Abstract. Background: Totally implantable central venous port systems provide a safe and effective, long-term means of access for administration of hyperosmolar, local irritant medication, such as chemotherapy, antibiotics and parenteral nutrition. Aim: To evaluate the combination of access site and level of experience on fluoroscopy times (FT) and dose area products (DAP) during implantation of port catheters in a large patient population. Materials and Methods: A total of 1,870 patients (992 women, 878 men; age: 61±13.14 years) were reviewed investigating two groups of junior (≤50 implantations) and senior (>50) radiologists. Results: Senior radiologists required less FT/DAP (0.24 s/57.3 μGy m² versus 0.43 s/68.2 μGy m², respectively; p<0.001). Right jugular vein access required the least FT/DAP (0.25 s/56.15 μGy m²) and right-sided implantation lower FT/DAP (right: 0.26 s/56.4 μGy m², left: 0.40 s/85.10 μGy m², p<0.001). Conclusion: Due to DAP/FT reductions, the right jugular vein seems to be the most favorable implantation side for port systems. For further dose reduction, residents should be well-trained.

Totally implantable central venous port catheters have proven to be a safe and provide effective, long-term means of access for administration of medication. A central venous access is mandatory for hyperosmolar, basic (pH ≤4.0), alkaline (pH ≥9.0) and local irritant medication, such as chemotherapy, antibiotics and parenteral nutrition. Moreover, high pressure infusions such as those required for computed tomographic examinations of up to 5 ml/s, as well as blood tests, which can be performed through such selected systems, streamlining workflow and increasing patient quality of life (1-3).

Introduced by the surgeons Niederhuber et al. in 1982 (4), the first radiological inserted port system was reported a decade later by Morris et al. (5). While the surgical procedure includes either landmark-based puncture of a central vein using Seldinger technique, or a cut-down technique of the cephalic vein, the radiological approach is based on ultrasound-guided vessel puncture and tip positioning under fluoroscopy (3). Moreover, electrocardiogram- (ECG)-guided implantations have been reported (6).

However, surgical approaches using the cephalic and the subclavian vein led to complication rates of between 5% and 24.6%, whereas radiological placements had lower complication rates, of between 1.3% and 20.7% (7-13). Landmark-mark based punctures of the subclavian vein in particular were associated with increased rates of pneumothorax (11, 13-17). In addition, infection rates were lower for ultrasound-guided approaches with the Seldinger technique (1.1-8.8%) (3, 11, 13, 18, 19) compared with surgical cut-down (0.8-16.3%) (10, 20-25). Moreover, the radiological technique does not require general anesthesia and is cost effective (26).

Nevertheless, fluoroscopic guidance is always associated with radiation exposure of the patient, the operator and assistant staff, but compared to other interventions, radiation exposure is comparably low (27). First studies in small populations demonstrated that the level of training has a significant influence on fluoroscopy times (FT) in several interventional procedures (28, 29). Moreover, while FT and dose area products (DAP) associated with other thoracic interventions, such as percutaneous coronary interventions, seem not to differ significantly based on the site of vascular access, for chest port implantations, radiation doses seem to vary depending on the access site and target vessel (30).
The purpose of this study was to evaluate the influence of the combination of venous access site and level of experience on FT and DAP during implantation procedures for totally implantable central venous ports in a large cohort of patients.

Materials and Methods

In this retrospective, single-center study, venous port implantation procedures of 1870 consecutive patients (992 women, 878 men; age: 61±13.14 years) referred by different specialists between March 2010 and April 2015 were reviewed. All patients received a Bard port system (Bard Access Systems, Salt Lake City, UT, USA). The MultiDiagnost Eleva FD2.1 (Philips Healthcare, Best, the Netherlands) fluoroscopy unit was equipped with a flat panel detector. Radiologists (N=28) were divided into two groups: junior (N=15) and senior radiological interventionalists (N=22) based on the number of procedures they had performed (≤50 or >50). Radiologists could therefore be part of both groups as soon as they performed their 51st procedure. The procedures performed by radiologists of both groups were analyzed with regard to FT and DAP provided by the manufacturer’s DAP meter. The data was saved after each procedure to our radiology information system together with the report including the access site and the name of the interventionalist.

Procedure. Access vessel patency was routinely assessed by ultrasound using a 7.5 MHz linear array probe immediately before the procedure. At our Institution, the preferred implantation site is the right internal jugular vein due to its direct access to the superior vena cava, hence the right internal jugular vein is always used unless contraindicated.

Once the target vessel was identified, skin disinfection and sterile dressing were performed. Local anesthesia with prilocaine and epinephrine (Xylonest 1%; AstraZeneca, Wedel, Germany) was performed at the vascular puncture site, as well at the subclavicular aspect of the ipsilateral thoracic wall. The target vessel was punctured under continuous ultrasound guidance with an 18-G needle on a syringe filled with sterile saline. Subsequently a 0.035-inch guide wire was advanced through the needle below the diaphragm to ensure venous puncture. After dilatation of the puncture tract, the needle was exchanged with a 6F peel-away sheath in using the Seldinger technique.

Next, a pouch for the port reservoir was prepared 3-5 cm caudal of the ipsilateral clavicle. A subcutaneous tunnel was made from the reservoir to the puncture site. The 6F polyurethane port catheter was advanced under fluoroscopy guidance to the caval atrial junction (approximately 2-3 cm below the crossing of the superior caval vein and right main bronchus) and the distal tip was connected to the port reservoir. The system was fixed to the pectoral fascia with two absorbable sutures (3-0 Vicryl, Ethicon, Norderstedt, Germany) and the skin incision sutured using a continuous intracutaneous suture. A final radiograph was then performed to ensure correct placement of the device and exclude complications such as pneumothorax (18).

Statistical analysis. This included the Shapiro–Wilk test, Spearman’s correlation, Mann–Whitney U-test and the Kruskal–Wallis test using SPSS Statistics (Version 23, Armonk, NY, USA). Differences with p-values of less than 0.05 were considered significant. Institutional Ethics Committee approval (EA4/043/15) and written informed consent were obtained.

Results

All 1870 reported venous port implantations were performed successfully without any major adverse events according to the Society of Interventional Radiology guidelines (31).

Overall, senior radiologists performed about four times more procedures than the junior subgroup during this study (Table I). Senior radiologists required significantly less FT (total median FT: Senior: 0.24 s, Junior: 0.43 s). Subgroup analysis revealed significant differences between junior and senior radiologists for right- and left-sided approaches (p<0.001). Moreover, DAP was significantly lower for senior radiologists (median: Senior: 57.3 μGy m², Junior: 68.2 μGy m²; p<0.001) in comparison to junior radiologists (Figure 1, Table II). Again, subgroup analysis showed significant differences for left- (p<0.001) and the right-sided approaches in both groups (p=0.009).

Moreover, FT and DAP were significantly influenced by the designated target vessel (p<0.001); access through the right jugular vein required the least FT and DAP (median of 0.25s and 56.15 μGy m², respectively; Figure 2, Table III).

Furthermore, port implantations performed from the right side were associated with significant savings in terms of FT (right: 0.26 s, left 0.40 s) and DAP (right: 56.4 μGy m², left:
85.10 μGy m²; both p<0.001, Figure 3, Table IV). There was no significant difference between the junior and senior radiologists regarding the number of right- and left-sided approaches carried out (p=0.637).

**Discussion**

A prospective study of Bernard et al. revealed that experience of more than 50 catheterizations correlated with lower complication rates (32). Therefore, we separated our radiologists into two subgroups: junior radiologists with fewer than 50 and senior ones with more than 50 implantations.

FT and DAP should be kept as low as reasonably achievable for patient, operator and staff safety. Our study shows that right-sided puncture is correlated with lower FT and radiation doses for both junior and senior operators. Moreover, jugular access required significantly less DAP and FT than subclavian insertion of port catheters in both groups.
Predominantly, this might be due to the straight anatomical course to the superior vena cava reducing FT and hence the required radiation dose for correct catheter placement. These findings are in concordance with an earlier study on a smaller cohort of 138 patients by Plumhans et al. stating that jugular access reduces radiation dose by approximately 46% compared to the subclavian route. In our study, a DAP reduction of 33% was achievable for the right jugular vein compared to the mean DAP of both subclavian accesses. The left jugular vein was found to have the highest mean DAP, probably due to the curvy anatomical course. Furthermore, the right-sided approach is purported to reduce DAP by about 34% in comparison to the left (30), which is consistent with our results of a DAP reduction of 43% in a larger patient population for both subgroups.

The radiation dose depends on multiple factors, for example the fluoroscopy unit used, copper spectral beam filtration used, field of view acquired, pulse frequency and the potential number of digital subtraction angiography runs (27). The level of experience is another important factor as senior radiologists required a median 42% less FT and 16% less DAP than junior radiologists ($p<0.001$). FT mainly serves as a surrogate parameter for intervention time, which decreases with interventionalist’s experience. However, it has been shown that years in residency alone did not lead to significant reduction in FT (29).

A wide range of DAPs have been published for venous chest port implantations, for example by Plumhans et al. (subclavian: 1120 μGy m$^2$, jugular: 513 μGy m$^2$, left side: 1091 μGy m$^2$, right side: 725 μGy m$^2$) and Storm et al. (mean of about 371 μGy m$^2$) (30, 33). The mean values in this study lie below these DAPs and under the level of deterministic radiation effects.

### Table III. Fluoroscopy time (FT) and dose area product (DAP) according to puncture site.

| Measure | VJIL | VJIR | VSCL | VSCR |
|---------|------|------|------|------|
| FT (s)  | 0.39 | 0.25 | 0.54 | 1.12 |
| Mean    | 4.37 | 1.44 | 1.15 | 1.63 |
| Max     | 452.00 | 130.00 | 6.50 | 15.34 |
| Min     | 0.04 | 0.01 | 0.16 | 0.14 |

| Measure | VJIL | VJIR | VSCL | VSCR |
|---------|------|------|------|------|
| DAP (μGy m$^2$) | 83.90 | 56.15 | 114.10 | 112.00 |
| Mean | 186.14 | 104.31 | 148.20 | 164.98 |
| Max | 3830.00 | 6099.00 | 359.20 | 654.00 |
| Min | 3.11 | 0.05 | 40.90 | 24.30 |

VJIL: Left internal jugular vein, VJIR: right internal jugular vein, VSCL: left subclavian vein, VSCR: right subclavian vein.

### Table IV. Mean and median values of the dose area product (DAP) and fluoroscopy time (FT) according to access side.

| Measure | Left | Right |
|---------|------|-------|
| FT (s)  | 0.40 | 0.26  |
| Mean    | 4.25 | 1.44  |
| Max     | 452.00 | 130.00 |
| Min     | 0.04 | 0.01  |

| Measure | Left | Right |
|---------|------|-------|
| DAP (μGy m$^2$) | 85.10 | 56.45 |
| Mean | 184.78 | 105.07 |
| Max | 3830.00 | 6099.00 |
| Min | 3.11 | 0.05  |
Another promising implantation technique uses ECG guidance for tip positioning. Usually a post implantation radiograph will confirm correct tip placement. Wang et al. reported no p-wave changes in about 10% of their patients, especially in left-sided approaches. Furthermore, patients with high p-waves in basal ECG-assessment tended not to show any p-wave changes during implantation. Furthermore, ECG guidance seems to be more reliable for shorter and stiff catheters due to more stable lead connections (34). Another drawback for the ECG method is its inability to differentiate between intra- and extravascular catheter position (35). On the other hand, real-time fluoroscopy guidance might be desirable in cases with anatomical variants, venous thrombosis or strictures facilitating the implantation (6).

In terms of complications, earlier studies revealed that port systems inserted through the internal jugular vein showed less dysfunction, catheter migration and catheter-induced venous thrombosis or early local infection (7, 18, 36). Moureau et al. reported for 696,370 port catheter days a complication rate of 0.52/1,000 catheter days, whereas infections were described in 0.30/1,000 catheter days and dysfunctions in 0.21/1,000 catheter days (37). The risk of thrombosis is higher if the port system is inserted through the subclavian vein compared to the internal jugular vein (38, 39). Furthermore, the stenosis rate is lower with insertion in the jugular vein due to its large diameter and high blood flow (40). Ultrasound-guided puncture of the internal jugular vein reduces the risk of arterial puncture, hematoma and pneumothorax compared to the subclavian approach (41). The risk of the pinch-off syndrome, a mechanical stress on the catheter compressed between the first rib and the clavicle, is nil in using jugular access and could be increased using a very lateral puncture site in subclavian approaches. This can be avoided by jugular access (42). Hence, the right jugular vein appears to be the best target vessel for prevention of catheter-related complications.

This study is limited due to its retrospective design. Further prospective studies should include additional dose measurements with patient radiation dosimeter so that effective doses can be calculated.

In conclusion, because of significant DAP and FT reductions associated with right-sided approaches and jugular access routes, we suggest that the right jugular vein is the most favorable implantation side for totally inserted venous port systems.

For further dose reduction and increase in safety of patients and staff, residents should be well-trained.

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