Relato de Caso

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Ultrasound Guided Venous Catheterization: A Case Report and Literature Review

Cateterización Venosa Guiada por Ultrasonido: Relato de Caso y Revisión de Literatura

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SUMMARY

The central venous catheterization (CVC) is a procedure often performed in a hospital environment, but it has complications such as damage to structures adjacent to the vessel, bleeding and pneumothorax. This case report aims to illustrate the importance of ultrasound, helping guided central venous puncture at the bedside, which facilitates the decision about which vessel is in a better condition for the puncture, thus making the procedure technically more precise and particularly more safe for the patient. After that, a review of the literature will be done, with the current state of ultrasound guided CVC, focusing on technical and practical aspects for its implementation.

Descriptors: Central Venous Catheterization; Ultrasonography; Jugular Veins, Thrombosis

RESUMEN

El cateterización venosa central (CVC) es un procedimiento realizado frecuentemente en ambiente hospitalario, sin embargo, no está exento de complicaciones como lesión de estructuras adyacentes al vaso, sangramiento y neumotórax. Este relato de caso tiene el objetivo de ilustrar la importancia del Ultrasonido (US), auxiliando la punción venosa central al borde del lecho, lo que facilita la toma de decisión sobre cuál es el vaso en mejores condiciones para la punción, tornando así el procedimiento técnicamente más preciso y principalmente, más seguro para el paciente. Después será hecha una revisión de la literatura mundial, con estado actual de la CVC, guiada por US, enfocando aspectos técnicos y prácticos para su realización.

Descriptores: Cateterismo Venoso Central, Ultrasonografía, Venas Yugulares, Trombosis

CASE REPORT

Female patient, 56 years old, suffering from breast malignancy, admitted to the ward 10 days before, under chemotherapy. Patient evolved with fever, respiratory distress, and hemodynamic instability. Laboratory tests showed granulocytopenia (WBC = 809 / μL) and thrombocytopenia (platelets = 52.000 / μL). Still on the ward, attempt was made to catheterization of left internal jugular vein without success.

Due to the high risk of bleeding and the patient's clinical picture, she was referred immediately to the Intensive Care Unit (ICU).

On admission, the patient presented agitated, dyspneic, pale, and with profuse sweating. Blood pressure was 80 x 55 mmHg and heart rate was 114 beats per minute. She was immediately intubated and put on mechanical ventilation.

Due to the need of central venous access, in thrombocytopenic patient with previous unsuccessful attempt to puncture the

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left internal jugular vein, we opted for ultrasound-guided catheterization of the internal jugular vein.

After viewing by ultrasound the internal jugular vein and verifying its patency, the puncture procedure was performed, passing the guide and introducing the double-lumen catheter under ultrasound viewing, uneventful (Figures 1 and 2). It was also possible to verify the presence of thrombosis in the left internal jugular vein, and this being the reason why the blind puncture was not successful (Figure 3).

Figure 1: *Cross-sectional view of the catheter inside the internal jugular vein.*

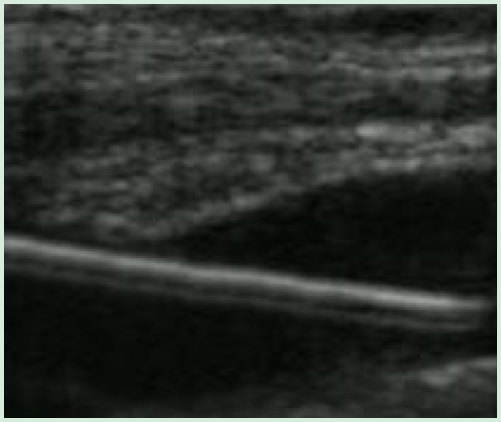

Figure 2: *Longitudinal view of the catheter inside the internal jugular vein.*

LITERATURE REVIEW

Central venous catheterization (CVC) is a procedure often performed in a hospital setting. The conventional technique takes into account as reference the anatomical structures adjacent to the vein. This procedure, however, is not free of risks, reaching rates of mechanical complications close to twenty percent[1].

Figure 3: *Thrombosis of the left internal jugular vein.*

The most common mechanical complication is arterial puncture, regardless of the puncture site. Other frequent complications are the following: hematoma, pneumothorax, and hemothorax. Some of these complications can be attributed to the characteristics of higher risk related to the profile of the patient, as is the case in morbid obesity, patients with chest deformities, hypovolemic patients, coagulopathies, or mechanical ventilation. However, a large number of failures occur due to anatomical variation of veins and the adjacent structures, as shown in Figure 4, which shows the variability of the relationship between the internal jugular vein and the carotid artery. Furthermore, the relationship between the artery and vein has a dynamic nature, i.e. when the neck is subjected to rotation the overlap of vessels can occur, increasing the risk of accidental arterial puncture[2].

Historically, ultrasound (US) has been used in order to decrease complications related to CVC, since the decade of 1970[4], when its use was initiated by anesthesiologists. As the use of US reduces the number of attempts of puncture, it has also been attributed to, in addition to decreasing the mechanical complications, the reduction of occurrence of infections [5] and thrombosis [6-7] related to catheters.

Karakitsos et al [8] studied 900 patients, where 450 underwent real-time US-guided CVC of the internal jugular vein,

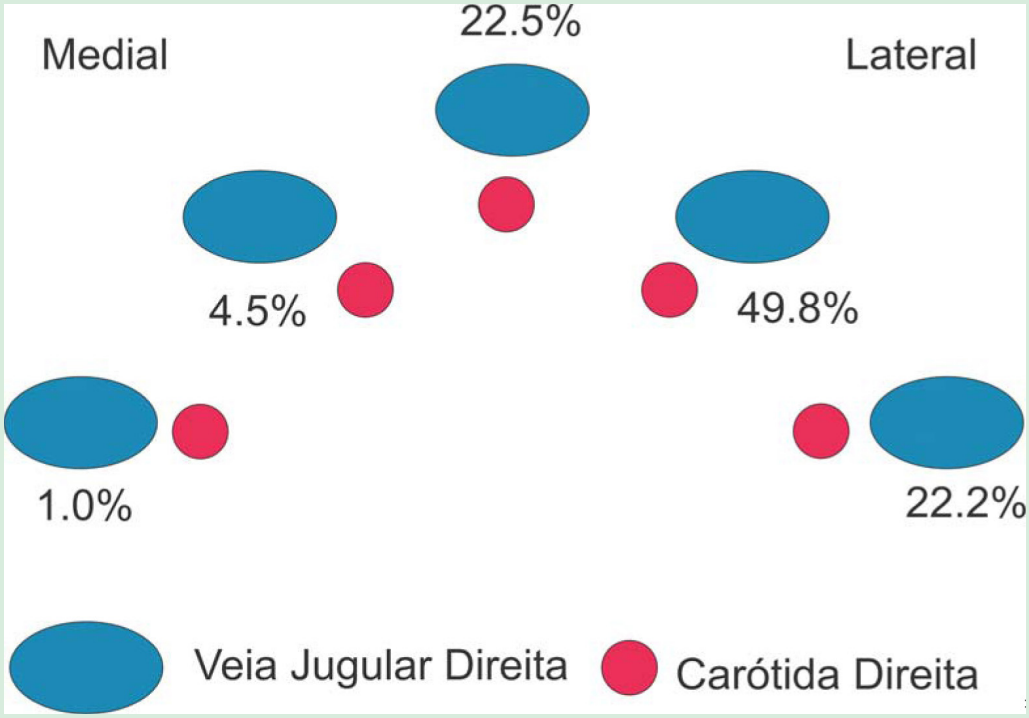

Figure 4: *Varying relationship between the jugular vein and the carotid artery. Adapted from J Vasc Interv Radiol*[3].

and 450 had the internal jugular vein cannulated by the conventional technique. The success rate was 100% in the group of US-guided CVC and 94.4% in the group with the conventional technique ($p < 0.001$). The rate of complications such as accidental puncture of the carotid artery, hemothorax, pneumothorax, and hematoma, as well as the total procedure duration and the occurrence of bloodstream infection associated with catheter, was significantly lower in the group that underwent US-guided CVC.

Three meta-analyzes have been published on this topic, addressing different vascular accesses in adult and pediatric patients[9-11].

In 2001, the U.S. Agency for Research and Health Quality elected the US-guided CVC as one of the eleven procedures that increase the safety of patients[12]. In the following year, the British National Institute for Clinical Excellence published a similar recommendation[13].

In 2011, it was published in the *Journal of American Society of Echocardiography,* the first Guideline of US-Guided Vascular Catheterization[14], approaching CVC, peripheral venous catheterization, and arterial catheterization.

In 2012 were published the International Evidence-Based Recommendations on Ultrasound-Guided Vascular Access by the International Committee on Ultrasound Vascular Access[15], and more recently the Guidelines on Central Venous Access of the American Society of Anesthesiology[16].

METHODS

A literature search was performed on PubMed for the year 1978-2012 by using the following terms: *ultrasound, vascular access,* and *central venous access*. A total of 362 articles were found, including three meta-analyzes, two guidelines on US-guided vascular catheterization, and a guideline on venous access, previously mentioned. In the guidelines, the axillary vein catheterization was evaluated together with subclavian vein catheterization.

TECHNIQUE

The transducer chosen for this procedure is a linear, high frequency transducer (Figure 5), since the vascular structures are typically shallow. Some services also use the microconvex transducer (Figure 6) for this purpose.

The insonation of the vessel to be punctured, prior to catheterization, is essential to the analysis of its diameter, its precise location, and its patency.

The differentiation between artery and vein can be performed with two-dimensional ultrasound by compression or using Doppler (spectral or color), the latter did not show superiority over the first[17].

Figure 5: *Linear transducer.*

Figure 7: *Use of sterile apron and guides.*

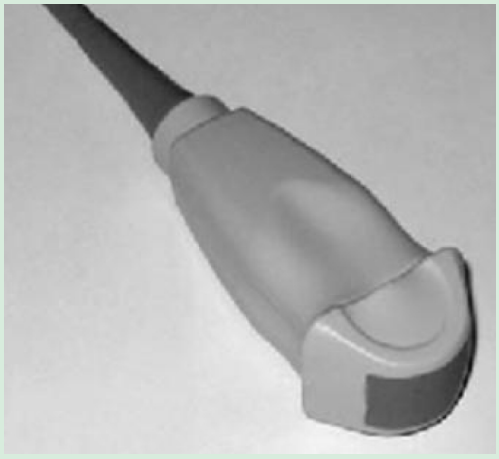

Figure 6: *Microconvex transducer.*

The procedure can be performed by two techniques: the static and dynamic techniques. In the static technique, after the ultrasound examination of the vessel, a skin marking is done and the vessel is then catheterized. In dynamic technique, the echographic approach is in real-time and the whole procedure is accompanied by the use of US, observing the aseptic precautions (Figure 7) with the use of sterile sheath and gel.

The dynamic technique can be performed in three views. The transverse or short-axis approach is the one that has the advantage of shorter learning curve and allows visualization of structures adjacent to the target vessel, but has the disadvantage of greater risk of injury of the posterior wall of the vessel (Figure 8). The longitudinal or long-axis approach requires greater dexterity, but allows wide visualization of the vessel, guide-wire, and catheter, being the most recommended for the evaluation of the latter two (Figure 9)[18]. More recently, a third approach, the oblique, has been performed as an intermediate alternative to the previous two (Figure 10)[19].

CVC can be performed by one or two operators. When performed by one operator, the needle is manipulated by the dominant hand and the transducer by the non-dominant one. The path of the needle must be monitored at all times, and once the vein is punctured, the transducer is left on the side and the guide-wire passed. This should then be visualized by the US, which checks its proper location. The catheter is then positioned and the US is again used to check its location in the lumen of the vein.

When the procedure is performed by two operators, the second operator remains holding the transducer and may assist in passing the first guide-wire.

Regarding the positioning of the device during the procedure, it is important that the US display to be aligned with the US transducer (Figure 11). With regard to patient positioning, Trendelenburg position facilitates the jugular and subclavian venous catheterization, and reverse Trendelenburg position facilitates femoral venous catheterization. The Valsalva maneuver can be used to temporarily increase the venous diameter.

During the procedure, the needle is inserted at 45 degrees angle, noting that the distance from the needle to the transducer is equal to the depth from the transducer to the vessel (Figure 12).

Currently, it has been studied the use of 3D ultrasound for CVC, but the size of the transducers and equipment costs have limited their use[21].

TRAINING

Doctors of various specialties can acquire the ability to perform the US-guided CVC[22]. This training includes the basic

Figure 8: *Cross-sectional position of the internal jugular vein (IJV).*

Figure 9: *Longitudinal position of the internal jugular vein (IJV).*

Figure 10: *Oblique position of the internal jugular vein (IJV).*

learning for using US equipment, increasingly portable and affordable, the acquisition and interpretation of images, with a focus on practical training. This training is generally performed with the use of known training dummies as *Phantoms* (Figure 13) or live animal models. According to the Guidelines of the American Society of Echocardiography and Cardiovascular Anesthesiologists, were considered trained those who performed ten supervised procedures and demonstrated competence to perform them independently.

SUMMARY OF CURRENT RECOMMENDATIONS

The vast majority of studies evaluated the internal jugular vein catheterization[23-32], but more recently, the accesses to subclavian and femoral veins have been studied[33-37], initially focusing on adults and subsequently on children. Short-term, tunneled, and fully implanted accesses were analyzed.

According to the Guidelines of the American Society of Echocardiography and Cardiovascular Anesthesiologists, recommendations have been established for CVC in three main puncture sites for adults and children.

The recommendation for adults is preferably for internal jugular vein catheterization and US should be used whenever possible by physicians trained on dynamic technique, i.e. in real time, or, if not possible, at least US should be used for marking the skin[14].

In subclavian vein catheterization it is recommended the use of US in patients at high risk of complications, in order to assess its location and patency. For femoral vein, US can be used to evaluate, in addition to its patency, the overlap of the artery and vein.

In pediatrics, this Guideline recommends the routine use of US for catheterization of the internal jugular vein and femoral vein in order to decrease complications, particularly those related to the insertion of large catheters. No mention is made on subclavian vein access[14].

In February 2012, the International Committee of Ultrasound Vascular Access published its recommendations and concluded that, in light of current evidence, the vascular catheterizations must be guided by US due to the efficacy and safety provided to the procedure.

In the case of children and neonates, US-guided access leads to a decreased failure rate, faster access, reduced mechanical complications, but the learning curve is higher than for adults, and the routine use of US is strongly recommended in the pediatric group for venous access in short and long term. The internal jugular vein must be the first choice of vessel and the use of US should be considered at least for the pre-procedure.

Figure 11: *Proper pre-procedure alignment.*

There are also recommendations for US-guided puncture of the subclavian vein and femoral vein. For adults the benefits of ultrasound in CVC occur both when it is used previously to the procedure for marking the puncture site and during the same in real time. As in the pediatric group, its routine use is recommended for guiding venous catheterization for catheters of short and long term use.

For both the adult and pediatric group, the US performed after the procedure can detect possible complications such as pneumothorax, cardiac tamponade, and hemothorax[15].

Finally, the task force on Central Venous Access of the American Society of Anesthesiologists recommends using the US with the static method for elective situations in pre-catheterization of the internal jugular vein, and it can be used for cannulation of the subclavian and femoral veins, as well as also recommends the real-time US (dynamic method), noting that the use of the latter may not be possible in emergency situations[16].

CONCLUSIONS

Central venous catheterization guided by US has demonstrated, over time, its superiority over the traditional technique, both

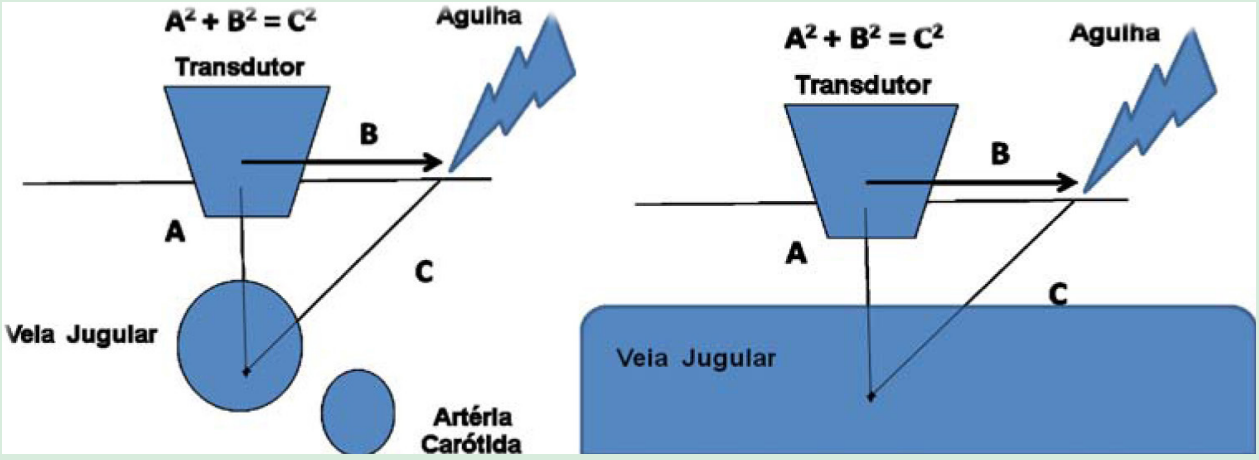

Figure 12: *Positioning and insertion of needle in transverse axis and in longitudinal axis[20].*

Figure 13: *Two types of Phantoms and their image by US. Authorized by www.bluephantom.com.*

by its efficacy and safety and thus accumulating scientific evidence already approached in meta-analyzes, guidelines, and recommendations of various International Societies.

The technique of US-guided CVC is attractive because it has fast learning curve and can qualify physicians of various specialties for its use.

To date, the catheterization of internal jugular vein is the one with more evidence in the literature, but also includes recommendations for catheterization of the subclavian vein and femoral vein.

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