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Comparison Between Open and Ultrasonography Guided Venous Access Ports in Children with Malignancy

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ABSTRACT

Background: Long-term central venous access is used in children for various reasons specially for delivering chemotherapy. Since vessels in children have smaller diameters, they are more prone to injury and complications such as thrombosis. Different methods are used for implantation of port-a-cath in children. We aimed to compare the complications of insertion of central venous access ports between two methods of open and ultrasound (US) guided.

Methods: All children who were referred to pediatric surgery department of a children hospital from April 2018 to March 2020 for implantation of port-a-cath were included. Right jugular vein was the target vein and patients were randomly divided between two methods of insertion of open lateral neck exploration and ultrasound real-time guided percutaneous insertion and the reservoir was fixed in subpectoral fascia pouch. All open cases in which jugular vein was ligated proximally were excluded. Patients were followed up for early and late complications two days and one week later by the surgical team, then monthly by a trained nurse and were referred to the surgeon if any complication or malfunction had occurred for at least 6 months.

Results: We included 76 patients (21 girls and 55 boys) less than 18 years of age: 24 patients with ultrasound guided method (1-13 years, median 3 years) and 52 patients with open exploration method (4 months-17 years, median 6 years). We observed no statistically significant difference between two groups with respect to sex, underlying disease, and complications. Most patients had hematological malignancies including ALL (52.9%), AML (19.1%) and the rest had solid organ malignancies. Early complications were observed in 2 (3.8%) in the open and 1 (4.2%) in the US- guided group (P=1). Late complications were observed in 9 (17.3%) patients in the open group and 1 (4.2%) in the US guided group. Infection was observed in 9.6% and malfunction in 5.8% of the open group leading to earlier removal of the catheter. There was not any complication indicative of infection in the US-guided group.

Conclusion: US-guided method can be suggested for routine use as a safe method of insertion of port venous access in children.

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Introduction

Central venous catheters are widely used in children for short-term use as peripherally inserted central catheters (PICC); intermediate as central venous lines for specific purposes in intensive care units; tunneled central venous lines in bone marrow transplantation settings;

or long term as Shaldon and permicath for dialysis and plasmapheresis or Port-a-cath for chemotherapy and long-term total parenteral nutrition. Children with small diameter vessels are more prone to developing thrombosis of catheters (0.67-5%) and other complications as vascular perforation, pneumothorax, hemothorax, hematoma and malfunction.[1] Catheters can traditionally be inserted through open exploration of the lateral side of the neck or percutaneous with the guide of anatomic landmarks or with the guide of ultrasonography (US) as suggested by recent studies because of availability of portable ultrasound device in most operating room settings in recent years.[2] Different central veins are used including internal and external jugular veins, subclavian vein or femoral vein. In some studies, catheter tip displacement and dislodgement were reported to be less in groups using internal jugular vein[3,4] Central venous access devices are inserted by different specialists such as anesthesiologists, intensive care specialists and surgeons (especially for long term devices such as port-a-caths). Numerous studies and meta-analyses are performed to evaluate the efficacy and safety of different methods of insertion. Hematology/oncology patients are among those who need most to undergo insertion for central venous access ports. In this study, we aimed to compare the results and complications of the two methods of open and US guided insertion of central venous access ports.

Materials and Methods

All children under 18 years old who needed long-term or permanent central venous access devices referred from hematology/oncology departments from April 2018 to March 2020 for insertion of Port-a-cath, with no history of previous central venous cannulation were enrolled in the present study. All children in our study needed permanent central venous access for their treatment and all procedures were in accordance with the ethical standards of the institutional and the faculty of medicine, Shahid Beheshti University of Medical Sciences and the National Research Committee. They were randomly selected for traditional open exploration or percutaneous US-guided method. Portable ultrasonography devices were available in the operating room. Procedures were performed under general anesthesia by the same experienced pediatric surgery team including attending pediatric surgeon or the training fellowship of pediatric surgery in the last year of training. Right internal jugular vein was used for cannulation. Preparation of surgical field was performed with povidone iodine solution and the procedure was performed in sterile conditions. In the open approach, a small 1 cm incision was performed in right lateral side of the neck, right jugular vein was explored and proximal and distal control with silk suture 4-0 was performed. The vein was punctured with the needle and the guide wire was used (seldinger technique) to insert the catheter. If the vein was ligated, it was excluded from the study. In the US guided approach, the right jugular vein in lateral side of the neck was found by US probe between sternocleidomastoid muscle heads and the probe was hold by the assistant, the vein was punctured by the needle and then the guide wire was inserted, and its route was checked by US and then the catheter was inserted on the guide wire with the Seldinger technique. In both methods, the appropriate length of the catheter to superior vena cava near right atrium was estimated before insertion and was confirmed by C-arm radiology at the end of the procedure. The proximal end of the catheter was tunneled subcutaneously to the location of the port reservoir which was fixed in the subpectoral fascia pouch on the costal periosteum with a 2 cm skin incision in the third intercostal space, midclavicular on the anterior chest wall in both methods. because less complications such as skin necrosis and reservoir rotation was reported in this method of port fixation compared with subcutaneous method in our institute experience.[5] Before fixation of the reservoir, the catheter was controlled for not being kinked and also for appropriate function by aspiration and infusion of sterile normal saline solution and then was heparinized with a solution of heparin. After complete hemostasis, subcutaneous tissue was sutured with vicryl 3-0 and skin was sutured subcutaneously with Nylon 4-0 and sterile dressing was put on the incision sites. Postoperative chest radiograph was requested for all patients and observed by the surgeon to confirm the appropriate fixation of the catheter. The patients were visited two days and then one week later by the pediatric surgery team and were followed up and re-checked by a trained nurse for the appropriate function of the catheter while it was heparinized every 4 weeks. In case of any complaint of swelling, erythema, malfunction, or suspicion of infection, they were evaluated and referred to the pediatric surgery clinic. Follow up was continued for at least 6 months. Data including demographic information and underlying disease and early and late complications were gathered in a questionnaire and analysis was performed by SPSS version 22.

Results

Seventy-six patients (21 girls and 55 boys) were enrolled in our study in a two-year period from April 2018 to March 2020. There were 52 open and 24 US-guided procedures. The age range of the patients was 4 months-17 years (median 3 years) in the open group and 1-13 years (median 6 years) in the US group (P=0.006). Gender distribution was not different between the two groups: 14 (29.6%) girls in the open and 7 (29.2%) girls in the US group (P=1). Seventy-two patients were referred from the hematology/oncology department, 49 in open and 23 in US group and 4 were referred from other departments. Sixty-eight patients were referred with underlying malignancy requiring long-term chemotherapy including 36 ALL (52.9%), 13 AML (19.1%), 7 lymphomas (10.3%), 5 neuroblastomas (7.4%), 3 Sarcomas (4.4%), 2 Wilm's tumors (2.9%), 1 Yolk sac tumor (1.5%) and 1 insulinoma (1.5%). The distribution of different malignancies between two groups is presented in Table 1. Non-malignant etiologies were cystic fibrosis, nephrotic syndrome, histiocytosis, aplastic anemia and immune deficiency. Distribution according to the type of malignancy was also the same between the two groups (P=0.715). History

Table 1: Frequency of the type of malignancy between open and US guided port-a-cath implantation

Type of malignancy	Open port implantation No. (%)	US guided port implantation No. (%)	All cases of port catheter implantation No. (%)
AML	9 (20%)	4 (7.4%)	13 (19.1%)
ALL	23 (51.1%)	13 (56.5%)	36 (52.9%)
Neuroblastoma	3 (6.7%)	2 (8.7%)	5 (7.4%)
Lymphoma	5 (11.1%)	2 (8.7%)	7 (10.3%)
Wilm's tumor	1 (2.2%)	1 (4.3%)	2 (2.9%)
Yolk sac tumor	0 (0%)	1 (4.3%)	1 (1.5%)
Sarcoma	3 (6.7%)	0 (0%)	3 (4.4%)
Insulinoma	1 (2.2%)	0 (0%)	1 (1.5%)
All cases	45	23	68

Table 2: Frequency of complications between open and US guided port-a-cath implantation

Catheter related complications	Open port catheter insertion No. (%)	Ultrasound guided Port catheter insertion No. (%)	All cases of Port catheter insertion No. (%)
Early complications during first 24 h			
hematoma	0	0	0
Malfunction	0	1 (4.2%)	1 (1.3%)
Catheter displacement	1 (1.9%)	0	1 (1.3%)
Pneumothorax	1 (1.9%)	0	1 (1.3%)
Hemothorax	0	0	0
Infection	0	0	0
All early complications	2 (3.8%)	1 (4.2%)	3 (3.9%)
Late complications			
Intravenous thrombosis	1 (1.9%)	0	1 (1.3%)
Venous stenosis	0	0	0
Malfunction	3 (5.8%)	1 (4.2%)	4 (5.3%)
Displacement	0	0	0
Infection	5 (9.6%)	0	5 (6.6%)
Early removal of catheter due to complication	9 (17.3%)	1 (4.2%)	10 (13.2%)

of previous chemotherapy was observed in 65 patients (85.5%), including 22 (91.7%) in the US guided group and 43 (82.7%) in the open group.

Short-term complications during the first 24 hours were not significantly different between the two groups (P=1). Short term complications were observed in 3 (3.9%) patients; one case in the US-guided group which was port malfunction, and 2 cases in the open group which were catheter displacement and pneumothorax, respectively.

Long-term complications were observed in 10 cases (13.2%), including one case (4.2%) in the US guided group which was port malfunction and 9 cases (17.3%) in the open group: one case (1.9%) of intravenous thrombosis, 3 cases (5.8%) of port malfunction and 5 cases (9.6%) of port site infection causing subcutaneous fasciitis in one of them, all leading to early removal of the catheter before the expected time of the treatment. No infection in the US group was observed during 6 months of follow-up. Frequency of the complications are presented in Table 2. There was no report of coagulopathy in any of the patients before surgery; however, 7 patients (4 in the US guided and 3 in the open group) had thrombocytopenia before surgery which was corrected to higher than 50,000 before operation.

Discussion

Children have vessels with smaller diameters that make them more prone to injury, thrombosis, and other complications. Central venous access insertion is performed by different specialists including anesthesiologists, intensive care specialists and surgeons; however, permanent devices such as port-a-cath are implanted by experienced surgeons. There are numerous studies that have evaluated and compared different vessels for access (Internal jugular, external jugular, subclavian, femoral) and different sides (right or left) and have analyzed various methods of implantation such as open explore and cut down, open explore and guide wire, percutaneous anatomical landmarks and percutaneous US guided (static or real time) regarding ease of insertion, complications, time and costs.

In our study, we used right jugular vein access. Open explore and real-time US guided method were both safe and successful with similar frequency of early complications (3.8% vs 4.2%) between the two groups as observed in other studies.[6, 7] In terms of late complications, we had more complications in the open group (17.3% vs 4.2%) including port site infection leading to early removal of the catheter which was only observed in our open group and malfunction due to thrombosis in the catheter and one

case of venous occlusion by thrombosis. Central venous access failure before completion of treatment course was observed in 10 cases including 9 cases in open method (17.3%) and 1 case in US guided method (4.2%) with frequencies less than other similar studies.[8] Infection was the most common complication leading to early removal of the catheter like many other studies,[2, 6, 9-12] but we did not observe this complication in the US guided group. Although in some studies; infection was more frequent in the open group, in other studies no statistically significant difference was observed between open and close methods and between the jugular or the subclavian vein used.[2, 12] While in another study subclavian access was related to more frequent infectious complications.[11]

Most of our patients had underlying malignant diseases who needed port-a-cath for chemotherapy. The most common malignancies were hematologic malignancies and then solid tumors mostly lymphoma; with incidences and frequencies similar between the two groups and comparable to the other studies.[5, 9, 10, 13, 14]

Early complications in our study were catheter displacement and pneumothorax in the open group and malfunction due to early thrombosis in one case of the US group. There was no mortality observed among our patients. In some other studies, carotid puncture and vascular rupture have been reported which were mostly in the groups with landmark guide.[9, 15] In some studies, more venous thrombosis was observed as late complications.[15]

Late complications observed in follow up of patients were venous thrombosis, malfunction and infection in the open group and only one case of malfunction in the US guided group. We did not have any case of catheter dislodgement. The frequency of venous thrombosis resulting in early removal of the catheter was reported to be more in the open group in other studies[2] which could be explained by doing cut down and venorrhaphy, but we used venous puncture and insertion on guide wire in the open group of our study. We did not observe skin necrosis in the follow up of our patients.

We had a case of ALL with pancytopenia who developed progressive fasciitis and cellulitis at the port site twenty days post insertion who was treated by removal of the catheter and broad-spectrum antibiotics along with several sessions of irrigation and debridement in the operating room. In our study we used right jugular vein for insertion of central venous catheter device as it was used in previous studies of our center with good results and success rate in line with other studies since 2016.[9, 10] We had no adverse events during catheter placement, but it has been observed in some other studies as high as 17.4% which may be due to their method of landmark guidance. Even after successful cannulation of the veins, complicated guide wire insertion has been reported in 7.6% of cases in one study leading to conversion to venous cut down.[16] In a study on children with malignancies, adverse events were observed between 4.5-22% during insertion of central venous access catheters.[17] In a study by Karakitsos et al. on 900 patients, complications were observed in landmark group without US guidance; but in our study there was no significant difference; may be due to smaller number of our patients.[18]

In a meta-analysis by Chamberlain et al. in 2016 on 8 studies including 760 patients, 31.8% increase in success of catheter insertion by US guided method was reported.[19] In contrast to our study, in a study from Spain on patients older than 18 years with 228 cases of vascular dissection versus 155 cases of vascular puncture, complications including thrombosis (more in vascular dissection group) and infection (more frequent in the US group) were reported.[20]

Martynov et al. evaluated safety of tunneled central venous devices with percutaneous landmark method without US guidance mostly in right internal jugular vein among 69 patients younger than 20 years old between 2008 and 2019 with primary immunodeficiency diseases. Late complications were observed in 25% and the most common was infection related to catheter in 9.8% and noninfectious complications in 4.4-6.5%.[16] Their results were almost like our cases of open approach.

There are also other studies reporting lower complications among children who underwent US guided method for central catheter insertion.[21, 22] However, Choi et al. have reported that US guided insertion of catheter was associated with similar success and complications compared to the cut down group.[23]

In a study that used US guided port-a-cath insertion in children with cancer, malfunction and infection was reported in 9 (28.1%) and 4 (12.5%) cases which was more common than our patients which may be related to higher number of patients or earlier experience with port-a-cath use.[14]

This study had several limitations. It was a single center and cross-sectional study with small number of patients. All procedures were performed by the same team of pediatric surgeons. Follow up was performed for at least 6 months, whereas some complications may be observed later or during removal at the end of the period that the catheter is needed.

Conclusion

In our study to compare port-a-cath implantation by two methods of open and US guided, no statistically significant difference regarding gender of the patients and their underlying disease were observed. In both groups, complications were mostly late onset and most were observed in the open group; infection as a complication leading to the early removal of catheter was only seen in the open group in our study. US guidance in central venous catheter implantation can be suggested as a safe and accepted method in the pediatric age group. In addition, multicenter studies with more patients are recommended to be able to more accurately evaluate both methods and its complications.

With advance in technology all pediatric surgeons should be encouraged to increase their skill in the use of US guided insertion of port-a-caths in current practice. Also using color doppler US in the follow up of the patients is valuable in evaluating thrombosis formation and stenosis in the central veins and catheter flow rate to find asymptomatic cases earlier.

Ethical Approval

All children in our study needed having permanent central venous access for their treatment and all procedures were in accordance with the ethical standards of the institutional and the faculty of medicine, Shahid Beheshti university and national research committee.

Informed Consent

Written informed consent was obtained from all patients' parents or legal guardians or judicial authorities in case of orphan care center residency.

Conflict of Interest: None declared.

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