualization of vessels, adjacent structures, and the puncture needle. It is necessary to use an ultrasound machine equipped with a vascular probe with frequencies ranging from 5 to 15 MHz [12,13], as it provides good spatial resolution for superficial areas. Compression of the vascular structures is performed using the probe to distinguish the compressible, non-pulsatile vein from the non-compressible, pulsatile artery.

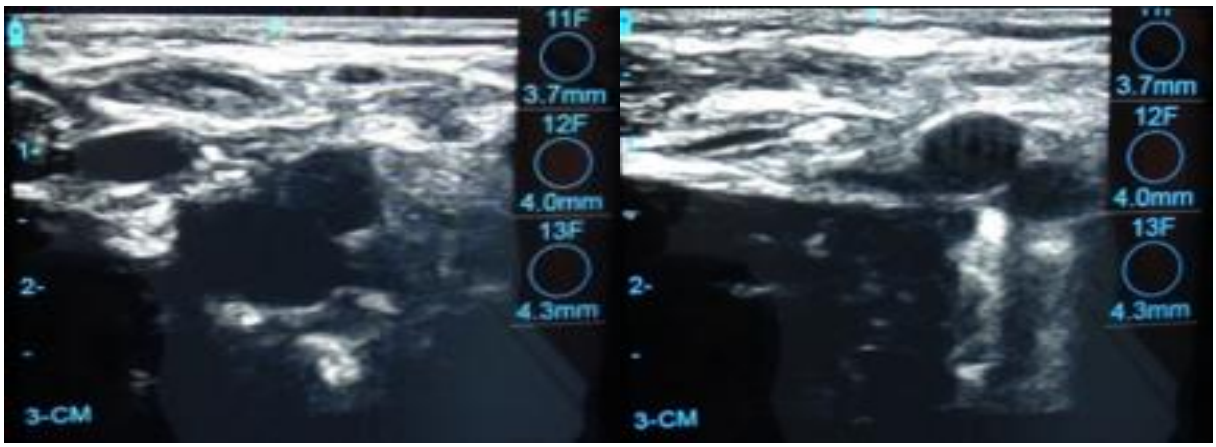

Figure 6: Appearance of vascular structures on ultrasound.

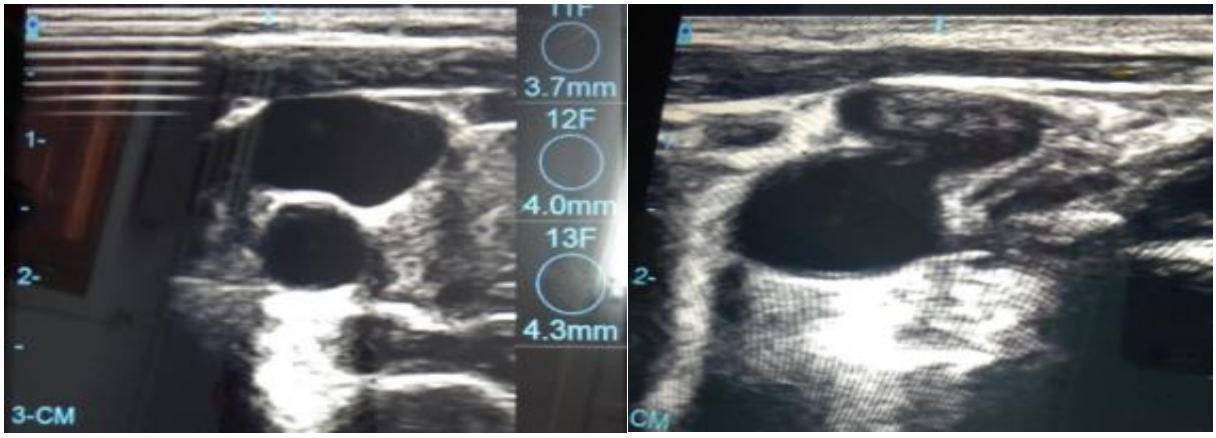

Figure 7: Ultrasound appearance of vascular variations and thromboses.

CONCLUSION:

In our study, ultrasound significantly improved the success rate and the rate of success on the first puncture, while significantly reducing the incidence of insertion-related complications of catheters, aligning with international studies. For all these reasons, ultrasound guidance should be the preferred approach for hemodialysis catheter placement, regardless of the site or the operator's experience. However, it's essential to ensure the availability of traditional placement techniques in situations where ultrasound is unavailable or in cases of extreme urgency.

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