Radiology Implanted Forearm Ports: A Review of the Literature

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Abstract

Background: *Insertion of totally implanted venous access devices; that is, port systems, in the forearm is an option for long-term venous access. To better understand the radiology literature reported for this anatomic location, we performed a search for, and an analysis of, previous publications related to forearm implantation of these devices by interventional radiology department personnel.*

Materials and Methods: *A review of the literature was performed for articles describing radiology implantation of forearm ports. Articles published between 1990 and 2015 were reviewed.*

Results: *Eleven articles were found that met the review criteria. None were randomized studies and only 1 was a prospective study. All of the other studies were retrospective reviews of a variety of different port devices. An analysis of these articles was performed.*

Conclusions: *Forearm port implantation had high technical success rates (range, 98%-100%; mean, 99.7%). A wide variety of complications were encountered, none of which exceeded the Society of Interventional Radiology threshold levels for complications associated with port insertion. A subset of the studies were upper arm venipunctures with the port catheter and housing subsequently implanted in the forearm distal to the antecubital fossa.*

Keywords: *central venous, catheter, totally implanted venous access device, venous port, implantable port, venous access port, port catheter, radiology, interventional radiology, forearm*

Introduction

Interventional radiologists, and interventional radiology departments, have become more involved in the insertion of venous access devices, particularly totally implanted venous access devices (TIVAD), also known as ports or port systems. First developed in 1982, TIVADs allow for the administration of chemotherapy, antibiotic therapy, parenteral nutrition, and recurrent blood sampling or transfusion.[1] TIVADs are safe and effective venous access devices for many patients who require long-term, intravenous therapy. They have also been shown to have long-term durability.[2]

TIVADs can be implanted in the upper chest, the arm, and the forearm. Each site has different possible complications. Chest ports are associated with the possible risks of pneumothorax, hydrothorax, and carotid or subclavian artery cannulation. Arm port TIVAD insertions do not expose patients to the possibility of these complications, but inadvertent brachial artery and median nerve injury are possible. The forearm, that is, the area distal to the antecubital fossa, is an anatomic option for TIVAD insertion.[3-13]

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Table 1. Technical Elements of the Manuscripts Reviewed

Reference	Venous access	Port type (n)	Catheter	Antibiotics	Age range (y)	Number of ports	Technical success rate (%)	Catheter indwell-days (mean)	Total catheter-days
3	Palpation	PAS[a]	Polyurethane	Yes	NR	32	100	39-488 (NR)	6225
4	Venography	PAS[a]	Polyurethane	Yes	26-84	118	100	40-220 (161)	24,151
5	Venography	Vital Port Mini Titanium[b]	Silicone	Yes	33-78	32	100	3-445 (90)	2878
6	Venography	PAS[a]	Polyurethane	Yes	12-92	105	100	5-459 (88)	9124
7	Palpation	Healthport MiniMax[c] (76)	Polyurethane	NR	22-87	100	100	0-597 (90)	12,688
		PAS[a] (22)	Polyurethane	NR					
		PeriPort[d] (1)	Polyurethane	NR					
		Titan Low Profile[e] (1)	Polyurethane	NR					
8	Venography	Vital Port Mini Titanium[b]	Silicone	Yes	23-89	399		1-1325 (252)	98,633
9	Ultrasound, Venography	X Port[e]	Polyurethane	Yes	15-87	750	99.3	1-1032 (430)	327,499
		Vital Port Mini Titanium[b]	Silicone	Yes		13			
10	Palpation	Celsite[f]	Silicone	No	20-91	115	100	NR (NR)	
11	Ultrasound	PAS[a]	Polyurethane	Yes	18-88	152	100	NR (NR)	50,834
12	Palpation	Vital Port Mini Titanium[b]	Silicone	NR	16-91	1704	99.2	0-2996 (381)	643,200
13	Venography	Vital Port Mini Titanium[b]	Silicone	NR	26-81	248	98	8-2132 (364)	90,276
Total						3768			1,265,508

NR = Not reported.
[a]Smith Medical, Dublin, OH.
[b]Cook Medical, Bloomington, IN.
[c]Baxter Deutschland, Unterschleissheim, Germany.
[d]PeriPort™ peripheral access system (Strato/ Infusaid, Pfizer Hospital Products Group, Norwood, Mass., USA).
[e]Bard, Karlsruhe, Germany.
[f]B. Braun Medical, Bethlehem, PA.

Table 2. Thrombosis and Infection

	Venous thrombosis			Total infection			Pocket infection			Systemic sepsis		
Reference	n	%[a]	n/1000[b]	n	%	n/1000	n	%	n/1000	n	%	n/1000
3	1	3.10	0.16	4	12.50	0.64	2	6.3	0.32	1	3.1	0.16
4	3	2.00	0.12	13	8.30	0.54	8	5.30	0.33	5	3.3	0.21
5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
7	8	8.00	0.63	4	4.00	0.31	NR	NR	NR	4	4	0.31
8	3	NR	0.03	11	2.80	0.01	3	0.75	0.03	3	0.75	0.03
9	65	NR	0.19	41	5.40	0.12	NR	NR	NR	NR	NR	NR
10	NR	NR	NR	9	7.80	0.53	5	4.3	0.29	4	3.5	0.24
11	15	9.90	0.29	9	5.90	0.18	6	3.9	0.12	3	1.9	0.014
12	40	2.34	0.06	62	3.60	0.10	50	2.9	0.078	12	0.7	0.019
13	8	3.20	0.88	16	6.50	0.18	9	3.6	0.1	7	2.8	0.08

NR = Not reported.
[a]n/Total ports × 100.
[b]n/1,000 catheter-days.

Aims

Although several recent cohort studies have assessed forearm implantation technical success and complication rates, a comprehensive review of the literature has not be conducted before this article. Forearm implantation, if venous access is achieved distal to the antecubital fossa, minimizes the risk of larger (brachial) artery cannulation and median nerve injury. In this literature review, we will explore and discuss forearm TIVADs inserted in a radiology department. A meta-analysis was performed to evaluate the data and facilitate a more objective assessment of the available publications.

Materials and Methods

Previously, Burbridge et al[14] collated and discussed TIVAD references pertaining to radiologically inserted upper arm ports. A similar methodology will be employed to assess the forearm site for port implantation. A comprehensive literature search was performed using relevant biomedical databases, including MEDLINE, PubMed, Embase, Google Scholar, and Cochrane Library from 1946 to February 2016, using the following keywords: *central venous*, *catheter*(*s*) (*indwelling*), *total implanted venous access device*(*s*), *TIVAD*(*s*), *venous port*(*s*), *implantable port*(*s*), *venous access port*(*s*), *port catheter*(*s*), *radiology*, *interventional radiology*, and *forearm*. A search was also conducted in a variety of clinical radiology journals published from 1946 to 2015.

All articles that discussed the outcomes and complications of forearm TIVADs inserted in radiology departments were reviewed and summarized for analysis. Only articles pertaining to human subjects were reviewed. Each unique reference was then cross-referenced using the reference lists of these articles to ensure that as many relevant publications as possible were included in this review.

We extracted relevant data from the articles, including the year of publication, country of origin, study design, method of placement (venography, ultrasound, or palpation), port type, catheter insertion site, antibiotic use, number of ports, catheter indwelling range and mean days, total catheter-days, complications (venous thrombosis, infection, pocket infection, systemic sepsis, catheter malfunction, aspiration problem, injection problem, injection and aspiration problem, and catheter tip displaced), ports removed for a complication (infection, deep vein thrombosis, port or catheter damage, wound dehiscence, system blockage, and catheter fracture), and technical success rate. To facilitate the discussion, we present a summary of the salient elements of the review with a more detailed display of the data in the table provided (Table 1).

Articles that focused on forearm TIVAD but were not implanted in a radiology department were excluded, as were articles pertaining to chest or arm TIVAD insertion. Abstracts from conference proceedings, editorials, letters to the Editor, and case reports were also excluded.

Statistical Analysis

Statistical analysis was performed by the Clinical Research Support Unit of the College of Medicine, University of Saskatchewan. For all analyses, the significance level of 0.05 was used. Statistical analysis was performed using R with the Metafor Package and Comprehensive Meta-Analysis, version 2 (R Foundation for Statistical Computing, Vienna, Austria).

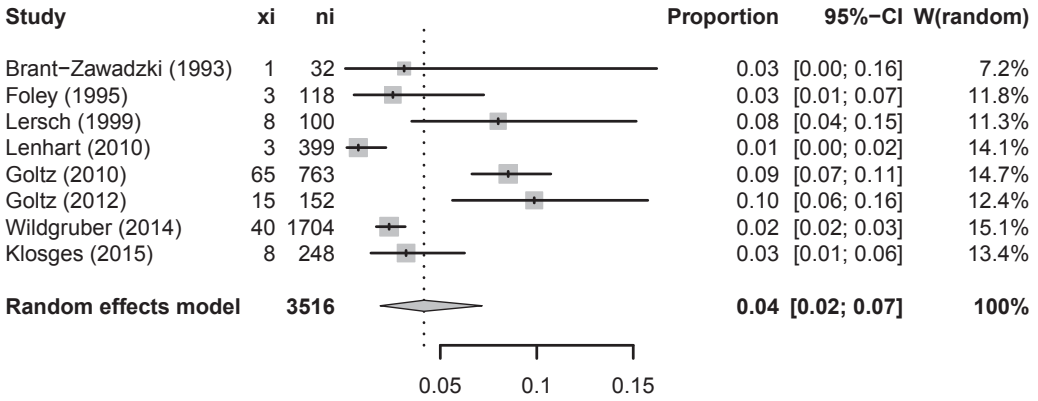

Figure 1. **Forest plot for thrombosis events.**

For the quantitative review, a forest plot strategy was used to obtain an overview of the proportions of events for each study.[15,16] This analysis of the proportions for the different possible complications was performed to assess if any unusual rates of complications were encountered. The Society of Vascular and Interventional Radiology Guidelines for Vascular Access were used as an objective comparator to determine whether the proportions of any complications exceeded recommended standards.[17]

Meta-analysis was undertaken using the random-effects model to take into account the variation in the effect between studies. Results were compared against those generated by the fixed-effects model to evaluate the degree of heterogeneity. Heterogeneity among studies was examined using I^2 statistics and P values were obtained from Q statistics for each outcome. Proportions were arc−sine transformed for stability during the analysis and then back-transformed to provide overall combined summary proportions for each of the outcomes of interest.[18,19]

Egger regression test was used to evaluate the statistical significance of possible reporting bias.[20]

If a clinical feature, or complication, from the dataset had fewer than 4 publications available for meta-analysis, this feature was not discussed in detail in the Results section.

Results

A total of 11 cohort studies were included in our literature review. Seven studies were from Germany,[5,7-9,11-13] 2 were from Japan,[6,7] and 2 were from the United States.[3,4] There were 5 studies published between 1993 and 1999[3-7] and 6 studies were published between 2010 and 2015.[8-13]

A single study was a prospective, cohort study.[3] The remaining 10 articles reviewed were retrospective, cohort studies.[4-13] The total number of ports assessed was 3768, with catheter indwell times ranging from 1 to 2,996 days. The total number of catheters-days in situ for the review cohort was 1,265,508.

Port types included PAS (Smiths Medical, Dublin, OH), Vital Port Mini Titanium (Cook Medical Inc, Bloomington, IN), Healthport MiniMax (Baxter Deutschland, Unterschleissheim, Germany), and the X Port (Bard, Karlsruhe, Germany). One study included ports from 4 different port manufacturers, whereas another used 2 different ports. None of the studies randomized subjects to different devices. The references described the catheter material used for the ports as polyurethane for 5 studies and silicone catheters in 5 studies, whereas 1 study deployed ports that had both polyurethane and silicone catheters.

Venography was the most common approach of venous access for port placement.[4-6,8,9,13] Palpation of the vein was the

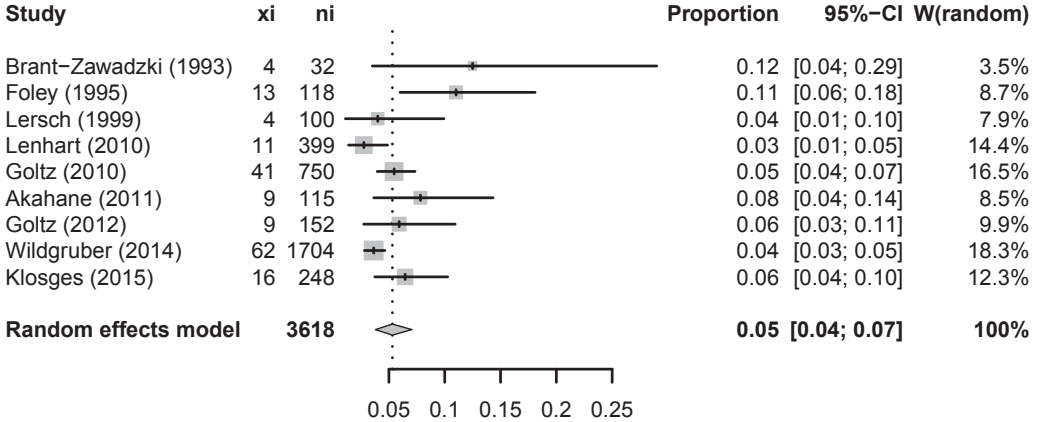

Figure 2. **Forest plot for infection events.**

Table 3. Port Dysfunction, Catheter Displacement, and Catheter Fracture

	Aspiration			Injection			Injection and aspiration			Catheter displaced			Catheter fracture		
Reference	n	%[a]	n/1000[b]	n	%	n/1000	n	%	n/1000	n	%	n/1000	n	%	n/1000
3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1	3.1	0.16
4	NR	NR	NR	NR	NR	NR	5.00	3.30	0.21	NR	NR	NR	NR	NR	NR
5	NR	NR	NR	NR	NR	NR	1.00	3.10	0.03	NR	NR	NR	4	12.5	1.4
6	NR	NR	NR	13.00	12.40	1.40	NR	NR	NR	2.00	1.90	0.22	NR	NR	NR
7	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
8	5	1.25	0.05	10	2.5	0.1	15	3.75	0.15	NR	NR	NR	NR	NR	NR
9	NR	NR	NR	NR	NR	NR	NR	NR	NR	6	0.78	0.018	NR	NR	NR
10	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
11	6	3.9	0.009	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
12	15	0.9	0.233	17	0.9	0.0264	NR	NR	NR	10	0.59	0.015	13	0.76	0.02
13	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	4	1.6	0.04

NR = Not reported.
[a]n/Total ports × 100.
[b]n/1,000 catheter-days.

second most common venous access method.[3,7,10,12] Ultrasound alone was used in only 1 study,[11] whereas 1 study used either ultrasound, venography, or both.[9]

Prophylactic intravenous antibiotics were used in 7 studies.[3-6,8,9,11] One study stated that prophylactic antibiotics were not used.[10] The remaining studies did not provide any data about antibiotic use.[7,12,13]

One study used a power injectable port, the PAS port.[11] None of the other devices implanted in the other studies reviewed were approved for power injection.

The procedural technical success rate was uniformly high. Most studies (9 articles) reported a 100% success rate with the lowest rate being 98%.[10] One study did not report technical success.[8]

Interestingly, 3 studies from Germany used an upper arm (superior to the antecubital fossa) venous access site (ie, upper arm basilic, brachial, or cephalic vein) for the introduction of the catheter into the venous system. The implanted catheter for these studies was then tunneled subcutaneously from the vein insertion site crossing the antecubital fossa, with the port housing subsequently residing in the forearm.[9,11,13] Hence, 8 of 11 studies reported true forearm venous access for catheter insertion.[3-8,10,12]

Detailed descriptions of the major elements of the reviewed articles are summarized in Table 1.

Data for venous thrombosis and infection were provided. When possible, the total infection rate was subdivided into pocket infection or systemic sepsis. The results are shown in

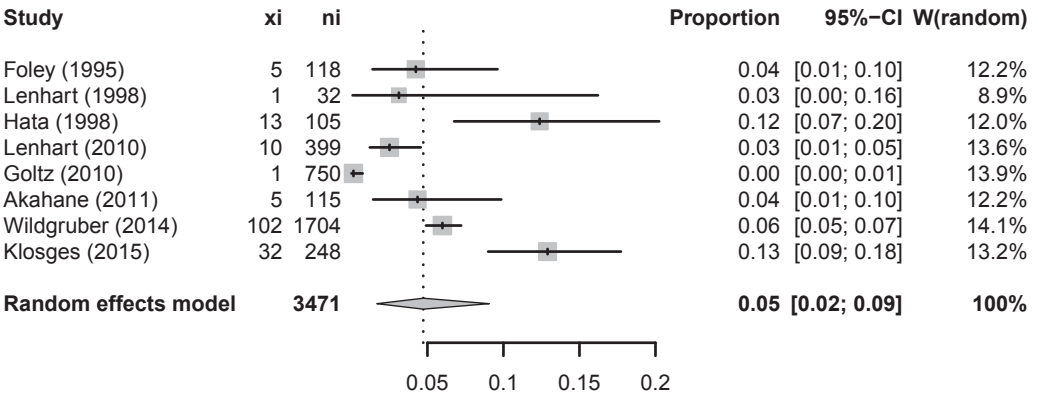

Figure 3. **Forest plot for port malfunction.**

Table 4. Ports Removed for a Complication

	Any complication			Infection			Deep vein thrombosis			Port/catheter damage			Wound dehiscence			Blockage		
Reference	n	%[a]	n/1000[b]	n	%	n/1000	n	%	n/1000	n	%	n/1000	n	%	n/1000	n	%	n/1000
3	4	12.5	0.64	4	12.5	0.64	NR	NR	NR	NR	NR	NR	1	3.1	0.16	NR	NR	NR
4	5.00	4.20	0.20	2.00	1.70	0.08	3	2.5	0.12	NR	NR	NR	NR	NR	NR	NR	NR	NR
5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
6	6.00	5.70	0.65	1.00	0.90	0.11	NR	NR	NR	NR	NR	NR	NR	NR	NR	2	1.9	0.21
7	NR	NR	NR	2.00	2.00	0.16	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
8	11	2.8	0.11	6	1.5	0.06	1	0.25	0.01	3	0.75	0.03	1	0.25	0.01	1	0.25	0.01
9	42	5.5	0.13	35	4.6	0.11	5	0.65	0.015	2	0.26	0.006	NR	NR	NR	NR	NR	NR
10	22	19.1	NR	9	7.8	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	4	3.5	NR
11	9	5.9	0.17	9	5.9	0.17	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
12	140	8.2	0.21	59	3.4	0.091	10	0.59	0.016	44	2.5	0.068	8	0.46	0.012	9	0.53	0.014
13	46	18.5	0.51	16	6.5	0.18	NR	NR	NR	6	2.4	0.07	5	2	0.06	6	2.4	0.07

NR = Not reported.
[a]n/total ports × 100.
[b]n/1000 catheter-days.

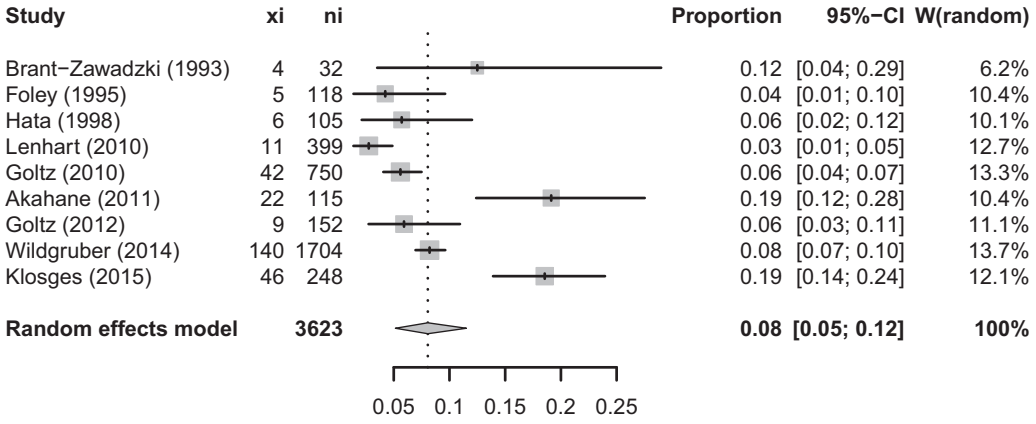

Figure 4. **Forest plot for removed for complication.**

Table 2. The forest plots for this complication are illustrated in Figures 1 and 2.

Catheter malfunction, if possible, was subdivided into aspiration problems, injection problems, and injection and aspiration problems. The data for these parameters are shown in Table 3. The forest plot for catheter malfunction as a whole is provided in Figure 3.

Catheter tip displacement and catheter fracture were rare events, with catheter fracture ranging from 1 to 13 events in the 4 studies that reported data on this complication.[5,7,12,13] Three of these studies reporting catheter fracture involved the Vital Port Mini Titanium.[5,12,13] Only 1 of these studies entailed accessing the vein cranial to the antecubital fossa and then tunneling the catheter across the antecubital fossa to the forearm.[13] The fourth study that reported catheter rupture, which deployed 4 different port designs, did not report whether the catheter of a particular vendor was prone to fracture; however, the author stated that the cause for catheter rupture in their series was probably the handling of the catheter with sharp instruments during insertion, leading to catheter injury and subsequent catheter rupture.[7]

Data on port removal for complications; that is, infection, thrombosis, port or catheter damage, wound dehiscence or breakdown, and blockage are shown in Table 4. The forest plot for this complication is provided in Figure 4.

A summary table of the major features evaluated by the meta-analysis of the data is provided in Table 5.

The Society of Vascular and Interventional Radiology recommendations on complication frequencies and threshold levels for these complications are provided in Table 6. Table 6 also provides the available compiled data from the literature review.[17]

Discussion

A variety of unique patient cohort studies related to the implantation of forearm ports in a radiology department were assessed. To our knowledge, this is the only summary of the literature discussing the forearm implantation site for TIVADs.

Table 5. **Major Features Evaluated by the Meta-Analysis of the Data**

Event	No. of Studies	Total subjects	No. of events	Overall incidence (%)	95% Confidence interval[a]	I^2	*P* value from test of heterogeneity	*P* value from funnel plot
Thrombosis	8	3,516	143	4.2	2.0-7.0	89.6	<0.0001	0.6
Pocket infection	7	2,768	83	3.2	1.7-5.1	72.3	0.006	0.08
Systemic infection	8	2,868	36	1.9	0.8-3.4	68.9	0.001	<0.0001
Total infection	9	3.631	169	5.4	3.8-7.2	71.4	0.002	0.008
Malfunction (dysfunction)	8	3.484	169	4.7	1.8-8.7	93.7	<0.0001	0.53
Removal due to infection	10	3,736	143	3.7	2.3-5.4	75.3	0.0008	0.31
Removal due to any complication	9	3,636	285	8.1	4.7-12.3	92.1	<0.0001	0.41

[a]Confidence interval by the random effects model.

Table 6. The Society of Interventional Radiology (SIR) Threshold Comparison for Technical Success and Complications Compared with Compiled Rates

Feature	Compiled rates (%)	95% Confidence interval	SIR reported reference rate (%)	SIR threshold (%)
Technical success	99.65	X	96	90
Thrombosis	4.2	2-7	3	6
Infection (pocket and generalized sepsis)	5.4	3.8-7.2	1-4	2-8
Catheter dysfunction	4.7	1.8-8.7	X	X
Device removal for complication	8.1	4.7-12.3	X	X
Arterial injury	NR	X	0.5	1

NR = Not reported; X = Not available.

The initial 5 forearm port studies were published between 1993 and 1999, and no further studies were published from 2000 to 2009.[3-7] The 6 subsequent published articles appeared between 2010 and 2015.[7-13] There was no apparent reason for this 10-year gap between publications.

As described earlier, 3 studies from Germany used an upper arm venous access site (brachial, basilic, or cephalic vein) with the catheter tunneled to the forearm and passing through the antecubital fossa. All of these publications were written after 2010.[9,11,13] Presumably, this approach could be more challenging to perform due to the long subcutaneous tunnel that must be created for the catheter to reach the forearm. The reason for this technical idiosyncrasy is unknown and not explained by the authors.[9,11,13] One of the advantages of using the forearm venous access site strategy is avoiding injury to the brachial artery and median nerve. These potential complications were not avoided for these 3 studies.

The majority of studies reviewed were retrospective cohort studies. Although these cohort studies allow for the calculation of incidence of port outcomes and complications, the risk of bias is higher compared with prospective investigations.

The meta-analysis of reviewed articles found a relatively high degree of heterogeneity in study results, based on the observed I^2 values of 68.9%, or larger, and Q statistic P values < 0.01 for the 7 reported outcomes, highlighting the need for the random effects modeling approach.[18] Publication bias was suggested for systemic infection ($P < 0.0001$), all types of infection ($P = 0.008$), and possibly for port pocket infection ($P = 0.08$).[19]

When reviewing the rates of complications tabulated in this study compared with those reported by the Society of Interventional Radiology as suggested threshold levels, there were no features that exceeded the threshold levels. Technical success rates for the reviewed publications also fell within acceptable threshold recommendations.[17]

Forearm insertion of ports is an anatomic option. Articles discussing this anatomic site are less common than those for chest and arm port implantation. The majority of the published works are from Germany. The number of devices implanted and the follow-up of these devices provide some valuable data. Wildgruber et al[12] demonstrated this fact in their cohort of 1704 patients with 643,200 catheter-days of follow-up.[12]

Unfortunately, data for complications and removal statistics were not uniformly, nor always, reported by authors. Therefore, the reported data are difficult to compare from 1 study to the next due to inconsistencies and variability in the definitions used for reporting. In the future, a more standardized approach to reporting complications would be helpful.[21]

Conclusions

This literature review has explored the outcomes and complications for forearm port implantations performed in a radiology department. There were 11 articles available for review, with 6 of these published between 2000 and 2015. The idiosyncrasy of upper arm venipuncture with subsequent tunneling of the catheter to the ventral forearm distal to the antecubital fossa is novel and of uncertain influence or benefit to patients. This insertion strategy was most commonly performed in Germany. The studies reviewed were for the most part retrospective, nonrandomized, and did not follow any standardized format for data collection, definitions of complications, and consistency of data reporting, a common problem encountered in literature reviews.

Relevance to Practice

Implanted venous access devices have altered the provision of long-term intravenous therapy.

There are a variety of anatomic locations that can be used for implantation of these devices. The forearm site is a less commonly utilized location for these devices. The literature available related to this anatomic site has been reviewed and summarized to better inform venous access teams about this possible TIVAD deployment site.

Disclosures

The authors have no conflicts of interest to disclose.

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