Effects of bolus tube feeding on cerebral blood flow velocity in neonates

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Abstract

Aim—To study continuously cerebral blood flow velocity in the middle cerebral artery before, during, and after tube feeding in neonates.

Method—Cerebral blood flow velocity was measured in 14 neonates using a Doppler ultrasound device. Blood pressure, respiration, and oxygen saturation were monitored.

Results—Mean blood flow velocity decreased from 37 cm/s before feeding to 33 cm/s ($P < 0.001$) 5 to 11 minutes after feeding. Prefeeding values were reached after 17 minutes. Arterial blood pressure, respiration patterns, and oxygen saturation did not change significantly during the study period.

Conclusion—Tube feeding in preterm infants may decrease cerebral perfusion, despite unchanged blood pressure and unchanged oxygen saturation.

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Keywords: tube feeding; cerebral blood flow velocity; blood pressure; oxygen saturation.

Jugular venous blood occlusion plethysmography has been used to study the effect of feeding on cranial blood flow in term infants.^{1,2} The results showed a temporary fall in cranial blood flow by 20 to 40%, with the lowest values after 15 to 60 minutes of oral feeding. The effect of feeding on cerebral blood flow velocity in preterm infants has recently been studied.³ In preterm infants with 33 to 35 weeks of gestation, blood flow velocity in the middle cerebral artery was similar 30 minutes after feeding as it was directly before feeding.

We hypothesised that cerebral blood flow velocity may change during and/or shortly after tube feeding, as pronounced immediate effects of tube feedings on cardiorespiratory functions have been observed in preterm infants.⁴

The present investigation was designed to evaluate the effect of tube feeding on cerebral circulation in stable preterm infants. A transcranial pulsed wave Doppler ultrasound device for continuous measurement of mean cerebral blood flow velocity (CBFV) in the middle cerebral arteries was used.

Methods

Fourteen neonates with a mean (SD) gestational age of 29 (2) weeks, birthweight of 1230 (250) g, postnatal age of 6 (1) weeks, and an actual body weight of 1650 (340) g were

studied with approval of the Ethical Committee of the University of Heidelberg and with the informed consent of the parents. At the time of the investigation all infants were in a stable clinical condition without respiratory or cardiac problems, signs of sepsis, or renal disease. They were not mechanically ventilated nor had they been treated with sedatives, steroids, diuretics, oxygen, or vasoactive drugs. The infants were fed via a nasogastric tube either with their mothers' breast milk (supplemented with 5% FM85) or a preterm formula. All infants were fed three hourly and received 14 (3) ml/kg per meal over a period of 5 minutes.

CEREBRAL BLOOD FLOW VELOCITY (CBFV)

Measurements were done when the infants were in a quiet sleep state, determined by one observer (CH), using the criteria of Prechtl.⁵ Quiet sleep was assumed when the infants' eyes were closed without rapid eye movements; no movements were observed apart from occasional stable reactions and regular respiration.

CBFV in both middle cerebral arteries (MCA) was recorded continuously for 10 minutes before feeding, during the 5 minutes of tube feeding, and 45 minutes after feeding, using a transcranial Doppler ultrasound device (TCD Multi Dop X system, DWL Electronic, Sipplingen am Bodensee, Germany, 2 MHz pulsed-wave button probe; diameter 10 mm, depth 8 mm).⁶ Both transducers were fixed on the babies' temporal bones, and the Doppler sample volume, depth, and length were adjusted electronically to optimise the signal by optical and acoustic quality, in an attempt to obtain the maximum envelope from both middle cerebral arteries. The direction of the flow in this region is directed towards the transducer. A microprocessor carried out Fast Fourier Transform analysis of the signal, enabling real time spectral display. From the spectral wave form, mean cerebral blood flow velocity was automatically analysed beat by beat, derived from peak systolic and end diastolic velocity values. Velocity values were derived from the peak velocity envelope of the spectral waveform. The average of five consecutive, homogeneous flow cycles at the beginning of each minute was taken for measurement. There were no significant differences in blood flow velocity between the two arteries. Therefore, only the results of the right middle cerebral artery are shown.

The safety of transcranial Doppler sonography instruments depends on energy output—that is, peak acoustic pressure—peak negative pressure, output beam intensity, spatial-peak

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Figure 1 Mean (SE) cerebral blood flow velocity in the middle cerebral artery before ("prefeeding" values), during (5–10 minutes), and after bolus tube feeding. $P < 0.001$ when "prefeeding" values were compared with those 5 to 16 minutes after feeding.

temporal-average intensity and linearity of power reduction.^{6,7} Ipsiroglu *et al*⁸ determined these parameters for five transcranial Doppler instruments and found that the Multi Dop X system used in our study had the lowest energy output. Continuous measurements of 54 minutes resulted in a temperature rise in the skull by 1°C.⁶

Mean arterial blood pressure was measured in the right upper arm in 5 minute intervals using an oscillometric technique (Dinamap 847, Critikon Inc., Tampa, Florida, USA). Some infants woke up during blood pressure measurements so that we can not preclude that blood pressure and/or cerebral blood flow velocity changed in these patients. Transcutaneous oxygen saturation (tcSaO₂) and heart rate were recorded on the infants' palm or digit, using a pulse oximeter device (Hellige, Freiburg, Germany).

STATISTICAL ANALYSIS

A two tailed paired *t* test was used to test for differences in the measurements before, during, and after feeding; a *P* value of 0.001 was considered significant. Means and standard deviations were calculated for each of the minute by minute values. The mean and standard deviation of the 10 prefeeding minute values—140 individual values—were used as control "prefeeding" value. As blood pressure was measured every 5 minutes, the average of the two prefeeding measurements were used as a control.

Results

Mean (SD) minute by minute values of cerebral blood flow velocity in the middle cerebral arteries are shown in fig 1. Ten minutes before feeding, CBFV varied between 35.6 (11.1) and 37.4 (10.0) cm/s. The average of the prefeeding values was 36.8 (11.2) and was used as control "prefeeding" value.

One minute after starting tube feeding, CBFV fell to 34.8 (15.4) cm/s ($P < 0.05$). One minute later, CBFV increased to 37.7 (13.2)

cm/s, and changed little over the following 3 minutes. Five minutes after feeding, CBFV decreased to 33.3 (8.8) cm/s, and 32.8 (9.8) cm/s 11 minutes after feeding. Between 5 and 16 minutes after feeding, CBFV was significantly ($P < 0.001$) decreased when compared with the prefeeding value. Seventeen to 24 minutes after feeding, the mean CBFV values were similar to the prefeeding value. Thereafter, CBFV tended to increase above the prefeeding value.

The mean arterial blood pressure decreased insignificantly from 44 (5) mm Hg before feeding to 43 (4) mm Hg 5 minutes after feeding and reached the control level after 35 minutes. At 35 to 45 minutes after feeding, the mean blood pressure increased to 45 (8) mm Hg. The mean baseline arterial oxygen saturation was 95 (3)% and the mean heart rate was 145 (15) 1/min throughout the study period. There was no significant correlation between the changes in blood pressure and in cerebral blood flow velocity after feeding.

Discussion

The mean blood flow velocity in the middle cerebral artery in our study was similar to measurements by other authors using the same method.⁶ Blood flow velocity measured in the anterior cerebral artery and the internal carotid artery are slower than those measured in the middle cerebral artery.^{7–9}

Previous studies on the effect of feeding on cerebral blood flow were done in term neonates by means of jugular venous blood occlusion plethysmography. This method measures total cranial blood flow—cerebral, skull, and head skin blood flow. The authors observed that cranial blood flow decreases by 20–40% 15 to 40 minutes after oral feeding.^{1,2} Forehead skin blood flow in term neonates falls by 30% 30 to 50 minutes after feeding.¹⁰ Martinussen *et al*³ found no effect of oral feeding in preterm infants with 33 to 35 weeks of gestation on blood flow velocity in the middle cerebral artery. Feeding intervals were three hourly as in our study. However, they studied CBFV only 30 minutes after feeding and may, therefore, have missed earlier flow reduction. We observed a fall in CBFV by 11% 11 minutes after tube feeding. During tube feeding itself, CBFV did not change (fig 1).

Both tube feeding and oral feeding of preterm infants cause a substantial rise in the mean blood flow velocity of the superior mesenteric artery.^{3,11} Fifteen minutes after tube feeding, mesenteric blood flow velocity increases by about 50%,¹¹ and 30 to 45 minutes after tube or oral feeding, the mesenteric flow velocity increases by about 80%.^{3,11} To increase blood flow to the gut after feeding, preterm infants increase their cardiac output³ and maintain peripheral circulation¹²; term infants maintain their cardiac output³ and decrease peripheral blood flow.^{12,13} Our finding of an early decrease in the cerebral blood flow velocity after tube feeding suggests that the rise in gastrointestinal blood flow is initially not sufficiently compensated for by an adequate increase in cardiac output. The 10% reduction

in the mean CBFV 5 to 16 minutes after feeding is probably not meaningful for preterm infants as long as the arterial oxygen saturation does not fall. However, several authors observed that the arterial oxygen pressure may fall noticeably in preterm infants 5 to 15 minutes after feeding^{4 14 15} — that is, at the time of minimum CBFV. Thus oxygen supply to the brain may fall substantially in some preterm infants after tube feeding. On the other hand, we cannot rule out that the fall in CBFV was accompanied by a dilatation of cerebral arteries, thereby keeping cerebral blood flow unchanged.

In conclusion, we found that bolus feeding in preterm infants provokes a considerable decrease in cerebral blood flow velocity in spite of unchanged blood pressure and heart rate.

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