Role of Interventional Radiology in Provision of Venous Access

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Abstract: The **aim** of this study was to illustrate different types of vascular access devices, their indications & associated complications as well as to highlight the role of interventional radiologists & image guided techniques in safe placement of these devices. **Methods:** forty patients were included in our study with an age range 15 – 62years, divided into 3 groups (oncology, dialysis and critical care groups), they underwent full history taking, clinical examination and laboratory tests including complete blood count, serum creatinine & coagulation profiles. Ultrasound & color Doppler were performed for all cases & contrast venography to some cases to select access route. Image guided insertion of vascular access devices was performed through traditional (jugular, subclavian & basilic) & non-traditional (brachiocephalic, SVC collateral, hepatic & internal mammary) routes. 39 long term (ports, dialysis catheters & Hickman) & 1 intermediate term (PICC) devices were used. Patients were followed up clinically & radiologically (by ultrasound & X-ray) for 3months, all complications were reported. **Results:** technical success was achieved in all cases, 37 cases from single puncture. Among our cases 2 patients (5%) had intra-operative minor complications (arterial puncture & puncture related hematoma), 4 patients (10%) suffered catheter related infections; 2 were removed & the other 2 were exchanged, 2 devices (5%) became non-functioning due to catheter thrombosis & fibrin sheath III formation and were resolved by balloon & catheter exchange, 1 device was accidentally dislodged. Among all, 3 patients were lost to follow up. **Conclusion:** Radiologists are ideally suited to provide vascular access services to children & adults because of inherent safety advantages and higher success from using image-guided techniques. The choice of the VAD primarily depends on the indication for its insertion & duration of need.

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1. Introduction

Venous access is a method that allows direct access to the blood stream for physicians to deliver medicine or withdraw samples without repeatedly puncturing the blood vessels.

The use of **totally implantable venous access devices (TIVADs)** has revolutionized the care and quality of life for cancer patients and patients requiring long-term intravenous therapy. These devices allow chemotherapy infusion, antibiotic administration and blood sampling without the need for repeated venepuncture. ***(Zaghal et al, 2012)***.

Venous access can be divided into two categories – **peripheral venous access and central venous access.** Peripheral venous access lines, including conventional peripheral intravenous lines (PIVs) and midline catheters, terminate in peripheral veins outside of the thorax. Central venous access catheters terminate within the central veins of the thorax, ideally at or below where the superior vena cava and right atrium meet at the cavoatrial junction. ***(DePietro et al, 2018)***

Interventional radiologists are well-equipped to place and maintain these devices given their skills in traversing chronic venous occlusions and their use of thrombolytics and other methods to restore catheter patency in almost 90% of cases. Short-term complications of port placement, such as malposition, hematoma formation, and pneumothorax, are practically nonexistent due to the routine use of **ultrasound and fluoroscopic guidance** during these procedures. ***(Walser et al, 2012)***.

Imaging-guided placement; particularly **ultrasound guidance** is the preferred method of insertion in many institutions because of higher success rates & dramatic decrease in insertion related implications. **Combined fluoroscopy & ultrasound guidance** can provide faster & more accurate insertion technique as well as minimizing procedural related complications. ***(Gallieni et al, 2008)***

The complications of venous access devices can be classified into 2 main categories; **(A) early** (intra-operative and post-implantation period to first use) and **(B) late** complications. They include rrhythmia, puncture hematoma, device occlusion, break or mal-position, line-related infections & pleural injuries. ***(Shengfen et al, 2012)***.

2. Patients and methods

Between December 2018 and May 2019, we performed insertions of VADs for forty patients requiring I.V. access. Patients were classified into 3 main groups according to the need for venous access:

1. Oncology group (19 patients).
2. Dialysis group (15 patients).
3. Critical care group (6 patients).

From the technical aspect, our methods are described according to the inserted VAD including:

A) PICC lines.
B) Short term central lines.
C) Tunneled central lines.
D) Implantable venous ports.

All procedures were performed in the "Interventional Radiology Unit" of the Radiology Department, Sayed Galal university hospital.

Inclusion criteria:

Patients of any age group requiring emergency or long term I.V. access.

Relative contraindications:

Patients with bleeding tendency, hypertension, respiratory distress preventing them from lying supine, infection at insertion site.

Pre-procedure assessment & preparation:

Clinical:

History (personal, detailed present, past and family history).

Physical examination included an assessment of vital signs, the pulmonary and cardiac status.

Decisions about overall strategy were made ahead of time, to permit accurate device selection, smooth and efficient performance during the case. Plans included:

Choice of access vessel.

Device types and sizes.

Site for subcutaneous tunnel or pocket.

The protocol of management was discussed & planned with the referring physician.

Explanation of the decided protocol of treatment and its possible complications to the patient was done. Informed consent was taken in all cases.

Patients with hypertension and bleeding tendency were medically controlled till the time of procedure.

Patients were required to fast for 4-6 hours prior to the procedure, except for medications.

One peripheral intravenous line was placed for I.V. medication and/or contrast injection, if imaging of the contra-lateral limb was needed, another peripheral line was placed.

Laboratory:

Blood work was performed and revised (CBC, liver function tests, kidney function tests, PT, PC and INR)

Imaging:

All previous radiological investigations including Doppler ultrasound, CT and MRI studies of the patients were reviewed.

Intra-operative Doppler ultrasound examination of the patients was done, to understand the target vessel geometry and patency, as well as to exclude central occlusion & anatomical variations.

Technique:

Doppler ultrasound examination of the target vessel & planning for site of entrance, local anesthesia was given.

A high-frequency linear array transducer (10–15 MHz) was used. The transducer was covered with a sterile sleeve or sterilized with alcohol & betadine, then used for real-time vascular puncture. The transducer was oriented transversely in cases of jugular & internal mammary veins punctures, and longitudinal to the vessel being punctured in the rest of cases.

After localizing the target vessel, the puncture needle was advanced into the subcutaneous tissues. The tip of the needle was identified in the tissues by placing the US transducer almost directly over the skin puncture site. When the tip was confidently identified, the needle was slowly advanced toward the target vessel. The US transducer was slowly advanced keeping the needle tip and target vein in view.

Single wall puncture was achieved by changing the angle of puncture such that the needle became more parallel to the vessel especially with superficial veins. When deeper vessels were punctured, puncturing the back wall was avoided. Achieving a single-wall puncture ensured successful catheterization.

After the front wall of the vein was punctured, the needle tip was identified within the lumen. The needle was advanced within the vessel lumen using US to avoid puncturing the back wall.

Venogram was done in cases with suspected occlusion of central vein or to visualize collateral pathways. I.V. contrast was injected into peripheral lines or directly into the puncture needle.

A) PIC line insertion

The following set was used:

- o PICC with stylet
- o 5fr peelable sheath
- o 22g introducer needle
- o 10ml syringe
- o Mini scalpel
- o 0.018'' x 100cm "j" flex guide wire
- o Tape measure
- o Catheter securement device
- o Patient information pack
- o Patient chart sticker

The right basilic vein was used for insertion.

Applying a tourniquet at mid arm.

Cannulation of the target vein just above the elbow joint using the introducer needle under US guidance.

Insertion of the guide wire under fluoroscopic guidance till just below the shoulder joint.

Removal of the tourniquet.

Withdrawal of the needle.

Introduction of the peel-away sheath over the wire.

The length of catheter is adjusted according to the required tip position using the measurement tape; the remaining part is cut off.

Removal of the wire & dilator.

Advancement of the PIC line with the stylet under fluoroscopic guidance & adjusting tip position at SVC–right atrial junction, then removal of the stylet.

B) Short term central lines

The following sets were used:

o catheter
o Introducer needle
o Vessel dilator
o 5ml syringe
o Mini scalpel
o 0.035'' x 100cm "j" flex guide wire
o Movable wing
o Injection caps
o Patient chart sticker

The right IJV was used in most cases.

With a towel under the patient's shoulder, central vein puncture was made using the introducer needle.

The US transducer was oriented transverse to the jugular vein, and the puncture was made longitudinal to the transducer, approaching the vein laterally. This allowed the catheter to have a gentler curve into the vein and prevents kinking.

The guide wire was introduced.

The puncture site was dilated using the set dilators.

The catheter was advanced over the guide wire under fluoroscopy, and the guide wire was removed.

The catheter was immediately accessed and flushed with saline & heparin lock.

Sutures (non-absorbable silk 2.0 or prolene 2.0) applied at exit site to secure catheter.

C) Tunneled central lines

The following sets were used:

o Hickman set:
o Dialysis catheter (permacath):
o Catheter
o 10fr vascu-Sheath
oTunneler
o Scalpel
o 0.035" x 100cm "j" flex guide wire
o Patient ID label
o Injection caps
o 18GA needle

Same steps as explained in short term central line were used till insertion of the guide wire.

The subcutaneous tunnel was created. An exit site approximately midway between nipple and axilla was selected, avoiding breast tissue in female patients. After a small incision was made, the tract entrance was expanded with blunt dissection.

A plastic or metallic tunneler (blunt trocar) -with the catheter attached to its end- was used allowing the catheter to be pulled through the tunnel, exiting at the venipuncture site in the neck.

The catheter with Dacron cuff was then pulled well into the tunnel so that the cuff was approximately at midpoint of the tunnel.

The catheter length was either predetermined in case of using a haemodialysis catheter by selecting appropriate cuff-to-tip length, or adjusted by cutting the catheter to length using fluoroscopy while the catheter was laid over the patient's chest in case of Hickman's catheters.

After that, attention returned to the venipuncture site.

The peel-away sheath was introduced, and preparation for catheter insertion was made. During the subsequent step, the dilator was removed from the peel-away sheath and the catheter was introduced. The risk of air embolism was minimized by having the patient suspend respiration or applying positive-pressure ventilation with anesthesia.

The dilator & wire were quickly removed and the catheter tip introduced into the peel-away sheath.

The tip position at atrio-caval junction or within right atrium was verified with fluoroscopy and the sheath removed.

Fluoroscopy of the entire catheter course confirmed that there were no kinks or twists in the catheter.

In two dialysis cases, the guide wire was inserted to help straighten and reposition the catheter.

The catheter was immediately accessed and flushed with saline & heparin lock.

Sutures (non-absorbable silk 2.0 or prolene 2.0) were applied at exit site to secure catheter.

D) Implantable venous ports

The following set was used:

o Implantable port
o 2.8mm x 50cm Venous polyurethane catheter
o Connection ring
o Rinse catheter
o Huber straight needle
o Syringe
oTunneler
o Peel-away introducer
o Guide wire
o Puncture needle

o Huber extension set

o User manual & sticker

The site of veni-puncture is the right IJV in almost all cases.

The site for port placement was selected laterally on the flat anterior chest wall, avoiding breast tissue and axillary crease. The second anterior rib, marked fluoroscopically, was used to provide stability when accessing the port later.

The incision for the pocket was created just above the planned pocket location, and local anesthesia was achieved with lidocaine. The incision was made with a scalpel blade. The pocket between the subcutaneous fat and the muscle fascia layer was then created using blunt dissection with curved clamp instruments and little finger tip inserted to expand the pocket.

When the port fitted into the pocket easily, then the subcutaneous tunnel was created connecting the pocket to the venipuncture site at the neck. The catheter was pulled through the tunnel.

The catheter was connected to the port and the port placed into the pocket.

Suturing the port to the fascia (using a single non absorbable suture) was used to avoid flipping of the port.

The catheter was then cut to length as explained in tunneled devices.

Introduction of the catheter through the peel-away sheath at the neck was done with measures to eliminate risk of air embolism. The port was immediately accessed and flushed with saline & heparin lock.

The port pocket was then closed with simple interrupted sutures using 2.0-3.0 non absorbable (e.g. prolene) suture to close the skin.

The neck incision was closed with one subcutaneous stitch.

Post-procedural care & follow up:

The patient was kept at bed rest in a flat position, for 1-2 hours.

Post procedural Doppler assessment of the targeted vein patency was performed.

Post-procedural medical management were prescribed according to the condition of the patient:

Analgesics for puncture site pain.

Antibiotics for implantable ports, combination of 2 broad spectrum antibiotics (e.g. Augmentin & Ciprobay), for 1 week, the dose was adjusted according to the patient's age.

Clinical follow up was done during the 3 months following the procedure, to detect any clinical complication related to the catheter placement. The follow up period was divided into 1 month, 1-3 months post procedural follow up intervals.

Any clinical event during or within 1 month after treatment, minor or major, transient or permanent, which might be even remotely associated with the procedure, was considered to be procedure related.

If any complication occurred, the suitable imaging modality was done (either plain X-ray, fluoroscopy with contrast injection or CT), aiming for exact explanation of its cause.

Follow up plain X-ray was done 3 months after the procedure to check catheter position.

Instructions to the physician & patient:

Special instruction were given to the caring physician and/or nurse regarding handling of the catheter to prolong its duration & minimize the complications including:

o Using aseptic technique while using the catheter & changing the dressing.

o Careful handling of the catheter to avoid dislodgement.

o Flushing the catheter with saline before & after usage as well as applying heparin lock.

o Checking for any emerging complications such as infection at puncture site or tunnel, catheter obstruction or extra-vasation, and reporting such complications to the interventionist.

Other instructions were given to the patient such as avoiding contamination of the puncture site, subcutaneous tunnel or pocket especially before complete healing of the wound, compliance with post procedural medications and reporting any unusual symptoms to the attending physician such as excessive pain or constitutional symptoms.

3. Results

Venous access devices were provided for 40 patients. There were 10males (25%) and 30females (75%) with a mean age of 38.17 years (range, 15-62 years).

Table 1. Sex of patients

		Count	%
Sex	Male	10	25%
	Female	30	75%

Table 2. Age of patients		
	Mean	**Standard Deviation**
Age	38.17	29.99

Table 3. **No of patients**	
1 session	36
2 sessions	4

36 patients underwent 1 session, 4 underwent 2 sessions for catheter exchange or fibrin sheath disruption.

Table 4. **Patients lost to follow up**	
Lost to follow up	3
Total	40

Among all, 3 were lost to follow up.

Indication for venous access:

Table 5. Indication for venous access		
	Number of patients	**%**
Chemotherapy	19	47.5
Dialysis	15	37.5
IV infusions	6	15

Out of the 40 patients, 19 of them were oncology patients who needed chemotherapy, 15 had chronic renal failure and were on haemodialysis, 6 were in the critical care unit and needed IV infusion.

Choice of VAD:

Long term tunneled devices were inserted for 39 patients & 1 intermediate term device was inserted for 1 patient.

- Implantable ports were used for the 19 patients coming for chemotherapy (prolonged, intermittent use), sizes used were 9fr & 7fr.
- Dual lumen cuffed dialysis catheters (permacath) were used for the 15 patients with chronic renal failure who required hemodialysis, sizes used were 8fr x 18cm and10fr x 24cm.
- Double lumen cuffed Hickman catheters were used for the 5 patients who needed long term IV infusion, size use was 9.5fr.
- One single lumen PICC line was inserted for 1 patient who needed intermediate term IV infusion, size used was 4fr x 60cm.

Table 6. Type of VAD				
Duration	type	size	Count	%
Intermediate term	PICC	4fr x 60cm	1	2.5
Long term	Dialysis catheter	8fr x 18cm	10	25
		10fr x 21cm	5	12.5
	Hickman	9.5fr	5	12.5
	Port	9fr	17	42.5
		7fr	2	5

Puncture site:

- The right internal jugular vein was the main site of entrance for 26 cases; 18 of the port cases, 5 patients for IV infusion & 3 patients on hemodialysis.
- The left internal jugular vein was used for 1 port case.
- The right brachio-cephalic vein was used in 2 dialysis patient.
- The right basilic vein was used for 1 PICC line case.
- Non-traditional access routes were used for 10 patients on regular dialysis; the hepatic veins were used in 7 patients, the right internal mammary vein was used in 2 patients and collateral to the SVC was used in 1 patient.

Table 7. Puncture site				
Vein	side	reason	Count	%
IJV	right	Patent vein	26	65
	left	Occluded right side	1	2.5
Brachio-cephalic	right	Occluded jugular veins Preserve subclavian vein for fistula	2	5
Hepatic	Right		5	12.5
	Middle		1	2.5
	left	Occluded neck and central veins	1	2.5
Internal mammary			2	5
Collateral to SVC			1	2.5
Basilic	right	superficial	1	2.5

Procedural details:

1. **Use of ultrasound:**

Ultrasound guidance was used for all cases.

2. **Use of fluoroscopy:**

Intermittent fluoroscopic guidance was used for all cases.

3. **Contrast injection:**

Intra-procedural contrast injection was performed in 11 cases; 1 case with PICC line & 10 cases with non-jugular access (5 transhepatic accesses, 2 brachio-cephalic accesses, 2 internal mammary accesses & 1 SVC collateral access).

The aim of contrast injection was to confirm patency of central veins, detect collaterals or to check flow around catheter tip & side halls.

29 cases didn't require contrast injection.

Table 8, Use of IV contrast		
Contrast used	**Count**	**%**
Yes	11	27.5%
No	29	72.5%

4. **Type of anesthesia:**

Local anesthesia was used for all patients.

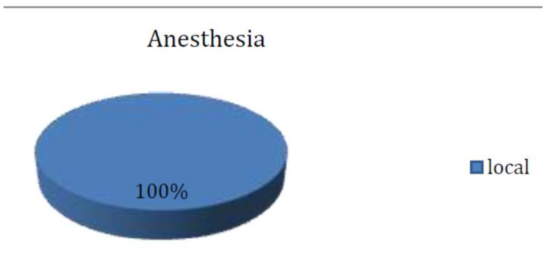

Fig 1, Type of anesthesia

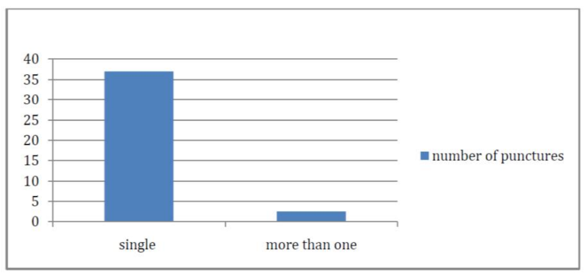

Fig 2, Number of punctures

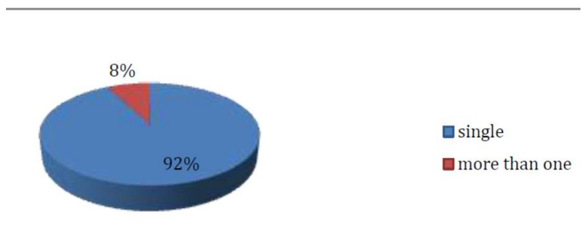

Fig 3, Number of punctures

5. **Number of punctures:**

In 37 cases, the target vein was punctured using a single puncture. In 3 cases only 2 punctures were required; 1 due to accidental arterial puncture leading to a small hematoma that needed to be compressed, second case was due to misplaced needle during wire insertion & the last case due to needle obstruction by a blood clot.

6. **Intra-procedural complication:**

In all patients, only 1 dialysis patient was complicated by arterial puncture with a resultant small hematoma that was controlled by manual compression, and the procedure was completed successfully, follow up Doppler ultrasound revealed no arterial stenosis or dissection, the hematoma resolved within 1 week.

In another patient coming for port insertion, a small hematoma was also formed around the punctured jugular vein despite normal coagulation profile. The hematoma resolved after few days on follow up ultrasound.

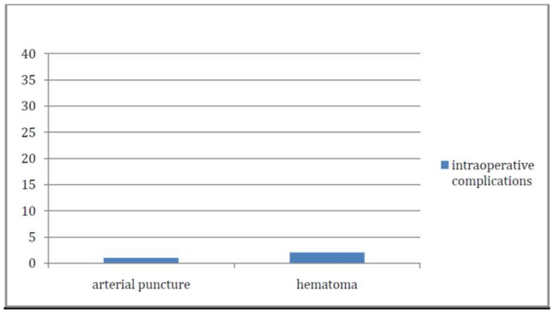

Fig 4, Intra-operative complications

Immediate outcome:

Technical success was defined as achieving the venous puncture, insertion of the VAD with tip position at atrio-caval junction or within the right atrium with free in & out flow through the catheter.

For the dialysis catheters, adequate in & out flow was observed through the side openings & tip of the inserted catheters in all dialysis patients.

Fluoroscopy was used to confirm absence of kinks along the course of the inserted catheters, tip positioning & free flow of contrast through the catheter with opacification of the right atrium & absence of extra-vasation (in the injected cases).

The catheter tip was inserted in the at the atrio-caval junction in 32 patients & in the right atrium in 8 patients.

No kinks or contrast extra-vasation were encountered.

Table 9, Immediate outcome

	type	Count	%
Technical non-success		0	0
Catheter tip	Atrio-caval	32	80
	Right atrium	8	20
Intra-operative complications		2	5
Free in & out flow with no resistance		40	100
Contrast injection confirmed free flow & no extra-vasation		11	27.5

1 month follow up:

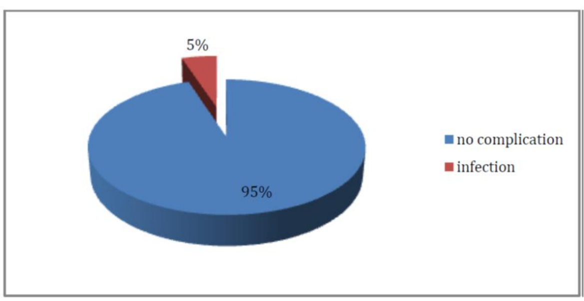

Fig 5,1 month follow up results

During the 1st month follow up period 38 patients didn't suffer any complications with adequately functioning access devices. The PICC line was removed after 2 weeks following the insertion of the line.

1 patient with an implantable port developed cellulitis at the site of the infra-clavicular pocket, attempts to control the infection by systemic antibiotics failed with subsequent sloughing of the overlying skin. The port was removed 26 days after its insertion.

1 critical care patient developed fever with positive blood culture from the catheter & the catheter had to be exchanged with a new one in a 2nd session.

1-3 months follow up:

38 patients were followed up in this period; 18 oncology, 5 critical care & 15 dialysis patients.

Another critical care patient developed fever with positive cultures from the catheter, the catheter was removed. For theother 4 critical care patient, the catheters were removed during the 3 months follow up period.

1 dialysis patient with a dialysis catheter inserted through the right IJV suffered from poor flow through the catheter. The patient was scheduled for a 2nd session where contrast injection revealed fibrin sheath in the SVC & around the catheter tip. Disruption of the fibrin sheath using a balloon was performed. The catheter was exchanged with restoration of adequate blood flow.

A 2nd dialysis patient suffered also from poor flow through the catheter and was scheduled for a 2nd session. Intra-luminal thrombi were found inside the catheter and the catheter was exchanged with a new one.

1 dialysis patient with tunneled catheter suffered from infection around the exit site with failed antibiotic therapy, the catheter was exchanged in a 2nd session and the tunnel course was shifted medially away from the infected site.

Another dialysis patient returned for the 3 months follow up, his catheter was found to be accidentally dislodged & was replaced by a bed side central line to be exchanged latter by a tunneled catheter.

3 patients were lost to follow up in the 1-3 months follow up period, 2 dialysis patients died from severe chest infections, 1 patient with breast cancer who had an implantable port died from progressive brain metastasis.

The rest of the patients remained free of complications with functioning access devices for the rest of the 3 months follow-up period.

Table 10, 1-3months follow up results

		Count	%
Lost to follow up		3	7.8
Complicated	infection	2	5.2
	thrombosed	1	2.6
	dislodged	1	2.6
	Fibrin sheath	1	2.6
Non complicated and/or removed		30	78.9

4. Discussion

Venous access is a method that allows direct access to the blood stream for physicians to deliver medicine or withdraw samples without repeatedly puncturing the blood vessels. Establishing and maintaining venous access forms an increasing proportion of the workload in interventional radiology due to the role image guided techniques in safe placement of these devices.

Patients of different age groups were referred form many departments such as oncology & nephrology departments as well as the critical care unit. They had different indications for venous access. The choices of the access device as well as the access route were planned carefully according to the indication & available sites of insertion.

We combined ultrasound & fluoroscopy guidance in all cases with the use of contrast venography in some patients aiming at reducing the complications rate & shortening the procedural time.

Forty patients were included in our study & were divided into 3groups (oncology, dialysis & critical care groups); they underwent full history taking, clinical examination and laboratory tests.

Image guided insertion of vascular access devices was performed through traditional (jugular, subclavian & basilic) & non-traditional (brachiocephalic, SVC collateral, hepatic & internal mammary) routes. 39 long term (ports, dialysis catheters & Hickman) & 1 intermediate term (PICC) devices were used.

Patients were followed up clinically & radiologically for 3 months, all complications were reported.

Patient demographics:

In our study, the mean age of the patients was 38.7 years. The patients' ages ranged between 15 & 62 years which explains the broad need for venous access among different age groups & elaborates the important role played by interventional radiologists to provide such access. ***Hwang, 2012***, stated that in the United States only, about 5 million central venous catheters are inserted every year.

In our study, we concluded that the need for venous access varies according to patients' age, where in pediatric group the access is mostly for prolonged provision of infusions, dialysis or measuring venous pressure, while in elderly patients, the need for access for chemotherapy & dialysis was predominant. This agrees with the results concluded by ***Lyon et al, 2008.***

There was a female predominance in our study. We performed the venous access for 30 females and only 10 males, that is to say that females represented 75% and males 25%, however the female ***et al, 2014)*** discussing outcome of radiological-guided venous access. predominance was mostly in the oncology group, 18 out of 19 patients, most of them had cancer breast or cancer colon which are more prevalent in females. Female dominance is also reported in recent studies ***(Granziera et al, 2014) & Seok.***

Implantable ports insertion in females was easier than the male case due to abundant subcutaneous fat facilitating the creation of the pocket for port insertion, however female patients were more challenging in terms of less tolerance to local anesthesia as well as for cosmetic fears. Guided insertion helped minimize the procedure time & the extent of dissection needed. Similar results were concluded by ***Zhou et al, 2014,*** which stated that using a US guided IJV puncture to completely implant a port is feasible and safe in patients with breast cancer.

In the non-oncology group including the dialysis & critical care group, the female to male ratio was 4 to 3.

Indication for venous access:

Lyon et al., 2008 stated that, several patient groups require venous catheters for variable reasons, medium-term to long-term catheters for chemotherapy, anti-microbials & parental nutrition, while short term venous catheters are required mainly for haemodialysis. In our study, 2 maincategories contributed to more than 75% of the cases, these categories were patients who had cancer & needed chemotherapy (referred to as oncology group) & patients who needed haemodialysis (referred to as dialysis patients).

The abundance of cancer patients especially females with cancer breast is justified with the age standardized cancer incidence rate per100,000 Egyptian females being 157.0 and the commonest site being the breast (15.4%). ***(Amal et al., 2014).*** Our oncology patients required prolonged chemotherapy as adjuvant therapy or as a method for palliation, in addition to multiple follow up imaging that usually require IV contrast injection.

Our 2nd largest target group was the haemodialysis patients. The incidence of dialysis patients in Egypt in the year 2000 was estimated to be75.1/1000000. However, end-stage renal disease (ESRD) has significantly increased in Egypt & other developing countries in the last decade. Diabetes mellitus is still the leading cause of ESRD, while numbers of hypertensive patients among the population have significantly risen. ***(Soliman et al, 2012).***

In the dialysis group, we used tunneled-cuffed catheters as a bridge to fistula creation or in case of a non-functioning fistula since they are associated with lower rates of bacteraemia & exit site infection as stated in many studies. ***(Asif et al., 2005).***

Strategy of venous access provision:

a) Choice of venous access device:

Our strategy for choosing a vascular access device was primarily dependant on the purpose for the line i.e. the indication for venous access.

We agreed to Gallieni, 2008, which stated that short term central lines are ideal for continuous, short term infusions for 1 to 3 weeks, and that dual lumen lines can be used temporarily for haemodialysis. In our institution we insert the short term central lines for the hospitalized patients due to the associated high risk of blood stream infection, and practically due to incompatibility with daily life activities. We use central lines as a temporary access for haemodialysis until a cuffed catheter is made available or in case of an infected or obstructed catheter.

According to ***Bishop et al, 2007***, intermediate term vascular access devices are suitable for prolonged intermittent use typically for 2 or 3 months duration. PICC lines can be used for continuous infusion therapy in hospitalized patients or intermittent use in outpatients e.g. for chemotherapy or blood transfusion. Our experience with PICC lines is limited due to limited number of referrals, we only did one case which was an old male patient with poor peripheral veins, the referring clinician needed an alternate for short central line insertion for fear of infection. The patient had the line for only 2 weeks and was removed afterwards.

The low rate of PICC line use in hospitals is mainly due to their physical properties being small in caliber & difficult to manipulate. This was stated by ***Ponikvar et al, 2005,*** which also stated that thrombosis rate rises from 21% with SVC tip position to 60% with a subclavian or in nominate position. 21% of catheters are emoved because of premature failure predominantly due to occlusion or phlebitis.

We used long term tunneled, cuffed access lines for prolonged mostly intermittent use i.e. more than 3 months duration. In our study tunneled catheters were used for haemodialysis. This agrees to ***Ameuser, 2005,*** who stated that tunneled cuffed catheters have anchoring Dacron cuffs which induce fibrosis in the subcutaneous tunnel helping catheter fixation within 3-4 weeks after insertion & reducing the associated risk for infection.

Implantable ports were reserved for outpatients receiving prolonged intermittent chemotherapy infusions, usually on weekly or monthly basis. Only single lumen ports were used as there was no specific indication for double lumen ones (reserved for simultaneous infusion of non-compatible drugs). This agrees to ***Biffi et al, 2001 & Seok et al, 2014*** who also stated that ports allowed better bathing & provided better appearance with no impairment of lifestyle, and above all there was no associated risk of dislodgement.

b) Puncture site:

Traditional access route:

Oliver, 2001 & Bose et al, 2014, stated that the internal jugular & subclavian veins are favored access sites for tunneled and non-tunneled devices. Subclavian venous catheters are better avoided in patients with severe hypoxemia as pneumothorax is less readily tolerated. Subclavian access is contra-indicated in dialysis patients to avoid subclavian stenosis.

A low right internal jugular access has the least likelihood to develop catheter dysfunction, venous stenosis or occlusion and to deliver higher flow rates for dialysis patients.

We followed these results in our study, where the right IJV was the1st choice for puncture site for the central lines followed by the left IJV followed by the right brachiocephalic vein (whenever accessible) followed by the subclavian route. If these routes weren't available, we startedsearching for non-traditional routes.

Twenty six patients (more than 65% of the cases) had their linesinserted through a low right IJV puncture. One patient from the oncology group had her line inserted through the left IJV due to chronic occlusion ofthe right side. Two patients from the dialysis group had their lines inserteddirectly into the right brachiocephalic vein which was still patent whileboth jugular veins were occluded.

The single PICC line used was inserted through the right basilica vein at mid arm following ***Donaldson, 2006*** who stated that the basilic veinwas the preferred site for access being the most superficial vein running in the groove between the brachialis & biceps muscles and that access midway between the elbow & axilla kept the catheter well above the elbow & well tolerated by the patient.

Non-traditional access route:

For the remaining 10 patients (25% of the cases) we had to search for alternate non-traditional routes, collaterals to the SVC were first studied using Doppler ultrasound & venography. If such route wasn't feasible, we referred to transhepatic route. This disagreed to ***Yaacob et al,2011,*** which referred to translumbar route before considering the transhepatic access in cases with central venous occlusion for fear of possible complications associated with transhepatic route, such as bleeding, catheter dysfunction, and biliary-related complications especially with the use of large catheters.

c) Ultrasound guidance:

Gallieni et al,* 2008,** described ultrasound guidance as state of the art being the only procedure that has been evaluated in RCTs, and that during internal jugular venous catheterization, ultrasound guidance (both2-D & Doppler guided methods) clearly reduced the number of complications, failures & time required for insertion. ***Hwang, 2012, also stated that ultrasound guidance for central vascular cannulation should be routinely performed in clinical anesthesia.

We used ultrasound guidance with all patients in order to reduce the complications rate & shorten the procedure time. We aimed at pointing out the paramount role of ultrasound guidance in the provision of venous access devices & inherently the important role played by interventional radiologist being the pioneers in ultrasound use.

d) Number of punctures:

Ultrasound guidance was the gold standard in all cases, in 37patients (92% of the cases), the target vein was punctured from the firstattempt, in only 3 patients 2 punctures were required, one of them was a left IJV puncture which may be attributed to technical difficulty, the other 2were due to a blood clot inside the needle & needle misplacement during wire insertion respectively. Our results were better than results reported.

by ***(Bose et al, 2014,);*** the success rates for insertion at first, second, and third attempt were 52.6%, 31.6%, and 5.2% for IJV.

e) Need for anesthesia:

Local anesthesia was sufficient & well tolerated by all patients which can also be attributed to short procedural time & limited number of punctures. This is of particular importance as most patients needing venous access have co-morbidities that affect their tolerance to general anesthesia.

f) Combined fluoroscopy:

Combined intermittent fluoroscopy was used in all cases. However contrast was only used for 11 patients, mostly with non-traditional access.

The role of fluoroscopy and venography was: a) to confirm central venous occlusion or stenosis & to assess collateral circulation as an alternate route, b) to monitor the guide wire progress to avoid any misplacement, c) to ensure proper catheter placement & proper tip positioning & finally d) to ensure absence of complications such as catheter rupture, obstruction or extravasation.

Intravenous contrast was not used for patients in which the right IJV was punctured as the ultrasound confirmed its patency. This agrees to ***Caridi et al., 2000,*** who stated that Contrast venography has its limitation since it can't be used for jugular, portal & hepatic venous access because none of these vascular structures can be directly opacified with contras material unless directly punctured using ultrasound guidance. In our study, we tried to minimize contrast use especially in patients with renal impairment.

Immediate radiographic outcome:

The one point of particular importance on using fluoroscopy is the adjustment of catheter length to ensure a proper tip position since this affects the long term outcome of the catheter inserted. ***Schwartz et al, 2000 & Granziera et al, 2014,*** stated that the catheter tip position has emerged as the main independent prognostic factor for malfunction and reduced duration of the device, placement of the catheter tip high in the SVC results in a higher incidence of thrombosis than low placement in the SVC or at the atrio-caval junction. ***Chu et al, 2004,*** also stated that hemodialysis can require full atrial positioning of the catheter tip, at least for cuffed catheters and that thrombosis also seems to more common when catheters are inserted entering the left subclavian vein.

Following these guidelines in our study, the catheters tips were positioned at the SVC-right atrial junction in 32 patients (80% of the cases), while in 8 patients, the catheters tips were placed in the right atrium including the dialysis patients with transhepatic cases.

No catheter rupture, obstruction or extra-vasation was encountered during the sessions for all patients.

Immediate post-procedural results:

In all patients, we succeeded in achieving the venous puncture, establishing the subcutaneous tunnel (whenever applicable) & inserting the VAD with tip positioning at the atrio-caval junction (in 32 patients) or within the right atrium (in the other 8 patients) with free in & out flow through the catheter.

Intra-operative complications:

In only 1 case (2.5% of the patients), arterial puncture was done which was early in our study and was mostly attributed to operator's growing experience & familiarity with the technique. 2 cases (5% of the patients) developed small hematomas related to punctures that were selflimited & resolved few days after the procedure.

No major complications such as pneumothorax, vascular thrombosis & large growing hematomas were encountered in our study.

This agrees with results obtained by ***Reusz et al, 2013***, who succeeded in CVC insertion in 41 patients with severe uncorrected coagulopathy and in a further 76 patients with coagulopathy of moderate severity using ultrasound guidance with no associated major complications. ***Granziera et al, 2014,*** also stated that early complications such as arterial puncture, technical failure & access site change after first attempt were less frequent using the ultrasound guided technique. ***Seok et al, 2014,*** however presented better results with only 4cases with intra-operative complications among 165 VAD insertions with a complication rate of 2%. ***Hind et al, 2003***, compared percutaneous techniques to surgical techniques & concluded that percutaneous procedures were superior in terms of theatre time, cosmetic result and local infective complications. The surgical failure rate was 4.5%; multiple access attempts were required in13% in the surgical group & 3.7% of the surgically inserted catheters were misplaced. In our study, no comparison was made to surgically inserted.

VADs, which requires more research in the future.

No complications from local anesthesia were encountered in all patients.

Clinical & radiological follow up:

Four sets of complications were encountered in the follow up postoperative period of 3 months duration.

a) Dislodgement:

One of the dialysis patients was discovered to have an accidental dislodgement of his catheter on the return for the 3 months follow period & was replaced by a bed side central line to be exchanged latter by a tunneled catheter. In addition to the fixing sutures of the catheters, the Dacron cuffalso helps in its fixation by inducing local fibrotic response. Delayed catheter dislodgment raises the importance of educating the nurses and the patients about the catheter care & ideal dealing with the catheter especially during the dialysis session. Low degree infection can sometimes erode the fibrous tissue in the subcutaneous tunnel making it loose. ***Granziera et al,2014,*** reported catheter dislodgment in 7 patients in a study that included796 patients.

b) Fibrin sheath formation/ c) catheter thrombosis:

Two patients from the dialysis group suffered from poor flow through the catheter (inadequate for hemodialysis). They were scheduled for a 2nd session where contrast injection revealed fibrin sheath in the SVC. & around the catheter tip in 1 patient & intra-luminal thrombi in the other.

In the first patient disruption of the fibrin sheath using a balloon was performed & the catheter was exchanged with restoration of adequate blood flow. In the 2nd patient, the catheter was exchanged with a new one.

Ameuser, 2005, stated that fibrin sheath thrombus is common and may begin as early as 24h post insertion. Almost all catheters are covered by a fibrin sheath that also increases the risk of catheter related infection.

Fibrin manifests as difficulty in blood aspiration as a valve mechanism at the catheter tip. In venography it appears as poor stream from the tip or delayed clearance of contrast around the catheter.

Venous thrombosis maybe partially or completely occlusive and occurs in 12-74% of all central catheters, usually 71% are asymptomatic. ***(Schwarz et al., 2000).*** In our study, instructions were given to the caring physicians & nurses about prophylactic flushing with un-fractionated heparin and saline being the standard care to maintain catheter patency.

In our institution, non-invasive therapy for catheter thrombosis centers on the infusion of fibrinolytic drugs. Invasive treatment involves mechanical removal by sheath stripping using a balloon, which again is the area of expertise for an interventionist. Historically, there is no significant difference in the patency between the two methods ***(Gray et al., 2000).***

However updates to these results should be addressed by further research.

d) Infection:

Catheter related infection (CRI) includes exit-site infection, tunnel/port infection & catheter related blood stream infections (CRBSI); it doesn't include catheter colonization. Infection begins after contamination of the exit site with subsequent migration along the external surface leading to intra-luminal colonization or by haematogenous seedling. Infections occurring within 10 days of insertion are typically due to skin flora. ***(Lyon et al, 2008)***

In our study, we had 4 cases of CRIs; 2 cases in the 1st month & 2 cases later on. 1 patient with an implantable port developed cellulitis at the site of the infra-clavicular pocket, with failed medical control, port had to be removed 26 days post insertion. 2 critical care patients has developed fever with positive blood culture from the catheter, the catheter had to be exchanged in one case & removed in the other patient (who was close to discharge). Finally, 1 dialysis patient with a tunneled catheter had exit site infection in the 1-3 months follow up period with failed antibiotic therapy, the catheter was exchanged in a 2nd session and the tunnel course was shifted medially away from the infected site.

Diagnosis of CRI was made clinically by the presence of fever and signs of infection along the exit site or subcutaneous tunnel (e.g. redness, hotness, pus discharge…), and was confirmed by laboratory investigations (CBC with differential, cultures from blood & catheter, swab from exit site infection).

Sometimes clinical signs are insensitive or not specific so we searched for better diagnostic tools. Differential time to positivity (DTTP) has emerged as a reliable diagnostic technique described in literature; where paired blood cultures (aerobic & non-aerobic) from a peripheral vein & the catheter were obtained, if the culture from the CVC turns positive before the peripheral sample (diagnostic cut off 2 hours), a CRI is diagnosed. ***(Bouza et al, 2002).*** Unfortunately this method isn't broadly implemented in our institution.

Our plan of antimicrobial coverage post catheter insertion was admission of a combination of amoxicillin and clavulanate (augmentin) in addition to a quinolone (ciprobay) for a period of 7 days.

We agreed to ***Shim et al, 2014,*** which stated that CRI is affected by many factors such as adequate sterilization during the catheter insertion, handling of the catheter by the nurses & the patient himself, the immune state of the patient as well as the coverage by antimicrobial therapy. The incidences of infection were higher in patients receiving chemotherapy or who where immune-compromised. This aggress to ***Shim et al, 2014,*** who stated that the incidences of infection were seemingly higher in the patients who received the procedure during inpatient treatment, patients with hematologic malignancy and patients receiving palliative chemotherapy.

The decision to Remo availability of other access sites, specific pathogen involved & presence of complications (e.g. septic emboli, endocarditis). ***(Gallieni et al, 2008).***

During the follow up period, we had 4 cases of symptomatic infection related to VADs (about 11% of the total living patients), however only 2 infection cases occurred in the 1st month post insertion period (about 5%) of the cases that are presumed to be related to the device insertion procedure. Our results however were inferior to several studies evaluating the incidence of infection among VADs inserted by radiologists; ***Vardy, 2004,*** reported an infection rate of 4% & ***Granziera et al, 2014,*** reported an infection rate of 3.6% which is obviously lower than in our study warranting additional effort to be exerted in order to decrease the infection rates in our institution.

Non-traditional access

Another important goal of our study is to point out the role of interventional radiologist in providing venous access through nontraditional routes.

This is where the role of image guidance excels, in cases were traditional routes fail, we had to search for alternative non-traditional routes, otherwise we would have lost many of our patients.

In patients with occluded veins or with relative contra-indications for certain access routes e.g. the subclavian veins prior to AV fistula, we searched for collaterals to the SVC or to the brachiocephalic veins (including the internal mammary veins), such collaterals become hypertrophied in patients with chronic central vein occlusion.

Our next approach was the transhepatic route which we considered a last resort before inserting catheters directly into the IVC which usually eliminates the patient's chances for renal transplantation.

Such routes represent a big challenge to our experience & demands high skills in ultrasound guidance to canulate the internal mammary, hepatic veins & superior mediastinal collaterals without injuring surrounding vital structures such as the lungs or liver.

We agree to ***Yaacob et al, 2011***, who stated that transhepatic catheters are associated with specific complications such as kinks, migration and even atheter dislodgement with respiratory motions, obstruction may lead to haemoperitoneum.

Therefore they require close follow up & monitoring of the dialysis flow rates. Maintaining the catheter tip in the right atrium or even in the IVC is sometimes very difficult.

According to our experience which agrees with results concluded by ***Mohamed et al, 2014*** that when comparing other unconventional vascular haemodialysis access routes, such as the translumbar route, the transhepatic route presents less likely risk of damage and bleeding from surrounding. If complications occur, these can be easily controlled if necessary by embolization of the liver parenchyma tract. Also, the transhepatic access is often easier, especially in obese patients. This approach can be successfully performed even when the lower portion of the IVC is totally occluded. Revision is easier than the translumbar route, in which fibrosis forms along the retroperitoneal tract, sometimes making revision technically difficult.

We had 7 patients who had catheters inserted via the hepatic veins, 2of them died in the follow up period due to severe chest infection & 1 had his catheter exchanged due to thrombosis. The other patients managed to keep their catheters functioning through the follow up period. We recommend further futuristic analysis of such group in many terms such as duration of patency, dialysis flow rates & complications encountered through prolonged follow up periods in a detailed study to establish the concept of using the transhepatic route not only as a temporary access before transplantation or Av fistula surgery but as a valid long term dialysis route.

Finally, we agree with ***Backlund et al, 2012,*** who stated that although the majority of surveyed emergency physicians feel ultrasound guided insertion of central lines was a valuable technique and do performit, a significant percentage reported receiving no training in the procedure and also reported being uncomfortable performing it. This suggests that there continues to be a need for education and training of physicians & interventionists to overcome these barriers.

Summary & Recommendations

Venous access is required daily for a vast number of patients for many purposes such as IV infusions, parenteral nutrition, haemodialysis & chemotherapy. Venous VADs can be classified as short-term, intermediate (medium-term), and long-term accesses. They can also be classified as central or peripheral, it is important to understand this classification as each device has its different functions, advantages and limitations.

There is a growing need for the services of interventional radiologists & VADs are becoming daily practice in the intervention suites. Radiologists are ideally suited to provide vascular access services to children & adults because of inherent safety advantages and higher success from using image-guided techniques.

Oncology & hemodialysis patients represented the majority of our target population in our study; however our services are beneficial to the whole institution.

Proper pre-operative assessment of the patients by Doppler and/or contrast enhanced imaging (in nonemergency cases) is crucial for determining the best access route, any stenosis or occlusions & the state of collaterals. This helps shorten the procedure time & increases success rates.

Ultrasound guidance has proven to be of prime role in VADs insertion helping to select the access site, facilitating its canulation by the seldinger technique, following the guide wire, avoiding & detecting intra-procedural complications.

The cost of providing ultrasound machines & training intervention radiologists is totally justified by the priceless patients lives that can be saved by an emergency venous access, as well as the cost of the complications management that can be almost totally avoided using that technique.

The role of combined fluoroscopy is to confirm central venous occlusion, to assess collateral circulation as an alternate route, to monitor the guide wire progress, to ensure proper catheter placement & tip positioning & to ensure absence of complications such as catheter rupture, obstruction or extravasation.

The choice of the VAD primarily depends on the indication for its insertion & duration of need.

Complications directly related to VADs guided insertion are limited however they should be known in order to be avoided. Infection is still the most frequent encountered complication in our institution, its causes & preventive tools should be further analyzed to minimize its occurrence.

Duration of VAD is not only dependant on its insertion, but also on its maintenance.

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