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Early childhood development of boys with genital anomalies

Francisco J Schneuer PhD^{1*}, Jason P Bentley MBioStat¹, Andrew JA Holland PhD², Samantha J Lain PhD¹, Sarra E Jamieson PhD³, Nadia Badawi PhD⁴, and Natasha Nassar PhD¹

¹Menzies Centre for Health Policy, School of Public Health, University of Sydney; ²Discipline of Paediatrics and Child Health, The Children's Hospital at Westmead, Sydney Medical School, The University of Sydney, NSW, Australia; ³Telethon Kids Institute, The University of Western Australia, Crawley, Western Australia; ⁴Grace Centre for Newborn Care, The Children's Hospital at Westmead, Sydney, Australia

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Correspondence to: Dr Francisco Schneuer, Level 6 The Hub, Charles Perkins Centre D17, The University of Sydney, NSW 2006, Australia. Telephone: +61 2 86274674. Email:

francisco.schneuer@sydney.edu.au

Conflicts of interest

None to declare

Abstract

Background: Male genital anomalies often require surgery in early life to address functional and cosmetic consequences. However, there has been little assessment of developmental outcomes of affected boys.

Methods: We conducted a population-based cohort study of all boys born in NSW, Australia and undergoing school-entry developmental assessment in 2009 or 2012. Health and developmental information was obtained via record-linkage of birth, hospital and Australian Early Development Census data. Boys with hypospadias or undescended testis (UDT) were compared to those without. Developmental outcomes were assessed in five domains (physical health, emotional maturity, communication, cognitive skills; and social competence) and boys were categorized as vulnerable (<10th centile of national scores), developmentally high risk (DHR; vulnerable in 2+ domains) and special needs.

Results: We included 420 boys with hypospadias, 873 with UDT and 77,176 unaffected boys. There was no difference in the proportion of boys developmentally vulnerable in any domain or DHR between boys with hypospadias (DHR: n=49; 13.1%; P=0.9), UDT (n=116; 15.2%; p=0.06) and unaffected boys (n=9,278; 12.9%). Compared with unaffected boys (n=4,826; 6.3%), boys with hypospadias (n=43; 10.2%; P<0.001) or UDT (n=105; 12.0%; P<0.001) were more likely to have special needs. Stratified analyses revealed that only boys with UDT and coexisting anomalies had increased risk of being DHR (OR: 2.65; 95%CI: 1.61-4.36) or special needs (OR: 2.91; 95%CI: 2.00-4.22).

Conclusion: We found no increased risk of poor development among boys with hypospadias or UDT. However, boys with UDT and coexisting anomalies were more likely to have poorer development and special needs.

Keywords: Hypospadias, undescended testis, cryptorchidism, early childhood development, physical health, cognitive development, emotional development, social competence

Introduction

Hypospadias and undescended testis (UDT) are the two most common genital anomalies in boys affecting approximately 0.5% and 1% of the population, respectively (Schneuer et al., 2015; Schneuer et al., 2016). Hypospadias occurs when the urethra opens anywhere between the ventral aspect of the glans and the perineum. UDT is defined as one or both testis not present in the scrotum after birth and fail to descend in the first 6 months of life. It has been proposed that these anomalies share a common origin during fetal gender development in early pregnancy (Skakkebaek et al., 2001). Both anomalies require surgical correction to address long term adverse consequences on functionality, fertility and cosmetic appearance (Chan et al., 2014; Chertin et al., 2013; Schnack et al., 2010).

The impact of genital anomalies on overall cognitive, social and emotional development of boys is less well understood. The inherent awareness of the anomaly after surgery in early life may represent a significant challenge affecting the cognitive and emotional components of personality in male infants together with their body image (Masi et al., 1999). In addition, parental overprotection from increasing anxiety during child development may affect their autonomy and self-confidence (Sandberg et al., 2001). To date, the results of studies assessing the effect of hypospadias or UDT on developmental or behavioural outcomes have been inconsistent and have mostly assessed outcomes during adolescence or adulthood. Some studies have reported lower IQs, increased anxiety, low self-esteem, cognitive and thinking inhibition; and higher sexual inhibition for males previously treated for hypospadias or UDT (Depue, 1988; Marte et al., 2014; Masi et al., 1999). In contrast, others have reported normal academic achievement, excellent quality of life, normal psychosocial adjustment and gender role behaviours assessed post-operatively (Liu et al., 2015; Sandberg et al., 2001; Sung et al., 2014). However, studies have been limited by comparatively small sample size (ranging from 15 to 385 cases) and there have been no consistently applied measures of development making results imprecise and difficult to interpret. Population level instruments for assessing the development of children at school entry age have been validated and implemented in many countries, including Australia (Carr et al., 2016; Janus et al., 2016). The collection of this information represents an ideal

opportunity to conduct large population-based studies to evaluate the impact of conditions arising in the perinatal period on early childhood development. The aim of this study was to investigate the early childhood developmental outcomes of boys with hypospadias or UDT requiring surgery.

Materials and Methods

Study population and data sources

We conducted a population-based record linkage cohort study including all boys born in New South Wales (NSW), Australia that had a developmental assessment in their first year of full-time schooling (ages 4 to 6) in 2009 or 2012. Record-linkage was used to combine birth information from the Perinatal Data Collection (PDC), hospital admission information from the Admitted Patient Data Collection (APDC) and child development information from the Australian Early Development Census (AEDC) and was conducted by the NSW Centre for Health Record Linkage independent of the research. The PDC is a statutory population-based database of all live births and stillbirths in NSW, of at least 20 weeks gestation or 400 g birth weight that includes information on maternal demographic, pregnancy, delivery factors, and infant outcomes. The APDC is a census of all in-patient hospital admissions from NSW public and private hospitals which collects demographic and clinical information based on hospital medical records. Diagnosis and procedures for each admission are coded according to the 10th revision of the International Classification of Diseases, Australian Modification and the Australian Classification of Health Interventions, respectively. The AEDC is a nationwide triennial assessment of child development first conducted in 2009. It is an adaptation of the Canadian Early Development Index (Janus and Offord, 2007). It includes child demographics, school ID and results from teachers assessment in over 100 items which contribute to scores for five developmental domains; physical health and well-being, emotional maturity, communication skills and general knowledge, language and cognitive skills (numeracy and literacy); and social competence (Brinkman et al., 2014). Ethics approval for access and linkage of data was obtained from the NSW Population and Health Services Research Ethics Committee.

Study outcomes and explanatory variables

Primary study outcomes were based on developmental outcomes of boys identified from AEDC data. Boys who scored below the 10th national percentile of AEDC scores were categorized as developmentally vulnerable for the corresponding developmental domain. Boys developmentally vulnerable in two or more domains were identified as developmentally high risk (DHR), a cross-domain summary measure of poor childhood development. Boys with special needs (requiring assistance due to chronic medical, physical or intellectually disabling conditions) were analysed separately as they are not included in the national distributions of AEDC scores.

The main study factor was a recorded diagnosis of hypospadias or UDT requiring corrective surgery identified from relevant infant hospital admissions in APDC data. Cases were identified from the APDC using relevant diagnosis and procedures codes and classified by severity or type of UDT as described previously (Schneuer et al., 2015; Schneuer et al., 2016). Boys with recorded diagnoses of coexisting anomalies were also differentiated from isolated cases, excluding minor anomalies such as tongue-tie, naevus, skin tags, unstable hip and feet defects. Boys without recorded genital anomalies were considered as the unaffected comparison group.

Perinatal and child assessment characteristics known or previously associated with developmental outcomes were included in the study as explanatory variables: maternal age, parity (nulliparous/multiparous), preterm birth (<37 weeks gestation), smoking during pregnancy, socio-economic disadvantage, birth weight z-scores, plurality (singleton/twins), age and year at developmental assessment and English as a second language. Socioeconomic disadvantage was determined by postcode using the Socioeconomic Indexes for Areas relative disadvantage scores developed by the Australian Bureau of Statistics and classified into quintiles (Australian Bureau of Statistics). Individual birth weights were expressed as a z-score (categorized into <-2, -2 to 2 and >2 standard deviation from the mean) by subtracting the mean and dividing by the standard deviation of the Australia distribution of birth weight by gestational age (Dobbins et al., 2012).

Missing information for explanatory variables and outcomes was uncommon and <1%: 26 (0.03%) maternal age, 557 (0.7%) smoking, socio-economic disadvantage 60 (0.007%), gestational age 17

(0.002%), 249 (0.3%) physical health and well-being, 679 (0.9%) emotional maturity, 260 (0.3%) communication and general knowledge, 275 (0.4%) language and cognitive skills and 297 (0.4%) social competence records.

Statistical analysis

Perinatal and child assessment characteristics, vulnerability by domain, DHR and special needs of boys with hypospadias and UDT were each compared to unaffected boys using contingency tables. Chi-squared tests were used to assess the association of each outcome for cases and unaffected boys. For those associations with a p-value <0.2 , we conducted univariate and multivariate analyses using binary generalized estimating equations with a logit link and exchangeable correlation to estimate the odds of poorer developmental outcomes for cases compared with unaffected boys while taking into account perinatal and child characteristics and the clustering of boys within schools. Only relevant covariates were retained in final models. Stratified analyses by the presence of coexisting congenital anomalies or severity were also performed. A two sided P-value <0.05 was considered statistically significant and all analyses were performed using SAS, version 9.4 (SAS Institute, Cary, NC, USA).

Results

A total of 78,447 boys born between 2002 and 2007 with corresponding early development assessment were included. Of the cohort, 420 (0.5%) had a recorded diagnosis and associated surgery for hypospadias, 873 (1.1%) for UDT and 77,176 were unaffected and without genital anomalies. 22 boys had both hypospadias and UDT. Among those with hypospadias 203 (48%), 129 (31%), 30 (7%) and 58 (14%) were anterior, middle, proximal and unspecified, respectively. There were 750 (86%) boys with unilateral UDT and 123 (14%) with bilateral UDT. The mean (standard deviation) age at genital surgery and developmental assessment were 2.4 (2.4) years and 5.6 (0.4) years, respectively.

Table 1 presents the perinatal and child assessment characteristics for cases and unaffected boys.

Boys with hypospadias or UDT were more likely to be first born, preterm and have a lower birth weight z-score. Boys with hypospadias were more likely to come from families where English was a second language, while boys with UDT were more commonly from backgrounds with the least socio-

economic disadvantage. Compared with unaffected boys, those with hypospadias or UDT had higher rates of coexisting congenital anomalies.

Figure 1 presents the developmental outcomes of cases with genital anomalies compared to unaffected boys. Although there was no association between hypospadias and poor development ($P \geq 0.2$), there was a consistently higher proportion and some association found between boys with UDT and vulnerability across developmental domains and DHR ($P < 0.2$) (**Figure 1**). On further analysis and adjusting for important confounders, boys with UDT were at a slightly increased risk of being vulnerable in physical health and wellbeing (adjusted odds ratio (aOR): 1.24; 95% CI: 1.01 – 1.52) and being DHR (aOR: 1.22; 95% CI: 1.00 – 1.49) (**Figure 2**). Stratified analyses revealed that the association between vulnerability and boys with UDT was strongest for those with coexisting congenital anomalies with more than a 2-fold increased risk of being vulnerable in all developmental domains or DHR (aOR: 2.65; 95% CI: 1.61 – 4.36), compared with unaffected boys having other anomalies (**Figure 2**).

Compared with unaffected boys (6.3%), boys with hypospadias (10.2%; $P < 0.001$) or UDT (12.0%; $P < 0.001$) had higher rates of special needs due to disability conditions (**Figure 1**). The proportion of boys with special needs was higher among those with coexisting anomalies (hypospadias: 25.8%; UDT: 35.3%) and for severe cases of proximal hypospadias (23.3%) and bilateral UDT (41.4%).

Figure 3 presents the univariate and adjusted associations between cases of genital anomalies and having special needs. There was a significant association between cases and having special needs in univariate analysis and after adjusting for relevant confounders. Overall, boys with hypospadias or UDT were 39% and 65% more likely to have special needs (hypospadias: aOR: 1.39; 95% CI: 1.01 – 1.91; UDT: aOR: 1.65; 95% CI: 1.35 – 2.02). When analyses were stratified by isolated or coexisting anomalies, only boys with UDT and coexisting anomalies had a 3-fold increased risk of having special needs (aOR: 2.91; 95% CI: 2.00 – 4.22). There was also a dose response effect with increasing odds for special needs by severity for hypospadias and type of UDT, although estimates for proximal hypospadias were not significant due to small numbers (**Figure 3**). Post-hoc analysis revealed that

among boys with special needs, a higher proportion with UDT (n=33/105; 31.4%; P<0.001) had a recorded diagnosis of developmental disorders such as autism, cerebral palsy, mental retardation or autism spectrum disorders, compared to boys with hypospadias (n=8/43; 18.6%) or unaffected boys (n=535/4,826; 10.9%).

Discussion

This is the largest population-based study to investigate early childhood developmental outcomes of school age boys with hypospadias or UDT. We found no increased risk of developmental vulnerability in cognitive, social and emotional domains among boys aged 4-6 years and either genital anomaly. However, boys with UDT and other coexisting anomalies were more likely to be vulnerable on various developmental domains or have special needs.

While we found no association, previous studies assessing early childhood development of boys with hypospadias are somewhat contradictory. Using parental questionnaires of children aged 6 to 10 years (N=508) one older study from 2001 reported that, compared to unaffected children, boys with hypospadias had similar academic achievement and showed less aggressive or delinquent behaviour, but had lower social competency (Sandberg et al., 2001). In another study from Switzerland, normal psychological adjustment but lower scores in self-assessed quality of life (five health scales, two emotional scales) was reported among boys with hypospadias, compared with boys undergoing inguinal repair (N=77) aged 6 to 17 years (Schonbucher et al., 2008). Others have found excellent quality of life across physical, emotional, social and cognitive domains among 25 patients following hypospadias repair using parental and patients questionnaires but this study did not include a control group (Liu et al., 2015). In another investigation authors found that boys with hypospadias had normal gender role behaviour assessed between 4 and 5 years of age (N=57), although they more often expressed negative communication behaviours compared to normal children (Sung et al., 2014). Despite the limitations of previous studies including small sample size and potential bias from their design by using parental or self-questionnaires, they are mostly consistent with our findings suggesting that boys with hypospadias experience similar developmental outcomes to their peers.

For young boys with UDT there has been very limited assessment of their developmental outcomes with only one study examining cognitive development and reporting a 2.5 odds of having low IQ (<70) at four years of age (Depue, 1988). Given an IQ score of <70 is used to define individuals with mental or intellectual disability this results would seem consistent with the association found between UDT and special needs in our study.

Later studies assessing social and emotional outcomes of older boys with hypospadias or UDT during adolescence or adulthood have identified a tendency to experience negative genital/body image and psychosexual identity which may increase anxiety, depression or hyperactivity and lower psychosocial functioning (Masi et al., 1999; Mondaini et al., 2002; Mureau et al., 1997; Xi et al., 2015). However, these symptoms were not present in our study or may not have been yet expressed at such young age.

Although we found that boys with genital anomalies were at increased risk of having special needs, defined as those boys requiring assistance due to chronic medical, physical or intellectually disabling conditions our findings suggest that this association was mediated by coexisting congenital anomalies, particularly for boys with UDT. While our findings are consistent with others, these did not account for coexisting anomalies. Specifically, a population-based study reported a 70% increased prevalence of intellectual disability in children with urogenital anomalies (boys and girls) (Pettersen et al., 2007) and a Swedish population-based study reported an overall 1.2 fold increased risk of psychiatric disorders in boys with hypospadias including a 1.9 fold increased risk of intellectual disability (Butwicka et al., 2015). Post-hoc analyses revealed that boys with UDT had increased rates of developmental disorders such as mental retardation and cerebral palsy, compared with unaffected boys. Indeed, the incidence of UDT in men with cerebral palsy or mental disabilities is significantly higher than the normal male population, ranging between 39% and 53%, respectively (Cortada and Kousseff, 1984; Rundle et al., 1982) and another study found that boys with UDT were 3.6 times more likely to have low motor function and cerebral palsy at age 4 (Depue, 1988). These findings suggest that UDT and central nervous system disorders may share common pathways during fetal

development. Genetic investigations have revealed shared genetic variations associated with UDT and various co-morbidities, with several syndromes and developmental delay amongst the most common (Urh and Kunej, 2016). Specifically, there is evidence of some expression of gene *VCX3A* in the brain which is strongly expressed in the testes (Hadziselimovic et al., 2014), and a study found deletion of this gene on the x chromosome in males with x linked mental retardation (Fukami et al., 2000). Moreover, expression of the spermatid perinuclear RNA-binding protein (STRBP) gene which appears to regulate the development of both the brain and testis is also lower in males with both Down syndrome and UDT (Salemi et al., 2012). Another possible cause of UDT in boys with cerebral palsy relates to the increase of spasticity of the cremaster muscle that progressively pull the testis to a higher position, but this may only occur in adolescent or adult patients and does not apply for boys with autism or mental retardation (Smith et al., 1989).

Nevertheless, our results contribute to inform clinicians, psychologists and the counseling of parents about the cognitive, social and emotional development of boys with genital anomalies, which in absence of other anomalies, is not different from unaffected boys. This should serve to reassure parents and reduce the potential anxiety and distress that may affect the rearing of their children (Pope et al., 2005). Our study also highlights the need for the routine examination for early detection of UDT in boys with developmental disorders due to its high incidence and to ensure timely surgical repair. Other clinical or psychological management of these boys may be prioritized and UDT overlooked (Haire et al., 2015), delaying surgical repair and increasing the risk of testicular cancer later in life (Chan et al., 2014).

Strengths of the study were the large size and coverage of the population-based health databases used that includes reliable and validated health information (Lain et al., 2012). Developmental outcomes from AEDC data are also reliable and their validity has been demonstrated through extensive development and testing (Janus et al., 2011). The developmental assessment conducted by teachers in the AEDC also avoids the potential bias of previous studies using parent or self-reported questionnaires. A limitation of the study is that using routinely collected administrative data, we were

not able to include all potentially relevant characteristics that may influence children development, for example parental education.

In conclusion, we found no increased risk of poor early childhood development across physical, cognitive, social and emotional domains among boys diagnosed with hypospadias or UDT. However, boys with UDT and coexisting congenital anomalies were more likely to have poorer developmental outcomes and have special needs associated with physical or intellectual disability, particularly those with UDT.

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Legends

Table 1: Perinatal and child characteristics of cases of hypospadias, UDT and unaffected boys in New South Wales (NSW), Australia

Table 1 legend: * Due to missing information numbers within characteristics may not equal column totals.

^a Comparing hypospadias with unaffected boys; ^b Comparing undescended testis with unaffected boys;

^c Excluding minor anomalies (e.g. naevus, tongue tie, unstable hips, skin tags)

Figure 1: Developmental outcomes at school-entry assessment of boys with hypospadias, UDT and unaffected boys

Figure 1 legend: * $P < 0.001$; DHR: developmentally high risk (vulnerable in two or more domains); DHR: developmentally high risk

Figure 2: Association between undescended testis and school-entry developmental outcomes

Figure 2 legend: * Adjusted for coexisting congenital anomalies, maternal age, smoking during pregnancy, socio-economic disadvantage, parity, preterm birth, age at assessment, birthweight z-scores, year of assessment and English as second language; ^ Adjusted for all previous covariates except coexisting anomalies. UDT: undescended testis; CA: congenital anomalies; DHR: developmentally high risk (vulnerable in two or more domains)

Figure 3: Association between genital anomalies and having special needs, overall and stratified by coexisting anomalies and degree of severity

Figure 3 legend: * Adjusted for coexisting anomalies, smoking during pregnancy, socio-economic disadvantage, preterm birth, age at assessment, birthweight z-scores and year of assessment. # Adjusted for all previous covariates except coexisting anomalies. UDT: undescended testis; CA: congenital anomalies

Perinatal and child assessment characteristics	Hypospadias N=420 n (%)[*]	Undescended testis N=873 n (%)[*]	Unaffected N=77,176 n (%)[*]
<i>Perinatal characteristics</i>	p-value ^a	p-value ^b	
Maternal age (years)	p=0.25	p=0.54	
<25	67 (16.0)	145 (16.6)	13,759 (17.8)
25 to 34	274 (65.2)	535 (61.4)	47,269 (61.3)
35+	79 (18.8)	192 (22.0)	16,123 (20.9)
Smoking during pregnancy	p<0.01	p=0.38	
Yes	39 (9.3)	115 (13.2)	10,940 (14.3)
No	379 (90.7)	754 (86.8)	65,687 (85.7)
Parity	p<0.001	p<0.001	
Nulliparous	206 (49.1)	417 (47.8)	31,759 (41.2)
Multiparous	214 (50.9)	456 (52.2)	45,417 (58.9)
Socioeconomic disadvantage (quintiles)	p=0.14	p<0.01	
1 (most disadvantaged)	88 (21.0)	167 (19.1)	14,024 (18.2)
2, 3 and 4	239 (56.9)	479 (54.9)	45,511 (59.0)
5 (least disadvantaged)	93 (22.1)	227 (26.0)	17,582 (22.8)
Preterm birth (<37 weeks gestation)	p<0.001	p<0.001	
Yes	60 (14.3)	109 (12.5)	5,195 (6.7)
No	360 (85.7)	764 (87.5)	71,964 (93.3)
Z-score of birth weight by gestational age	p<0.001	p<0.001	
<-2	35 (8.3)	39 (4.5)	1,634 (2.1)
-2 to 2	372 (88.6)	810 (92.8)	73,199 (94.9)
>2	13 (3.1)	24 (2.8)	2,343 (3.0)
Plurality	p=0.05	p=0.28	
Singleton	401 (95.5)	842 (96.4)	74,916 (97.1)
Twins	19 (4.5)	31 (3.6)	2,260 (2.9)
Coexisting anomalies ^c	p<0.001	p<0.001	
Yes	66 (15.7)	136 (15.6)	5,468 (7.1)
No	354 (84.3)	737 (84.4)	71,706 (92.9)
<i>Child assessment characteristics</i>			
Age at developmental assessment (years)	p=0.55	p=0.08	
<5	32 (7.6)	52 (6.0)	4,873 (6.3)
5	337 (80.2)	691 (79.2)	62,768 (81.3)
6+	51 (12.1)	130 (14.8)	9,535 (12.4)
English as a second language	p=0.03	p=0.74	
Yes	90 (21.4)	141 (17.1)	13,508 (17.5)
No	330 (78.6)	724 (82.9)	63,668 (82.5)
Year of assessment	p=0.72	p=0.21	
2009	204 (48.6)	435 (49.8)	36,819 (47.7)
2012	216 (51.4)	438 (50.2)	40,357 (52.3)





