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Original articles

Why do so many small infants develop an inguinal hernia?

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SUMMARY Prevalence and incidence of inguinal hernia in a representative sample of low birthweight survivors were determined by tracing children at 3 years of age. Prevalence was examined in relation to perinatal factors recorded in hospital case notes, using a logistic regression model to allow for confounding variables.

Of the 1074 two year survivors, 995 (93%) were assessed. Seventeen per cent of 497 boys and 2% of 498 girls had a hernia by 3 years of age, a total cumulative prevalence of 9·2%: it was significantly increased by lower birth weight, male sex, neonatal intravenous feeding, and lack of respiratory disease. Neonatal illnesses were otherwise not associated with herniation, and most infants were well when they presented. Peak incidence was at the expected full term of gestation. Bilateral hernias were increasingly more common than unilateral hernias at lower gestational ages.

It is proposed that causes of increased abdominal pressure in healthy neonates are important causes of herniation during a critical period of inguinal development.

Inguinal hernia is the commonest indication for surgery in childhood, with a peak incidence in the first months of life.[1] Little is known about its aetiology, and its prevalence is not known, owing to the difficulties in tracing a large unbiased population.

Low birthweight infants have a higher prevalence of inguinal hernia in early childhood than other infants.[2] We investigated the incidence, prevalence, and clinical features of inguinal hernia in a large representative sample of low birthweight infants to give an indication of the surgical workload associated with increasing survival of low birthweight infants.

Low birthweight infants suffer far more perinatal illness than do other infants, but it is not known whether this accounts for their increased susceptibility to herniation. We used the data afforded by their close observation after birth to investigate which factors might be implicated in the aetiology of inguinal hernia in childhood.

Patients and methods

The sample comprised survivors of birth weight ≤2000 g born in 1979, 1980, and 1981 to residents of five health districts in Merseyside. It was derived from searches of birth notifications and admission registers of local maternity hospitals. Survivors were traced and, where possible, assessed in their homes. Presentation of inguinal hernia by 3 years of age was ascertained by history and examination and was verified by examining hospital follow up records. Questionnaires were sent to the parents and guardians of children who could not be visited at home.

Perinatal data were gathered from the case records of each hospital that cared for each mother and infant. Gestational age was recorded according to neonatal assessment if obstetric assessment was uncertain. Centiles of birth weight according to gestational age were derived from recent data.[3] Hypertension in pregnancy was defined as recorded maternal diastolic blood pressure of more than 90 mm Hg. Mechanical ventilation was defined as support with continuous positive airways pressure or intermittent positive pressure ventilation for a minimum of 12 hours. Respiratory disease was defined as treatment with oxygen or mechanical ventilation, or both, for more than 24 hours, starting in the first week of life. Intravenous feeding was defined as the continuous use of intravenous amino acids for more than 24 hours during the neonatal period.

The SPSS-X[4] and GLIM[5] packages were used to analyse the data and check the accuracy of their collection. Confidence intervals were calculated using a continuity correction, and χ^2 tests for trends were calculated according to standard methods.[6] Variables were tested separately for degree and significance of association with inguinal hernia by tests appropriate for the type of variable: those used were the χ^2 with Yates's correction for 2×2 tables, the Mann-Whitney, and Student's unpaired *t* test.

Variables were tested for independent association with inguinal hernia if they were associated with it according to the univariate analyses (p about 0·1 or less). For this purpose a logistic regression model with presence and absence of inguinal hernia as the independent variable was used. The model allowed for the confounding effects of sex and birth weight, which were strongly associated with inguinal hernia according to the univariate analyses; it was decided to allow for birth weight rather than gestational age because its association with inguinal hernia was the stronger, their effects not being significantly additive. Different sequences and combinations of variables were tested to achieve the best model for estimating the probability of a hernia. Only variables that significantly improved the fit were included in this final model; thus these variables were significantly and independently associated with prevalence of inguinal hernia ($p<0·05$).

Results

The sample. Of 1420 liveborn infants, 1074 survived to 2 years. Occurrence of inguinal hernia by 3 years was ascertained for 995 (93%) of the survivors, who form the sample. Children for whom there was insufficient information did not differ significantly from the sample in terms of birth weight, gestational age, sex, or neonatal illness.

Prevalence by sex, birth weight, and gestational age. (Table 1) Inguinal herniotomy was performed in 9·2% (95% confidence interval=7·6–11·3%) of the 995 survivors by 3 years and was twice as common as any other surgical procedure. There were no unoperated hernias. Prevalence increased significantly with decreasing birth weight or gestational age, but their effects were not significantly additive. Small for dates infants were not more likely to have a hernia than other infants. Boys had a higher prevalence of hernia than girls in every birth weight and gestational age group, with an overall relative risk of 9·2 to 1. Prevalence increased significantly with decreasing gestational age in both sexes.

Clinical features. Of 89 children for whom laterality was confirmed, 32 (36%) had a right sided and 15 (17%) had a left sided unilateral inguinal hernia. The 41 children (46%) with bilateral herniation included five who had had unilateral herniotomy with subsequent contralateral presentation. Bilateral hernias were increasingly more common than unilateral hernias at lower birth weights or gestational ages (Table 2).

Incidence peaked in the second month after birth (Table 3). Adjustment for the gestational age of each infant gives a peak incidence around the time of full term of gestation. Children with bilateral hernias presented earlier in relation to full term of gestation than did children with a unilateral hernia ($p=0·018$).

Eighty five per cent of the infants of birth weight

Table 1 *Numbers of children and prevalence of inguinal hernia (%) by 3 years of age, by sex, birth weight, and gestational age*

	Birth weight (g)										*All birth weights (% with hernia)*	
	501–1000		*1001–1250*		*1251–1500*		*1501–1750*		*1751–2000*			
	m	*f*	*m*	*f*	*m*	*f*	*m*	*f*	*m*	*f*	*m*	*f*
Gestation (weeks):												
25–27	5	13	7	3							50	6
28–30	8	12	30	23	29	29	13	7	1	4	21	4
31–33	4	1	14	8	31	34	48	41	72	53	17	2
34–36	2	1	5	6	17	19	39	49	108	108	14	1
>36			1	1	1	4	17	23	45	59	12	1
% With hernia:												
Male	37		23		21		17		12		17	*
Female		4		5		1		3		0		2
Both sexes	17·4		15·3		10·4		10·1		6·2			
(95% Confidence interval)	(8–32)		(9–24)		(6–16)		(7–15)		(4–9)			

m=Male, f=female.
Trend with gestational age: in males, p=0·009; in females, p=0·036.
Trend with birth weight: in males, p=0·001; in females, p=0·066.
*Sex difference: p<0·001.

Table 2 *Ratios of unilateral to bilateral hernias*

(a) According to gestational age

Hernia	*Gestational age (weeks)*				
	25–27	*28–30*	*31–33*	*34–36*	*>36*
Unilateral	3	5	16	15	9
Bilateral	3	15	14	8	1
Not known	1		1	1	

χ^2 For trend=9·84, p<0·005.

(b) According to birth weight

Hernia	*Birth weight (g)*				
	501–1000	*1001–1250*	*1251–1500*	*1501–1750*	*1751–2000*
Unilateral	2	4	8	14	20
Bilateral	5	11	9	9	7
Not known	1	–	–	1	1

χ^2 For trend=10·99, p<0·001.

Table 3 *No of children presenting with inguinal hernia* up to 3 years of age according to month after birth or after full term*

	Month											
	−3	*−2*	*−1*	*1*	*2*	*3*	*4*	*5*	*6*	*7–12*	*>12*	*All*
After birth:												
No				7	29	25	7	2	3	3	10	86
Cumulative %				8	41	70	78	81	84	87	100%	
After full term†:												
No	1	6	25	25	8	5	1	2	1	2	10	86
Cumulative %	1	8	37	66	75	81	82	84	85	87	100%	

Information was not available for six children with a hernia.
*For non-concurrent bilateral hernia, time of presentation of first hernia.
†Month after birth corrected for gestational age in each case.

>1500 g who developed a hernia presented after discharge home from neonatal care compared with only 40% of those of birth weight ≤1500 g (p<0·001). This is because most of the larger infants were discharged home before the age of peak incidence of herniation.

Initial presentation was invariably with a lump in the groin, often first noticed by parents and diagnosed by health visitors in the weeks after discharge from neonatal care. Two children presented during whooping cough infection. Diagnosis usually led to early surgery, but there was a delay of several months in four children who were at home. Six children had emergency herniotomy for irreducible incarceration, but we could not determine accurately how many other children developed incarceration.

Immediate post-surgical complications in 86 children included one case each of testicular infarction, scrotal abscess, and groin abscess. Five (5%) of the children had an ipsilateral recurrent hernia.

Prevalence of inguinal hernia was not significantly related to major forms of neurological disability such as cerebral palsy or educational subnormality.

Associations of perinatal factors with inguinal hernia. Factors not significantly associated with hernia in the univariate analysis included maternal age, marital state, social class, smoking, anaemia in pregnancy, antepartum haemorrhage, induction of labour, prolonged rupture of membranes, duration of labour, breech delivery, forceps delivery, multiple birth, birth order, hospital of birth, infant bruising, hypoglycaemia, malformation, duration of treatment with oxygen, pneumothorax, bacteraemia, fits, apnoeic attacks, and peak bilirubin concentration.

Some factors were associated with inguinal hernia by virtue of their association with birth weight: they were associated with hernia in the univariate analysis but not when allowing for birth weight in the regression analysis. They included gestational age, Apgar score at one minute, intubation at birth, day of full enteral feeding, duration of mechanical ventilation, treatment with theophylline, antibiotics, or indomethacin, necrotising enterocolitis, phototherapy, persistent ductus arteriosus, and intraventricular haemorrhage.

The best predictive model gave a risk of hernia that was inversely related to birth weight, with increased log odds according to sex (male:female=11·5:1), intravenous feeding (yes:no=3·1:1), and absence of respiratory disease (absent:present=2·4:1) (p<0·05 in each case). Although hypertension in pregnancy, a low Apgar score at five minutes, and hypothermia on admission to the neonatal unit were associated with increased prevalence of hernia when allowing for birth weight and sex (p<0·1), their effects on this final model were not significant.

The best models for predicting unilateral and bilateral inguinal hernias differed: birth weight was predictive only of bilateral hernias, while maternal hypertension (which included pre-eclampsia) was predictive of unilateral hernia. Mechanical respiratory support was not associated with increased prevalence of hernia but was predictive of bilateral rather than unilateral hernia when considering only those infants who did develop a hernia.

Discussion

The prevalence of inguinal hernia in children and adults is not known, but repair of inguinal hernia is the commonest operation performed by general surgeons on children[1] and men.[7] It is by far the commonest operation performed on low birthweight infants in early childhood.

Many hospitals have reported a high incidence of inguinal hernia in low birthweight survivors[8] after a report that 11 of 37 infants of birth weight ≤1000 g developed an inguinal hernia.[9] The prevalence of inguinal hernia by 6 months of age is significantly higher in infants born before 37 weeks' gestation than in full term infants.[2] Our data confirm that prevalence of inguinal hernia, in particular of bilateral hernias, increases with lower birth weight or lower gestational age. Numbers with bilateral hernias may have been overestimated owing to contralateral exploration in cases of left sided hernia, but others have also reported that bilateral hernias are common in preterm infants.[2 10 11]

Prevalence of inguinal hernia was similar among the 223 twins and the singletons in the sample. The reported higher prevalence in twins than singletons[12] did not allow for birth weight, but the mean of the reported birth weights for twins was less than 2500 g.

Inguinal hernia is hazardous in infancy, when the rate of incarceration may be over 25%;[10 11] it is the commonest cause of intestinal obstruction between 1 week and 4 months.[13] Testicular infarction is more common after emergency surgery.[11 14] Rates of recurrence of hernia in children are higher after bilateral herniotomy and emergency surgery,[11] and our data suggest that recurrence is common in low birthweight infants. Postoperative pulmonary complications and episodes of apnoea are common in preterm infants.[15] We found few serious sequelae of inguinal hernia, but this is a tribute to standards of care rather than a cause for complacency.

The dilemma of whether to explore the other side of the unilateral hernia in infants[16] may be relevant to low birthweight infants in particular. Bilaterality increases with lower birth weight or gestational age, especially in infants who are ventilated mechanically.

The aetiology of inguinal hernia must relate to a defect in the abdominal wall and a force sufficient to propel viscera through it. Clearly, a lesser force is necessary with a larger or more distensible defect.

The nature of the defect in adults is controversial,[17] but herniation in infants is through the processus vaginalis.[1] This peritoneal pouch descends in the eighth or ninth month of gestation into the scrotum ahead of the testis or into the labium. It usually closes and atrophies some time after birth, although postmortem studies have shown a persistent processus vaginalis in 80–94% of neonates, 57% of 1 year olds and 15–37% of adults.[1] Herniography has shown a contralateral persistent processus in 63% of infants with unilateral hernia before 2 months, declining to about 40% at 2 years and beyond, of which a high proportion develop a hernia on the side of the persistent processus some time in life.[16] The role of the processus vaginalis in determining herniation at any age is not clear, however, because there is no available non-invasive technique for its prospective study in those without a demonstrable hernia. The low relative risk of inguinal hernia in very preterm girls implies that a persistent processus vaginalis is not the sole anatomical factor that determines herniation. Similarly, congenital anomalies and increased abdominal pressure do not increase frequency of patency of the processus but are associated with increased frequency of bilateral hernias.[18]

The inguinal canal is very short in infancy, and the external ring is almost directly over the internal ring,[1] which presumably facilitates testicular descent. Failure of testicular descent, and thus orchidopexy, is associated with inguinal hernia.[1] The right testis descends later than the left testis: inguinal hernia is commoner on the right than the left side. In very preterm infants neither testis is fully descended at birth: bilateral hernias are increasingly common with lower gestational age. This suggests that inguinal hernia results from birth during a critical period when developing inguinal anatomy facilitates herniation on both sides. The peak age at presentation by the expected full term of gestation is consistent with this hypothesis, as is the earlier presentation of bilateral compared with unilateral hernias in relation to full term of gestation.

Most preterm infants, however, do not get a hernia, so that non-anatomical factors may be important in determining which ones do. Other data also suggest that respiratory disease and treatment do not increase susceptibility to herniation: 8·2% of 73 ventilated infants of birth weight <1501 g who survived to 24 months of age developed a hernia[19] compared with 8·7% of 172 unselected survivors of similar birth weight who developed a hernia by 6 months of age.[20]

A relation with growth retardation was not apparent within the low birthweight range, although low birthweight infants born at full term had a high prevalence of inguinal hernia. There was no evidence that prenatal factors were important determinants of bilateral hernias when allowing for birth weight and sex, although maternal hypertension seemed to increase susceptibility to unilateral hernia.

Intravenous feeding was routine in sick neonates and may have been a marker for a factor not included in the analysis, such as weight loss or abdominal distension. Neonates with conditions associated with abdominal destension have an increased incidence of inguinal hernia.[10 18] Necrotis-

ing enterocolitis was diagnosed in 31 infants, seven of whom developed a hernia. This proportion was higher than for infants without necrotising enterocolitis by univariate analysis ($p=0{\cdot}02$). Necrotising enterocolitis did not contribute to prediction of inguinal hernia when allowing for other variables, but this may have been due to the fairly small number of children who had necrotising enterocolitis.

Other than the relation with intravenous feeding, there were no significant relations between neonatal illnesses and inguinal hernia, and most infants were healthy at presentation. Precipitation of an inguinal hernia must relate to increased abdominal pressure and occurs in the absence of respiratory or other disease in most infants. It is conceivable that the large volumes of milk given to healthy underweight infants contribute to herniation (most receive an adult equivalent for weight of more than three gallons a day). Enteral feeding, vigour, and healthy lungs may precipitate herniation in immature infants, in whom inguinal anatomy is designed for testicular descent in the calm of life in utero.

The incidence of inguinal hernia in all children is highest in the neonatal period.[1] If preterm infants develop a hernia because they are born before inguinal development is normally complete other infants may do so because their inguinal development is abnormally incomplete at full term, whether governed by genetic or other factors.

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