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Dental caries experience in children with congenital heart disease: a case-control study

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Summary. *Objectives.* To compare the dental health of a group of children with complex congenital heart disease with that of age and gender matched healthy controls.
Design. Case-control study.
Setting. Faculty of Medicine and Odontology/Pediatric cardiology and Pedodontics, Umeå University, Sweden.
Sample and Methods. All the cases and their controls lived in the county of Västerbotten in northern Sweden. Each group comprised 41 children with a mean age of 6·5 years. Data were collected from medical and dental records while all bitewing radiographs were read separately by one of the authors.
Results. Children with congenital heart disease had significantly more caries in their primary teeth than the control group. The mean dmfs-value was $5{\cdot}2 \pm 7{\cdot}0$ in the cardiac group compared to $2{\cdot}2 \pm 3{\cdot}5$ in the control group ($P < 0{\cdot}05$). Twenty-six of the children had all four 6-year-molars, and their mean DMFS-values were $0{\cdot}9 \pm 1{\cdot}9$ in the cardiac group compared to $0{\cdot}3 \pm 0{\cdot}6$ in the control group ($P > 0{\cdot}05$). The children with congenital heart disease had received more caries prevention based on the use of fluorides than the control group. There was a significant correlation between the number of fluoride varnish treatments and the dmfs value of the child ($r = 0{\cdot}411$, $P < 0{\cdot}01$). Fifty-two per cent of the children in the cardiac group had been prescribed fluoride tablets on one or more occasions compared to 17% in the control group ($P < 0{\cdot}01$). Number of months on digoxin medication and the dmfs-value had a significant correlation ($r = 0{\cdot}368$, $P < 0{\cdot}05$). Ten of the children had been on digoxin medication between 6 and 87 months; this subgroup had a mean dmfs-value of $10{\cdot}1 \pm 8{\cdot}5$.
Conclusion. Swedish children with complex congenital heart disease have poorer dental health than healthy age and gender matched controls in spite of intensive preventive efforts. In many cases, intervention had been given when caries were present. A closer cooperation between paediatric cardiology and paediatric dentistry is needed.

Introduction

Congenital cardiac disease is one of the most common development anomalies in children and affects approximately 8 : 1000 live births. Children with complex anomalies constitute approximately one-third of all children with congenital heart disease [1]. Paediatric cardiology has undergone extensive evolution during recent decades. The introduction of new surgical and anaesthetic techniques together with the development of special paediatric intensive care units have improved the treatment and care of patients with congenital heart disease [2]. In children with complex heart disease, other problems often appear that may jeopardise dental health. For example, many of these children have difficulties with nutrition during their

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first years of life. Vomiting is a common problem. To compensate for this, feeds are frequent and night meals are often necessary to maintain energy intake at an acceptable level. In addition, some of the medicines for heart disease contain sucrose together with diuretics that can cause xerostomia [3]. Infections often last for longer periods than in normal children with an increased need for drinking, sometimes at night, when salivary protection is low.

More untreated caries and a higher caries prevalence compared to healthy children have been shown in children with congenital heart disease in the past [4–6]. However, no studies on the dental health of children with congenital heart disease have yet been carried out in communities with a comprehensive dental care for children and strong caries-preventive approaches. In Swedish communities, dental health information is provided to parents of children as young as one year old. Information from such communities could help in planning dental care for the increasing number of children with complex heart anomalies who are being successfully treated with surgery.

This study compares the dental health in a group of children with complex congenital heart disease with an age and gender matched control group of healthy children. The null hypothesis was that the distribution of caries did not differ from the distribution in healthy children.

Materials and methods

The study was performed using a case-control design during 2002 in Västerbotten, a northern Swedish county. Dental care for children in Västerbotten has a strong preventive approach, all children being offered dental care free of charge between the ages of 3 and 19 and all parents being offered dental health information from when the child is one year old. The area is unfluoridated and the fluoride content of the drinking water is generally low.

All surviving children with congenital heart disease, complexity grading II and III, born between 1991 and 2000 and living in the county of Västerbotten were selected from the Paediatric Cardiology Outpatient Clinic at University Hospital in the city of Umeå, Sweden. The complexity of congenital heart disease followed the grading made by the National Swedish Board of Health and Welfare [7]. Children with other serious medical diagnoses or children with learning difficulties were excluded. Using this system, 43 patients were selected. A control-group was selected from the population register in the county of Västerbotten. For each child with congenital heart disease, a healthy child with the same date of birth and gender was selected. The first child in the register who met the inclusion criteria was included in the control-group. All participants were given written information about the study. Informed consent was received from the parents of 95% of the selected groups, which resulted in 41 children in each group. The mean age of the children was 6·5 years and there were 25 boys and 16 girls.

Data collection

Information concerning the cardiac diagnosis, surgery carried out, the age at each surgical operation and medication was collected from the medical records. Information about nutritional problems and contacts with social workers was also collected from the same records.

For both groups of children, copies of their dental records and radiographs were obtained from the dental clinic where the child received dental treatment. All children who were 5 years or older and two 4-year-old children with congenital heart disease had been examined with bitewing radiographs. Data on decayed, missing, filled and carious surfaces (dmfs/DMFS) were collected from the records. Data on approximal caries were collected from bitewing radiographs which were read separately by one of the authors (CSB) who was blind to the group to which the child belonged. All initial (in the enamel) and manifest (in the dentine) caries lesions on approximal surfaces in posterior teeth; i.e. primary molars in the primary dentition and 6-year-molars in the permanent dentition, were included in the dmfs/DMFS values. A primary molar that had been extracted due to caries was counted as three missing surfaces in the dmfs-values [8]. Data on the number of occasions the child had been treated with fluoride varnish and professional polishing was also noted from the dental records, as well as the number of times fluoride tablets had been prescribed.

Ethical approval

The study was approved by the research ethics committee of the Faculty of Medicine and Odontology at the University of Umeå.

Statistical methods

Data were processed using the SPSS software Version 11·0. One-way ANOVA was used to compare differences between groups. Spearman's rank correlation was used to explore relationship between dental health and selected variables. The level of statistical significance was set at 5%.

Results

The main diagnoses and the ages of the participating children are given in Table 1.

The mean dmfs-value was 5·2 ± 7·0 in the cardiac group compared to 2·1 ± 3·5 in the control group ($P < 0·05$). When initial lesions were excluded, corresponding values were 4·7 ± 6·3 in the cardiac group

Table 1. Main cardiac diagnoses, age, and dmfs/DMFS values in the cardiac and the control group.

		Cardiac group		Control group	
Case and main diagnoses	Age	dmfs	DMFS	dmfs	DMFS
1 PA, VSD	3	0	–	0	–
2 PA, VSD, cong. corr TGA	4	0	–	0	–
3 CoA, heart transplanted	8	9	0	3	1
4 AS	5	2	–	0	–
5 PA, VSD (TCPC)	8	2	0	7	2
6 TGA, VSD (PM)	9	16	2	8	1
7 DIV, TGA, VSD (TCPC)	8	16	0	4	0
8 AS	7	11	1	5	0
9 PA, VSD (TCPC)	9	14	4	1	0
10 AS	4	30	–	0	–
11 AS, CoA	9	2	0	13	1
12 TOF	9	2	8	0	0
13 VSD	9	6	0	0	0
14 TOF	8	4	0	11	1
15 TOF	3	0	–	1	–
16 AS, CoA, VSD	8	18	4	1	0
17 AS	9	3	1	1	0
18 PA, IVS (TCPC)	7	1	0	0	0
19 PVS, PDA	4	0	–	0	–
20 TGA, VSD	8	6	1	0	0
21 VSD, PHT	9	0	0	5	1
22 DILV, TGA, VSD (TCPC)	8	6	0	0	0
23 HLHS (TCPC)	5	0	–	1	–
24 Cong corr TGA, VSD (PM)	2	0	–	0	–
25 AVSD	8	0	0	5	0
26 AVSD	5	0	–	7	–
27 PS	5	1	–	0	–
28 ASD prim, MI	11	6	0	0	0
29 TGA	3	0	–	0	–
30 TOF	4	15	–	0	–
31 TGA	8	1	0	11	0
32 AS	5	0	–	1	–
33 TGA	3	0	–	0	–
34 AS	8	0	0	0	1
35 PA, IVS, ASD	7	11	0	0	0
36 TGA	2	0	–	0	–
37 TOF	5	0	0	0	0
38 VSD	8	0	0	0	0
39 TGA	8	15	0	1	0
40 IAA, VSD	8	3	2	0	0
41 IAA, VSD	8	14	0	4	0
Mean	6·5 ± 2·4	5·2 ± 7·0	0·9 ± 1·9	2·1 ± 3·4	0·3 ± 0·6

AS, aortic stenosis; ASD, atrioseptum defect; AVSD, atrioventricular septum defect; CoA, coarctatio aortae, cong.corr; TGA, congenitally corrected transposition of the great arteries; DILV, double inlet left ventricle; HLHS, hypoplastic left heart syndrome; IAA, interrupted aortic arch; IVS, intact ventricular septum; MI, mitral valve insufficiency; PA, pulmonary atresia; PDA, persistent ductus arteriosus; PHT, pulmonary hypertension; PM, pacemaker; PS, pulmonary stenosis; PVS, pulmonary vein stenosis; TCPC, total cavopulmonary connection; TGA, transposition of the great arteries; TOF, tetralogy of Fallot; VSD, ventricular septum defect; DMFS was assessed in 6-year-molars; –, no molars erupted.

and 2·1 ± 3·4 in the control group ($P < 0·05$). In four children in the cardiac group, nine molar teeth had been extracted due to caries. Sixteen of the children in the cardiac group compared to 22 in the control group had caries-free primary teeth. Twenty-six of the children had four 6-year-molars erupted, and the mean DMFS-values were 0·9 ± 1·9 in the cardiac group compared to 0·3 ± 0·5 in the control group ($P > 0·05$). When initial lesions were excluded, the corresponding values were 0·6 ± 1·7 in the cardiac group and 0·3 ± 0·6 in the control group ($P > 0·05$). The distribution of the dmfs/DMFS values is given in Table 1. The mean number of treatments with fluoride varnish was 3·8 ± 4·0 for children in the cardiac group compared to 1·8 ± 2·2 in the control group ($P < 0·01$). Thirteen of the children in the cardiac group had been treated on five or more occasions compared to only three of the children in the control group. One child in the cardiac group had been treated on 15 occasions. Fifty-two per cent of the children in the cardiac group had been prescribed fluoride tablets on one or more occasions compared to 17% in the control group ($P < 0·01$). Non-parametric correlations between selected variables and dmfs values are given in Table 2. There was a significant positive correlation between the number of fluoride varnish treatments and the dmfs value of the child ($r = 0·411$, $P < 0·01$). The number of months the child had been on digoxin medication and the dmfs-value had a statistically significant positive correlation ($r = 0·368$, $P < 0·05$). Ten of the children had been on digoxin medication between 6 and 87 months; this subgroup had a mean dmfs-value of 10·1 ± 8·5, compared to 3·7 ± 5·3 in the non-digoxin group ($P = 0·01$). Only one child, who had received digoxin medication, was caries-free. He was a 2-year-old boy. Mean ages in the two groups were 6·9 ± 2·2 years and 6·5 ± 2·5, respectively ($P > 0·05$). Forty-five per cent of the children in the cardiac group had notes in their medical records that the family had been in contact with a social worker, but there was no evidence of a correlation between the frequency of these contacts and dental caries. In four of the cardiac children, there was no information in the dental record that the child had cardiac disease and in 14 there was no information indicating that the child should be provided with antibiotic cover as endocarditis prophylaxis before invasive dental treatment.

Table 2. Spearman rank correlation between dmfs-values and selected variables in cardiac children.

Variable 1		Variable 2	*r*	*P*
dmfs	v	No. of fluoride varnish treatments	0·436	0·004**
dmfs	v	No. of professional polishing	0·411	0·008**
dmfs	v	No. of fluoride tablets prescription	0·324	0·039*
dmfs	v	Months on diuretics	0·086	0·592
dmfs	v	Months on Potassium substitution	0·252	0·112
dmfs	v	Months on Digoxin (contains sucrose)	0·368	0·018*
dmfs	v	Months on ACE blocker	−0·045	0·782
dmfs	v	Contact with social worker	0·004	0·978

*Correlation is significant at the 5% level (two-tailed).
**Correlation is significant at the 1% level (two-tailed).

Discussion

This study shows that Swedish children with complex congenital heart disease have poorer dental health than healthy age and gender matched controls and confirms earlier findings of a high caries prevalence in children with congenital heart disease [4–6].

In the case-control design chosen for this study, ideally the same examiner would have examined all the children in both groups to remove the effects of variation in caries diagnosis between different examiners. However, all children included received comprehensive dental care in the area where they lived. Families with children with serious heart diseases already face heavy demands due to their medication, surgery, recurrent illness and occasional nutritional problems. As the children have many medical contacts already, it was considered unreasonable to add to their burden and the study was therefore performed on data that had already been collected at the dental clinics, despite the disadvantages of this procedure. Partly to reduce the effect of variation in caries diagnoses, all data on approximal caries were collected by one of the authors from bitewing radiographs for both groups of children.

Only age and gender were used to match the children although socioeconomic level may also influence dental health [9]. All children came from one county but it might have been of value to match on this variable also. During recent years, prevention provided by dental health professionals has moved towards a high-risk strategy. As part of the comprehensive dental care offered to all children free of charge, a risk assessment is performed at each examination. Children at risk are offered individualized prevention aiming at reducing inequalities in dental

health. It is, however, unclear if there were any socio-economic differences between the cases and the controls that may have influenced the results. The difference in dental health was most obvious in the primary dentition. The same trend was seen in permanent teeth but did not reach statistical significance. The poor health of primary teeth in cardiac children could perhaps indicate the difficult situations these children face during their first years of life.

The high prevalence of dental health problems in cardiac children are a special cause for concern as there are several reasons why healthy teeth are of benefit to these children. The overall increased vulnerability of the cardiac child to stressful treatment procedures is one major reason to focus on caries prevention. If dental treatment is necessary, painful and stressful situations should be avoided. Local anaesthesia should be used and sedation should be considered. In some vulnerable children, treatment using sedation has to be performed in cooperation with the child's cardiologist. Poor dental health also gives an increased risk of dental bacteraemia that may lead to infective endocarditis [10]. Healthy teeth may decrease this risk. Dentists are advised to provide antibiotic prophylaxis against endocarditis before invasive dental procedures and healthy teeth among cardiac children may therefore contribute to a decrease in the use of antibiotics, which are commonly needed for other infections. An additional factor supporting the benefits of dental health is the increased risk of general anaesthesia and the risk of prolonged bleeding amongst children taking warfarin. Of major significance is the fact that untreated caries can be a contra-indication for heart surgery [10]. As patients with more complex anomalies often require several surgical interventions, it is particularly important that scheduled surgery does not have to be postponed because of dental disease.

Interestingly, there was a significant correlation between the number of months on digoxin and the dmfs-value. Digoxin is administrated in a sucrose containing syrup (Lanoxin®). Today, sucrose is avoided as a sweetener in most medicines because it is widely accepted that sugar-containing medicines are a cause of dental caries in chronically sick children [11,12]. At present there are no alternatives available for children who need digoxin. For these patients, the development of sugar-free digoxin syrup is a priority.

Only four children had notes on nutritional problem in their medical records. With such a limited number, any analysis and conclusions about association between nutritional factors and oral health would be speculative.

More caries preventive efforts had been directed towards the cardiac group than to the controls. However, it was apparent that in many cases caries prevention had been provided only when the child already had caries, limiting its effects. One of the main reasons for the late caries intervention is the lack of regular dental care for these children during the first years of life. They may be in hospitals for long periods because of surgery or illness and are in many cases not identified in the dental care system until a caries problem is evident.

Dentistry should give priority to patients whose general health may be put at risk by poor dental health, however, a lower frequency of regular dental care has been shown in children with heart defects than in children without this medical problem [13,14]. Closer cooperation between paediatric cardiologists and paediatric dentists could help improve dental care for these children. The goal should be to prevent disease and maintain excellent oral health. Children with severe disease should be referred to a paediatric dentist before they are 1 year old. An individual treatment plan to maintain oral health, based on risk assessment, should be established for all children with cardiac disease [9,15]. The focus should be on caries prevention and include dietary counselling, oral hygiene, and fluoride supplements if necessary. The demanding situation for the parents and families of the patients with cardiac disease should be acknowledged and understood.

Résumé. *Objectifs.* Comparer la santé buccale d'un groupe d'enfants porteur de pathologie cardiaque congénitale complexe avec celle de témoins sains appariés en âge et en sexe.
Protocole. Etude avec population témoin
Mise en place. Faculté de Médecine et Odontologie/ Cardiologie pédiatrique et Pédodontie, Université d'Umeå, Suède
Echantillon et Méthodes. Tous les cas et leurs témoins vivaient dans la région de Västerbotten dans le nord de la Suède. Chaque groupe comprenait 41 enfants d'un âge moyen de 6,5 ans. Les données des dossiers médicaux et dentaires ont été recueillies, tandis que toutes les radiographies bitewings ont été lues séparément par l'un des auteurs.
Résultats. Les enfants avec cardiopathie congénitale avaient significativement plus de caries des dents temporaires que ceux du groupe témoin. L'indice

caof moyen était de 5,2 ± 7,0 dans le groupe cardiopathies contre 2,2 ± 3,5 dans le groupe témoin ($p < 0,05$). Vingt-six des enfants avaient toutes leurs dents de 6 ans, et l'indice CAOF moyen était de 0,9 ± 1,9 dans le groupe cardiopathies contre 0,3 ± 0,6 dans le groupe témoin ($p > 0,05$). Les enfants avec cardiopathie congénitale avaient reçu plus de prévention anti-caries à base de fluorures que les autres enfants. Il y avait une corrélation significative entre le nombre de traitements protecteurs à base de vernis fluorurés et la valeur du caof chez l'enfant ($r = 0,411$, $p < 0,01$). Cinquante-deux pour cent des enfants du groupe cardiopathies avaient fait l'objet d'au moins une prescription de supplémentations fluorurées contre 17% dans le groupe témoin ($p < 0,01$). Le nombre de mois avec médication à la digoxine et la valeur de caof étaient significativement corrélés ($r = 0,368$, $p < 0,05$). Dix des enfants avaient eu leur médication à la digoxine entre 6 et 87 mois; le caof de ce sous-groupe était 10,1 ± 8,5.
Conclusion. Les enfants suédois avec cardiopathie complexe ont une moins bonne santé buccale que des témoins appariés en âge et en sexe en dépit d'efforts de prévention intensifs. Dans de nombreux cas, des traitements ont eu lieu quand les caries étaient présentes. Une coopération plus étroite entre cardiologue et dentistes pour enfants est nécessaire.

Zusammenfassung. *Ziele.* Vergleich der Zahngesundheit einer Gruppe von Kindern mit komplexen angeborenen Herzfehlern mit Kindern, die nach Alter und Geschlecht gematcht wurden.
Design. Fall-Kontroll-Studie.
Untersuchungsumgebung. Pädiatrische Kardiologie und Kinderzahnheilkunde der Universität Umea, Schweden.
Stichprobe und Methoden. Alle Fälle und deren Kontrollen leben in der Region Västerbotten, Nordschweden. Jede Gruppe bestand aus 41 Kindern mit einem mittleren Alter von 6.5 Jahren. Die Daten wurden aus den medizinischen und zahnmedizinischen Akten herausgesucht, die Bissflügel-Röntgenaufnahmen wurden separat von einem der Autoren analysiert.
Ergebnisse. Kinder mit angeborenen Herzfehlern hatten signifikant mehr Karies der Milchzähne als ihre Kontrollen. Der mitlere dmfs-Wert lag bei 5.2 ± in der Gruppe der herzkranken Kinder, verglichen mit 2.2 ± 3.5 in der Kontrollgruppe ($p < 0.05$). Sechsundzwanzig der Kinder hatten alle 4 Sechsjahrmolaren, die mittleren dmfs-Werte waren 0.9 ± 1.9 in der Gruppe der herzkranken Kinder sowie 0.3 ± 0.6 in der Kontrollgruppe ($p > 0.05$). Gemessen an dem Gebrauch an Fluoriden hatten die Kinder mit Herzerkrankung mehr Kariesprävention erfahren als die Kontrollen. Es bestand eine signifikante Korrelation zwischen der Verwendung von Fluoridlack und Karies ($r = 0.411$, $p < 0.01$). Zweiundfünfzig Prozent der Kinder in der Gruppe der Herzkranken hatten ein- oder mehrmals Fluoridtabletten verordnet bekommen im Vergleich zu 17% in der Kontrollgruppe ($p < 0.01$). Die Anzahl der Monate mit Digoxinmedikation war signifikant mit dem dmfs-Wert korreliert ($r = 0.368$, $p < 0.05$). Zehn der Kinder wiesen eine Digoxinmedikation zwischen 6 und 87 Monaten auf. Die dmfs-Werte in dieser Gruppe lagen bei 10.1 ± 8.5.
Schlussfolgerungen. Schwedische Kinder mit komplexen Herzvitien haben eine schlechtere Zahngesundheit als gesunde Kontrollen (gematcht nach Alter und Geschlecht), trotz intensiverer präventiver Bemühungen. In vielen Fällen war nach Auftreten der Karies eine Versorgung erfolgt. Eine engere Zusammenarbeit zwischen pädiatrischen Kardiologen und Kinderzahnärzten wäre erforderlich.

Resumen. *Objetivos.* Comparar la salud dental en un grupo de niños con enfermedad cardíaca congénita con controles sanos emparejados por edad y sexo.
Diseño. Estudio caso-control
Población. Facultad de Medicina y Odontología/ cardiología pediátrica y Pediatría, universidad de Umeå, Suecia.
Muestra y métodos. Todos los casos y sus controles vivían en el condado de Västerbotten en el norte de Suecia. Cada grupo comprendía 41 niños con una media de edad de 6,5 años. Los datos se recogieron de registros médicos y dentales mientras que todas las radiografías de aleta de mordida fueron leídas de forma separada por uno de los autores.
Resultados. Los niños con enfermedad cardíaca congénita tenían significativamente más caries en los dientes temporales que en el grupo control. La media del índice caod fue de 5,2 ± 7,0 en el grupo cardíaco comparado con 2,2 ± 3,5 en el grupo control ($p < 0,05$). Veintiséis niños tenían todos los molares de los 6 años y la media CAOD fue de 0,9 ± 1,9 en el grupo cardíaco comparado con 0,3 ± 0,6 en el grupo control ($p > 0,05$). Los niños con enfermedad cardíaca congénita habían recibido más medidas de prevención de caries basadas en el uso de flúor que el grupo control. Hubo una correlación

significativa entre el número de tratamientos con barniz de flúor y el índice caos del niño ($r = 0{,}411$, $p < 0{,}01$). Diez de los niños habían estado en medicación con digoxina entre los 6 y 87 meses; el subgrupo tenía un índice caos medio de $10{,}1 \pm 8{,}5$.

Conclusión. Los niños suecos con enfermedad cardíaca congenita compleja tienen salud dental más pobre que los controles emparejados por edad y sexo a pesar de los intensos esfuerzos preventivos. En muchos casos, la intervención se ha efectuado cuando la caries estaba presente. Es necesaria una cooperación más intensa entre la cardiología pediátrica y la odontopediatría.

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