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Tunnelled central venous access devices in small children: A comparison of open vs. ultrasound-guided percutaneous insertion in children weighing ten kilograms or less☆,☆☆

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ABSTRACT

Purpose: Ultrasound-guided (USG) percutaneous insertion of tunnelled central venous access devices (CVADs) has been shown to be safe and effective in adults. However, there have been concerns over the safety of this technique in small children. This paper analyses the safety of USG percutaneous CVAD insertion in the pediatric population weighing ten kilograms or less.
Method: All surgically inserted CVADs for children weighing ten kilograms or less, between January 2010 and December 2015 at the Children's Hospital at Westmead were retrospectively reviewed. Open and USG percutaneous techniques were compared with intraoperative complications as the primary outcome variable. Secondary outcome measures included conversion to open technique, postoperative complications, operating time and catheter longevity.
Results: 232 cases were identified: 96 (41.4%) open, 136 (58.6%) USG percutaneous. Age ranged <1–48 months; weight 0.7–10 kg. CVADs ranged 2Fr–9Fr in size. Eleven USG percutaneous cases required conversion to open. There was no significant difference in intraoperative complication rate between open (11/96, 11.5%) and USG percutaneous (19/136, 14.0%) groups ($p = 0.574$). There was no significant difference in overall postoperative complications, operative time or catheter longevity. Mechanical blockage was significantly higher in the open group than the USG percutaneous group (21% vs 10%, $p = 0.015$).
Conclusion: USG percutaneous CVAD insertion is safe in children weighing ten kilograms or less. Open catheter insertion may be associated with higher rates of post-operative catheter blockage in small children.
Level of evidence: Level III.

Tunnelled central venous access devices (CVADs) are essential in the management of children requiring long term parenteral nutrition, chemotherapy, antibiotics or frequent blood sampling [1,2].

While traditionally placed by open surgical cut down (henceforth "open"), percutaneous insertion of CVADs has been shown to be safe and effective in adults. There are concerns over the safe use of percutaneous technique in small children, where potential complications of hemothorax, pneumothorax, arterial puncture and even death are well reported [3–6].

Ultrasound-guided (USG) percutaneous approaches are considered superior to landmark techniques, particularly in children under six years of age where anatomical variation could complicate insertion [7]. Recent research encourages a movement away from open technique, which has been associated with higher rates of venous occlusion [8–10]. There are a number of studies that examine percutaneous central venous catheter insertion in the pediatric population. Arul et al. in a large prospective series (500 patients) of tunnelled CVADs suggested that while a learning curve did exist, USG percutaneous insertion was safe for all children regardless of size, age or diagnosis [11]. However, this series included only seventeen patients under five kilograms, and did not further stratify results based on weight. A further series of USG percutaneous insertions in patients weighing less than five kilograms reported thirty-six successful insertions, with no complications [4]. The technically demanding nature of the procedure was emphasized: all catheters were placed by consultants. Janik et al. have reported on the impact of catheter size, finding significantly higher

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complication rate in patients weighing less than ten kilograms receiving a catheter greater than six French (Fr) [12].

This is the first study that directly compares the complication rates of open and USG percutaneous techniques in low weight patients. Furthermore, we are unaware of any series of low weight patients that includes both trainees and consultant surgeons as operators.

1. Materials and methods

A single centre retrospective review of patients identified through the Children's Hospital at Westmead (CHW) operative and central line database was conducted. All patients weighing ten kilograms or less who underwent surgical CVAD placement from January 2010 to December 2015 were included. A retrospective review of their medical record was performed. All but three patients were exclusively managed at the Children's Hospital at Westmead. For those patients managed elsewhere, clinical data were obtained by telephone.

The primary outcome was difference in complications between open and USG percutaneous techniques for children weighing ten kilograms or less.

Data collected included patient factors: sex, age, weight, indication for central access; operative factors: technique, site, type and size of inserted device and operative time; complications: intraoperative and postoperative; length of follow up and longevity of catheter. Intraoperative complications assessed included hemothorax, pneumothorax, arterial puncture, pericardial effusion, inability to access the intended vein and inability to pass catheter to correct position. Conversion to open technique was not itself considered an operative complication (as this complication could only occur within the USG percutaneous group). Rather, the incident requiring conversion to open (eg: inability to access the intended vein) was noted as the complication.

Postoperative complications were separated into mechanical (blockage, breakage, dislodgement) or catheter infection. Catheter infection was determined by clinical suspicion based on local signs, or systemic symptoms with positive catheter cultures. Operative time was calculated as the difference in minutes from the operation start and finish times recorded in the theatre nursing operation chart. Catheter longevity was calculated as the number of days from insertion to removal date; or where the catheter remained in situ, the census date of data analysis (December 1, 2016). All patients were assessed for postoperative complications for at least one year following catheter insertion. The complication rate per 1000 days was calculated as 1000 times the number of complications divided by the total number of catheter days [13].

Data was analyzed using an intention to treat analysis. Analysis was performed using Microsoft SPSS (version 22). Normal data distribution was assessed using a Shapiro–Wilks test. Binary outcomes were compared using a Pearson Chi-square test. Continuous variable hypothesis testing was undertaken with either Student t-test (parametric data) or Wilcoxon rank-sum test (nonparametric data). Multivariate analysis modeling was performed using statistically significant results or clinically important variables. In particular, patient weight was further subdivided for multivariate analysis into ≤5 kg or > 5 kg. A P value of <0.05 was considered as significant.

1.1. Preferred operative technique

Both open and USG percutaneous techniques are performed under a general anesthetic. A Trendelenburg position is utilized to encourage dependent filling of neck veins. The patient is placed supine with a small roll under the patient's shoulders to extend the neck.

Open technique involves incision over the chosen vessel (internal or external jugular), dissection and direct control of the vein with vessel loops. A venotomy is made and the central access catheter passed under direct vision. If required, the venotomy is then closed with a 6-0 or 7-0 Prolene suture.

USG percutaneous technique utilizes a 2D ultrasound probe, within a sterile cover. Cuffed tunnelled central lines used were 4.2Fr, 6.6Fr or 7Fr Bard percutaneous insertion kit (Bard Access Systems Inc, Salt Lake City, UT). The 2.7Fr Bard cuffed central line (Bard Access Systems Inc, Salt Lake City, UT) does not come as a percutaneous set and hence was used in conjunction with an Arrow 3 Fr PICC Seldinger Conversion Set (Arrow International Inc., Reading, PA). The chosen vein is identified and then punctured under ultrasound vision just above the clavicle, observing the tip of the needle within the vessel lumen. A guidewire is then ideally passed into the inferior vena cava, but if technically unable, it is left at the right atrium/superior vena cava junction. A dilator with peel-away sheath is passed over the guidewire using a Seldinger technique. The dilator insertion is observed under image intensification fluoroscopy to minimize potential complications. Once in position the guidewire is removed, and catheter passed via the peel away sheath to its final position. The preferred catheter tip position is in the lower superior vena cava or two vertebral bodies below the carina. Correct placement was confirmed intraoperatively with image intensifier radiographs, aspiration and flush of catheter.

The percutaneous technique was introduced to CHW by two surgeons and thus training and performance of the percutaneous technique are relatively uniform. There is some variation in neonates or small infants with some surgeons preferring initial access with a 22 g cannula and 0.018″ wire which is then exchanged using graded larger cannulas to the j-tip wire included in the packaging (range 0.021–0.035″). The open technique is uniform in approach as described.

Both insertion techniques utilized the same fixation practices and postoperative catheter care. Central catheters were tunnelled subcutaneously to the anterior chest. Totally implantable venous access devices were secured to the pectoral fascia in a subcutaneous pocket with three to four nonabsorbable sutures.

2. Results

A total of 232 consecutive surgical CVAD insertions in children weighing ten kilograms or less were identified. Patient age ranged from <1 to 48 months; patient weight ranged from 0.7 to 10 kg. CVADs were inserted to either left or right internal jugular or external jugular veins. Catheters ranged from 2Fr to 9Fr in size.

CVADs were inserted by registrars (either independently or supervised) or by consultant surgeons. Fifteen individual consultant surgeons had overseen the care of the total 232 central catheter insertions. Five of the fifteen consultant surgeons utilized only the open technique, while one of the fifteen utilized only USG percutaneous technique.

A total of ninety-six (41.4%) procedures were performed using the open technique, 136 (58.6%) using the USG percutaneous technique. Eleven of the USG percutaneous insertions required conversion to open technique, and were analyzed as an intention to treat. No percutaneous insertions were performed without the use of ultrasound.

The demographic and operative data for both open and USG percutaneous groups are shown in Fig. 1. Median weight was significantly higher in the USG percutaneous group (5.36 kg) compared to the open group (4.58 kg, $p = <0.001$). The distribution of weight by one kilogram increments is shown in Fig. 2.

Further significant differences between the groups were observed in site of catheter insertion, catheter size and operator. This included a higher proportion of right internal jugular, larger caliber lines and consultant surgeon operators for the ultrasound group. There was no significant difference in median age, sex, type of device between the two groups.

Approximately 70% of catheters were inserted for either chemotherapy or parenteral nutrition. Other indications for insertion included liver, renal, hematological or metabolic diseases, or for the administration of intravenous antibiotics.

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