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The comparison of intra-operative ultrasonography guidance with open surgical method for venous port catheter placement for chemotherapy

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ABSTRACT

OBJECTIVE: One of the leading methods of venous access for chemotherapy is venous port catheter (VPC). Open surgical or ultrasound-guided techniques can be performed. In our study, VPC placement via open or ultrasound-guided techniques were compared.

METHODS: A total of 180 consecutive patients who underwent the procedure of VPC placement either via open or ultrasound-guided methods in two centers between January 2014-January 2016 were included in the study. Patients' data were reviewed retrospectively. Groups were compared in terms of intervention-related complication rates, total procedural time and requirement of control imaging with ionizing radiation.

RESULTS: The mean total procedure time was significantly shorter (19.5±4.6 min; 46.7±19.6 min) ($p<0.001$) in the ultrasound-guided group than the open method. The rate of catheter malposition was significantly less in the ultrasound-guided group than in the open group ($p<0.001$). The need for per-operative imaging with ionizing radiation and the need of reversion in the preferred technique were not observed in the ultrasound-guided group, whereas in the open group they were observed in 90 (100%), and 6 (6.7%) patients, respectively ($p<0.001$; $p=0.01$).

CONCLUSION: Intraoperative ultrasound guidance for VPC placement; shortens the processing time and eliminates the need for routine imaging methods that require the use of ionizing radiation. In accordance with the recommendations of the current guidelines, intraoperative ultrasonography should be preferred as much as possible during placement of the VPC. However, the need for the surgical teams in centers to maintain the necessary educational processes for both techniques should not be overlooked.

Keywords: Central; interventional; operative procedures; ultrasound; venous catheterization.

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The need for venous access is increasing in patients with malignancy [1]. There is a need for continuous venous access for blood sampling for routine control of patients, parenteral fluid and blood products administration as well as for chemotherapy applications [1]. One of the leading methods used for venous access for chemotherapy is the placement of venous port catheter (VPC) [2]. VPC systems, which are used for these purposes allow multiple punctures [1]. Open surgical or ultrasound-guided techniques can both be performed for

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this procedure [1–3]. In our study, the patients who were planned to undergo chemotherapy and underwent the procedure of the VPC placement either via open surgical or ultrasound-guided techniques were compared.

MATERIALS AND METHODS

A total of 180 consecutive patients who underwent the procedure of VPC placement for chemotherapy either via open surgical method or with ultrasound-guided technique in two centers between January 2014 and January 2016 were included in the study after the informed consent was taken. Study was approved by local ethics committee (approve number: 83045809-604.01.02-A-25). Both techniques were used in both centers. Patients' data were reviewed and the study was conducted retrospectively in accordance with the principles of the Declaration of Helsinki. Statistical comparisons were made between the two groups in terms of demographic variables, intervention-related complication rates, total procedure time and requirement of control imaging with ionizing radiation. Routine pre-interventional ultrasound evaluation was performed for puncture/surgical intervention sites. All patients were monitored with ECG tracing, pulse oximetry, and blood pressure measurements during the procedure.

During the ultrasound-guided technique, USG probe was covered with a sterile sheath and positioned in the surgical field. Both ipsilateral and contralateral sites of subclavian and internal jugular vein regions were prepared and draped for ultrasound evaluation for malposition. Additionally, in case of failed advancement of the guide wire, other sites were ready in the surgical field. During the procedure, local anesthesia with 1% Lidocaine Hydrochloride was used. All ultrasound-guided puncture was made in the right internal jugular vein site. Guide wire image in the venous lumen was evaluated in the puncture site as well as other contralateral and ipsilateral venous regions. In the ultrasound-guided technique, the length of the catheter line was measured externally and individually in a patient-based manner. Then, the catheter line was propagated to the puncture sheath via right internal jugular vein.

The skin incision of delto-pectoral sulcus region was made and a pocket for the main body of VPC was prepared in both technique. In the ultrasound-guided technique, the proximal part of the catheter line was passed through a curved C-shaped tunnel to reach the delto-pectoral pocket region. The open surgical technique included the exploration of cephalic vein and the placement of the catheter line via cephalic vein.

Routine X-ray imaging control was used in open surgical technique for validation of position of the catheter. Additionally, the determination of the length of catheter line was obtained via using this control imaging in open surgical technique as well. The connection between the line and main body was then made and the main body of the VPC was placed to the delto-pectoral pocket in both technique. Stay sutures was used to fix the VPC main body. The VPC was controlled via blood aspiration, then main body and catheter line was washed out with 10 mL of 50 IU/mL standardized heparin included saline solution.

Statistical analysis

Categorical variables were expressed as number (percentage), and continuous variables as mean±standard deviation. Categorical variables were compared using the chi-square test and Fisher's exact test and continuous variables using the Student's t-test. The p value of less than 0.05 was considered significant. IBM SPSS software package version 21.0 (SPSS, Chicago, IL, USA) was used for statistical analysis.

RESULTS

There were 90 patients in both groups. The mean age of all patients was 58.7±11.9 years. Total of 69 patients (38.3%) were female. There were no significant differences between the two groups in terms of demographic data such as age and gender (Table 1). The mean duration of the intervention for all patients was 33.1±19.7 minutes. The mean total procedure time was significantly shorter (19.5±4.6 min; 46.7±19.6 min) ($p<0.001$) in the procedures performed with ultrasound-guided technique than the open surgical technique (Table 1). The

Table 1. Demographic variables

Variable	OST (n=90)	UGT (n=90)	p
Age (years) mean±SD	57.6±12.4	59.8±11.3	0.22
Gender (female) n (%)	35 (38.9)	34 (37.8)	0.88

OST: Open surgical technique; UGT: Ultrasound guided technique; SD: Standard deviation

TABLE 2. Intervention-related variables

Variable	OST (n=90)		UGT (n=90)		p
	n	%	n	%	
Total number of vein puncture (mean±SD)	–		1.1±0.3		–
Duration of the intervention/surgery (minutes) (mean±SD)	46.7±19.6		19.5±4.6		<0.001
Need of reversion in the preferred technique*	6	6.7	0	0	0.01
Control imaging including ionizing radiation	90	100	0	0	<0.001
Complications (total)	39	43.3	1	1.1	<0.001
Arterial puncture	0	0	0	0	1
External bleeding	2	2.2	0	0	0.16
Local hematoma	2	2.2	1	1.1	0.56
Pneumothorax	1	1.1	0	0	0.32
Catheter malpositioning	34	37.8	0	0	<0.001
Early catheter dysfunction	0	0	0	0	1

*: Reversion to open surgical technique in the failure of ultrasound guided technique or reversion to ultrasound guided technique in the failure of open surgical technique. OST: Open surgical technique; UGT: Ultrasound guided technique; SD: Standard deviation.

rate of catheter malposition was significantly less in the ultrasound-guided technique group than in the open surgical technique group [0 (0%), 34 (37.8%), respectively] (p<0.001). All catheter malpositions were corrected under the guidance of fluoroscopy in the open surgical technique. The total rate of complications except catheter malposition for all patients was 6 of 180 (3.3%). The rates of arterial puncture, bleeding, local hematomas, pneumothorax and early catheter dysfunction were similar for both groups (p>0.05). Pneumothorax was developed in one patient (1.1%) in the open surgical technique group. This patient had need of reversion in the preferred technique and had multiple punctures by using an anatomical landmark technique in the right subclavian vein region. The need for per-operative imaging with ionizing radiation and the need of reversion in the preferred technique were not observed in the ultrasound-guided technique group, whereas in the open surgical technique group they were observed in 90 patients (100%), and 6 patients (6.7%), respectively (p<0.001; p=0.01). Among these 6 patients whom preferred technique were reversed, 4 of them were catheterized in the right subclavian vein region and 2 of them in the right internal jugular vein region.

DISCUSSION

The total number of venous puncture needs are increased for various reasons in patients with malignancy [1]. Therefore, VPC placement can be a life-saving procedure for these patients. VPCs have special membrane in their puncture site allowing multiple punctures [1]. There are two major techniques for VPC placement that previously described: Open surgical exploration technique, and ultrasound-guided technique. It is a conventional method of placement of the VPC, which is considered to be the insertion of the port catheter line by exploration of cephalic vein with open surgical technique. The placement of the VPC by surgical exploration of the vein is considered to have a lower risk of damage to the adjacent arterial and neural structures than those using blind anatomical landmark puncture techniques. However, due to higher procedural success rates, placement of VPC with subclavian or internal jugular vein puncture has begun [4, 5]. Risks of pneumothorax, hemothorax, arterial puncture, hematoma development or catheter malposition are present during both VPC implantation techniques [6–8]. In order to place the catheter in the proper position, imaging methods are frequently used for verification purposes. The most commonly used imaging methods are direct radiographic or fluoroscopic imaging with ionizing radiation. There are also additional methods including ultrasound-guided technique used in the detection of complications such as malposition of the catheter and pneumothorax [9]. It is currently not recommended to routinely use X-ray imaging methods for position confirmation during and after VPC placement

[10–13]. However, the use of X-ray imaging is recommended if a clinical suspicion suggests pneumothorax presence [1]. At this point, performing an open surgical procedure requires an imaging confirmation, even though it provides an advantage for catheter position. Additionally, in the open surgical procedure, the position of the catheter line was determined during the confirmation with the use of ionizing radiation imaging method while catheter length was determined individually by patient-based external line measurement in ultrasound-guided procedures. In our study, all of 90 patients in the open surgical technique group had need for per-operative imaging with ionizing radiation while none of the patients had in the ultrasound-guided technique group ($p<0.001$). The main explanation of this major difference was about the procedure requirement. The approach of the surgical group included the advancement of the guide wire through the subclavian vein. This region had a high risk of malposition to the contralateral subclavian as well as ipsilateral internal jugular vein. Therefore, in the open surgical technique group, position of the guide wire and the catheter were usually required to be validated using intra-operative imaging with ionizing radiation.

Furthermore, open surgical procedures can prolong the processing time. We found that the mean total procedure time was significantly shorter in the ultrasound-guided technique group (19.5±4.6 min) than the open surgical technique group (46.7±19.6 min) ($p<0.001$). For this reason, ultrasound-guided technique can be used more frequently nowadays with the distinct advantages for placement of VPC for chemotherapy [14–19].

Additionally, it is found to be safe and effective to place line of VPC systems in the right internal jugular vein with ultrasound-guided technique [1]. Due to the continuity of right internal jugular vein with superior vena cava and right atrium, the possibility of catheter malposition is significantly reduced. Although there was some study describing the single-incision techniques for VPC placement, complications including arterial puncture, vein thrombosis, malpositioned guide wire were also described [20]. Contrary to these findings, we found no such complications in the ultrasound-guided technique via right internal jugular vein. As in the case of VPC placement, the use of ultrasonography in central venous catheterization provides significant advantages both before and during the procedure [21].

The use of ultrasound-guided technique may allow faster confirmation of the catheter position [21, 22]. Catheter malposition has been reported in central venous catheterizations in 2–37% of cases [6, 23, 24]. Herein, the anatomic position, extension of the vein, and the presence of collateral veins in which the puncture is to be performed is important. In addition, distal vein site punctures carry more malposition risk than those performed from a more proximal vein. In terms of anatomic position advantage, the use of the right internal jugular vein region instead of the subclavian vein comes out to the forefront [6, 25]. Because of these reasons, the right internal jugular vein region was preferred in all of our ultrasound-guided procedures. In our study, we found that the rate of catheter malposition was significantly less in the ultrasound-guided technique group than in the open surgical technique group [0 (0%), 34 (37.8%), respectively] ($p<0.001$).

The development of pneumothorax is reported in 0.5–3% of central venous catheterization procedures [10, 26] The risk of developing pneumothorax has also been reported in punctures performed in the right internal jugular vein [14, 19] More ratios than these series have been reported in the series where subclavian vein puncture is preferred [25]. In our study, pneumothorax was developed in one patient (1.1%) in the open surgical technique group. This patient had need of reversion in the preferred technique and had multiple punctures in the right subclavian vein region. At this point, the use of blunt anatomical landmark technique, subclavian vein as puncture zone, and the need for multiple punctures are leading factors that increase the risk of pneumothorax development [1, 25, 26]. In order to reduce this risk, it is suggested that the ultrasound-guided technique should be preferred before and during the procedure and that the right internal jugular vein site should be preferred as the puncture region [1]. In parallel to these literature suggestions, in our study, it has been shown that preferring the right internal jugular vein as the puncture region and performing the procedure with ultrasound-guided technique could help to minimize possible risks. If the center has the facility, it is recommended to prefer ultrasound-guided procedures. It should be kept in mind that, however, explicit instructions must also be applied in order to complete the learning curve, which is necessary for open surgical intervention in emergencies, at all centers.

On the other hand, the retrospective conduction and small number of patients could be accepted as limitations of our study. However, the results of comparison of two different techniques could be inspiring for further studies.

Conclusion

Intraoperative ultrasound-guided technique for venous port catheter placement; shortens the procedure time and eliminates the need for routine imaging methods that require the use of ionizing radiation. In accordance with the recommendations of the current guidelines, intraoperative ultrasonography should be preferred as much as possible during the placement of the VPC [27]. However, the need for the surgical teams in centers to maintain the necessary educational processes for both techniques should not be overlooked.

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