■ CHILDREN'S ORTHOPAEDICS

An evaluation of prenatal ultrasound screening for CTEV

ACCURACY DATA FROM A SINGLE NHS UNIVERSITY TEACHING HOSPITAL

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Congenital Talipes Equinovarus (CTEV) is one of the most common congenital limb deformities. We reviewed the records of infants who had received treatment for structural CTEV between 1 January 2007 and 30 November 2012. This was cross-referenced with the prenatal scans of mothers over a corresponding period of time. We investigated the sensitivity, specificity, and positive and negative predictive values of the fetal anomaly scan for the detection of CTEV and explored whether the publication of Fetal Anomaly Screening Programme guidelines in 2010 affected the rate of detection.

During the study period there were 95 532 prenatal scans and 34 373 live births at our hospital. A total of 37 fetuses with findings suggestive of CTEV were included in the study, of whom 30 were found to have structural CTEV at birth. The sensitivity of screening for CTEV was 71.4% and the positive predictive value was 81.1%. The negative predictive value and specificity were more than 99.5%. There was no significant difference between the rates of detection before and after publication of the guidelines (p = 0.5).

We conclude that a prenatal fetal anomaly ultrasound screening diagnosis of CTEV has a good positive predictive value enabling prenatal counselling. The change in screening guidance has not affected the proportion of missed cases. This information will aid counselling parents about the effectiveness and accuracy of prenatal ultrasound in diagnosing CTEV.

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Congenital Talipes Equinovarus (CTEV) has a reported incidence of between one and three per 1000 live births[1-6] making it one of the most common congenital limb deformities. It is bilateral in approximately half of cases.[7] The outcome following conventional treatment used to be unsatisfactory with many adults having poor function[8] and persistent deformities of the foot. The outcome has improved considerably since Ponseti revolutionised treatment.[9-12]

Ultrasound has been used to detect fetal abnormalities in the United Kingdom since the early 1980s.[13] It was not initially considered detailed enough to diagnose CTEV[14] but many authors have since reported satisfactory results.[3-6] Ultrasound studies often focus on specificity in small numbers of patients rather than population screening studies, which have been less encouraging.[13]

Most studies have been carried out in countries outside the UK, often involving only tertiary referrals to fetal medicine units. There is also variation in the definition of CTEV, regarding the inclusion or exclusion of 'positional' talipes. There are no contemporary statistics available from a single centre in the UK about the effectiveness of the ultrasonographic diagnosis of structural CTEV.

In January 2010, the NHS Fetal Anomaly Screening Programme (FASP) published national guidelines[13] regarding the scans undertaken between week 18 and week 20 of pregnancy, with the intention of producing explicit direction for sonographers. These guidelines, however, do not include the detection of CTEV and consequently, since their introduction, our unit has operated an *ad hoc* screening programme for the detection of this deformity. The ultrasonographer notes an incidental finding of CTEV and refers the patient to the department of Fetal Medicine for further scanning. Parents are then counselled about the outlook and treatment options for their child by a paediatric orthopaedic surgeon or specialist children's physiotherapist. Prenatal counselling has had a positive impact on the parental experience of a diagnosis of CTEV.[15]

The primary aim of this study was to evaluate the effectiveness of ultrasound screening at the time of the fetal anomaly scan in the diagnosis of structural CTEV in a single NHS unit.

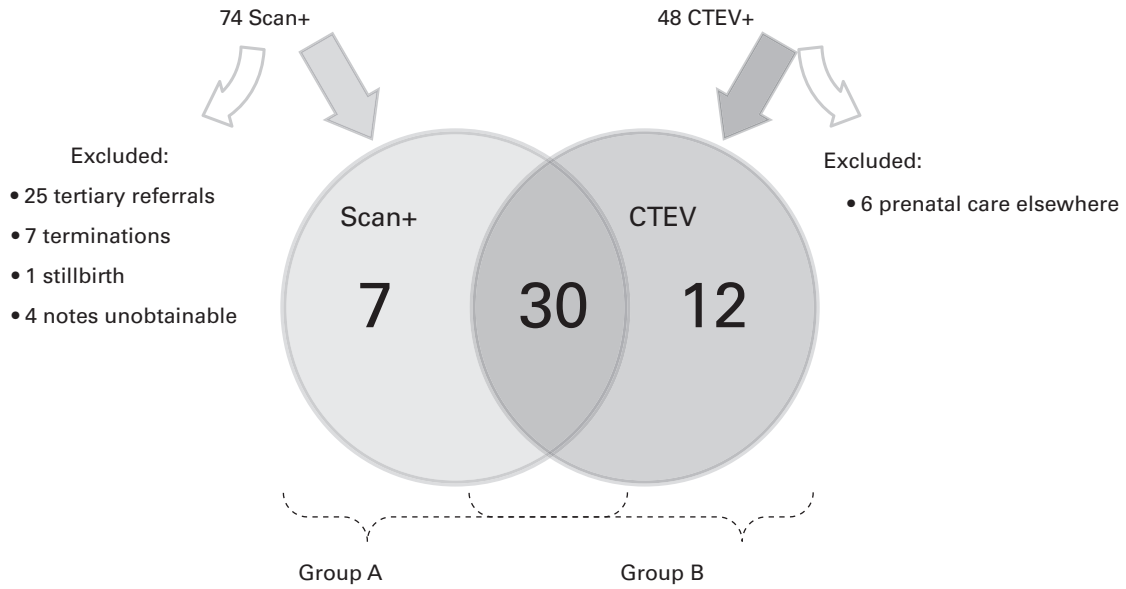

Fig. 1

Diagram showing numbers of scans that were positive for CTEV and number of CTEV positive children at birth. Includes exclusions for both sets of data.

Unlike previous studies, this evaluation includes sensitivity and positive predictive values. This information is important for counselling both pre- and postnatally, as well as guiding expected workload.

Our secondary aim was to determine whether the FASP guidelines, and our consequent move to incidental screening, had any adverse effect on the number of infants correctly identified with structural talipes prenatally.

As far as we are aware, this is the first geographically defined study in the UK which combines the ultrasound findings in an unselected low risk population with the postnatal findings, to ascertain the sensitivity and specificity of prenatal ultrasound in the diagnosis of CTEV. Although the results of this study are most relevant to centres in the UK, they would be equally relevant to any centre that performs fetal anomaly screening at about the same period of gestation.

Patients and Methods

The study was performed at a single NHS University Teaching Hospital which provides obstetric, fetal medicine and paediatric orthopaedic services. As we are the sole regional provider of Ponseti services we are confident that we treat all local infants diagnosed with CTEV. The study had ethical approval.

All expectant mothers booking with our obstetric department are offered a prenatal anomaly ultrasound scan between week 18 and week 20 of gestation as per national guidance. The scans are performed by appropriately trained ultrasonographers.

The results of all prenatal ultrasound scans are recorded in an electronic database. We identified all fetuses whose scan showed changes suggestive of CTEV between 1 August 2006 and 30 June 2012 (group A). The obstetric records were reviewed and tertiary referrals, terminations and stillbirths were excluded. Routine examinations of the babies are performed by doctors and midwives and these records were reviewed to confirm whether structural or positional CTEV was present at birth.

All infants born between 1 January 2007 and 30 November 2012 who received treatment for structural CTEV were identified from the database of the physiotherapy delivered Ponseti service (group B). Infants were excluded if their mothers had not received prenatal care at our hospital. In this group, we recorded whether the diagnosis of CTEV had been made prenatally (group B1), or postnatally (B2). In order to ensure that there had been no prenatal errors in documentation for group B2, a fetal medicine specialist (RPS) reviewed the obstetric database and maternal clinical records.

We also recorded the number of feet affected (unilateral or bilateral) and the Pirani score[16] at the start of Ponseti treatment.

Statistical analysis. We entered all data into a custom designed spreadsheet for analysis (Excel 2003, Microsoft, Redmond, Washington).We then cross-referenced the two groups to identify infants common to both groups.

We used the data to evaluate the effectiveness of our prenatal ultrasound screening for diagnosing CTEV through the calculation of positive and negative predictive values, sensitivity and specificity.

Due to the introduction of the FASP guidance in 2010, we subdivided group B for further analysis into those scanned before and after 2010. We created a 2×2 contingency table to compare the frequencies of pre- and

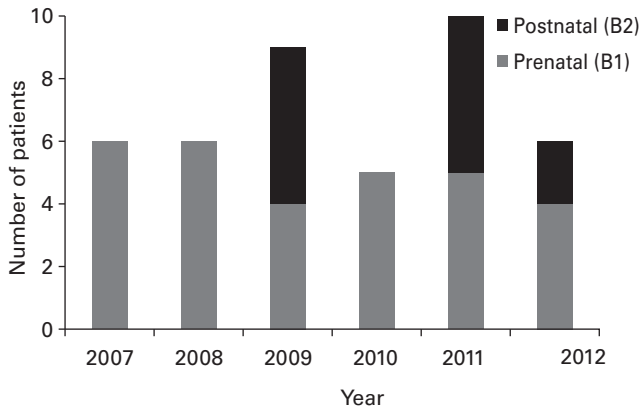

Fig. 2

Histogram showing timing of diagnosis of CTEV in each year from 2007.

postnatal detection for each, and used the χ^2 test to determine whether there was a statistically significant difference, at a p-value of < 0.05.

We compared the Pirani scores of group B1 and B2 using the Student's *t*-test. We created a 2×2 contingency table to also compare the relative frequencies of unilateral and bilateral cases using the χ^2 test.

Results

There were 34 373 live births during the study period. The overall incidence of CTEV was 1.2 per 1000 live births. Half of all infants had bilateral deformities. Fetal anomaly scanning identified CTEV in 74 foetuses prenatally; after applying the exclusion criteria, 37 were eligible for inclusion in the study (Fig. 1). At birth, 30 were found to have structural CTEV. The positive predictive value of the screening was therefore 81.1%. Of the seven false positive scans, two infants had a positional deformity, one had polydactyly and the remaining four had no deformity.

Our Ponseti service treated 48 infants during the study period. Six were excluded as they had received prenatal care elsewhere, leaving 42 in group B. The fetal anomaly scan had detected CTEV in 30 of these children (group B1); the sensitivity of the screening is therefore 71.4%.

In group B2, comprising the 12 cases not detected prenatally, it was noted during scanning that a high maternal body mass index had reduced the quality of the images in five cases.

A χ^2-test comparing groups B1 and B2 showed no significant difference in the relative frequencies of unilateral and bilateral cases ($\chi^2 = 0.12$, p = 0.69). There was no significant difference between the mean Pirani scores in groups B1 and B2 (5.21(3 to 6) and 5.31(3 to 6) respectively; p = 0.76).

Figure 2 summarises the number of cases of CTEV by year, and the proportions detected pre- and postnatally. The specificity and negative predictive value of fetal ultrasound screening for CTEV are both above 99.5%. There was no significant difference in the rate of pre- and postnatal detection for the periods between 2007 and 2009 (before FASP) and between 2010 and 2012 (after FASP) ($\chi^2 = 0.49$, p = 0.5).

Discussion

Although the prenatal diagnosis of CTEV on fetal ultrasound is well established in clinical practice, it may not be as important as once regarded. Historically, a sonographic diagnosis of CTEV was considered an indication for amniocentesis,[17] though recent studies suggest karyotyping is only indicated if there are associated anomalies on the sonographic survey.[18] It was reported in a recent review of the literature that the risk of fetal aneuploidy was between 1.7% and 3.6% for isolated CTEV.[3] However, the European Concerted Action on Congenital Anomalies and Twins (EUROCAT) network of congenital anomaly registries reported that 205 terminations were undertaken for CTEV in the UK between 2007 and 2011.[19,20] Whilst it is unclear what proportion had other fetal anomalies, it highlights the importance of evidence-based prenatal counselling.

There is controversy as to whether parents should be informed about a treatable deformity such as CTEV if detected prenatally, as it may then not be present at birth.[21] A combined American and Austrian survey showed that most parents preferred to know the diagnosis before birth in order to prepare practically and psychologically.[22,15] Any prenatal advice about the significance of the ultrasound findings should be based on data most appropriate to the population. However, there is a paucity of such data, which is summarised in Table I.[3-6,15,21-26]

Most previous studies, including the only three from the UK,[5,24,25] were undertaken before the recent advances in sonography and the wider acceptance of the Ponseti method of treatment.[24] Prenatal ultrasound cannot differentiate accurately between postural and structural CTEV[21] which has led to inconsistencies in the literature regarding the classification of deformities and the assessment of true or false positive results in anomaly scanning. Thus, the percentage of false positive results have been reported to vary between 0% and 40%.[21,24,26] Studies have also varied in the gestational age at prenatal diagnosis, which is important, as isolated unilateral CTEV detected later in pregnancy is more likely to be positional.[5,25] The rate of false positive findings may also vary as infants with normal feet at birth are often lost to follow-up.[21]

A positional deformity that does not require treatment is, in our opinion, a false positive result, as the parents will have been counselled about treatments that their infant does not require. Two previous studies included positional deformities in the calculation of the positive predictive value (PPV). Reclassifying positional deformity as a false positive would reduce the PPV in these studies from 96.3% to 86.9%[5] and from 93.6% to 83.9%,[25] comparable to our study.

Perhaps most crucially, few published studies do not correlate postnatal findings[5,25] with normal prenatal scans, so there is little information regarding the sensitivity of screen-

Table I. Summary of published data on the accuracy of prenatal ultrasound in detecting Congenital Talipes Equinovarus. Blank cells indicate data not specified in article

Author	Total screened	Incidence (%)	FPR* (%)	PPV* (%)	Sens* (%)	Spec* (%)	Notes
Rijhsinghani et al[4]	23 863	0.14	*5.7*	*94.3*			Tertiary centre
Katz et al[22]	13		*4.5*	*95.5*			
Tillett et al[24]	14		*34.8*	*65.2*	*95*	*66*	
Treadwell et al[26]	14 013	0.39	*10.7*	*89.3*			Tertiary care
Carroll et al[25]			*6.4*	*93.6*			Incl. Positional
Bakalis et al[5]	103 228	0.10	*3.7*	*96.3*			Incl. Positional
Bar-On et al[23]			*17*	*83*			
Offerdal et al[6]	49 314	0.20	*1.4*	*98.6*	*61.1*	*> 99.5*	
Glotzbecker et al[21]			*19.3*	*80.7*			Tertiary centre
Lauson et al[3]			*10.5*	*89.5*			Tertiary centre
Radler et al[15]					*42*		Varied by country
This Paper	30 077	0.12	*18.9*	*81.1*	*71.4*	*> 99.5*	

* FPR, False Positive Rate; PPV, Positive Predictive Value; Sens , Sensitivity; Spec, Specificity; Incl. Positional, the positive predictive value includes children born with a positional deformity

ing. This can be important information when faced with parents questioning why the diagnosis of CTEV was not made prenatally.

The rate of CTEV and the frequency of bilaterally affected feet in our study population is similar to that which has previously been reported.[4,5,15,27] Our high specificity and negative predictive value is to be expected because the incidences of structural CTEV and ultrasound positive CTEV are extremely low compared to the number of live births and ultrasound scans performed.

A number of other papers reporting PPVs are from tertiary referral centres (80.7%,[21] 89.3%,[26] 89.5%,[3] 94.3%[4]) and involve a pre-selected population, potentially skewing the results in favour of a higher PPV. Tertiary referral cases were excluded from our study in order to eliminate this confounding factor, and allow generalisation for an unselected population.

The differences between studies mean that the information about the effectiveness of the prenatal ultrasound detection of CTEV varies extensively, making any comparison, for example for audit purposes, difficult and potentially meaningless.

According to the results of this study, the publication of the NHS Fetal Anomaly Screening Programme Guidance, and a consequent move to a policy of incidental screening has not had a significant effect on the rate of prenatal diagnosis of CTEV in our unit. There was considerable variation in the proportions of cases detected prenatally between each year (Fig. 2), which we cannot explain. There was no change in sonography staff or protocol, so this would be ascribed to normal variation. However, the numbers in this study are small, and further investigation will be required. One potential weakness of our study is that patients will have been lost to follow-up if they left the region following their positive scan. The UK does not have a national congenital anomaly register, so this would be true for any NHS study regarding the prenatal detection of such abnormalities. Our population, however, is relatively stable, so any effect on the results is likely to be small. Further longer-term multicentre trials would be needed. The British Society for Children's Orthopaedic Surgery will be collecting outcome data relating to the Ponseti management of CTEV and we would suggest the extension to a national registry, which would provide useful data for many aspects of the management of CTEV, including the focus of this particular study.

A fetus found to have a CTEV deformity on scans between week 18 and week 20 of pregnancy, has an 81% likelihood of having a structural deformity requiring Ponseti treatment. Our screening programme, which is an example of standard clinical practice in the UK, fails to detect just over a quarter of cases prenatally. This information is essential, in our opinion, in order to counsel parents effectively. Our data should enable healthcare professionals to the discuss the prenatal ultrasonographic diagnosis of CTEV confidently in a UK based NHS setting and provide a useful benchmark against which other units can assess their results.

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