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REVIEW ARTICLE

Malpositioning of Long-Staying Central Venous Catheters in the Pediatric Population: Incidence and Potential Complications. A Single-Center Retrospective Study and a Narrative Review of the Literature.

Niki Kouna, Consultant Anesthesiologist, 2nd Department of Anesthesiology Attiko University Hospital, Athens Greece
George Noutsos, Consultant Anesthesiologist, Pediatric Hospital of Athens, Agia Sophia, Athens Greece
Christina Koufopoulou, Department of Anesthesiology, Areteio Hospital, Medical School, National and Kapodistrian, University of Athens Hospital, Athens, Greece MD, Resident Physician Anaesthesiologist
***Dimitrios Panagopoulos**, Consultant Neurosurgeon, Pediatric Hospital of Athens, Agia Sophia, Athens Greece. Email: dimpanayop@gmail.com
Antonis Kattamis, Professor of Pediatric Oncology, First Department of Pediatrics, University Pediatric Hospital of Athens, Agia Sophia, Athens Greece

ABSTRACT
Central Venous Catheters insertion is a very common procedure performed at the operation room and the Intensive Care Unit. In the paediatric population they are frequently used to administer fluids, blood products, resuscitation drugs, parenteral nutrition and chemotherapy. One of the reported complications, though a less commonly described one, is the inappropriate position of the tip of the CVC in a vessel other than the superior vena cava.
In this study, we initially present the anatomy of the superior vena cava system and that of the internal jugular vein, the optimal catheter tip position as well as the possible suboptimal catheter tip locations. Subsequently, paediatric chest X-rays of our hospital with catheter tip malpositioning are illustrated, after internal jugular vein catheterization. Following, we discuss possible mechanisms of central venous catheters malpositioning, signs and symptoms which could help us identify a wrong placement and also how to prevent as well as how to fix one. Finally, an interrelation between malpositioning, malfunction and the existence of infection or thrombosis is investigated.
Our study concluded that the right internal jugular vein should be the first choice in all cases of vessel implantation, mainly based on our statistical analysis results, which suggested that this vessel was associated with the least possibility of erroneous catheter placement. Another important clue of our study is based on the fact that the inappropriate positioning of a central venous catheter over the long term could be a significant predisposing factor of malfunction, along with infection and thrombosis.
Keywords: internal jugular vein, central venous catheter, malposition

Abbreviations
CVC: central venous catheter
SVC: superior vena cava
PLSVC: Persistent left superior vena cava

Introduction

The insertion of a central venous line represents one of the most common invasive or surgical procedures that are performed on a regular basis. More precisely, based on evidence that are derived from USA databases, it is estimated that more than 5 million of central venous catheters are inserted on an annual basis. Even though it is generally considered as a relatively simple and safe medical practice, as a general rule the insertion of such catheters in pediatric patients is technically more demanding, relative to their adult counterparts. This should be attributed to the smaller internal diameter of the relevant vessels in the pediatric population, which necessitates a greater degree of accuracy regarding the positioning of the tip of the central catheter.

When the relevant indications for the insertion of such catheters are considered, the most common include the administration of parenteral nutrition, blood and plasma, as well as chemotherapeutic regimens, antibiotics and vasoconstrictive medication[1]. The time period of their usage is widely variable, as they can be utilized from a period of several days till a lot of years. This is largely dependent on the underlying pathology of the patients, as well as on the overall clinical course of the offending individuals.

A wide spectrum of complications can be related with them, and they are arbitrarily divided as intra-operative and post-operative ones. The most commonly encountered complications that are intimately related with the insertion of central venous catheters in the neck and chest region include infection (5-26%), local hematoma (2-26%), pneumothorax (till 30%) and, to a lesser degree of frequency, hemothorax, hemopericardium and malposition of the catheter[2,3]. The relative frequency of the complications is intimately related with factors that are attributed to the patient (anatomical variations, tumors in the vicinity of the central catheter), the relevant experience of the interventional physician, the vessel that is going to be catheterized, along with the insertion technique[3]. Among the available vessels for catheterization, the internal cerebral vein is the most commonly selected vessel. This is mainly based on the fact that the catheterization of that vessel is associated with the minimum percentage of relevant complications, as well as its relevant anatomical location in the neck is predicable in the majority of cases. The latter is the main factor that is responsible for the high percentage of effective catheterization (90-99%)[4].

Estimated locations of the tip of the central catheter

The expected locations of the tip of the central venous catheter are various and are briefly reported below:

1. ***Ipsilateral subclavian vein***

There are several reports that mention that the central catheter tip follows a course that passes through the internal jugular vein and terminates into the relevant subclavian vein[5,6]. Nevertheless, the opposite route is more commonly encountered, that is a catheter that is initially inserted through the subclavian vein, terminating into the ipsilateral internal jugular vein. This constitutes approximately 60-70% of cases of erroneous catheter insertion via the subclavian vein route[7].

2. ***Contralateral internal jugular vein***

An uncommon route of a central venous catheter consists of being inserted from one internal jugular vein and terminating into the contralateral relevant vessel. An antero-posterior chest X-ray depicts a characteristic view that resembles a 'necklace'[8].

3. ***Left Pericardiophrenic vein***

It is located in line with the left side of the pericardium and it terminates to the left brachiocephalic vein, in the vicinity of the termination of the internal jugular vein. It is located on the left side when an anteroposterior chest x-ray is performed, whereas its relative position is at the middle portion of the mediastinum whenever a lateral chest x-ray is evaluated[9].

4. ***Azygos vein***

The insertion of the central catheter tip into the azygos vein is mainly encountered in cases of catheterization of the left jugular vein and it varies between 0.7-1.2%[10]. It occurs more frequently in cases of venous outflow congestion, such as in cases of cardiac failure[11], whereas it may be multiplicated with variations regarding its eruption, course, anastomotic network and termination.

5. ***Right and left internal mammary veins***

Both of them terminate into the relevant brachiocephalic vein. The tip of a central venous catheter can be located within one of the two relevant mammary veins, mainly in cases where an obstruction of the superior or inferior vena cava coexists. It is difficult to distinguish, based on an antero-posterior chest x-ray, whether the tip of the catheter is located within the right internal mammary vein, as it is projected on the superior vena cava. When this is the case, it is mandatory to perform a lateral chest x-ray, which depicts the tip of the catheter in the region of the anterior mediastinum[12].

6. ***Left superior intercostal/accessory hemiazygos vein***

The accessory hemiazygos vein drains the blood that is collected from the left intercostal veins, whereas the left superior intercostal vein collects the blood from the region of the superior left-posterior hemithorax. Both of them are components of the azygos-hemiazygos venous system. In case that one

central catheter is inserted via the route of the left internal jugular vein and terminates to one of these two veins, then a antero-posterior chest x-ray is going to imagine this tip to a left-lateral position. Apart from that, a lateral chest x-ray would imagine the tip of the catheter to the upper part of the posterior mediastinum. This ending of the catheter tip is frequently associated with obstruction of the left brachiocephalic vein[12].

7. Persistent left superior vena cava

This particular vein (PLSVC) represents the more commonly encountered anatomical variation regarding the venous complex of the superior vena cava. In certain cases, this may be responsible for the existence of a right to left shunt. Its prevalence is estimated in the range of 0.3-0.5%, when the general population is considered. On the contrary, when its occurrence is investigated in a subpopulation of patients with congenital cardiac defects, it ranges between 2.1-5%[6,13].

Purpose

The aim of our study is the investigation of the different potential end points of a long-staying central venous catheter (i.e., Hickman catheter) in a pediatric population, along with the recording of all the relevant potential complications. In our survey, the central vein that was selected for catheterization was the internal jugular vein (right or left). A systematic overview of the x-rays of the pediatric patients was performed, and all cases of inadvertent catheter position were recorded. For each relevant case, an antero-posterior chest x-ray was performed, in accordance with the patient's medical history and its general medical condition. Moreover, all other associated medical complications were recorded, and the implicated pathogenetic mechanisms are stated. Finally, the existing prevention methods as well as the mechanisms that could be recruited in order to correct an erroneous placement of the central catheter are discussed in detail. In this context, the potential correlation between an inappropriate positioning (mal positioning) of the tip of the central venous catheter and the occurrence of infection or thrombosis is investigated.

Materials and Methods

We analyze the results of a retrospective study, which is based upon the chest X-rays of children aged from 1 day to 14 years old, ASA III-IV. All of them have undergone a scheduled insertion of a central venous catheter (resembling Hickman catheter), either via a transdermal route or via an operative approach, which was intended to be long-staying. The selected vein for insertion of the catheter was the internal jugular vein and the whole procedure was performed under general anesthesia. The observation period extends between 10/10/2017 and 30/6/2021.

Regarding the demographic characteristics of the patients, we recorded the following parameters: age, body weight, offending pathology and the underlying etiology for insertion of the central catheter. We analyzed all the relevant chest X-rays and we recorded the following information for our database:

• Lateralization of the site of catheterization (left or right internal jugular vein).

• Final position of the tip of the catheter

Moreover, we recorded the cases that appeared malfunction of the catheter, along with other potential complications, such as pneumothorax, hemothorax, arterial puncture and hemopericardium. Under the term 'malfunction' we include all cases that shared in common the difficulty in administration of intravenous fluids, as well as the insufficient blood flow on suction. The latter could be recorded either immediately after catheter placement, while the patient is in the operating room, or at any time point thereafter. We utilized the data that were extracted from a previous relevant analysis of our department· this was referring to the mean duration of maintenance of a Hickman catheter, which was 5.46 $\pm$ 4.64 months (mean $\pm$ SD). The duration of that study was 2 years.

Based on that study, we hypothesized that a time interval of 3 months after the central catheter insertion was adequate in order to record all relevant complications. The final position of the tip of the catheter was verified via the aid of c-arm, before awakening of the patient. Additionally, we recorded all cases where immediate correction of an inappropriate catheter tip was established.

Results

Our study included 323 patients and 399 chest X-rays were analyzed. The demographic data of our participants are recorded at table 1 and at graphics 1,2,3 accordingly. The total number of patients with incorrect catheter placement was 38, which reflects a 9,52% of the total number of catheters that were inserted. These demographic data are depicted at table 1 and graph 1, regarding the gender of the participants. Table 2 and graph 2 depict the patient's relevant subdivision, based on their age distribution, whereas table 4 and graph 4 present their distribution based on the weight of the patients.

Table 1. Relevant demographic data, gender distribution

Gender	***n*** **(%)**
Male	223 (55.9)
Female	176 (44.1)
Total	399 (100)

Figure 1. Schematic representation of relevant demographic data, gender distribution

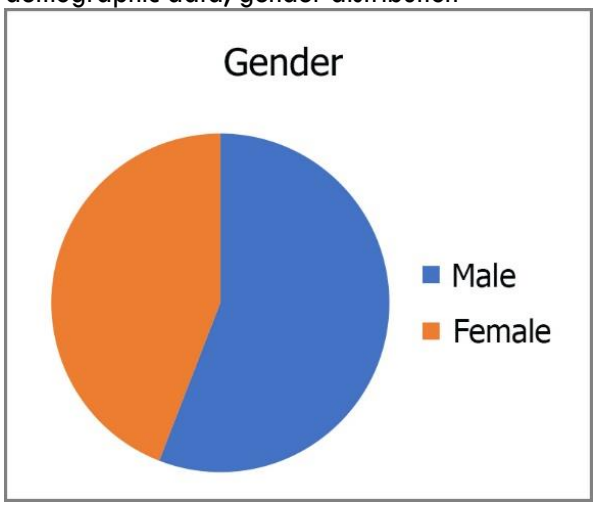


Table 2. Relevant demographic data, age distribution

Age (years)		
Mean		6,3101
Std. Error of Mean		0,26779
Median		4,8400
Mode		0,03
Std. Deviation		5,34920
Variance		28,614
Skewness		0,485
Std. Error of Skewness		0,122
Kurtosis		-1,197
Std. Error of Kurtosis		0,244
Sum		2517,71
Percentiles	25	1,4800
	50	4,8400
	75	11,2300

Figure 2. Schematic representation of relevant demographic data, age distribution

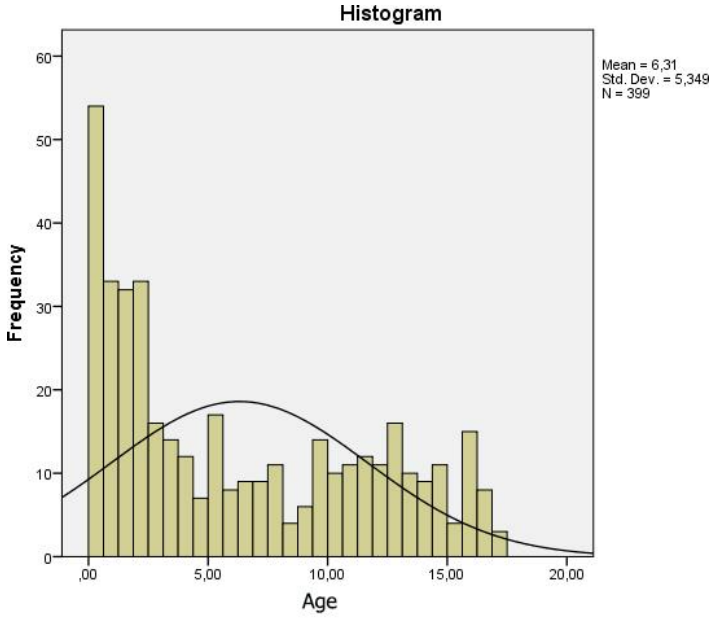
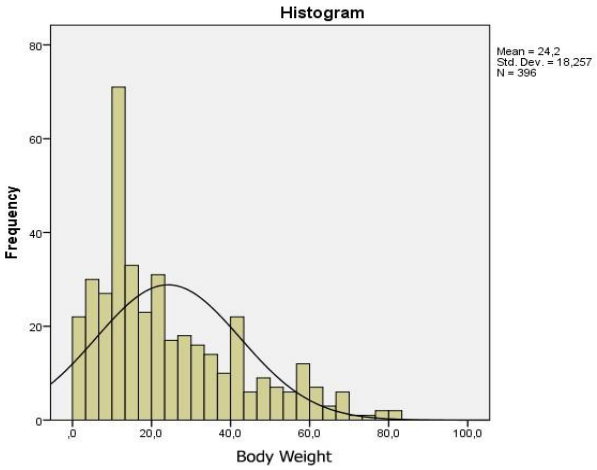


Table 3. Relevant demographic data, body weight

Weight (kg)		
Mean		24,196
Std. Error of Mean		0,9175
Median		18,000
Mode		12,0
Std. Deviation		18,2571
Variance		333,321
Skewness		0,979
Std. Error of Skewness		0,123
Kurtosis		0,135
Std. Error of Kurtosis		0,245
Sum		9581,6
Percentiles	25	10,500
	50	18,000
	75	35,750

Figure 3. Graphic illustration of relevant demographic data, body weight

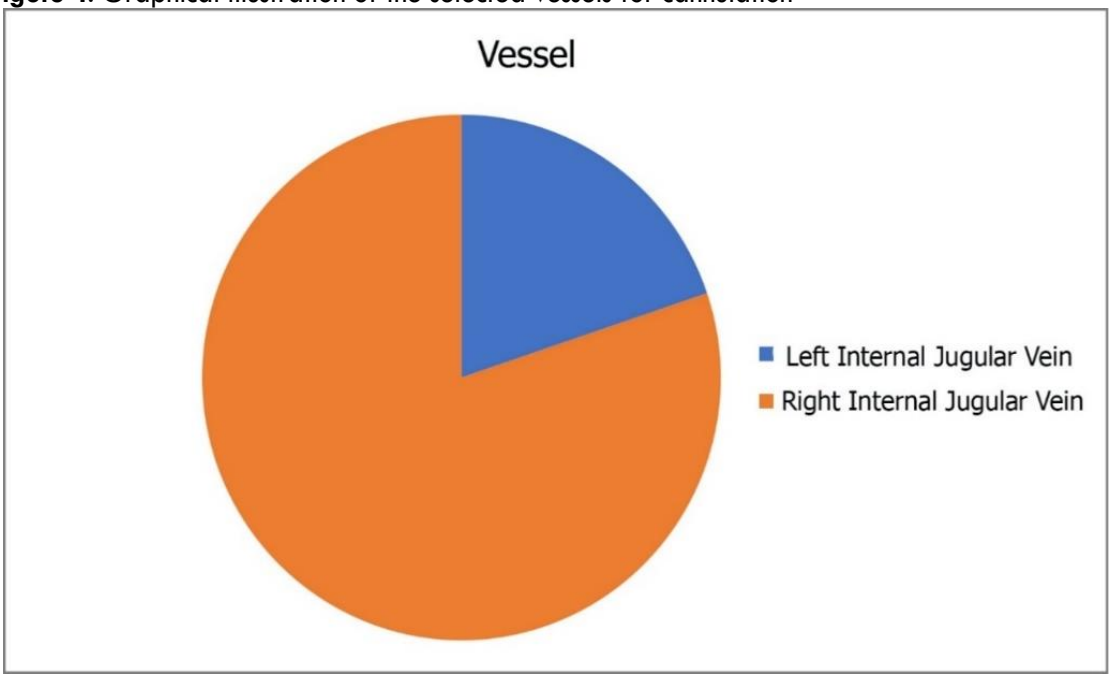


The right internal jugular vein was selected for catheterization in 80,2% of patients, as it is depicted on table 4 and figure 4. A total number of 38 catheters were erroneously inserted (mal-positioning) · among them, 23 were inserted via the right internal jugular vein and 15 via the route of the left internal jugular vein.

Table 4. Recording of the selected vessels for cannulation

Vessel	***n*** **(%)**
RIJV	320 (80.2)
LIJV	79 (19.8)
Total	399 (100)

Figure 4. Graphical illustration of the selected vessels for cannulation



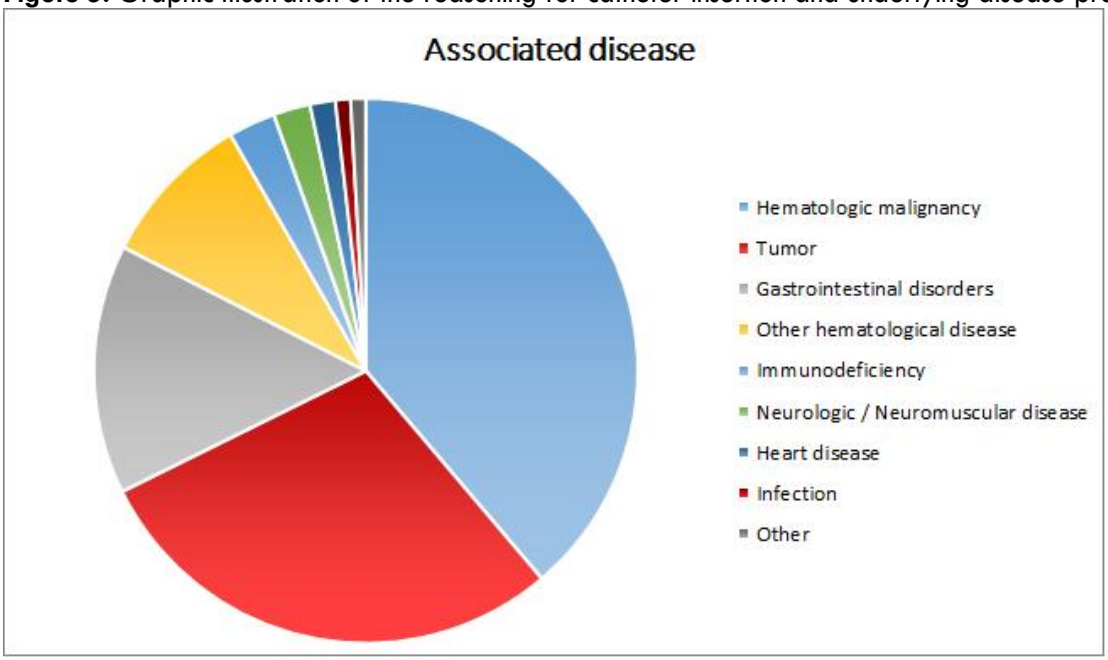
Regarding the underlying etiology of catheter insertion and the associated disease, all relevant data are recorded at table 5 and figure 5.

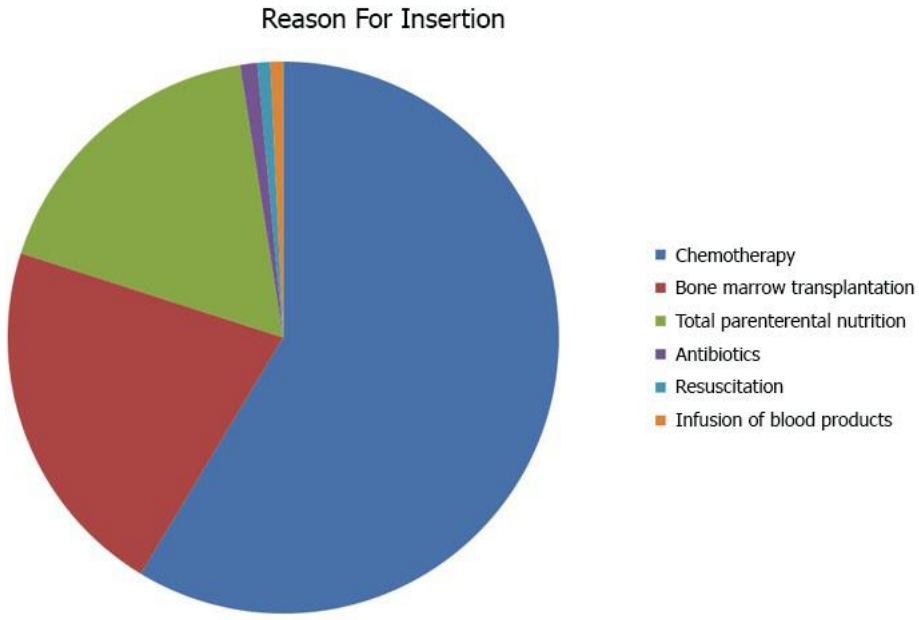
Table 5. Presentation of the reasoning for catheter insertion and underlying disease process

Reason for insertion	***n*** **(%)**
Chemotherapy	234 (58.6)
Bone marrow transplantation	85 (21.3)
Total parenteral nutrition	70 (17.5)
Antibiotics	4 (1.0)
Resuscitation	3 (0.8)
Infusion of blood products	3 (0.8)
Total	399 (100)

Associated disease	***n*** **(%)**
Hematologic malignancy	126 (38.8)
Tumor	94 (28.9)
Gastrointestinal disorders	48 (14.8)
Other hematological disease	30 (9.2)
Immunodeficiency	9 (2.8)
Neurologic / Neuromuscular disease	7 (2.2)
Heart disease	5 (1.5)
Infection	3 (0.9)
Other	3 (0.9)
Total	325 (100)

Figure 5. Graphic illustration of the reasoning for catheter insertion and underlying disease process.





The underlying table 6 and figure 6 summarize the techniques that were utilized for the insertion of the central venous catheters.

Table 6. Recording of the utilized techniques for insertion of central venous catheters

Technique	***n*** **(%)**
Percutaneous using landmarks	92 (23.1)
Percutaneous US-guided	125 (31.3)
Open surgical cut down	183 (45.6)
Total	399 (100)

Figure 6. Schematic illustration of the techniques adopted for the insertion of the catheters

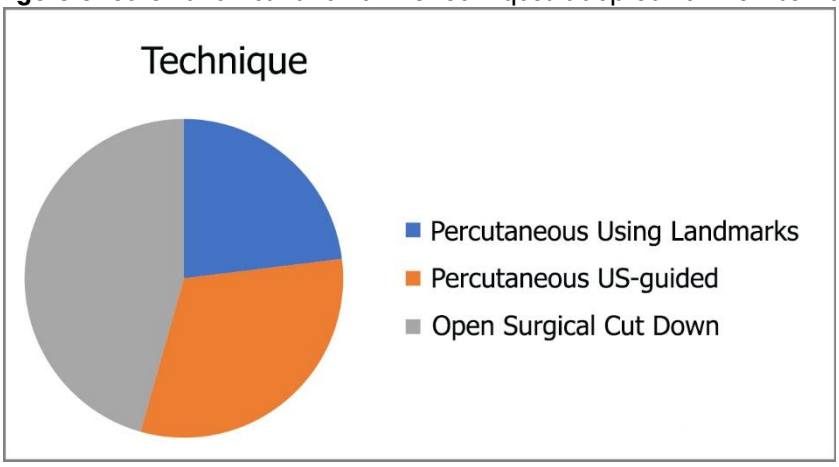


Table 7 and figure 7 illustrate the internal diameter of the selected central venous catheters, as shown at the relevant schemers.

Table 7. Recording of the internal diameter of the utilized central venous catheters

Internal diameter	***n*** **(%)**
4.20	54 (13.5)
6.60	101 (25.3)
7.0	122 (30.6)
7.60	1 (0.3)
9.00	68 (17.0)
9.60	51 (12.8)
10.00	2 (0.5)
Total	399 (100)

Figure 7. Graphic illustration of the internal diameter of the central venous catheters.

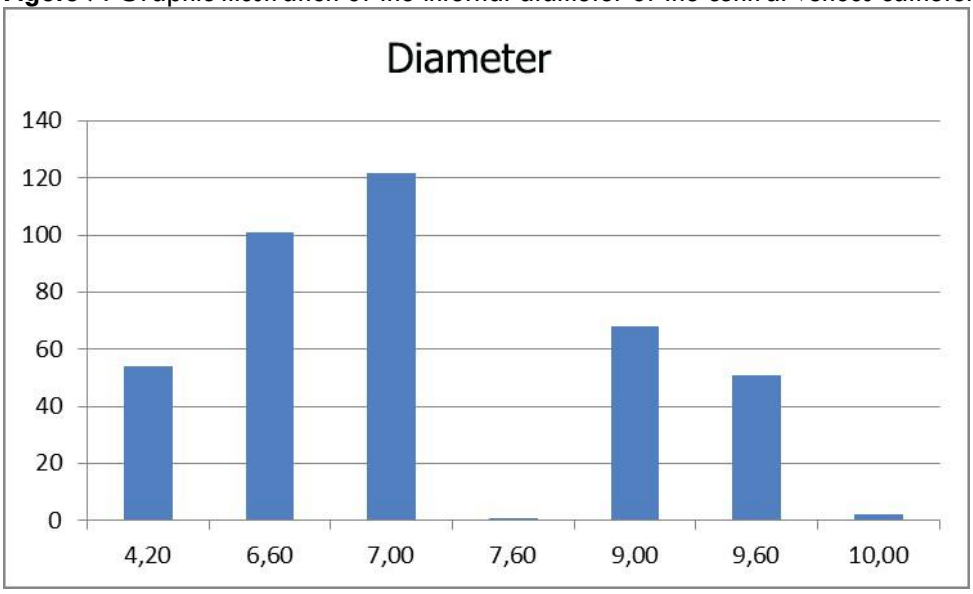


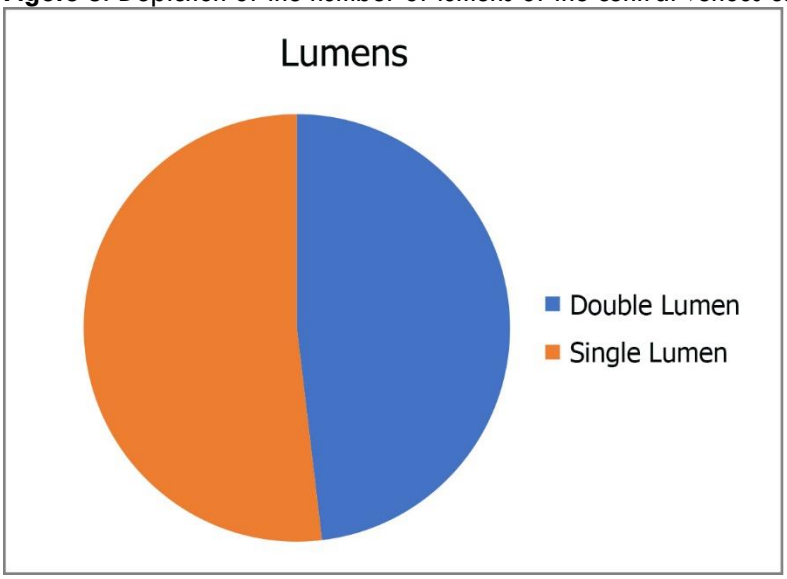
Figure 7. CVC internal diameter

Table 8 and figure 8 illustrate the number of lumens (one lumen versus double- lumen) of the utilized central venous catheters.

Table 8. Depiction of the number of lumens of the central venous catheters.

Lumens	Patients	n (%)
DL	192	48,1
SL	207	51,9
Total	399	100,0

Figure 8. Depiction of the number of lumens of the central venous catheters.



The erroneous positions of the central catheter tips are summarized at table 9 and are the following: Right and left subclavian veins, contralateral internal jugular vein, azygos vein, right internal mammary vein, pericardiophrenic vein and PLSVC.

Table 9. Recognition of the erroneous positions of the tip of the inserted central venous catheter, in association with the catheterized vessel. This table also refers the total number of malfunctioning catheters, as well as the number who underwent immediately repositioning.

	Vessel cannulated		Immediate correction	Malfunction
	RIJV	LIJV	*n*=11	*n*=7
Erroneous position				
R subclavian vein	11	0	4	1
L subclavian vein	0	2	0	1
PLSVC	0	1	0	0
RIJV	0	2	2	0
LIJV	1	0	1	0
R inter mammary vein	1	0	0	1
R sup intercostal vein	0	1	1	0
Azygos	1	0	0	0
Catheter bending	1	1	1	1
RA	3	4	1	0
Brachiocephalic vein	2	5	1	3

Under the term of mal positioning of the catheter tip, we have included all cases that were characterized by the existence of a loop of the distal catheter within the vessel which was selected as the site of insertion. Moreover, all cases with inappropriate ending of the distal catheter, that is within the right atrium or brachiocephalic vein, were included. The most commonly recorded suboptimal position of the distal tip of the catheter is associated with the involvement of the right subclavian artery, after catheterization of the right internal jugular vein (n=11), followed by an ending that involves the right atrium or the brachiocephalic vein (n=7 patients for each case).

The number of catheters that presented signs of malfunction, as well as the number of catheters who were immediately repositioned are recorded at table 9. As far as the cases of malfunction are considered, the catheter that was inadvertently introduced into the right internal mammillary artery was only associated with difficulty in suction and was subsequently removed. Moreover, malfunction was associated with 3 out of 7 catheters that were ending at the upper end of the relevant vessel (2 were inserted from the left internal jugular vein and one from the right one) · no catheter that its tip was located in the distal part of the catheter was associated with complications. Furthermore, we would like to mention that all of the catheters that were functioning in a suboptimal way shared in common mal positioning of their distal tip.

Finally, table 10 summarizes the reasons for removal of the previously introduced central venous catheters.

Table 10. Recording of the reasons that necessitated removal of existing central venous catheters).

Malposition	38
Immediate correction	11
Immediate removal	2
Reasons for removal	
Rupture	1
Pseudoaneurysm	1
Later removal	20
Reasons for removal	
Treatment completion	7
Malfunction	7
Infection	5
Mechanical	1
Thrombosis	5
Continuation of treatment	5

Discussion

In this study, we recorded an increased incidence of suboptimal mal-positions of the central catheter tip (9,5%), which should be mainly attributed to the fact that we incorporated patients to which their distal catheter tip was not located at the junction of the superior vena cava-right atrium. On the contrary, it was located at a superior location, more precisely in the brachiocephalic vein, or inferiorly, inside the right atrium· cases that presented with a loop of the distal catheter within the left auricle are also included. Such cases are not commonly included in the literature[2,3,14,15]. When we are managing pediatric patients, we strongly consider that we have to take special care regarding the positioning of the tip of the catheters, mainly because there is increased degree of difficulty regarding their insertion. This is secondary to the relatively small internal diameter of the vessels of these patients, as well as the overall decreased shape of them.

Possible pathogenetic mechanisms-risk factors.

Several different parameters may play significant role in the correct placement of the central venous lines and they may be related with the catheterization technique, as well as with the patient itself. For instance, in cases of catheterization of the internal jugular vein, the direction of the needle internally or caudally seems to be related with better advancement of the guide wire, as well as with a greater degree of success[16,17].

It is also supposed that patient characteristics such as obesity or a change in patient position from supine to sitting or upright, have an intimate relationship with the migration of the catheter tip. Nevertheless, their clinical significance is questionable, and is mainly restricted to cases which are characterized by concomitant anatomical abnormalities[2,18]. Another important implicating factor is related with the existence of venous anatomical variations, which can be congenital or acquired. As already mentioned, the most frequently encountered anomaly refers to the PLSVC, which is encountered in 0.3-0.5% of the general population and at 2.1-5% of patients with congenital heart disease.

In our study, the patient with PLSVC was not suffering from a congenital heart disease but from respiratory distress, due to stenosis to the main left bronchus, as well as from cardiac arrythmias, which could be combined with that entity. Other relevant congenital anomalies include the existence of dextrocardia, partial anomalous vein return, anatomical variations of pulmonary veins, as well as the variations of azygos vein, regarding their origin, course, anastomoses and termination[19].

In general, the acquired variations/abnormalities are more frequently encountered relative to the congenital ones, and are subdivided based on whether they are caused from external or internal causes. The most common external cause (>85%) is the existence of malignant or benign tumors, who are causing compression or obstruction of adjacent veins. The most common internal cause of venous anomaly includes the development of thrombosis due to patient immobilization, operative procedure, malignancy and chemotherapy. Apart from that, the repeated catheterizations of one specific vessel, as well as the selection of a left-sided approach are considered as significant risk factors[20]. More precisely, repeated punctures of the offending vessel are potentially associated with the development of pseudoaneurysm of the carotid artery. When the cases with catheter re-insertion are considered, our study revealed that the risk of incorrect placement is significantly increased (9 cases of incorrect placement out a total amount of 38 insertions, that is 23.68%). A possible explanation is based on the fact that there is an increased risk of thrombosis after repeated catheterizations of one particular vessel. This may be the reason for an erroneous direction of the route of the catheter insertion, as well as the selection of the left internal jugular vein, in case that the right one is not appropriate. Schummer et al[21] studied 1794 cases of central catheter insertion, and 37 cases of erroneous insertion were recorded. The main contributing factor to that was the predilection of the left internal jugular vein for catheterization (12%). Our study revealed that the possibility of inappropriate catheter route (mal-positioning) in cases that the left internal jugular vein was selected for catheterization was significantly higher, compared with that after catheterization of the right counterpart (18.07% vs 7.25%). This could be attributed to the fact that when the left IJV is catheterized, the catheter should come across the left brachiocephalic vein, which follows a long and oblique trajectory, in order to terminate at an angle to the superior vena cava. During this route, the existence in the territory of multiple small vascular branches is inherently related with an increased risk of inadvertent catheterization of these vessels[22]. An in vitro study supported that an acute angle $> 40^{\circ}$ within the superior vena cava, is intimately related with an increased risk of vessel rupture[23].

Recognition of erroneous insertion based on signs and symptoms.

The most frequent clinical sign that raise a clinical suspicion for incorrect placement or migration of the tip of the catheter is its suboptimal function. In our study, this was the case in 18.42% of the total cases of catheter insertion, which subsequently led to their removal. The most possible explanation for the

malfunction of these central venous lines is related with the fact that the negative intraluminal pressure due to suction is responsible for collapse of the walls of the offending vessel, which, in comparison with the superior vena cava, has a smaller internal diameter and a weaker vessel wall. Nevertheless, the existence of appropriate suction is not equivalent with correct catheter placement[24]. On the other hand, every case that is characterized by resistance or difficulty in the advancement of the catheter tip should be fashioned as a case of inappropriate direction of the catheter tip. Abood et al[25] presented a prospective trial based on adult patients, which showed that the estimation of the interventional physician, when it was based on co-morbidity and clinical signs and symptoms after central venous catheter insertion, was able to recognize only 20% of all cases implicated with inappropriate catheter insertion.

Prevention of suboptimal placement

The selection of the appropriate length and diameter of the catheter is very important and is determined by several factors, such as the height of the patient and the selected vessel for catheterization[26]. There are several methods available in order to determine the appropriate length of the catheter, such as: Peres formula, TEE formula (trans-oesophangeal) and calculation based on external landmarks[15] · this option was selected for our study. Another critical issue is the determination of the position of the catheter tip. The chest X-ray constitutes the easiest, fastest and most widely used method, and is considered nowadays as the gold standard technique for the recognition of cases with inappropriate catheter tip localization, although it is unable to detect all cases[27]. Only the trans-oesophangeal ultrasound is capable of precisely detecting the catheter tip, in relationship with the nearby vessels. Nevertheless, the learning curve for the interpretation of its findings is time-consuming in most cases, rendering its daily usage practically impossible[21].

The use of ultrasound techniques is valuable, mainly when we aim to recognize anatomical structures before and during vessel catheterization, as it may reveal thrombosis, stenosis, anatomical variations, findings that merit special consideration in the process of catheterization. Nevertheless, several studies have failed to verify its capacity to prevent all cases of suboptimal catheter tip[24,28].

Correction of catheter tip position

To the best of our knowledge, the existing literature centered on the issue of the correction of the catheter tip in cases of inappropriate catheter insertion in the pediatric population is insufficient. Rastogi et al[29] studied 187 cases with catheter insertion to neonates and they stated that an automatic correction could be anticipated within the first 24 hours. When we are studying pediatric patients, there are several special considerations that should be taken into account. These are related with:

• The decreased length and internal diameter of the vessels.

• The co-existence of co-morbidities associated with chronic oncological entities, as well as with inappropriate patient feeding. As a consequence of all of these issues, these patients harbor central venous catheters, along with several revisions of them, from almost the beginning of their life, a fact that renders the repositioning of the catheters not technically feasible.

• Pathological conditions that necessitate central venous access at an emergency basis, i.e., dehydration. Although, as we have already mentioned, the chest X-ray constitutes the gold standard in order to estimate the correct position of the tip of the catheter, there are several cases where this modality leads to equivocal findings. When an antero-posterior chest X-ray is performed, the two-dimensional imaging of the anatomical structures in the vicinity of the vessel, sets an obstacle to our effort to precisely determine the catheter tip. In every case that we have any suspicion of inappropriate position of the tip of the catheter, a lateral chest X-ray should be performed. The lateral X-ray serves as an adjunct in order to precisely identify the catheter tip at the anterior, middle or posterior mediastinum. In equivocal cases, more sophisticated imaging techniques should be utilized, which include the CT scan, MRI and echocardiogram.

Correlation between inappropriate position of the catheter tip and infection/thrombosis

Central venous catheters constitute the most significant source of infections to hospitalized patients. There seems to be a two-way interrelation between thrombosis and infection. Evidence from the literature[30] state that patients who suffer from an infection that is related with a central venous catheter are associated with an increased risk to develop thrombosis, and vice versa. This fact has led to the concept that thrombosis and infection constitute a unique and not separate entities.

Limitations of the study

An inherent limitation of our study is related with the fact that an attempt to identify the existence of a correlation between the insertion technique and the mal-positioning of the catheter tip was lacking. As we have already mentioned, the insertion techniques included the open surgical approach and the transdermal technique, based on external anatomical landmarks or via ultrasound guidance. Several other relevant studies have recorded the

complications that are associated with the different insertion techniques, including the case of erroneous catheter placement, along with the success rates associated with each method[31,32].

Conclusions

The insertion of central venous lines constitutes one of the most frequently performed invasive medical procedures that is performed at pediatric hospitals. A suboptimal or erroneous insertion constitutes one of the most devastating relevant complications and it can be associated with significant adverse effects. It seems to be related with congenital or acquired vascular abnormalities, benign or malignant tumors, as well as with the recipient vessel. An important and necessary precaution in order to avoid this complication is related with the confirmation of the position of the guide wire and of the tip of the catheter as well via the usage of fluoroscopy. In cases where there is suspicion for inappropriate location of the tip of the catheter and the antero-posterior and lateral X-ray are inadequate to definitively specify the position of the catheter tip, more sophisticated imaging techniques should be incorporated.

A very important relevant factor is associated with the diagnosis of malfunction of the central catheter. According to our study, all such cases were associated with mal-positioning of the tip of the catheter.

Our recommendation is that the right internal jugular vein should be the preferred vessel for catheterization, as it seems to be associated with the least possibility of erroneous catheter placement. We should also mention that the inappropriate positioning of a central venous catheter over the long term, could be related with an increased incidence of malfunction, as well as infection and thrombosis. This should definitely lead to its early removal, before the completion of the treatment scheme.

As a consequence, we would like to mention that the insertion of a central venous catheter is an interventional procedure which is intimately related with potentially devastating complications. The overall approach to such cases should be multi-factorial, mainly attempting to the recognition and amelioration of the risk factors, in order to extend the time period during which the central catheter is well functioning.

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