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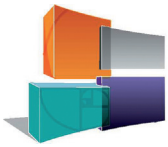

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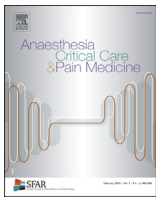

Original Article

Effectiveness and complications of ultrasound-guided subclavian vein cannulation in children and neonates

Nicolas Nardi [a,b,c,*], Eric Wodey [a,b,c], Bruno Laviolle [b,d], François De La Brière [a], Séverine Delahaye [a], Charlotte Engrand [a], Cécile Gauvrit [a], Sabrina Dessard [a], Anne Defontaine [a], Claude Ecoffey [a,b]

[a] Service d'anesthésie–réanimation 2, CHU de Rennes, 35203 Rennes, France
[b] Université de Rennes 1, 35000 Rennes, France
[c] UMR Inserm 1099, LTSI, université de Rennes 1, 35043 Rennes, France
[d] Service de pharmacologie, centre d'investigation clinique, CHU de Rennes, 35000 Rennes, France

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ABSTRACT

Background: The ultrasound (US)-guided supraclavicular approach to subclavian vein (Sup-SCV) catheterisation in children has recently been described and evaluated in a small cohort. The aim of this study was to assess this technique in a large paediatric cohort including neonates.
Methods: We conducted a prospective observational study between November 2010 and December 2013 which included 615 children divided into two groups according to their weight: Group 1 $\leq$ 5 kg (n = 124), Group 2 > 5 kg (n = 491). All procedures were performed under general anaesthesia by an anaesthesiologist or a supervised resident. The success rates of catheter insertion, the number of punctures required, the procedure time, and the complication rates were analysed.
Results: Sup-SCV catheterisation was successful in 98% of the cases and was higher in Group 2 than in Group 1 (99.4% versus 92.7%, $P < 0.001$). The success rate after the first attempt was higher and the incidence of multiple attempts ($\geq$ 3 punctures) was lower in Group 2 than in Group 1 (84.2% versus 64.5%, $P < 0.001$ and 4.5% versus 19.4%, $P < 0.001$). The success rate was similar between right and left cannulations (P = 0.404), and according to physician experience (P = 1.000). Procedure time was fast in both groups with a median time for all procedures of 40 seconds [30–90]. Among the procedures recorded, only five arterial punctures and no cases of pneumothorax were observed.
Conclusion: US-guided Sup-SCV catheterisation appears to be fast and safe in children and neonates, even if it remains a little more difficult to achieve in lower-weight patients.

1. Introduction

Central venous catheter insertion is a routine act in paediatric anaesthesia and intensive care, which can be associated with mechanical complications such as arterial puncture, haematoma, pneumothorax and malposition or failure of cannulation [1]. The use of ultrasound (US) facilitates and secures this medical act and is now widely used [2–5]. Internal jugular vein (IJV) catheterisation is the gold standard but remains difficult in infants weighing < 10 kg [6], and exposes the patient to a higher risk of infection compared with subclavian vein catheterisation [7,8]. Recently, a new method for a US-guided supraclavicular approach to the subclavian vein (Sup-SCV) in children has been described [9,10] and evaluated on a small cohort of children [11–14].

We therefore performed a 3-year prospective, observational study to assess the effectiveness and morbidity of this technique in a large cohort of children and neonates.

2. Methods

2.1. Study population

This prospective, single-centre, non-randomised, observational study was conducted from November 2010 to December 2013 at

* Corresponding author at: Pôle Samu urgence anesthésie–réanimation, hôpital Sud, 16, boulevard Bulgarie, 35203 Rennes cedex 2, France. Tel.: +33 6 34 81 230.
E-mail address: nicolas.nardi@chu-rennes.fr (N. Nardi).

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the University Hospital of Rennes, France. After approval by the local Institutional Review Board (no. 15.57), a computerised prospective registry of all central venous cannulation in children seen in the operating theatre was performed.

An US-guided technique for supraclavicular cannulation was used for all central venous lines required for children. The only exclusion criterion was the inability to visualize the SCV correctly but this situation was not encountered. The cohort was empirically divided into two groups according to weight: Group 1 $\leq$ 5 kg, Group 2 $>$ 5 kg.

2.2. Procedure

We used three types of catheters: short-term catheters (Seldiflex®, Prodimed), long-term tunneled open-ended catheters (Broviac® catheter, Bard), or venous implantable ports (Polysite®, Perouse). The diameters and lengths of the catheters were calculated according to the patient's weight.

All catheters were placed using ultrasound machines manufactured by General Electric Logic e® or Venue 40® with a high frequency "hockey stick" probe, at respectively 10 MHz and 18 MHz. We used a sterile cover specially designed for US devices (Pull up®, Protek Medical).

All procedures were performed in the operating theatre under general anaesthesia after tracheal intubation in the supine position with a Trendelenburg tilt. We used a standard-sized towel rolled under the child's shoulders with his/her head slightly turned to the opposite of the cannulation side. The operator sat on the cannulation side with the US device on the other side. All catheterisations were performed under aseptic surgical conditions. After transversal identification of the internal jugular vein and carotid artery at mid-cervical level, the vessels were traced in the caudal direction with the US probe. Once the probe was in the supraclavicular fossa, small movements in the caudal direction enabled visualization of the confluence of the internal jugular vein and subclavian vein in its longitudinal axis.

When a satisfactory image in the longitudinal axis of the vessel was obtained, the needle was introduced in the same axis as the probe. In this way, the needle without an attached syringe could be inserted under full vision into the vein. If spontaneous blood flashback was obtained, the end of the procedure was carried out using Seldinger's technique. If no spontaneous blood return was observed despite clear positioning of the needle bevel in the vessel lumen on US, a syringe was attached to the needle hub to aspirate blood and then the guide wire was introduced into the vein. If blood could not be aspirated, the needle was withdrawn and another attempt was made.

During the procedure, we used fluoroscopy to confirm that the guide wire was in the superior vena cava. The end of the procedure was defined by the correct positioning of the guide wire in the superior vena cava. In the recovery room, a chest X-ray was carried out to confirm the proper position of the catheter tip and to exclude any procedure complications.

2.3. Data collection

The following data were recorded: age, weight, operator experience (resident or anaesthesiologist), indication, the device used, catheter size, side of catheterisation, procedure duration (i.e. time in seconds between the first needle puncture and the end-of-guide placement), the number of punctures required to correctly insert the guide wire and complications (guide wire malposition, arterial puncture, haematoma, or pneumothorax).

2.4. Study endpoints

The aims of the study were to assess the success rates of catheter insertion, the number of punctures needed, procedure time, and complication rates. The success rates were also assessed between right and left cannulations and for residents versus anaesthesiologists.

Catheterisation failure was defined by the need to puncture another vein, including the contralateral Sup-SCV or to change operators to correctly insert the catheter.

2.5. Statistical methods

Statistical analysis was performed with SAS Software version 9.2 (SAS Institute, Cary, NC, USA). Data are presented as medians (first-third quartiles) for continuous variables and as numbers with the corresponding percentages for qualitative variables. Comparisons between groups were performed using Student's *t*-tests or Wilcoxon rank sum tests as appropriate for continuous variables, and Chi^2 or Fisher exact tests as appropriate for categorical variables. Statistical significance was defined as $P < 0.05$.

3. Results

During the 3-year study period, 615 procedures using the Sup-SCV approach were recorded in the database. The characteristics of the patients and devices used are summarized in Table 1. The children were aged from 0 to18 years and their weights ranged from 1.2 to 94 kg. There were 124 patients in Group 1 (median weight: 3.3 kg) and 491 patients in Group 2 (median weight:

Table 1
Patient characteristics and devices used.

	Total (n = 615)	Group 1 ($\leq$ 5 kg) (n = 124)	Group 2 ($>$ 5 kg) (n = 491)	P
Sex (male/female)	369 (60)/246 (40)	72 (58)/52 (42)	297 (60)/194 (40)	0.622
Age (months)	33 [6–111]	1 [0–2]	59 [17–133]	< 0.001
Weight (kg)	14 [7–27]	3.3 [2.7–4.0]	17 [10–32]	< 0.001
CVC indication				
Antibiotherapy	116 (19)	19 (15)	97 (20)	0.259
Surgery	170 (28)	49 (40)	121 (25)	< 0.001
Chemotherapy	202 (33)	3 (2)	199 (40)	< 0.001
Parenteral nutrition	51 (8)	26 (21)	25 (5)	< 0.001
Medical treatment	74 (12)	27 (22)	49 (10)	< 0.001
Device used				< 0.001
Short-term	382 (62)	111 (90)	271 (55)	
Tunneled catheter	136 (22)	13 (10)	123 (25)	
Venous implantable Port	97 (16)	0 (0)	97 (20)	
Catheter diameter (French)	4.2 [4–5]	3 [3–3]	5 [4–6]	< 0.001
Side (right/left)	337 (55)/278 (45)	65 (52)/59 (48)	272 (55)/219 (45)	0.552
Resident/anaesthesiologist	158 (26)/457 (74)	19 (15)/105 (85)	139 (28)/352 (72)	0.003

Results are expressed as medians [interquartile ranges] or numbers (%) of total patients in each group. CVC: central venous catheter.