Clinical and Experimental Health Sciences

Management of Mechanical Problems of Totally Implantable Venous Catheters

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ABSTRACT

Objective: Although the most common complications of totally implantable venous catheters(TIVC) are infection and thrombosis, mechanical complications can also affect the treatment and cause catheter removal. This study aimed to investigate mechanical complications of TIVC and prevention methods.

Methods: Data of 983 procedures in 961patients who underwent TIVC implantation between 2010 and 2019 in AcibademMaslak, Bakirkoy, and Atakent Hospitals were retrospectively analyzed for mechanical complications.

Results: Mechanical complications were encountered in 33(3.3%) cases: 12(1.2%) were detachment of TIVC, 8(0.8%) occlusions, 5(0.5%) pneumothorax, 1(0.1%) hemothorax, 1(0.1%) malposition, 1(0.1%) extravasation, 2(0.2%) TIVC rotation, 3(0.3%) skin necrosis and extrusions.

Conclusion: The catheter tip should be placed in distal superior vena cava, reservoir pocket must be sufficient in size, reservoir should be fixed to pectoral muscle or fascia at least two points with nonabsorbable sutures. Subcutaneous fatty tissue resection from reservoir pocket should be performed in obese patients. The nature of the withdrawn blood form Seldinger needle should be checked visually whether venous or not. Risk of pneumothorax and detachment can be reduced by inserting the catheter from 1/3 outer part of the clavicle during percutaneous technique. While complication rate can be reduced by peroperative fluoroscopy use, control X-ray should be taken in symptomatic patients, not routinely. Malposition can be seen in the peroperative period and can usually be corrected by good manipulation. Percutaneous transcatheter retrieval in addition to surgery is the gold standard treatment for detachment of TIVC. The most important factors in preventing complications are surgical experience and good care.

Keywords: Totally implantable venous catheter, complication, detachment, malfunction, malposition.

1. INTRODUCTION

Totally implantable venous catheters (TIVC), which have become a part of oncologic therapies today, are being used especially for the administration of chemotherapy agents (1-3). They are more tolerable in daily life as there is no external unit like peripheral central catheters (2-7).

Although the most common complications are infection and thrombosis, mechanical complications such as catheter malposition, pneumothorax, catheter detachment, malfunction can also affect the treatment of the patient and cause catheter removal (7).

This study aimed to investigate the mechanical complications of TIVC and prevention methods.

This is a single-institution retrospective cohort study of oncologic patients who had TIVCs implanted by the same surgeon.

2. METHODS

Data of patients who underwent TIVC implantation between 2010 and 2019 in AcibademMaslak, Bakirkoy, and Atakent Hospitals were retrospectively analyzed. Non-oncologic indications were excluded.

TIVC implantations were performed in operating room under general anesthesia through subclavian vein(SV). In cases where the percutaneous technique failed, TIVCswereimplanted with open technique.

Catheter was inserted into the SVby Seldinger technique from 1/3 outer part of the clavicle with the catheter tip directed to suprasternal notch and a sufficient pocket for reservoir was prepared two cm caudally. Under guidance of fluoroscopic examination, length of the catheter was adjusted so that tip of the catheter remained in superior vena cava(SVC) near right atrium(RA). Catheter is attached to reservoir and secured with lock mechanism.Reservoir was fixed on pectoral

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muscle fascia with 2/0 polypropylene sutures.After testing for catheter integrity, the system was filled with heparinized solution. Control chest X-ray was not performed if there were no complaints such asdyspnea, cough, arrhythmia or malfunction in postoperative period.

In open technique, cephalic vein was released from the incision made ondeltopectoral sulcus. Following the cut-down, the catheter was inserted into the vein and length of the catheter was adjusted similar as in percutaneous technique. The catheter was fixed to the vein by silk ligation. From the same incision, pocket for the reservoir was prepared and same procedures were applied as in percutaneous technique.

General TIVC care was performed every 40 days by experienced medical staff in chemotherapy units.

This study was approved by Ethical Review Board of Acibadem Mehmet Aydinlar University on 09 January 2020 with number of 2020/01.

3. RESULTS

Data of 983 procedures in 961 patients who underwent TIVC implantation were evaluated retrospectively. At the time of implantation, the median age was 48.6±12.3 years, body mass index (BMI) was 26.04±4.79 kg/m^2. Primary malignancy was breast in 789, gastrointestinal in 139, and miscellaneous in 33 cases.

Total complication rate was 6% (n=60). Venous thrombosis (n=12,1.2%) and detachment of TIVC (n=12,1.2%) were the most common complications. Mechanical complications were encountered in 33 (3.3%) cases: 12 (1.2%) were detachment of TIVC, 8(0.8%) occlusions, 5(0.5%) pneumothorax, 1 (0.1%) hemothorax, 1 (0.1%) late malposition, 1 (0.1%) extravasation, 2 (0.2%) TIVC rotation, 3 (0.3%) skin necrosis and port extrusions.

In patients with detachment of TIVC, reservoir and associated catheter was excised surgically, while embolizedfragment was removed percutaneously. Only in one patient, the catheter which was migrated to hearth wall could not be removed. The patient was followed-up with anticoagulant therapy and no complication was detected during 11 months' follow-up. TIVC explantation was required in patients with occlusion, extravasation, malposition and skin necrosis. Surgical correction was performed for port rotation. Thorax tube drainage was applied to three of five patients with symptomatic pneumothorax and to the patient with hemothorax. There was no mortality due to mechanical complications at mean 34±74 months follow-up period.

4. DISCUSSION

TIVC improves quality of life and has lower infection risk than other catheter types, however, mechanical complications still can be encountered (1-3, 5-7). Complications rate decreases as surgical experience increases (8). However, they still increase hospitalizationduration, treatment cost, and morbidity and may cause delay in treatment (9).

Tip of catheter

There is no clear consensus on where the catheter tip should be; distal SVC, RA or atriocaval junction (6, 7, 10-12). The important thing is that the catheter tip should be in a high flow vein not to constantly contact vessel wall or not be in heart leading to arrhythmia. Placing the catheter in small caliber vessels increases endothelial damage, risk of thrombosis, vascular stenosis, and perforation (11). While Mudan et al (6) placed mid-atrial, considering that there is less risk of thrombosis, Machat et al (7) and Zhang et al (12) placed at distal SVC. During implantations, the patient should be well monitored forarrhythmias. In our clinic, the catheter tip is placed in SVC near RA, and no complications associated with its location were detected.

Post-implantation X-ray

In many clinics, peroperative fluoroscopy is used to control the position of catheter, but post-implantation X-ray control can be performed in centers without fluoroscopy (13). Kim et al. (4) reported that surgical experience, asepsis, and fluoroscopy use were effective in reducing surgical complications. X-ray control after fluoroscopy-guided implantation is controversial. Some centers advocate X-ray necessity due to pneumothorax risk (6, 7). In minimal pneumothorax, patient can be followed without thorax drainage, however, drainage should be considered in patients with respiratory complaints. Chest X-ray should be performed selectively according to patient's complaints, not routinely. Mudan et al. (6) routinely performed X-rays. Considering the pneumothorax rate of 1.2% (n=12) in their series, unnecessary X-ray was taken in 978 patients. Similarly, Velioğluet al. (14) routinely performed X-ray at postoperative period, however, considering pneumothorax rate of 0.8%, X-ray was unnecessarily taken in 2038 patients. However, in another study, routine X-ray use was found not cost-effective due to low complication risk (7). In our clinic, routine X-raywas not used if patient was asymptomatic.

Subcutaneous thickness

Two problems may arise related with patient's BMI and local subcutaneous thickness in the implantation area. The first problem is cosmetic dissatisfaction especially in patients with low subcutaneous tissue or in petite patients. In TIVC with smaller reservoir, catheter diameter also decreases, which is not preferreddue to increased occlusion risk. Therefore, it is necessary to inform patient before implantation for cosmetic results.

Contrary, in patients with high BMI or subcutaneous tissue thicker than 2 cm, reservoir cannot be felt or reservoir remains too deep to place port access needle sufficiently. Because the reservoir is fixed to pectoral muscle fascia, tissue thickness over it gains importance. For this reason, subcutaneous tissue should be excised if needed. Fosh et al. (8) recommended to place port in subcutaneous pocket, rather than suturing to pectoral fascia and various authors suggested to prepare reservoir pocket superficially in fatty tissue in obese patients, however reservoir rotation risk increases, so we do not recommend (3, 6).

Arterial puncture

Arterial puncture during implantation has been reported up to 11% (7, 14, 15). It can be distinguished by observing withdrawn blood from Seldinger needle by the color and pulsation of the blood. Generally, arterial puncture alone does not cause any complication, however, if dilatator or catheter is inserted complications such as hemothorax, arterial dissection, embolism, neck hematoma,pseudoaneurysm, a-v fistula, and thrombosis can be seen (7). Clinically unrecognized arterial puncture can be detected by fluoroscopy or subsequent chest X-ray (7). Risk of arterial puncturing can be reduced with USG guidance (7). Although USG is recommended for this purpose, we believe that USG is not crucial in experienced centers because of no arterial catheterization and associated complications seen in our clinic.

Pneumothorax and Hemothorax

These are the most feared and fatal complications. Pneumothorax is not expected with appropriate open surgical technique, but it has been reported in 1.5-6% with percutaneous technique (7). Zerati et al.(3) reported thatpneumothorax rate was 0.1% and USG is not necessary to reduce pneumothorax risk. In contrast, Mudan et al. (6) detected pneumothorax as 1.2% under USG guidance and recommended routine use. In this study, rate of pneumothorax was 0.5% (n=5) and hemothorax was 0.1% (n=1), so we conclude that USG guidance is not crucial in experienced centers. BMI of three patients with symptomaticpneumothorax was 19.92, 19.48 and 19.13kg/m^2 and BMI of the patient with hemothorax was 16.8kg/m^2. Although statistical analysis cannot be performed due to low patient number, we think that more care should be taken in patients with low BMI, considering the mean BMI was 26.04±4.79kg/m^2 in this series.

Thorax drainage may not be necessary in all patients with pneumothorax. Li Ma et al. (10) observed pneumothorax in 9 (0.3%) patients and drained two of them. Velioğlu et al. (14) detected pneumothorax in 16 (0.8%) patients and 14 of these underwent thorax tube drainage. In this study, drainage was performed in three of five patients who had respiratory symptoms. Postoperative chest X-ray is recommended in case of suspicion. In some centers, chest X-ray is recommended routinely, but in our center, we recommend only if the patient has symptoms.

Skin erosion and extrusion

It has been reported in literature at 0.7-5% (4, 13, 15). Incision site tension, repeated needle puncture, extravasation of chemotherapeutics may lead to skin erosion especially in lean patient (16). The reservoir pocket must be sufficient in size in order to reduce incision site tension (4). In cachectic patients, TIVC with a smaller reservoir can be used to reduce tension. Kim et al. (4) found 6 (0.7%) erosions; TIVC was removed in two patients, debridement, irrigation and resuture in others. In this study, three patients had erosion, and two developed extrusions and TIVC removal was required in all patients. In series of Yanık et al. (15), decubitus developed in 121(3%) patients, even though reservoirs were placed behind pectoral muscle in patients with very thin subcutaneous tissue.

Malfunction

General definition is inability to infuse fluids and/or aspiration of blood (14, 17). Considering that the primary purpose of TIVC is infusion,not aspiration, we believe that definition of malfunction should be only inability of infusion. It may be encountered in cases where catheter tipwas not be placed in correct position, kinking of catheter especially at entrance to vein, clot formation in tip of catheter, andport rotation (3). As catheter enters vein at right angles, it may increase risk of complications as it will reduce infusion flow rate and require more forceful injection. Fibrin sheath occurs around catheter within the first 24 hours after implantation (11). This fibrin sheath is usually fragmented but may cause occlusion if complete.In situations such as prolonged infusion time, injection of saline cannot be done, arm swelling, neck pain, and inability to puncture reservoir or extravasation, mechanical complications with fluoroscopic examination have been reported in 4.3% (7). In cases while fluids can be infused but blood cannot be withdrawn, once the catheter has been checked with X-ray and deep venous thrombosis has been excluded, catheters can still be used.

By minimizing use of catheter in procedures (i.e. blood drawing) other than infusion of chemotherapeutics, risk of catheter occlusion may be reduced (14). In cases of catheter occlusion with clot, fibrinolytic agent can be a choice.

In open technique, the catheter should not be angled to prevent malfunction. Additionally, extremely tight knotting should be avoided during ligation and fixation of catheter to vein.

Port rotation

Port rotation isa rare complication where reservoir is reversed and cannot be punctured with a needle (10, 15). Diagnosis can be made by physical examination or by X-ray. Yanık et al. (15) reported 4 (0.12%) patients and Li Ma et al. (10) reported 3 (0.10%) patients with port rotation. Treatment is revision of the reservoir. To prevent this complication, reservoir should be fixed to pectoral muscle or fascia at least from two points with nonabsorbable sutures. Port rotation was detected in 2 patients during years 2016-2017 when absorbable sutures were used as fixation sutures in this series. Diagnosis was made by physical examination and corrected by simple surgical intervention

Malposition

When upper extremity veins were used, orientation of catheter tip to a vessel except SVC or RA is called malposition (14). Risk of malposition has been reported 0.1-4.5% (1, 2, 10, 13, 15). Matiotti-Neto et al. (2) found no difference between open and percutaneous techniques. Malpositions

usually occur at time of implantation, but may develop later in cases of increased intra-thoracic pressure (11).

Malposition of catheter inserted into the SV may occur in internal jugular vein (IJV) or vice versa, or in veins such as azygos/hemiazygos vein, internal mammary vein, or ipsilateral/contralateral SV (7, 11) (Fig. 1, 2). It can also form coil within vein or migrate into the subintimalzone (11). Such malpositions can be easily detected during fluoroscopy or postoperative chest X-ray. In case of suspicion, it is necessary to take two-way radiographies or evaluate with computed tomography (11).

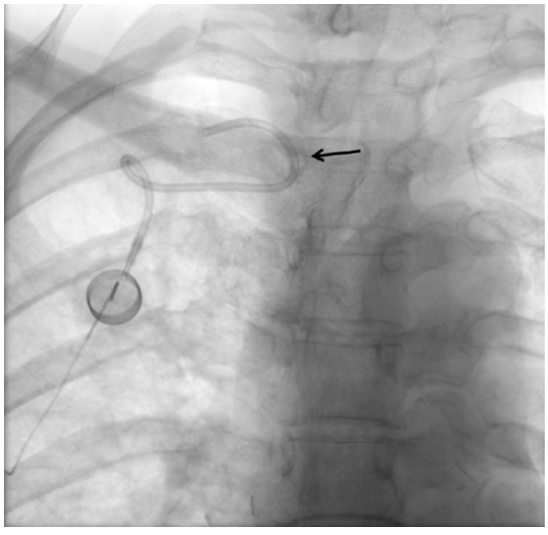

Figure 1. *Malpositionof catheter to ipsilateral subclavian veinis indicated by black arrow*

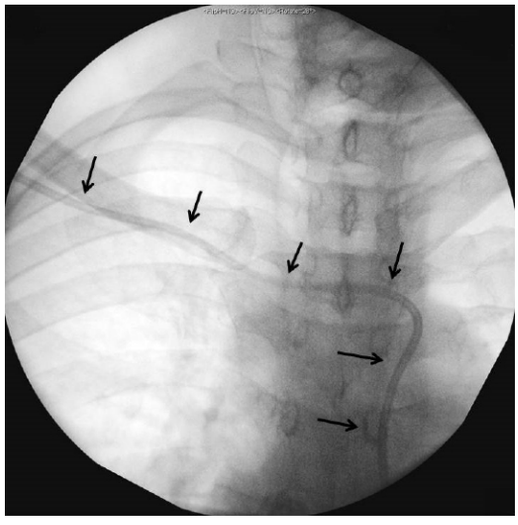

Figure 2. *Malposition of catheter to hemiazygos vein. The catheter is indicated by black arrows*

Venous thrombosis, erosion and perforation of the vessel wall, and catheter malfunction may be encountered due to malpositions.Various treatment methods can be tried (11). Catheter malposition can be corrected by forceful saline injection in small caliber catheters. If malposition is detected during implantation, inserting the guide wire into catheter and correcting malposition is an option.

Malposition of guide wire or catheter to contralateral SV during implantation is a condition we occasionally encounter (Fig. 3, 4). Correction of malpositions and orientation of catheter to SVC can be difficult. In such cases, we recommend to push forward the catheter rather than retracting and redirecting. Excess portion of catheter will be looped into the SVC,subsequently, when catheter is slowly retracted, tip will be placed in distal SVC by weight of the loop-shaped segment.

Malposition to IJVis rare in our clinic. To prevent this, patient is positioned to reverse Trendelenburg position while catheter is advanced.

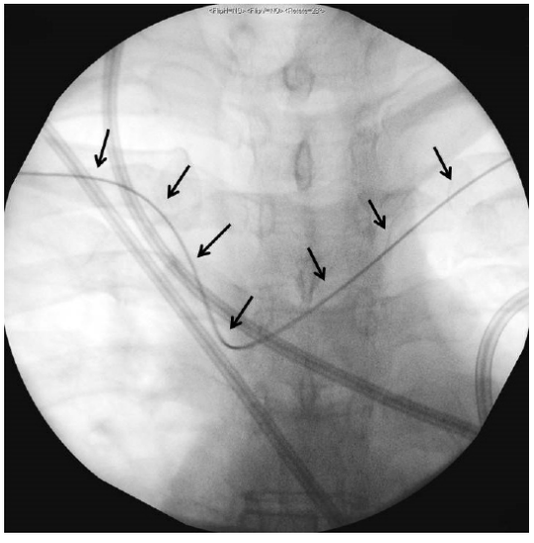

Figure 3. *Malposition of guide wire to contralateral subclavian vein is indicated by black arrows*

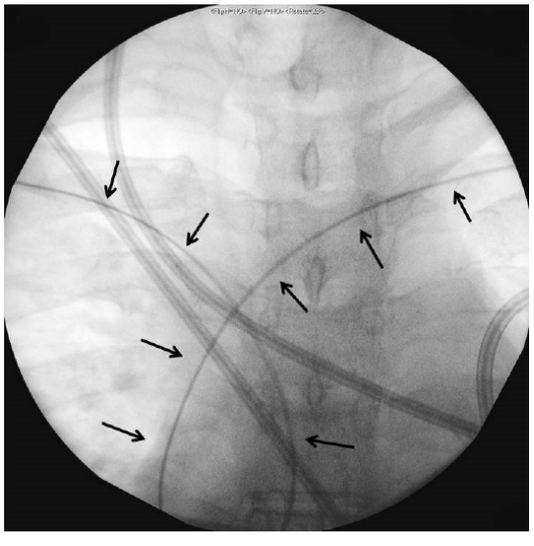

Figure 4. *Loop formation during correction of the malposition to contralateral subclavian vein. Black arrows indicate the looped guide wire*

Malposition into heart during implantation may be seen. Therefore, arrhythmias up to 41% have been reported in the literature (7). Catheter length should be well adjusted, should not be advanced too much and site should be checked by fluoroscopy during implantation. The presence of catheter on left mediastinum or aortic arch should suggest intraarterial malposition (11). Extravascular malposition should be suspected in cases where the catheter does not follow the expected venous trace, and care should be taken in this respect during follow-up, especially in post-traumatic radiographs (11).

The diagnosis of late malposition can be made on follow-up radiographs. Although routine chest radiography is not recommended as late malposition is not common, X-rays taken in the follow-up of primary disease should be looked at in this respect or should be taken if in doubt. Leaving the catheter tip short at the SVC may cause late malposition. We think that if catheter tip is left distal SVC or atrial, late malposition will not occur due to length and weight of catheter.Late malposition was detected in one patients and TIVC was excised because of catheter dysfunction (Figure 1).

Detachment

It is a rare complication reported requiring treatment due to potential complications (7, 18). In this series, we detected in 12 (1.2%) patients (Figure 5). It is usually seen after percutaneous SV catheterization, but it can also be seen when jugular vein is used or after open technique (19-22). Improper connection of catheter to reservoir, problems due to lock mechanism, incorrect manipulation, material fatigue, forced flushing, aggressive neck/extremity movements, trauma, orincreased intra-thoracic pressuremay lead todetachment of catheter. Pinch-off syndrome (POS) is the case where catheter is trapped and detached between 1st rib and clavicle (5, 9, 11, 23, 24).Surov et al. (21) reported POS (40.9%) as the most common cause of detachment, there was no etiologic factor in 19.1% of cases. In contrast, Chang et al.(24) reported fracture at the connection between reservoir and catheter (77 of 92 patient-84%) as the most common cause. It may be due to technical or production error (25). POS (66%) was the most common cause in this series.

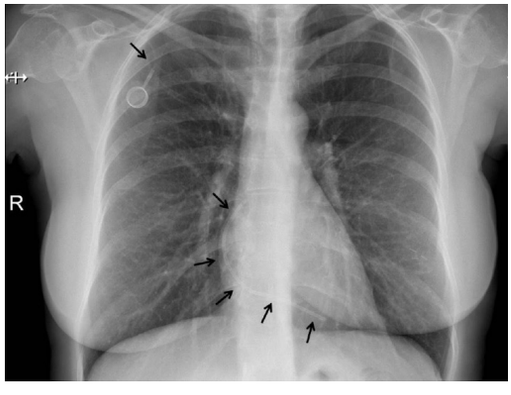

Figure 5. *Detachment and embolization of catheter to heart. The point of detachment and embolized catheter fragment is indicated by black arrows*

Most of the patients were asymptomatic and diagnosis was made by routine chest X-ray (3, 5). However, catheter malfunction, arrhythmia, pulmonary symptoms, septic syndromes, severe pain, inability to draw blood, extravasation, edema around the catheter and reservoir, and pain can also be seen (9, 21, 24, 26).

To prevent POS, insertion of catheter from lateral 1/3 of the clavicle is recommended (9, 23, 27). Two-stage treatment therapy is recommended (23). Percutaneous transcatheter retrieval of embolized fragment in addition to surgical removal of reservoir and attached catheter is the gold standard (5, 9, 21, 23, 24, 26, 28). If percutaneous removal is impossible, it can be removed by thoracotomy or followed by anticoagulant treatment for a long period (5, 21, 24, 29).

Experience and TIVC care

Experience of healthcare personnel is important in preventing complications. TIVC implantation following guidelines and with good care, complication rate can be reduced (6). Ertel et al. (30) reported that rate of complications was related to clinician implanting TIVC more than technique.Fosh et al. (8) draw attention to learning curve and report that complication rate is reduced with surgical experience. Particular care should be taken during port access needle entry toavoid accidental damage to catheter. Additionally, attention should be paid to infusion pressure range of implanted catheter.

It is recommended to wait for healing ofincision before use of TIVC, and flush catheter with heparinized solution after each use or at most 4-6 weeks (1, 5). However, Zhang et al. (12) stated that port can be used on implanted day. In our clinic, TIVCs are used by experienced nurses in the next day following implantation and we did not detect any complications associated with early use.

5. CONCLUSION

Diagnosis and treatment of mechanical complications of TIVCs are important to prevent delay in the treatment of the patient.The catheter tip should be placed in SVC near RA, the reservoir pocket must be sufficient in size, reservoir should be fixed to pectoral muscle or fascia at least from two points with nonabsorbable sutures. Subcutaneous fatty tissue resection should be performed in obese patients. The nature of the withdrawn blood form Seldinger needle should be checked visually whether venous or not. Risk of pneumothorax and detachment can be reduced by inserting the catheter from 1/3 outer part of the clavicle in percutaneous technique. While complication rate can be reduced by peroperative fluoroscopy use, control X-ray should be taken in symptomatic patients, not routinely. Malposition can be seen in the peroperative period and can usually be corrected by good manipulation. Percutaneous transcatheter retrieval in addition to surgery is the gold standard treatment for detachment of TIVC. The most important factors in preventing complications are surgical experience and good care.

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Informed consent: Informed consent was not needed due to being a retrospective study.

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