

Original Article

Cephalic Jugular Venous Blood Gas Measurement during Neonatal Venoarterial Extracorporeal Membrane Oxygenation

Timothy A. O'Connor, MD¹, Barbara M. Haney, RN¹, Stanley G. Shaffer², MD, Gary E. Grist, CCP^{1a}
Departments of Neonatology¹ and Surgery^{1a}, The Children's Mercy Hospital and University of Missouri - Kansas City School of Medicine, Kansas City, Missouri and St. Luke's Perinatal Center²,
Section of Perinatal Pediatrics, Kansas City, Missouri.

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Abstract

Cannulation of the cephalic portion of the right internal jugular vein during extracorporeal membrane oxygenation (ECMO) allows for increased venous return flow to the circuit.

This procedure also allows access to venous drainage from the brain. We reviewed data from simultaneous blood gases obtained from the cephalic jugular vein and the mixed venous return in 5 neonates during venoarterial

ECMO. Cephalic venous pO₂ values were significantly lower than mixed venous pO₂ values (P < .001). The values for pH and pCO₂ did not vary between the sites. Our experience with 34 infants using cephalic jugular drainage is reviewed. Since the institution of right jugular venous drainage, the intracranial hemorrhage rate in neonates undergoing ECMO at our center has decreased from 34% to 6% (p < .01).

Introduction

Mixed venous blood gas (MVBG) measurements have been utilized as the primary indicator of adequacy of oxygenation in infants receiving venoarterial extracorporeal membrane oxygenation (ECMO). Cannulation of the cephalic portion of the right jugular vein has been utilized to decrease cerebral venous congestion during ECMO. (*,***) This procedure may also be useful to monitor cephalic venous blood gases (CVBG). Although jugular bulb venous saturation has been used to guide therapy in pediatric patients at risk for neurologic injury, scant data is available concerning CVBG values during ECMO. (1)

This study was designed to examine CVBG values during ECMO and compare these with simultaneous MVBG values in infants who did not demonstrate neurologic injury. Our experience with cannulation of the cephalic portion of the right jugular vein is reviewed.

Address correspondence to:
Timothy A. O'Connor, MD
Department of Child Health
One Hospital Drive
Columbia, MO 65212

Materials and Methods

The records of 5 neonates requiring venoarterial ECMO therapy for respiratory failure were reviewed. All infants had normal head ultrasound examinations prior to, and daily, during the ECMO course. Likewise, all infants had a normal neurologic exam and normal computed tomography of the brain at the time of discharge.

Cannulation of the cephalic portion of the right jugular vein was accomplished at the time of initial ECMO cannulation. The internal jugular vein was surrounded by three soft ties and then ligated with the central tie. The vein was then cannulated through two separate venotomies, one proximal and one distal

- * O'Connor TA, Haney BM, Grist GE, Egelhoff JC, Snyder CL and Ashcraft KW. Decreased incidence of intracranial hemorrhage using cephalic jugular venous drainage during neonatal extracorporeal membrane oxygenation. *J Pediatr Surg* - in press.
- * * Taylor G and Walker L. Doppler US evaluation of the intracranial system following ligation of the right jugular vein in infants treated with extracorporeal membrane oxygenation. *Radiol* - in press.

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Table 1

Comparison of means \pm % SD of 197 paired simultaneous blood gas values from the cephalic portion of the right jugular vein and mixed venous samples during venoarterial ECMO.

Sample Site	Cephalic Venous	Mixed Venous
pH	7.38 \pm .06	7.39 \pm .06
pCO ₂	53.1 \pm 6.1	51.6 \pm 6.5
pO ₂	31.2 \pm 4.0	35.9 \pm 4.5*

*p < 0.001 vs. cephalic venous

to the central ligature. The right atrial venous cannula was placed first. A 9.6 French Vaso-cath^a modified with 2 side ports 1 cm from the distal end was utilized for the cephalic drain. This was advanced to its limit and then withdrawn 1 cm. The catheters were then secured and the cephalic jugular cannula connected to the venous return tubing. Catheter position in the jugular bulb was confirmed radiographically. A blood sampling port was placed in the jugular venous drain proximal to its connection with the central venous catheter to allow access for CVBG collection.

Serial CVBG and MVBG samples were obtained every 4-6 hours during the ECMO course. A total of 197 paired specimens drawn simultaneously were compared using descriptive statistics and linear regression analysis. Differences in values between the two blood gas sites were analyzed using analysis of variance (ANOVA) with a level of significance of 0.05.

Thirty-four consecutive neonates were reviewed who underwent ECMO with cephalic jugular cannulation. These infants were compared with the previous 34 neonates who underwent ECMO without cephalic jugular cannulation. All infants were monitored for intracranial hemorrhage (ICH) using daily cranial sonography, computed tomography upon discharge, or at autopsy. Rates of survival and ICH were compared with the Chi-square or Fischer's exact tests using a level of significance of 0.05.

Results

Table 1 demonstrates the mean (\pm standard deviation) values for the pH, pCO₂ and pO₂ values from the two sites. The cephalic venous pO₂ (CVpO₂) was less than or equal to the mixed venous pO₂ in 186 of the 197 samples. ANOVA for repeated measures revealed a significant difference between the two sites (p < .001). The CVpO₂ ranged from 23 to 43 mmHg while the mixed venous pO₂ ranged from 26 to 48 mmHg. The pH and pCO₂ were not statistically different from

Figure 1

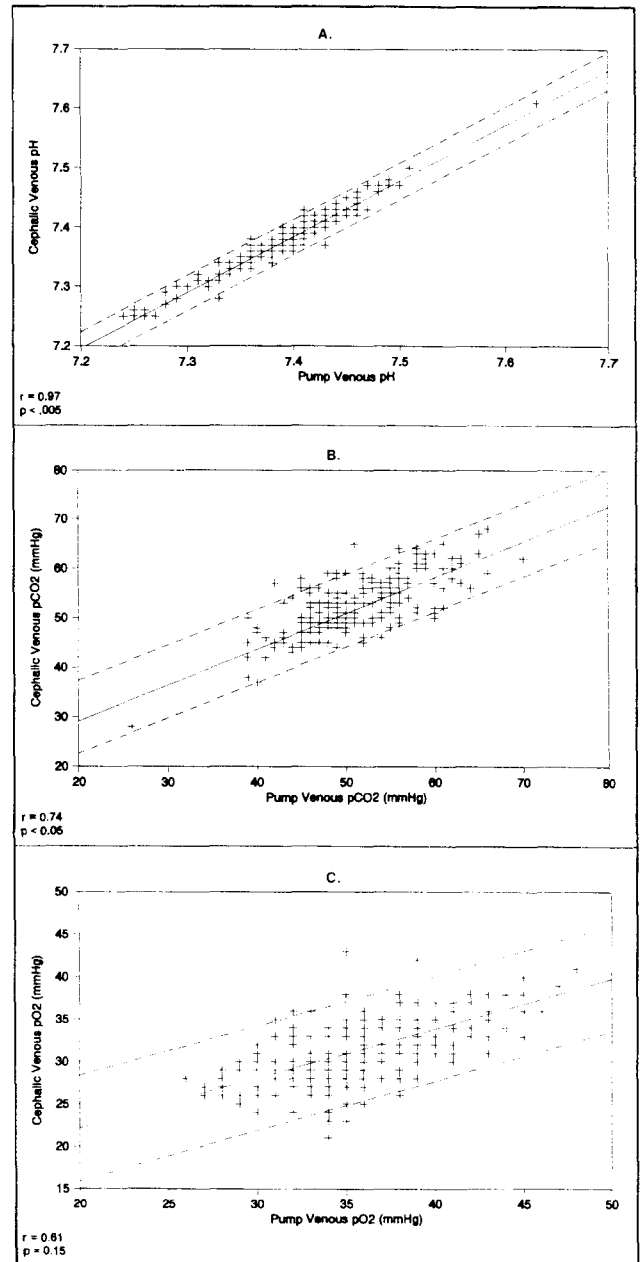
Scatter diagrams of data from 197 paired blood gases from the cephalic portion of the right jugular vein and the right atrium during venoarterial ECMO. Results of pH are represented in A, pCO₂ in B, and pO₂ in C.

The regression equations were:

CVpH = 0.94 \pm 0.44 (mixed venous pH)

CVpCO₂ = 17.1 \pm 0.70 (mixed venous pCO₂)

CVpO₂ = 11.4 \pm 0.55 (mixed venous PO₂)



a GESCO International, San Antonio, Texas

the two sites.

Figure 1 illustrates the linear regression analysis of the pH, pCO₂ and pO₂ from the two sites. The correlation coefficients for the pH, pCO₂ and pO₂ were 0.97, 0.74 and 0.61 respectively. The correlation did not vary significantly when variables such as pump flow and cephalic jugular venous flow were considered. Likewise, correlation was similar when the patients were analyzed individually.

Our experience with cephalic jugular drainage thus far has included 34 infants, 25 venoarterial and 9 venovenous ECMO. Survival has been 85% compared to 74% for the 2 year period prior to the use of cephalic jugular drains. Intracranial hemorrhage rates were 6% for those with cephalic jugular drainage and 34% for the 2 year period prior to the use of cephalic jugular drainage ($p < 0.01$). Both groups of infants were similar in gestational age and birthweight. No differences were found between the groups when pH or oxygenation index (oxygenation index = [mean airway pressure x FiO₂ x 100]/pO₂) prior to cannulation were compared. Likewise, no differences were found between the groups regarding platelet counts, ECMO duration, or bleeding complications other than ICH. Complications of the cephalic jugular catheters included displacement in 1 patient, and removal in 3 others because of low flow or clot formation. None of these 4 patients had an ICH.

Discussion

Cannulation of the cephalic portion of the internal jugular vein has become routine during neonatal ECMO at our institution. This procedure substantially augments the venous return to the ECMO pump with flow rates of 50-150 cc/min measured by Doppler technique from the cephalic jugular drain. This is especially advantageous during venovenous ECMO, which can become flow limited if venous return is insufficient, and the effects of recirculation of pump arterial blood into the venovenous catheter are diminished by the extra source of venous blood. Drainage of the cephalic portion of the jugular vein has also lessened the incidence of plethora of the head and may reduce cerebral venous pressure.

We reviewed simultaneous blood gases from the mixed venous return line and cephalic jugular drain on 5 venoarterial ECMO patients and found that pH and pCO₂ correlated well over a broad range of values. The cephalic venous pO₂ values were consistently lower than the mixed venous pO₂ values. The lower pO₂ values could be the result of differences of oxygen delivery or utilization and could not be further characterized by the methods of this investigation.

Although the survival rate of neonates with cephalic jugular drainage during ECMO were not significantly different from a group of historical controls, the incidence of ICH was significantly reduced. Thus, a randomized prospective trial of this technique is warranted to further clarify the apparent

reduction in ICH risk.

Drainage of blood from the cephalic portion of the right jugular vein during ECMO appears to be safe and efficacious. Further investigation is necessary to determine the preferred method of monitoring oxygen sufficiency during ECMO and to further define the benefits and risks of this technique.

References

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