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Two Approaches to Cannulation of a Child's Internal Jugular Vein

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Central venous catheters for pressure monitoring or drug and fluid therapy have become widely used in adults. However, in pediatric patients, peripheral, subclavicular, and external jugular approaches for catheter insertion often lead to inaccurate placement[1–3] and unacceptable complications.[4–7] Results of studies of the internal jugular approach by English *et al.*[8] in adults and Prince *et al.*[9] in children seemed promising. A new lower approach to the internal jugular vein reported by Rao *et al.*[10] attained a high success rate with few reported complications. This latter approach differs in that the point of entry is much closer to the clavicle. We have compared this low approach to the internal jugular vein with the more traditional high approach to determine whether either was more successful, and to assess the types and frequencies of complications with both approaches.

MATERIALS AND METHODS

One hundred consecutive patients undergoing cardiac, thoracic, or other major surgical procedures at The Children's Hospital of Philadelphia who would need central venous cannulation comprised the patient population. The approaches to the internal jugular vein were either "high" or "low," and choice was randomly determined by tossing a coin. All patients were placed in the 15–20-degree Trendelenberg position with the head turned away from the site of catheter insertion. The high approach consisted of locating the point of convergence of the sternal and clavicular heads of the sternocleidomastoid muscle; the needle was inserted at an angle of 30–45 degrees to the skin, aiming toward the ipsilateral nipple.[9] When this landmark was not clearly present the site of skin entry was identified as a point midway on a line between the mastoid process and the suprasternal notch, immediately lateral to the carotid artery.[8] The angle and direction of puncture were the same. In the low approach the needle was inserted immediately above a palpable notch in the superior aspect of the right clavicle located just lateral to the sternoclavicular junction. The needle was aimed caudad and parallel to the sagittal plane at an angle of 30–45 degrees to the skin.[10]

When a catheter could not be inserted via the randomly assigned approach (primary attempt), the other route was attempted (secondary attempt). Fifteen patients represent non-random high insertions because of the presence of a right-sided aortic arch. We consider the low approach to be contraindicated when this anomaly is present.[11] All high attempts except one were made on the right side. The right side was chosen because it is a shorter, more direct route to the superior vena cava and thus associated with more accurate placement. All low attempts were likewise on the right, in order to avoid thoracic-duct injury.[10] All catheters were inserted by one of the four investigators after induction of general anesthesia, muscle paralysis, endotracheal intubation, and controlled ventilation. Age, height, weight, body surface area, number of needle probes and initial central venous pressure (CVP) were recorded. Distance from skin to venipuncture, duration of catheter insertion, equipment malfunction, reason for catheter removal, and complications were also recorded. Catheter position was documented by a postoperative roentgenogram of the chest, and a continuous heparinized flush system was used to prevent thrombosis.

Catheters were introduced by use of the Seldinger technique.[12] Catheterization equipment components were designed to be of appropriate sizes for the patients' ages:‡

- <2 years, 4 cm long, 21-ga thinwall steel needle; guide wire 0.018 in (0.46 mm) in diameter, 20 cm long; 3.0-French Teflon catheter, 7 cm long (Cook "CVP 10")
- 2–10 years, 4 cm long, 20-ga thinwall steel needle; guide wire .021 in (0.53 mm) in diameter, 30 cm long; 4.0-French Teflon catheter, 12 cm long (Cook "CVP 11")

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TABLE 1. Results of Cannulation by Use of High and Low Approaches

	Successes/Patients		Complications/Patients	(Per Cent)
	Number	Per Cent		
High approach				
Coté *et al.*	59/71	83	Hematoma	4.2
			Arterial puncture	8.5
Prince *et al.*[9]	40/52	77	Hematoma	5.8
			Arterial puncture	2.3
			Horner's syndrome	3.8
English *et al.*[8]	77/85	91	Hematoma	0.6*
			Arterial puncture	0.6*
			Pneumothorax	0.2*
Low approach				
Coté *et al.*	38/51	74	Hematoma	3.9
			Pneumothorax	2.0
Rao *et al.*[10]	188/192	97	Hematoma	1.6
			Arterial puncture	1.6
			Pneumothorax	0.5
			Thoracic duct injury	1.0
Combined high and low approach				
Coté *et al.*	97/100	97	Hematoma	4.0
			Arterial puncture	5.0
			Pneumothorax	0.8

* Combined adult–pediatric study (500 patients). No indication of relationship of age to complications.

10–19 years, 4 cm long, 18-ga thinwall steel needle; guide wire 0.35 in (0.89 mm) in diameter, 40 cm long; 5.0-French Teflon catheter, 15 cm long (Cook "CVP 12")

Data were analyzed by the chi-square test or the Student *t* test for unpaired data as appropriate.

RESULTS

Age did not significantly affect the frequency of successful catheterization attempts in randomized patients (<2 years 23/29; 2–10 years 34/42; 10–19 years 25/33). Also, the type of approach (high *vs.* low) had no significant effect on the success rate with either primary (77 per cent/71 per cent) or secondary attempts (83 per cent /90 per cent). All primary attempts were less successful than secondary attempts (74 per cent/86 per cent). The 15 patients placed in the non-random high-approach category had a success rate of 100 per cent.

Arterial puncture occurred only during use of the high approach (table 1) and was not related to age, one puncture occurring in a 4-month-old infant, the remaining five in children older than 4.5 years. Hematomas of comparable incidences and sizes occurred after use of the two approaches. One pneumothorax, necessitating chest-tube drainage, resulted from use of the low approach in a 6-year-old child.

All 97 catheters successfully placed were in the superior vena cava or right atrium, as documented by postoperative roentgenograms. The distances of needle insertion from skin to free blood flow were consistently greater with use of the low approach (2.8 cm ± .18 SEM) compared with the high approach (2.2 cm ± .14). Successful insertion was not related to height, weight, body surface area, number of needle probes, or initial central venous pressure, which agrees with findings in a similar study.[9] There was no equipment malfunction, and a 100 per cent patency rate was maintained throughout anesthesia, operation, and the postoperative period. Catheters were removed when they were no longer needed for patient care. No other indication for removal was found in any case. The durations of placement averaged 61 hours (range 4–224 hours).

DISCUSSION AND CONCLUSIONS

This study has demonstrated that successful cannulation of the internal jugular vein in a child is not influenced by choice of a low *vs.* high cervical approach. Likewise, none of the other factors we examined had any effect. Experience may play a role, however. Rates of successful cannulation are higher in large series (English *et al.*, 91 per cent; Rao *et al.*, 97 per cent) than in smaller series (Prince *et al.*, 77 per cent; Coté *et al.*, 80 per cent). In one study of 500 patients an increasing success rate was observed as the study progressed.[8]

The use of the right internal jugular route resulted in 100 per cent true central placement in this study, and nearly 100 per cent similar positioning in other reports.[8,9]

The morbidity associated with the low approach is significant in its clinical import. We observed two additional cases of pneumothorax and one intrapulmonary hemorrhage that were not in the study group. All of these children needed aggressive treatment. One death associated with the low approach occurred in a child with a previous right Blalock-Taussig shunt.§ The continued use of the low approach seems unjustified because of these results.

When central venous cannulation in children is attempted by use of the high approach on the right side, a success rate of more than 80 per cent can be expected. A second attempt on the left (when hematoma did not occur following a failed right-sided attempt) would probably result in a still higher percentage of successful placement.[8,9] The complications associated with the high approach in this study were of minor clinical significance, and similar to those in previous reports (table 1). The high cervical approach is recommended because of a high rate of successful accurate placement associated with a low incidence of clinical morbidity.

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