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Research Article

Anatomical Ultrasound Study of the Cephalic Vein in the Deltopectoral Groove in Oncological Patients Eligible for a Totally Implantable Venous Access Port

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Abstract

Background: Cephalic Vein Cutdown (CVC) in the Deltopectoral Groove (DG) is a simple surgical technique used for the insertion of pacemakers or Totally Implantable Venous Access Ports (TIVAP), with few intra- or postoperative complications. Due to possible anatomical variations, its success rate has reported to be lower than percutaneous ultrasound-guided techniques. The aim of this study is to describe the anatomy of the Cephalic Vein (CV) in the DG.

Methods: A total of 2400 CVs in the DGs of 1200 patients were studied with ultrasound before the implantation of the TIVAP for chemotherapy treatment. Diameter, depth, tortuosity, CV/Axillary Vein junction (CV/AV) and AV patency were measured and related to gender and laterality.

Results: The mean age of the 1200 patients was 63.3 years, 744 (62.0%) of whom were women. The CV was absent in 155 (6.5%) cases and there were no significant differences between sexes. The mean diameter of the CVs, when present, was 3.8 mm and the mean depth was 13.6 mm (SD: 2.9). Both diameter and depth were significantly greater in men. In 91 (4.1%) cases there was stenosis of the CV/AV junction, being significantly greater on the left side. CV tortuosity and AV occlusion were observed in 32 (1.4%) and in 22 (0.9%) cases, respectively, with no statistically significant differences found between sexes. Two thousand and fifty-seven CVs (85.7%) had a diameter ≥ 3.0 mm.

Conclusions: The present study showed that the diameter and depth of the CVs were greater in men and on the right side. Stenosis of the CV/AV junction and tortuosity were more common in left-sided CVs.

Keywords: Cephalic Vein; Deltopectoral groove; Preoperative Duplex Ultrasonography; Totally Implantable Venous Access Ports

Introduction

The first available description of the Cephalic Vein (CV) was proposed in the 2nd century AD by Galen of Pergamon who transposed his observations made on monkeys onto humans and claimed that the CV (Galen's humeral vein) "arose" from the external jugular vein and encircling the clavicle "ran towards the periphery" [1]. The CV as a term originates from the Arabic word al-kefal, which means "outer" and was first used by Muslim physician Abu Ali al-Hossein ibn Adbullah Ibn Sina (known as Avicenna in the West), when the term was translated to Latin, cephalic inaccurately was selected to replace the Arabic origin of the term [2]. Until the last decade of the 20th century, most studies of the cephalic veins were anatomical and were performed on cadavers [3] or with intraoperative venography [4], while ultrasound is the most widely used technique nowadays [5]. Since the beginning of pacemaker implants in 1959 [6] and Totally Implantable Venous Access Port (TIVAP) in 1982 via the Cephalic Vein Cutdown (CVC) approach [7], this is the access route with the fewest intra- and postoperative complications, although due to variations in caliber and depth in the deltopectoral groove (DG), as well as other possible anomalies, a success rate of 71.0% has been reported [8]. Hence the importance of identifying the exact anatomy.

Materials and Methods

In January 2008, our Department of Angiology and Vascular Surgery´s Outpatient Clinic began performing a preoperative Doppler ultrasound on all patients referred by the Oncology Department for the implantation of a TIVAP for chemotherapy treatment. Although the first choice for implantation is the Left Cephalic Vein (LCV), except in left-handed patients, those who had undergone breast surgery on the left side with/without axillary lymphadenectomy or previous TIVAP/pacemaker implanted on this side, assessment of CVs in both DGs were made. During the outpatient clinic and with the patient in supine position the CV is displayed by means of a 7.5 – 12 MHz probe of MyLab50 and MyLabX5 (Esaote, Genoa, Italy) colour Doppler ultrasound at the level of both DGs, registering its diameter, depth, course, drainage of the CV to AV junction (CV/AV), as well as the patency of the AV. The CV diameter (in millimeters) is considered as the maximum transverse measurement in its course up to the CV/AV junction. CV depth as the distance (in millimeters) between the skin and its upper edge in its closest portion to the skin.

The CV was classified by its size into absent (when not visible), small (diameter < 3.0 mm) and normal (diameter ≥ 3.0 mm). This classification is used because the TIVAP implantation system is a NuPport HP* device (PHS MEDICAL - Fuldabrück, Germany) with a single-chamber titanium port and a silicone catheter with an external diameter of 9.6 F (≈ 3.0-3.2 mm). CV stenosis is defined as a narrowing of the vessel lumen of more than 50% of the total. The absence of flow signals in the AV with intraluminal echogenic material is considered as venous thrombosis. Figure 1 shows the different parameters assessed in this study**.**

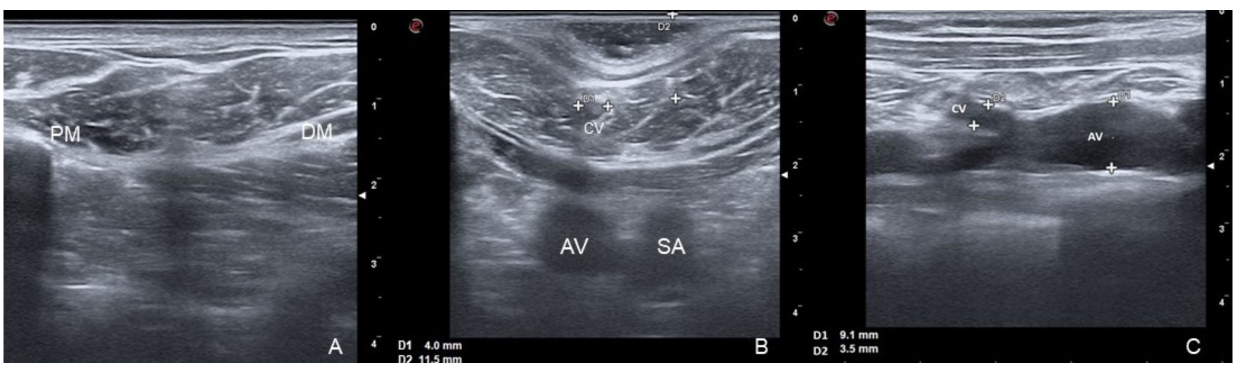

Figure 1: Ultrasound findings in the DG; **1A**: Cephalic Vein (CV) absent in the DG (located between Pectoralis Major Muscle [PM] and Deltoid Muscle [DM]); **1B**: CV diameter (D1) and CV depth (D2); Cross-sectional view of Axillary Vein (AV) and Subclavian Artery (SA); **1C**: confluence of the CV into the AV.

The surgical procedure for the implantation of TIVAP is always performed through a 3-4 cm single incision in the DG via CVC or Infraclavicular Subclavian Vein Puncture (SVP). The CVC surgical technique is perfectly described by Jouvin [9]. If the CV is small or there is a partial stenosis of the CV/AV junction, sometimes the venous access is possible with the help of a Micropuncture Kit (AngioDynamics - Latham, USA) with a 21-Gauge needle an a 0.018″ guidewire. When the CV is absent or not suitable, the TIVAP is placed through SVP using the Landmak technique [10]. Ultrasound studies and surgical techniques for TIVAP insertion and removal were performed by the same vascular surgeon with 35 years of experience in this field. The data obtained were recorded in a FileMaker Pro database. All patients provided signed informed consent for the procedures.

Statistical Analysis

The baseline characteristics of the study groups were described using means with their corresponding Standard Deviations (SD) for continuous variables and frequencies and percentages for categorical variables. Boxplots were plotted and medians and Interquartile Ranges (IQR) were computed in order to see differences in numerical variables distributions. Differences between sex were compared according to sociodemographic and clinical variables. If the compared variable was numerical, Wilcoxon rank-sum test was used for non-normally distributed data; if the variable was categorical, Chi-squared or Fisher's exact test was used, as appropriate. Differences between left and right veins were compared by Wilcoxon signed-rank test for related samples or by McNemar test depending on the nature of the compared variable. Statistical significance was set at P value ≤0.05 and statistical analysis were performed by using RStudio® version 4.3.1.

Results

Between January 2008 and December 2023 a total of 2400 CVs in the DGs of 1200 patients were studied with ultrasound before the implantation of the TIVAP, 744 (62.0%) of whom were women. The mean age was 63.3 years (SD: 11.6). Table 1 details the general characteristics of all patients. Men were significantly older and had a higher incidence of colorectal, digestive and laryngeal cancers, while breast cancer was significantly more common in women.

Table 1: General characteristics.

	Male (n=456)	**Female (n=744)**	***p***
Age, years (mean±SD)	65.4 ± 11.1	60.0 ± 11.4	<0.0001
Neoplasm Location n (%)			
Breast	2 (0.4%)	339 (45.6%)	<0.0001
Lung	60 (13.2%)	58 (7.8%)	0.0025
Colorectal	185 (40.6%)	171 (23.0%)	<0.0001
Digestive	118 (25.9%)	73 (9.8%)	<0.0001
Genitourinary	40 (8.8%)	67 (9.0%)	0.8904
Larynx	14 (3.1%)	4 (0.5%)	0.0005
Haematological	16 (3.5%)	12 (1.6%)	0.0347
Others	21 (4.6%)	13 (2.7%)	0.0760

SD: Standard Deviation

Of 2400 CVs scanned with ultrasound, in 30 occasions (2.5%) the CV was not visualized on either side, in 17 (1.4%) the right CV (RCV) was not found, and in 78 (6.5%) the LCV was not found. Excluding absent CVs, the mean diameter of CVs was 3.8 mm (SD: 0.5) and the mean depth was 13.6 mm (SD: 2.9). Table 2 shows the distributions of the CVs, comparing the findings between the two sides. The mean CV diameter and depth were similar on both sides. Although not reaching statistical significance, the number of CVs ≥ 3.0 mm was higher on the left side. Ninety-one (4.1%) stenosis at the CV/AV junction were observed, which were significantly more frequent in the LCVs. Tortuosity was found in 32 CVs (1.4%), all of them in CVs with diameters < 3.0 mm, with LCVs being the most significantly affected. AV thrombosis was found on 22 occasions (1.0%). Significant differences were not found between sexes for AV occlusion. Additionally, during the 2057 dissections of CVs ≥ 3.0 mm, 45 (2.2%) venous spasms occurred, 16 (2.0%) in RCVs and 29 (2.3%) in LCVs. The median ultrasound scan time per vein was 2.2 ± 1.1 minutes.

Table 2: CV distribution on both sides, except for CVs absent.

	RCV (n=1153)	LCV (n=1092)	*p*
Diameter (mm) (mean±SD)	3.7 ± 0.5	3.9 ± 0.5	0.0025
Depth (mm) (mean±SD)	13.9 ± 3.0	13.4 ± 2.7	0.0035
Diameter ≥3.0mm n (%)	1016 (88.1%)	1041 (95.3%)	0.0152
Crossing stenosis CV/AV n (%)	26 (2.3%)	65 (6 .0%)	<0.0001
Tortuosity n (%)	8 (0.7%)	24 (2.2%)	0.0021
AV Occlusion n (%)	8 (0.7%)	14 (1.3%)	0.3320

SD: Standard Deviation - RCV: Reigh Cephalic Vein – LCV: Left Cephalic Vein – AV: Axilar Vein

The Wilcoxon signed-rank test for related samples showed differences between the diameter and depth distributions of the CVs assessed (Figure 2). Although the median diameters of the RCVs and LCVs were similar (3.8 mm), as was the third quartile (4.0 mm), differences between both sides were observed as the diameters were smaller in the RCVs than in the LCVs (Q1 3.5 mm versus Q1 3.7 mm). The median depth was significantly higher in the RCVs (Q1 13.9 mm vs. 13.4 mm).

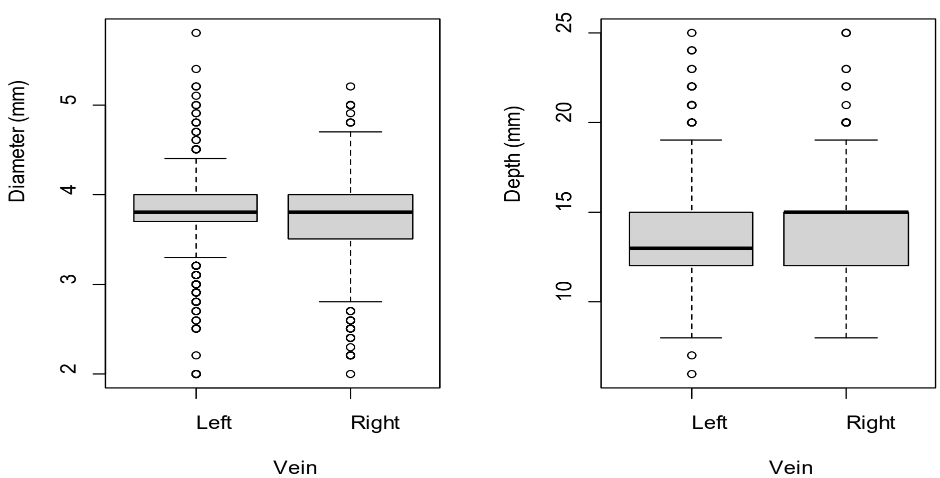

Figura 2: Box plot representation of CV diameter (mm) and depth (mm), comparing both sides.

Table 3 shows that CVR is absent in a higher percentage of women, being statistically significant. CVs diameter and depth on both sides were significantly greater in men. When comparing between sexes, by side of vein, no significant differences were found in the other variables

Table 3: CV distribution on both sides and sexes, except for CVs absent.

	Male (n=456)	**Female (n=744)**	***p***
RCV			
Absent (n) (%)	8 (1.8%)	39 (5.2%)	0.0025
Diameter (mm) (mean ± SD)	3.8 ± 0.5	3.7 ± 0.5	0.0002
Depth (mm) (mean ± SD)	14.4 ± 2.8	13.5 ± 3.0	<0.0001
Diameter ≥3mm n (%)	410 (89.9%)	634 (85.2%)	0.3688
CV/AV Crossing stenosis n (%)	11 (2.4%)	15 (2.0%)	0.7149
Tortuosity n (%)	3 (0.7%)	5 (0.7%)	1
AV occlusion n (%)	5 (1.1%)	4 (0.5%)	0.3218
LCV			
Absent	46 (10.1%)	62 (8.3%)	0.3026
Diameter (mm) (mean ± SD)	3.9 ± 0.5	3.8 ± 0.5	0.0005
Depth (mm) (mean ± SD)	14.0 ± 3.1	13.0 ± 2.8	<0.0001
Diameter ≥3.0mm n (%)	383 (84.0%)	630 (84.7%)	0.5209
CV/AV Crossing stenosis n (%)	22 (4.8%)	43 (5.8%)	0.5253
Tortuosity n (%)	10 (2.2%)	14 (1.9%)	0.6733
AV Occlusion n (%)	4 (0.9%)	9 (1.2%)	0.7764

SD: Standard Deviation; RCV: Reigh Cephalic Vein; LCV: Left Cephalic Vein; AV: Axilar Vein

In Figure 3 shows the same results: the median CVs diameter was significantly higher in men (3.9 mm [IQR: 3.7 mm - 4.1 mm]) versus women (3.8 mm [IQR: 3.6 mm - 4.0 mm]) as was the depth: 15 mm (IQR: 12mm – 16mm) in men versus 13 mm in women (IQR: 11 mm – 15 mm).

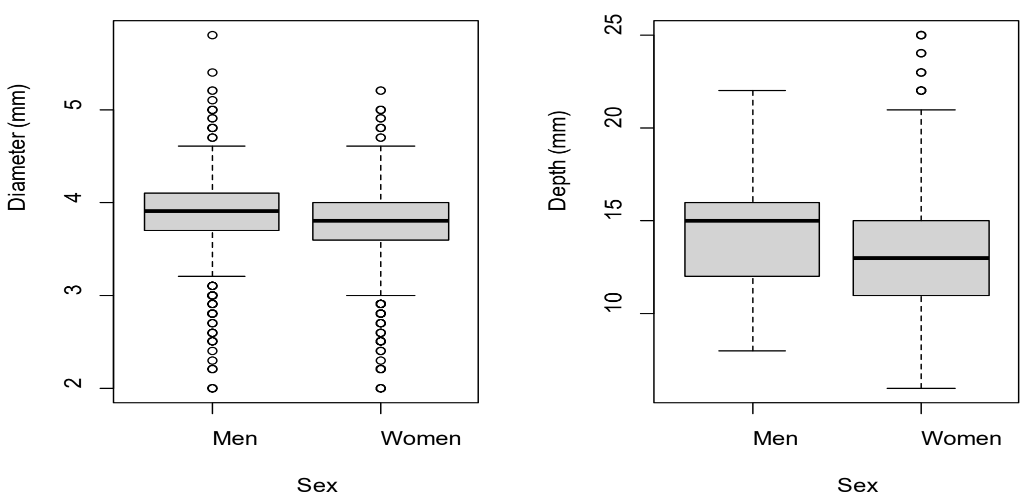

Figure 3: Box plot representation of CV diameter (mm) and depth (mm), comparing both sexes.

Discussion

The motivation for this study stems from my experience as a vascular surgeon trained in the last quarter of the 20th century, during which pacemaker implantation was taught and performed mainly via CVC and, although new approaches for pacemaker and TIVAP placement have emerged, for several authors it remains an effective and safe option [11,12]. Similarly, the decision to implant the TIVAP by CVC via the LCV as the first choice is based on three important facts: the curve traced by the catheter through this route is smaller than on the right side, not puncturing the subclavian vein as it passes through the costoclavicular space avoids possible pinch-off syndrome, and that since most of the population is right-handed, shoulder joint movement is more frequent on the right side [13]. Several methods for assessing the CV absence in the DG are reported in the literature. In autopsy studies, the percentages range between 3.3% and 14.0% [4,3] except Au [14], which found a CV in all 157 DG explored. When intraoperative venography was performed, CV absence was noted in 12.0% of cases [4]. During DG dissection in the surgical field, values range from 2.5% to 15.0% [15]. Finally, when preoperative ultrasound is used, the prevalence ranges between 5.9% and 14.3% [16,17]. In the present study, it is 6.5%.

Evidence [18,19] has shown that the mean CV diameter with ultrasound in the DG ranges between 3.1 mm and 4.6 mm, although Loukas [3] observed a mean diameter of 8.0 mm in his study on cadavers. Only Taleski [20] reported that CV diameter was statistically greater in women than in men. In the present study, as in most studies, CV diameter is higher in men (3.9 mm vs 3.8 mm). In relation to the mean CV depth at this level, the values range from 10.2 mm to 23.6 mm [15,21], not differentiating between men and women. However, as with the diameter, the present study also shows that the CV depth is higher in men (14.3 mm vs. 13.2 mm). The main factor influencing the success of the TIVAP implantation via CVC is CV diameter. Although values vary, most authors agree that a CV is small when it is < 3.0 mm [20-22], as in this study. This is because the catheters used are 9.6 F (approximately 3.0/3.2 mm external diameter). In the present study, 91.6% of all CVs were ≥ 3.0 mm.

Another factor to consider is the stenosis at the confluence of the CV and AV, which in the literature is reported in 3.5% to 7.5% of cases [20,23]. In this study it was found in 4.1% of cases and was more common in LCVs. Venous spasms during CV dissection have a prevalence ranging from 0.2% to 7.5% [24,25]; in this study, it was 2.2%. The diameter of the CV is directly related to success rates. CVC approach without using preoperative ultrasound has a success rate between 75.6% and 93.7% [26,27]. However, with its use Otsubo achieved a 97.2% success rate [15]. In this study, the success rate in CVs ≥ 3.0 mm increased to 98.7%. On the other hand, the success rates of SVP without intraoperative ultrasound range between 79.5% and 99.0% [28,29], while with its use, they increase up to 95.0% and 100.0% [30-32]. No literature has been found regarding CV tortuosity in the DG, nor for idiopathic AV occlusion. Finally, it is essential to acknowledge the limitations of this study, as it is observational, single-center, and conducted by a single operator. However, the objective was to provide information about the CV anatomy in the DG, prior to TIVAP implantation via CVC in order to improve its success rate.

Conclusion

Preoperative Doppler ultrasound of the CV in the DG is a very useful diagnostic method to determine its anatomical characteristics and possible anomalies. Both CV diameter and depth were greater in men. LCVs had a higher incidence of CV/AV junction stenosis and tortuosity than RCVs.

Declaration of conflicting interests

The author declare that they have no competing interests

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