Accessing Implantable Ports: An Opportunistic Computed Tomography-Based Audit

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Abstract
Aim: *Implantable ports are typically inserted by interventional radiologists or surgeons; however, daily maintenance, access, and de-access are often performed by members of nursing staff in accordance with manufacturers' guidelines and local policy. An audit of port access using retrospective computed tomography (CT) scanning was proposed.*
Methodology: *Across a 4-year period, all CT scans performed for any reason while a port was accessed were reviewed.*
Results: *Fifty-four CT scans of accessed ports were included. Mean depth of tissue between skin and port was 3.74 mm, and between port and pectoralis major was 5.91 mm. Port tilt in side-to-side and up-down axes measured 6.9° and 10.6°, respectively. Mean distance from needle to center of the septum was 1.96 mm. Mean distance from center of the chamber to the needle tip was 2.73 mm. In 2 cases (3.7%), the needle bevel was malpositioned, with the bevel still within the silicone-rubber septum. Mean angulation of the access needle from perpendicular was 11.5°. Angulation of the needle correlated with port tilt (r = 0.37; P = .006). Angle of the needle bevel relative to the port exit channel was 140.8°. No significant correlation between needle bevel directionality and needle angle, depth of port, or tilt of port was detected (all P values > .21).*
Conclusions: *Variability in accessing of implantable ports is described relative to research- and manufacturer-recommended needle bevel angle, needle puncture angle, and central puncture position. The extent to which such deviation influences port function deserves focused clinical research.*
Keywords: *implantable port, interventional port, vascular access*

Implantable ports are a form of totally implantable venous access device, combining a buried subcutaneous port and a tunneled central venous catheter (Figure 1). Implantable ports are ubiquitous in contemporary practice, with widespread applications in chemotherapy and antimicrobial therapy. These devices are typically inserted in the upper chest by interventional radiologists (IRs) or surgeons. Following insertion, responsibility for day-to-day care, accessing of the port, and de-accessing of the port typically passes to nursing staff, where practice reflects industry guidelines, manufacturers' instructions, and hospital policy, typically following appropriate skill competency validation. An IR or surgeon is consulted for problem-solving and line removal, and often has little involvement in line use once a patient leaves the department. Implantable ports are accessed with needles such as a Huber needle or Gripper needle (Smiths Medical, Minneapolis, MN), where needle design prevents coring of the rubber-silicone septum, which may lead to device leakage and failure.

Clinical research has identified a number of in vivo variables as risk factors for failure or blockage of vascular access devices. These can be categorized as patient-, position-, device-, and use-specific. Certain patient groups are at higher risk of device failure, such as children younger than age 3 years. Certain positional factors, such as the location of the device within a patient and small sized native vessels, are associated with a higher risk of failure. A number of device-specific factors, such as port design and the thrombogenicity of catheter coatings, have also been correlated with risk of failure. Finally, a number of use-specific factors, such as

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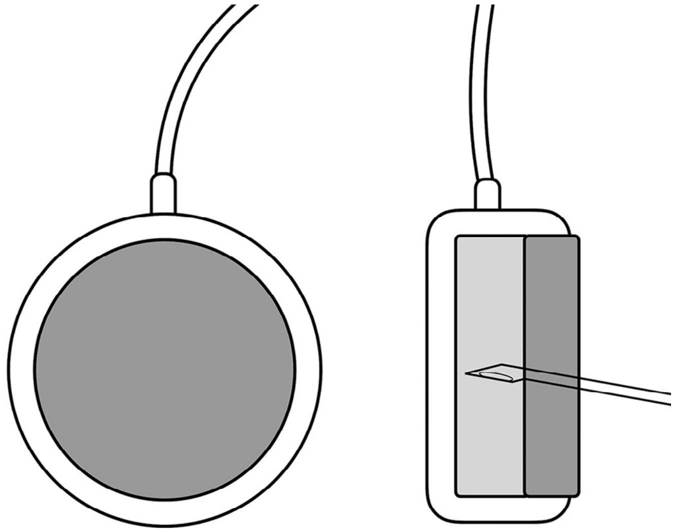

Figure 1. **Diagram of front and side view of standard implantable port design. The housing (white) is typically made of a metal such as titanium. The chamber is hollow (light grey). The septum (dark grey) is made of a durable silicone-rubber material. A catheter attaches to an exit channel, and is made from a durable plastic such as polyurethane. A noncoring offset-bevel needle is depicted accessing the port on the side view.**

frequency of access, flushing volume, flushing pulsatility, locking solution, and dressing schedules, are also associated with the risk of failure.[1,2] In addition to these clinical variables, a 2012 in vitro study by Guffiant et al[3] demonstrated that the angle of the needle point bevel relative to the exit channel (ie, where the catheter connects to the port) significantly influences flow rates and flushing success. Manufacturers' instructions often recommend an additional specific access technique, commonly needle insertion at a perpendicular angle (such as with the SmartPort [Angiodynamics, Latham, NY] and the PowerPort [Bard Medical, Covington, GA]), and central aim within the port (as in the PowerPort).[4,5]

Despite these in vitro findings, to the authors' knowledge no studies have assessed how implantable ports are being accessed in clinical practice, which may reflect the difficulty in accurately quantifying and measuring the relevant position of access needle and port. Many patients with implantable ports undergo serial computed tomography (CT) scanning for assessment of systemic disease. Using 3-dimensional positional information on CT scans of accessed ports, an opportunistic retrospective audit of port access was performed to assess compliance with best practice and manufacturers' instructions with regard to access needle positioning within ports.

Methods

All cases of tunneled port insertion from the adoption of the digital archive to time of study were examined. In each case, all CT scans, including the area of the port, were reviewed. When the port was accessed at time of imaging, a series of measurements was taken (Figure 2).

The depth and angulation of the port relative to the overlying skin and underlying pectorals major muscle was recorded. The angle of the needle's point bevel relative to the port exit channel was measured ($\alpha°$), with 180° (ie, the 6 o'clock position) known to be optimal.[3] Values 30° on either side (ie, from the 5 o'clock to 7 o'clock positions) were considered well positioned. Maximum angulation of the noncoring needle perpendicular to the port was measured ($\eta°$) (Figure 3).

A multiplanar reformat coronal to the port was used to record the coordinates of both the puncture site of the septum and of the needle tip within the port chamber. In cases where the needle was malpositioned, this was recorded. The inherent spatial resolution of CT scans necessitated the rounding of distance-based measurements to the nearest millimeter. Statistical analysis was performed using Prism 7 (GraphPad Software Inc, La Jolla, CA) and Numbers (Apple Inc, Cupertino, CA) software. A P value < .05 was taken to be significant, with the measurement of correlation performed using Pearson's r coefficient.

Results

Two hundred seventeen tunneled ports were inserted in 197 patients in a single institution from 2014 to 2017. Of all CT scans performed in these patients following port insertion, 54 CT scans (in 41 separate patients) completely imaged an accessed tunneled port. Mean interval between tunneled port insertion and CT scan was 271.2 ± 297.5 days (range = 10-1474 days).

All ports had only a single reservoir and single-catheter lumen, and were within the upper chest wall (either left or right) with catheterization of the ipsilateral internal jugular vein. All accessing needles were of a curved-tip offset-bevel variety, although the make and model were not retrospectively identifiable on imaging or in the medical records. Mean depth of tissue between skin surface and port was 3.74 ± 2.54 mm (range = 0-11 mm).