

Cord blood IgE

I. IgE screening in 2814 newborn children

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Screening of total IgE in 2814 cord blood samples was analysed by Phadebas IgE PRIST in 2 1-year birth cohorts (1983–1984 and 1985–1986) in Denmark ($n = 1189 + 1625$). 48.6% of the sera contained less IgE than the detection limit 0.1 kU/l. Cord blood IgE values ≥ 0.5 kU/l were regarded as elevated. 13.2% of the sera contained at least 0.5 kU/l of IgE, with a significant preponderance in boys. Geometric mean cord blood IgE was 0.13 kU/l and 0.12 kU/l, respectively. Geometric mean cord blood IgE was significantly higher in boys. A significant seasonal variation with lowest IgE values in the autumn was found. No correlation between cord blood IgE and birth weight or gestational age was demonstrated. Only few newborns had cord blood IgA values > 0.014 g/l, calculated as geometric mean cord blood IgA + 2 SD among children with no detectable cord blood IgE, indicating infrequent contamination with maternal blood.

Clinical aspects

Using a simple cord blood sampling method and a sensitive IgE analysis, Phadebas IgE PRIST, reproducible results of cord blood IgE in 2 unselected series of newborns were obtained. Cord blood IgA determination is recommended in all infants with cord blood IgE ≥ 1.0 kU/l in order to exclude contamination with maternal blood.

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The frequency of atopic diseases appears to have been increasing during recent decades, and atopic diseases in children are now one of the major problems. In a Danish study (34) an accumulated prevalence of definite and probable atopy of 13.3% was found in unselected 7-year-old children, consistent with previous reports (25).

Most children with atopic disease have allergy, here defined as IgE-mediated reactions. The development of atopic diseases has multifactorial causes. There is evidence that atopic predisposition as well as elevated cord blood IgE (CB-IgE) (3, 4, 5, 8, 9, 11, 22, 25, 27, 29, 31, 34, 35) or neonatal total IgE (6, 13, 14, 37) are indicators of atopy development. We do not know the exact value of this information, particularly due to the contradictory results from recent studies (20, 28, 39). Only 2 of these studies were reporting on unselected infants (9, 11, 27, 29). The use of CB-IgE as a predictor of atopic disease requires knowledge of normal values in unselected infants.

The aim of this study was to analyse CB-IgE in a group of unselected newborn infants in the Danish

municipalities of Viborg and Odense. This paper describes the normal range of CB-IgE and the influence of gender as well as month and region of birth. To evaluate the extent of contamination by maternal blood, IgA was determined in cord blood (CB-IgA). Subsequent papers will deal with the first follow-up examination at the age of 18 months, focusing on the predictive value of CB-IgE (17, 18), and the prevalence of atopic disease will be assessed (19).

Material and methods

CB was collected from infants born at the Viborg Hospital during the period November 1, 1983 – October 31, 1984. The total number of infants born during that period was 1193. CB samples were taken from 1189 infants (99.7%).

Correspondingly, CB of infants born at the Odense Hospital whose parents were residents of that municipality, was collected during the period January 7, 1985 – January 6, 1986. Of the 1762 infants CB samples were taken from 1625 (92.2%). In Denmark almost all infants are born in hospitals ($> 99\%$).

Thus the 2814 serum samples represent 2 1-year birth cohorts of unselected infants born between 1983 and 1986. CB was collected shortly after the umbilical cord had been severed by loosening the Péan clamp. CB was stored at 0–5°C until serum was extracted not later than 24 h after sampling. On the same day the samples were sent to Pharmacia, Hillerød, Denmark and analysed according to the Phadebas IgE PRIST method. To increase the sensitivity of the analysis compared to the standard method, the volume of the samples was raised from 100 µl to 200 µl. Further, the incubation time was extended from 3 to 20–24 h, with intervals of 10 min between washing stages. This procedure showed a good correlation between overnight and within-day procedures, and it was possible to improve on the intra-assay coefficient of variation from approximately 7% at 2.5 kU/l to approximately 3% at 1 kU/l and to <6% in the range 0.2–0.5 kU/l. One kU is equivalent to 2.4 µg of IgE. In a pilot study this method showed an optimum degree of reproducibility down to 0.5 kU/l, which was thus chosen as a cut-off value. Detection limit was 0.1 kU/l and lower values were noted as <0.1 kU/l. Values <0.1 kU/l were graphed as 0, but were considered as 0.05 kU/l in logarithmic calculations. The CB sampling method was associated with some risk of mixing maternal and CB. A high concentration of CB-IgA is an indicator of contamination with maternal blood. Applying a single radial immunodiffusion method (30), 440 CB serum samples – including the samples with CB-IgE ≥ 0.5 kU/l – were analysed for IgA. The method demonstrated contents of IgA as low as 0.002 g/l. Lower values (<0.002 g/l) were in logarithmic calculations regarded as 0.001 g/l.

The study was approved by the human research ethics committee. Informed consent was given by the parents before entering the study.

Statistics

Statistical analyses were performed using a statistics programme, Epistat – Tracy Gustafson, 1705 Gattis School Road, Round Rock, Texas 78664, USA. Mean values (geometric mean) and standard deviations (SD) have been calculated on logarithmically (ln) transformed values, since the CB-IgE and CB-IgA values were not normally distributed. Percentiles of 2.5 and 97.5 were calculated. Chi-square test and variance analysis (ANOVA) were also used. *p*-values ≥ 0.05 were regarded as non-significant.

Results

A total of 1189 serum samples from Viborg (Vi) and 1625 from Odense (Od) were analysed. 555 (Vi)

samples (46.7%) and 813 (Od) samples (50.0%) showed IgE < 0.1 kU/l, the detection limit.

Fig. 1 shows the distribution of CB-IgE for the total number of infants in the range up to 1.0 kU/l including 94.7% of the samples.

A total of 176 (14.8%) and 196 (12.1%) serum samples showed IgE ≥ 0.5 kU/l (Table 1). 70 girls (12.3%) and 106 boys (17.0%) from Viborg had CB-IgE ≥ 0.5 kU/l, whereas the corresponding figures for Odense were 65 girls (7.9%) and 131 boys (16.3%). Boys with CB-IgE ≥ 0.5 kU/l were clearly preponderant (Vi: *p* < 0.05. Od: *p* < 0.000001). The proportion of infants with CB-IgE ≥ 0.5 kU/l was larger in Viborg (*p* < 0.05), due to a larger proportion of girls with increased CB-IgE (*p* < 0.01).

Normal CB-IgE values are shown in Table 2. The CB-IgE mean value was 0.13 kU/l (Vi) and 0.12 kU/l (Od). The mean CB-IgE was significantly higher in boys (Vi: *p* < 0.01. Od: *p* < 0.00001).

The CB-IgE values (Vi and Od) were assessed according to month of birth and gender (Fig. 2). The mean values of CB-IgE fluctuate significantly from month to month (Vi: *p* < 0.0001. Od: *p* < 0.01) showing the lowest values in October.

CB-IgA values are shown in Table 3. The mean value of CB-IgA 0.005 g/l was the same in boys and girls. No significant correlation between different levels of CB-IgE and CB-IgA was found. 32 (7.3%)

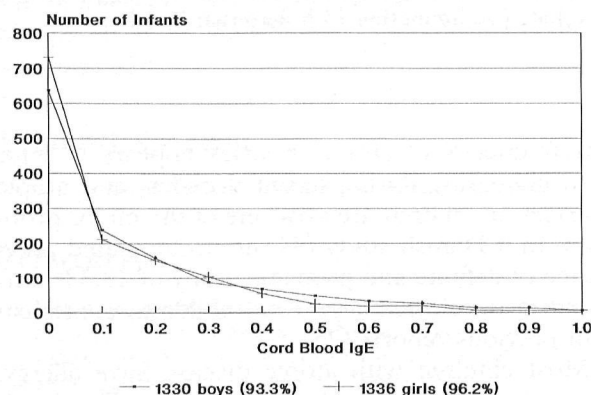


Fig. 1. Distribution of cord blood IgE < 1.1 kU/l.

Table 1. Number of infants according to the cord blood IgE cut-off value 0.5 kU/l

	CB-IgE < 0.5 kU/l (%)	CB-IgE ≥ 0.5 kU/l (%)
Viborg		
Total	1013 (85.2)	176 (14.8)
Boys	516 (83.0)	106 (17.0)
Girls	497 (87.7)	70 (12.3)
Odense		
Total	1429 (87.9)	196 (12.1)
Boys	672 (83.7)	131 (16.3)
Girls	757 (92.1)	65 (7.9)

Table 2. Normal values of cord blood IgE (kU/l)

	<i>n</i>	Range	Median	Mean	Mean + 1 SD	Mean + 2 SD	2½% perc.	97½% perc.
Viborg								
Total	1189	<0.1–47.0	0.1	0.13	0.40	1.24	<0.1	2.03
Boys	622	<0.1–47.0	0.1	0.14	0.45	1.49	<0.1	2.23
Girls	567	<0.1–16.0	<0.1	0.11	0.34	1.00	<0.1	1.48
Odense								
Total	1625	<0.1–19.0	<0.1	0.12	0.35	1.04	<0.1	2.30
Boys	803	<0.1–19.0	0.1	0.13	0.43	1.42	<0.1	3.00
Girls	822	<0.1–5.0	<0.1	0.10	0.27	0.73	<0.1	1.30

Table 3. Cord blood IgA values (g/l) and relation to cord blood IgE

	<i>n</i>	Range	Median	Mean	Mean + 1 SD	Mean + 2 SD	Mean + 3 SD	2½% perc.	97½% perc.
Total	440	<0.002–1.013	0.005	0.005	0.013	0.034	0.093	<0.002	0.030
Boys	274	<0.002–1.013	0.005	0.005	0.013	0.038	0.108	<0.002	0.071
Girls	166	<0.002–0.181	0.006	0.005	0.012	0.029	0.070	<0.002	0.023
CB-IgE ≥ 0.5 kU/l	289	<0.002–1.013	0.005	0.005	0.015	0.046	0.140	<0.002	0.102
CB-IgE < 0.5 kU/l	151	<0.002–0.030	0.005	0.004	0.008	0.017	0.035	<0.002	0.014
CB-IgE < 0.1 kU/l	71	<0.002–0.024	0.005	0.004	0.008	0.014	0.024	<0.002	0.015

had CB-IgA > mean CB-IgA + 2 SD and 17 (3.9%) had CB-IgA > mean IgA + 3 SD determined among 71 infants with no detectable CB-IgE (Table 3). 59% of children with elevated CB-IgA (> mean + 2 SD) had high CB-IgE (≥ 1.0 kU/l), 76% if using mean + 3 SD. Children with extremely high CB-IgE often had normal CB-IgA. We chose not to exclude the few samples with high CB-IgA from the study. No correlation between birth weight and CB-IgE was found (data not shown).

The gestational age was determined in 456 infants. No correlation between gestational age and CB-IgE was found (data not shown). Nine of 22 infants born before the 37th week of gestation (GA 27–36 weeks) showed CB-IgE ≥ 0.5 kU/l (range <0.1–1.7 kU/l). All 9 infants had CB-IgA values < mean CB-IgA + 3 SD.

Discussion

CB-IgE and atopic predisposition are the most important predictive factors of atopic disease. To establish a suitable cut-off value of increased CB-IgE, it is important to know the distribution of CB-IgE in unselected infants. In the present study the large number of unselected infants allowed us to determine a normal range of CB-IgE. The results obtained for the 2 regions (Vi and Od) were uniform. However, the proportion of girls with CB-IgE ≥ 0.5 kU/l was larger in Viborg. The results obtained for the boys were identical. The small geographic differences between the 2 regions and the fact that the study ran over 2 consecutive years might partly explain these findings. Atopic predisposition was similar in the 2 regions and between males and females, contradicting the study of Magnusson (29) reporting that parturients with atopic diseases gave birth to more boys than girls. In the male group mean CB-IgE and the proportion of infants with increased CB-IgE were significantly higher. This was in accordance with previous reports (15, 24).

In Table 4 our CB-IgE values are compared with values obtained in previous studies of unselected infants. Our mean CB-IgE values (Vi and Od) were considerably lower than most values measured in similar studies. Kimpen (23, 24) reported a mean CB-IgE of 0.25 kU/l, which is twice as high as that from the present study. Median CB-IgE, however, was 0.12 kU/l, corresponding to our result. Regarding mean and median CB-IgE both Haus (21) and, recently, Halonen (15) found almost exactly the same

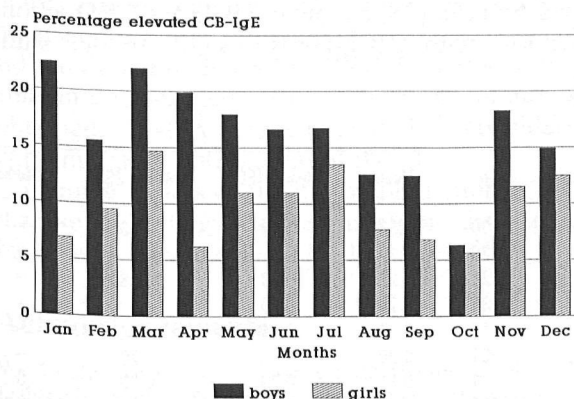


Fig. 2. Elevated cord blood IgE according to month of birth.

Table 4. Cord blood IgE concentrations (kU/l) in unselected materials

Author	Origin	Year	Method	Collection	n	Mean	Mean + 1 SD	Mean + 2 SD	Median
Michel (31)	France	1980	PRIST	needle asp.	136	0.32	0.86	1.40	—
Bhalla (1)	USA	1982	PRIST	simple	37	0.53	1.04	2.05	—
Cederqvist (7)	USA	1984	PRIST	simple	157	0.8	—	—	0.25
Tseng (36)	Hong Kong	1987	PRIST	needle asp.	142	0.27	0.76	1.25	—
Kimpen (23)	Belgium	1987	ELISA	simple	5353	0.25	—	—	0.12
Magnusson (29)	Belgium	1988	PACIA	simple	190	0.37	—	4.62	—
Haus (21)	S. Africa	1988	PRIST	needle asp.	52	0.12	1.03	1.94	0.12
Halonen (15)	USA	1991	PRIST	simple	1074	0.09	—	—	0.10
Hansen (Vij)*	Denmark	1992	PRIST	simple	1189	0.13	0.40	1.24	0.1
Hansen (Od)*	Denmark	1992	PRIST	simple	1625	0.12	0.35	1.04	<0.1

* The present study.

values as we did. The remaining studies showed even higher mean CB-IgE values, indicating a larger number of high CB-IgE values, since a large number of high CB-IgE values has a strong effect on CB-IgE mean values, but only little effect on median CB-IgE values. Our low mean CB-IgE indicates only a few high CB-IgE values. Very high CB-IgE values often indicate contamination with maternal blood. Our results were not influenced by there being different ethnic groups, as reported elsewhere (15, 21, 22, 36).

The calculation of SD has been made primarily in order to compare our results with previous studies, bearing in mind that percentile calculations may offer a better description of the material.

Other authors have examined selected infants with regard to atopic predisposition – family history. Infants prone to atopy have higher CB-IgE values than infants without predisposition (Table 5).

Magnusson (29) and Croner/Kjellman (9, 26) calculated CB-IgE cut-off values as mean CB-IgE + 2 SD among infants without atopic predisposition and without atopic symptoms at the age of 18 months. Their cut-off values of 1.2 kU/l and 1.3 kU/l were calculated on this basis. The cut-off value of the latter study was later changed to 0.9 kU/l with reference to a follow-up at the age of 7 years (27). Previously, a cut-off value of mean CB-IgE + 1 SD has been suggested (38).

The preliminary cut-off value of 0.5 kU/l in our study lies between mean CB-IgE + 1 SD and mean

CB-IgE + 2 SD calculated for non-predisposed infants without later development of atopic disease before 18 months of age (17).

CB-IgE values were not normally distributed. In the present study 48.6% of the samples had unmeasurable CB-IgE while 94.7% had total IgE < 1.1 kU/l. Use of a higher CB-IgE cut-off value of approx. 1.0 kU/l would only delimit a very small number of infants.

Specific CB-IgE was not analysed. Specific IgE in cord blood has rarely been reported (5, 31). The presence of IgE in CB is more likely due to a non-specific IgE hyperreactivity than to some congenital specific allergy. Considering the low number of high CB-IgA values, contamination of IgE from maternal blood seems to be an infrequent and minor problem. Our simple method of sampling CB appears to be reliable and more practical in daily use than other techniques used to exclude contamination with maternal blood, e.g. sampling of fetal blood by puncturing the umbilical vein (5, 31, 36) and blood sampling at the age of 5 days (6, 13, 14, 37). Amniotic fluid IgE has also been performed (35). Upper normal values of CB-IgA have been proposed by other authors, e.g. 0.04 g/l (33), 0.039 g/l (39), 0.0323 g/l (23), 0.018 g/l (15), and 0.0141 g/l (28). The value proposed by Kimpen (23) was calculated among all infants as mean CB-IgA + 3 SD and the value proposed by Lilja (28) as mean CB-IgA + 2 SD among newborns with CB-IgE < 0.12 kU/l. In our study

Table 5. Cord blood IgE concentrations (kU/l) in selected materials

Author	Origin	Year	Method	Collection	Atopic disp.	n	Mean	Mean + 1SD	Mean + 2SD	Median
Businco (5)	Italy	1983	PRIST	needle asp.	parents-sibl.	100	0.53	1.43	2.33	—
Kjellman (25)	Sweden	1976	PRIST	simple	mothers	30	1.1	—	—	—
Kjellman (26)	Sweden	1976	PRIST	simple	none	24	0.22	0.53	1.28	—
Dannaeus (12)	Sweden	1978	PRIST	simple	mothers	36	0.24	0.66	—	—
Dannaeus (12)	Sweden	1978	PRIST	simple	none	17	0.11	0.14	—	—
Magnusson (29)	Belgium	1988	PACIA	simple	none	81	0.20	—	1.20	—
Hansen (17)	Denmark	1992	PRIST	simple	none	74	0.11	0.29	0.76	0.1
Hansen (17)	Denmark	1992	PRIST	simple	none	106	0.12	0.36	1.06	0.1

3.9% of the infants had CB-IgA > mean CB-IgA + 3 SD in agreement with Kimpen (24) and Zeiger (39), who found 2.7% and 2.4%, respectively. If CB-IgA > mean CB-IgA + 2 SD was regarded as elevated, 7.3% in our study had elevated CB-IgA in agreement with Lilja (28), who found 10.8%. In our study mean CB-IgA + 2 SD = 0.014 g/l equals Lilja's mean CB-IgA + 3 SD. Values of CB-IgA in infants with no detectable CB-IgE (<0.1 kU/l) are suggested as normal CB-IgA values and since only 5% of our birth cohorts had CB-IgE $\geq$ 1.0 kU/l, it is only a minor problem to exclude contamination with maternal blood by CB-IgA determination, and we support the proposal of O'Connor (33) and Zeiger (39), that CB-IgA should be measured if CB-IgE $\geq$ 1.0 kU/l. We propose 0.014 g/l (mean CB-IgA + 2 SD) as the CB-IgA cut-off value of choice.

Contrary to the results of other studies, but in accordance with Kimpen (24), CB-IgE was found in 9 premature infants. All these 9 infants (gestational age < 37 weeks) had CB-IgA levels within the normal range, indicating no contamination with maternal blood. One infant born after 34 weeks gestation, with a birth weight of 2300 g, had CB-IgE 1.7 kU/l and CB-IgA < 0.002. We found no correlation between CB-IgE and birth weight, or between CB-IgE and gestational age, in agreement with earlier papers (24).

Previous papers reported seasonal variations in CB-IgE (10, 15, 23). We also found (Vi and Od) the lowest CB-IgE values in the autumn months, particularly October. The highest CB-IgE values were found in winter and spring. Birth in spring is associated with an increased risk of high CB-IgE and early contact with allergens such as tree and grass pollens. A higher incidence of pollen allergy in children born in the spring (2) as well as a higher incidence of allergy to house dust mites, when born in the autumn, has been described (32).

Conclusion

Using CB-IgE as a predictor of atopic disease requires knowledge of the normal values. Applying a simple cord blood sampling method and a sensitive IgE analysis Phadebas IgE PRIST, reproducible results in 2 unselected series of newborn infants were obtained. CB-IgA results indicated no considerable contamination with maternal blood.

Coming papers deal with the prediction of atopic disease and allergy, defined as atopic disease combined with elevated IgE (17, 18).

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