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Computed tomography frequency and power injection utilization for a cohort cancer patients with arm ports

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Abstract

Objectives: The goals of this study were to follow a cohort of patients with breast and colon malignancies to determine the frequency of follow-up Computed Tomography (CT) and arm port power injection for CT imaging over a one-year period. Power injection capability of a venous access device is a desired feature for patients who require intravenous contrast agents for CT.

Materials and methods: All patients had been randomized to receive a power injectable or non-power injectable port as part of a clinical trial. All the patients were enrolled with the provincial Cancer Agency and all had their CT images acquired and stored in a single, provincial, Picture Archive and Communication System (PACS). A review of the annual number of CTs was performed. Only patients with breast and colon cancer were analyzed for CT utilization. All power injectable ports were evaluated for utilization for follow-up CT.

Results: In the one-year period after their port was implanted, patients with colon cancer (n=77) underwent a greater number of CT studies than patients with breast cancer (n=75); 3.06 vs. 1.08 scans per patient ($p<0.001$). The number of CT studies performed increased with an increasing stage of cancer. The power injectable arm port was used to acquire contrast enhanced images in 114 of 241 (47%) CT studies. The use of the port for power injection of contrast agent for CT was affected by whether the CT was performed at a rural or urban location.

Conclusion: A power injectable port may not be needed for patients with more favorable stages of breast and colon due to the generally low utilization of CT for follow-up. Additionally, it was apparent that the ability to access the device for power injection, based upon local expertise, was a major factor in utilization of the power injection feature.

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Introduction/Objectives

CT is commonly utilized to follow patients with known malignancies. Iodinated intravenous contrast media (contrast) is often used for CT examinations to assess patient anatomy. For optimal CT follow-up of patients with malignancies, intravenous contrast injection is essential. If a patient does not have an indwelling, power injectable, venous access device, alternative venous access must be established for each CT related contrast injection. There are no other published indications for using a power injectable venous port for a patient with malignancy other than for the injection of intravenous contrast media.

There are a wide variety of venous access devices that can be used for the power injection of contrast. An implanted power injectable venous access device, port, can improve the quality of CT images acquired, increase the success rate of contrast injection, and improve the safety (reduced risk of extravasation) of contrast administration [1,2].

The local Cancer Agency routinely requests arm ports, also known as Totally Implanted Venous Access Devices (TIVADs), for the provision of intravenous chemotherapy. Several manufacturers have recently developed power injectable ports that are anatomically suitable for arm implantation. The power injection capability of the ports is used for intravenous contrast media injection for CT.

This manuscript reports upon a review of the frequency of follow-up CT utilization for a group of patients with malignancies. The utilization of the power injection capability of their ports for intravenous contrast was also analyzed. The outcome of this review could facilitate the decision-making process when considering the adoption of a power injectable port for routine clinical use.

Material and methods

All patients in the study were receiving intravenous chemotherapy for a malignancy. All patients were enrolled in a prospective, randomized, clinical trial of a power injectable port versus a non-power injectable TIVAD to determine device longevity and complication profile. This project received approval from the local University Research Ethics Committee and was registered with ClinicalTrials.gov. The patients provided consent for both the clinical implantation of the venous device for treatment and for participation in the research trial.

There were 209 patients being treated for 19 different tumors types. Of this group, 152 (73%) patients had breast or colonic malignancy (75 breast cancer and 77 colon cancer). The review of the CT utilization for the 152 patients who had breast and colon cancer was performed and the other 17 tumor types were excluded from this statistical analysis due to an insufficient sample size for the other tumor types. For the assessment of use of the power injectable feature of the ports there were 109/209 patients with a power injectable port who were eligible for analysis. All tumor types were included in the power injection assessment.

All vein ports were implanted in the upper arm, utilizing sterile technique, as described by previous authors [3,4]. The two TIVADs in question were: the AngioDynamics Vortex, Smart Port MP (Vortex) (AngioDynamics Inc., Manchester, GA, USA) (**Figure 1**) compared with the non-power injectable port, Cook Vital Mini Port (Mini) (Cook Canada, Mississauga, ON) (**Figure 2**). The technical specifications of the two TIVADs are provided in **Table 1.** The Vortex device was larger and had a larger carbothane catheter (6.6F). Of the 152 patients with breast or colon cancer, 77 received an Angiodynamics port and 75 received a Cook port. **Table 2** provides a breakdown of the patients by port type, malignancy type, age, and gender (**Table 2**).

A review of the patient's CT imaging was performed for one year after they had their port implanted. All the patients in the study were enrolled in the provincial Cancer Agency and all patients had their complete imaging record stored on the provincial Picture Archive and Communication System (PACS) (Philips IntelliSpace PACS, Philips Healthcare Informatics, Inc., Foster City, CA, USA). Therefore, there was only one PACS for all patients who received CT imaging ordered by the provincial Cancer Agency and the patient's entire CT history was available for review for this study. The CT Technologist's contrast injection notes were reviewed for every CT performed, as were the CT images, to determine which patients had their power injectable port injected for their CT examination or if a peripheral vein was accessed. The training and certification of the personnel needed to access port injectable ports for CT was the responsibility of the individual healthcare facility performing the CT.

The location of where the CT was performed was also reviewed, urban versus rural. An urban CT setting was any site with a population of > 100,000 people and a rural CT setting was any site that had a local population of < 100,000 people.

Staging of the patient's malignancy was based upon clinical data provided for imaging examinations and by review of the staging imaging at the time of port insertion. The staging review of the patient's imaging was performed by one of the authors (BB), a radiologist with over 25 years of experience in CT interpretation.

Statistical analysis

All analyses were performed using SPSS Statistics version 24.0 (IBM, Armonk, NY). Descriptive statistics, including means and standard deviations for continuous variables and frequencies and proportions for categorical variables, were determined. Statistical comparisons were performed using Fisher's exact test for categorical variables, and t-test/ANOVA with confirmatory non-parametric (Mann-Whitney *U* or Kruskal-Wallis) testing for continuous variables. A p-value of less than 0.05 was regarded as significant.

Results

CT Utilization, breast and colon cancer patients

There were 152 patients with breast cancer (n=75) and colon cancer (n=77) available for follow-up. A full one-year CT utilization follow-up data was not available for 22 patients with breast cancer and 26 patients with colon cancer because the arm port was removed due to a complication (n=3), the port was removed at completion of chemotherapy (n=33), or the patient died (n=12). The mean duration of follow-up for those patients who did not complete the full year follow-up was 225 and 227 days for breast and colon cancer patients, respectively. The two tumor groups were therefore, not disproportionately disadvantaged by an asymmetrical loss of data in one group or the other. A summary of the patients who did not complete the full one-year follow-up and the duration of their port implantation is provided in **Table 3**.

Overall, patients with colon cancer underwent a greater number of CT studies during the one-year follow-up period than

patients with breast cancer (3.06 vs. 1.08 scans per patient; p< 0.001). The number of CT studies performed increased with increasing stage, ranging from 0.22 to 2.13 studies per patient (p<0.001) for patients with stage I and stage IV breast cancer, respectively (**Table 4**). The number of CT studies performed for patients with stage I and stage IV colon cancer ranged from 0.67 to 3.23 studies per patient, respectively, which was significant with parametric testing (p=0.03), though did not meet significance with non-parametric testing (p=0.052).

Power injection utilization:

There were 109/209 (52%) patients who had a power injectable arm port. For this group of patients, a total of 241 CT studies were performed over a one-year follow-up period, an average of 2.2 studies/patient. The power injectable arm port was used to acquire contrast enhanced images in 114 (47%) of these studies. The proportion of studies which used the power injectable arm port for contrast administration was similar between patients with breast cancer or colon cancer (60% vs. 48%, p=0.22). Overall, the power injectable arm port was used for contrast administration for 1.04 studies per patient over the one-year follow-up period.

Urban vs. Rural CT, Power Injection

CT studies were performed at six urban and six rural sites, 43 (17.8%) were performed at a rural site and 198 (82.2%) were performed at an urban site. The power injectable arm port was not used for contrast administration for any of the studies performed at rural sites, while the power injectable arm port was used for 114 of 198 CT studies (57.6%) acquired at an urban site (p<0.001).

Discussion

Ports are obviously beneficial for chemotherapy and other intravenous treatments. Most of the port access events for patient with a malignancy do not require power injection i.e. intravenous fluids, chemotherapy, drug infusions, and blood sampling, etc. The power injectable feature of vein ports is only used for the injection of water soluble intravenous contrast media for CT imaging. It has no role in the active treatment of a malignancy otherwise.

Limitations of this study were: It was limited in scope, and; we had no control over the presence or absence of personnel who were trained to access ports for power injection. However, these limitations did help to focus the work and provide a real world, local, assessment of the utilization of CT imaging and power injectable ports for CT.

The vein accessed for catheter insertion related to a power injectable port must be larger due to the larger catheter size. Inserting larger catheters into peripheral veins has been proven to increase the risk of venous thrombosis. Grove, et al, found the following rates of venous thrombosis related to peripheral venous catheters 5F – 6.6%, 6F – 9.8% [5]. The power injectable catheter used in this study was 6.6F in diameter vs. 5F for the non-power injectable device. Numerous authors have commented upon the correlation between catheter diameter vs. vein size and recognized that larger catheters in smaller veins increase the risk of venous thrombosis. Hence, if a larger catheter size is not clinically required, a port with a smaller diameter catheter may be warranted [6,7]. An additional challenge for catheter size related venous thrombosis is the lack of an agreed upon strategy for prophylactic anticoagulation for upper limb veins [8,9].

The role power injection plays in device related complications remains uncertain as conflicting reports have been published suggesting both an association with increased complications and no evident association [7].

Power injectable ports are slightly larger in size and this results in a device that requires a larger insertion site skin incision and causes a more noticeable skin bulge than a smaller non-power injectable option. This may have an adverse impact upon body image.

Do patients with breast and colon cancer require a power injectable device? The results statistically support the supposition that patients with colon cancer have follow-up CT performed more commonly than those with breast cancer. The disparity for CT utilization was also statistically evident for those with more favorable disease staging for both malignancies with this being quite noticeable for breast cancer patients. It was apparent that there was no compelling need to insert a power injectable port for all patients requiring chemotherapy based upon CT utilization. If an arbitrary cut-off of more than two power injected CT scans/patient/year was applied to justify a power injectable port, this level of utilization was met by those patients with stage 4 breast cancer and stages 3 and 4 colon cancer. It would seem reasonable to suggest that for patients with more favorable staging of these diseases, a power injectable port is not needed due to the generally low utilization of CT for follow-up. However, patient fear of venipuncture should be taken in to consideration when determining if a power injectable port is warranted.

The technical ability to access the port for power injection, based upon local expertise, is also a major factor in utilization of this feature. A patient selection criteria for placement of a power injectable port, optimally, should include the locale in which CT scans are likely to be performed. Based upon this review, familiarity with accessing and utilizing power injectable ports appears to be very limited in rural areas. However, even in urban areas where the CT technologists have been trained to access, inject contrast agent, and close the port with flushing solution, the utilization rate for power port injection was only 57.6%.

Conclusion

Complications associated with peripheral venous access devices are complex and multi-factorial. Fallouh, et al, have suggested that patient, provider, and device related factors all play a role in potential complications [7]. Larger catheters in peripheral veins have an increased risk of venous thrombosis [6]. When deploying an arm port for venous access consideration should be taken as to whether the potential increased risk associated with larger catheter size is warranted based upon malignancy type and the stage of the malignancy. Limiting the impact of catheter diameter may help diminish device related complications.

The availability of personnel trained to access and utilize power injection is an imperative. If there is a lack of trained personnel in CT the power injectable port will be of no benefit. Thus, the personalization of the selection process for an arm port may help to minimize potential complications and improve patient care.

Figures

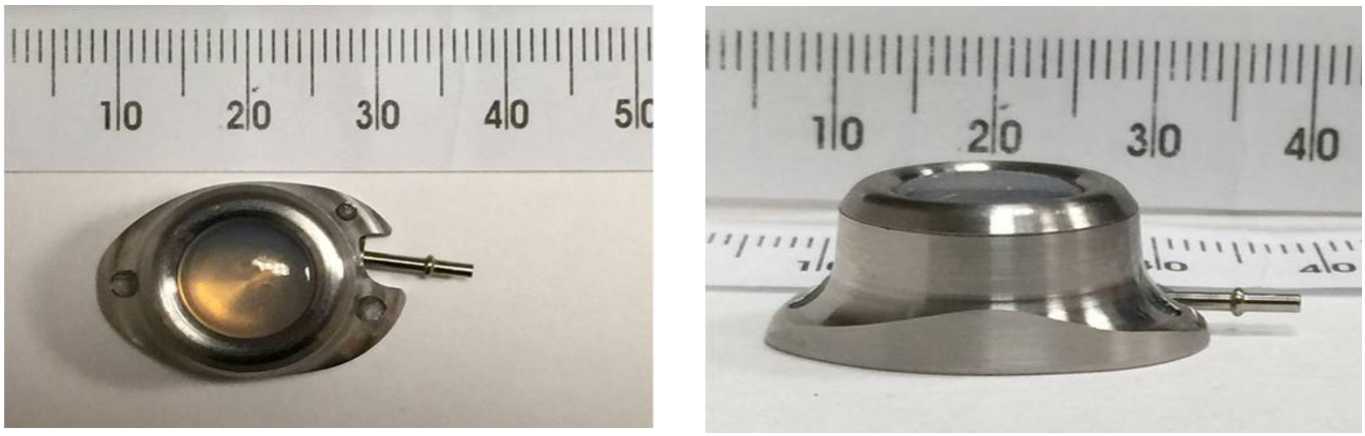

Figure 1: Angiodynamics TIVAD. a) Cranial view b) Lateral view.

Figure 2: Cook TIVAD. a) Cranial view b) Lateral view.

Tables

Table 1: Specifications of the TIVADs evaluated.

Feature	Cook, Vital, Petite, Mini Port	Angiodynamics, Vortex, Smart Port MP
Height	7.2 mm	10.77 mm
Width of the port base	19 mm	23.88 mm
Septum diameter	6.6 mm	10.21
Septum surface area	137 square mm	327 square mm
Volume of the port chamber	0.15 mls	0.3 mls
Outer diameter of the port catheter	5 French	6.6 French
Catheter material	Silicone	Carbothane

Table 2: Breast and colon cancer patient demographics by port type, malignancy, age, and gender.

	Power injectable port (AngioDynamics)			Non-power injectable port (Cook)		
	Breast	Colon	Total	Breast	Colon	Total
Male	0 (0%)	24 (16%)	24 (16%)	1 (1%)	19 (13%)	20 (13%)
Age (male)	0	62.9 (10.41)		57	66.7 (9.89)	
Female	36 (24%)	17 (11%)	53 (35%)	38 (25%)	17 (11%)	55 (36%)
Age (female)	57.2 (12.58)	63.9 (9.47)		60.8 (10.67)	54.2 (13.33)	
Total	36 (24%)	41 (27%)	77 (51%)	39 (26%)	36 (24%)	75 (49%)

Values presented are n (%), age mean (S.D.).
None of the paired T-test results for port type, malignancy, age, or gender, reached statistical significance of p < or = 0.050

Table 3: Patients not completing the full one-year follow-up.

	Breast		Colon	
Reason for end of follow-up	n	Port days in situ	n	Port days in situ
Port removed at end of therapy	20	222 ± 98 (range 106-361)	13	213 ± 97 (range 61-351)
Port removed due to a complication	0	–	3	177 ± 154 (range 14-321)
Deceased	2	252 ± 97 (range 183-320)	10	261 ± 57 (range 147-328)
Total	22	225 ± 96 (range 106-361)	26	227 ± 92 (range 61-351)

Values presented are mean ± SD.

Table 4: Number of CT studies performed per subject over a one-year follow-up period based upon tumor staging.

	Breast cancer			Colon cancer		
Stage	CT studies per subject	n		CT studies per subject	n	p-value[a]
I	0.22 ± 0.43	18		0.67 ± 0.58	3	0.126
II	0.43 ± 0.90	23		2.33 ± 1.53	3	0.004
III	0.33 ± 0.58	3		2.83 ± 1.33	6	0.019
IV	2.13 ± 1.28	31		3.23 ± 1.52	65	0.001
Total (all stages)	1.08 ± 1.32	75		3.06 ± 1.55	77	<0.001

Values presented are mean ± SD.
[a]Means compared by t-test; conclusions were consistent with non-parametric (Mann-Whitney U) testing.

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