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REVIEW ARTICLE

The frequency of undescended testis from birth to adulthood: a review

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Summary

We performed a systematic review and critique of the literature on the frequency of undescended testis (UDT) among boys from birth to adolescence. Special attention was given to whether previous testicular position was taken into account to distinguish between congenital and acquired UDT. We searched Medline, Embase, Cinahl and the Cochrane Library. Any study reporting on the frequency of UDT was included. Study population age, number of boys studied, period of examination, primary examiner, area of study, study design, ethnicity, definitions used and previous testicular position were analysed. A total of 46 studies met the inclusion criteria. Twenty-three of the 46 (50%) studies involved newborns. Definitions were described in half of the studies; however, the definitions used were heterogeneous. Previous testis position was described in 11% (5/46) of the studies. At birth, in term and/or birth weight >2.5 kg infants, the UDT rate ranged from 1.0 to 4.6%, and in premature and/or birth weight <2.5 kg infants from 1.1 to 45.3%. At the age of 1 year UDT in term and/or birth weight >2.5 kg infants was seen in 1.0–1.5%, at 6 years in 0.0–2.6%, at 11 years in 0.0–6.6% and at 15 years in 1.6–2.2% of boys. The frequency of UDT shows variable figures in the literature. The actual frequency of acquired UDT essentially remains unclear because of the shortage of studies performed at an older age, and of studies reporting on previous testicular position.

Introduction

Undescended testis (UDT) represents the most common disorder of male sexual differentiation. Important long-term sequelae include risk for impaired spermatogenesis and testicular tumour.

At present, orchidopexy (ORP) is recommended in the treatment of UDT as early as 6–12 months of age. However, three out of four ORP are carried out later in childhood. In addition, the ORP rate outnumbers the UDT rate by two to three factors (Steeno *et al.*, 1988).

Despite the many studies published on the incidence of UDT, the incidence from birth to adolescence is still to a certain degree a *terra incognita*. This might be because of the difficulties encountered when comparing the incidence rates of UDT as reported in various publications (Toppari & Kaleva, 1999) and the recent recognition of acquired UDT.

To further elucidate the frequency of UDT, the literature is reviewed in this article. Other key questions, such as pathogenesis and increased risk of infertility, testicular cancer and inguinal hernia are not addressed (Taran & Elder, 2006). We specifically analysed cryptorchidism rates according to age and whether previous testicular position was taken into account, enabling recognition of acquired UDT.

Materials and methods

Search strategy

Literature was collected and analysed to summarize the incidence rates of UDT. The electronic databases searched were Medline (from inception to July 2006), Embase (from January 1980 to July 2006), Cinahl (from January 1982 to July 2006) and the Cochrane Library. Searches were performed using key words in various combinations, including cryptorchidism, UDT, incidence and prevalence.

We performed the search with human limitations. There were no language restrictions. Non-English articles were translated. This complex search, which is defined as using a combination of types of search terms, retrieved a broad selection of studies. The reference lists of all relevant reports were scrutinized to identify additional studies, and the Related Article feature of PubMed was also used. Electronic searches were performed using the names of key authors who were known to have published widely in this field of study.

Inclusion criteria and study appraisal

Studies were included if they provided data on UDT rates from birth to adolescence, and excluded if the study population appeared twice, if the study quality (Higgins & Green, 2006) was poor and not interpretable and if the studies were case reports. We additionally excluded studies only assessing ORP rates.

Two reviewers (KS, WH) screened the titles and abstracts of all retrieved records to identify studies, which were potentially eligible for inclusion in the review and to adjudicate their inclusion. Full copies of the reports were obtained for each of the non-rejected records.

Data extraction

Data on the UDT rates were collected and in each study information was extracted on the study population according to the age, number of boys studied, years of examination, primary examiner, area and design of the study, ethnicity and the definitions used, to assess homogeneity. A cohort study was defined as a study in which boys were physically examined prospectively. We additionally analysed whether previous testicular positions were taken into account, especially in elder boys.

Results

Included studies

Of the 97 full text articles obtained, we identified 46 eligible studies between 1934 and 2006 (see Table 1), in which incidence rates of UDT (from birth to adolescence) were described, 38 studies were prospective and 11 retrospective, describing a total of 704 225 patients. Prospective and retrospective data within the same article were counted separately, resulting in a total of 49 studies.

Number of studies by age

A total of 23 of the 46 (50%) studies reported on incidence of UDT in newborns. Seven studies described UDT rates at 3 months of age, two studies at 6 months, two studies at 9 months and six studies at 1 year. After the age of 1 year, the number of studies describing UDT rates decreased. Studies describing UDT rates at different ages were counted separately. Sixteen of the 46 included articles reported UDT rates at several age groups (see Table 1) (King, 1934; Drake, 1934; Williams, 1936; McCutcheon, 1938; Johnson, 1939; Smith & Camb, 1941; Baumrucker, 1946; Ward & Hunter, 1960; Cour-Palais, 1966; Mital & Garg, 1972; Borghans-Delvaux *et al.*, 1976; Blom, 1984; Onuora & Evbuomwan, 1989; Yücesan *et al.*, 1993; Simsek *et al.*, 1995; Adeoti *et al.*, 2004).

Period

The years of examination are shown in Table 1.

Performing the examinations

In 30 of 46 studies (65%), the examinations were performed by doctors.

Ethnicity

Six of 46 (13%) studies recorded ethnicity (Harris & Steinberg, 1954; McIntosh *et al.*, 1954; Halevi, 1967; John Radcliffe Hospital Cryptorchidism Research Group, 1992; Berkowitz *et al.*, 1993; Preiksa *et al.*, 2005). Most of the included studies (40 of 46 or 87%) did not use strict criteria for ethnic origin.

Definitions

Twenty-three of the 46 (50%) included articles used a definition to define and to diagnose UDT. There was considerable variation in definitions used among studies. Five of the 46 (10%) articles were based on the definition given by Scorer (1964) (Mital & Garg, 1972; John Radcliffe Hospital Cryptorchidism Research Group, 1992; Berkowitz *et al.*, 1993; Boisen *et al.*, 2004). Nineteen articles (instead of 18) were based on a definition by position since the John Radcliffe Hospital Cryptorchidism Research Group used the definition given by Scorer as well as by position. Thirteen of the 46 (28%) articles included (Buemann *et al.*, 1961; Villumsen & Zachau-Christiansen, 1966; Blom, 1984; van Gelderen & Vermeer-de Bondt, 1986; Morley & Lucas, 1987; Choi *et al.*, 1989; John Radcliffe Hospital Cryptorchidism Research Group, 1992; Thong *et al.*, 1998; Okeke & Osegbe, 2001; Ghirri *et al.*, 2002; Kaleva *et al.*, 2005; Pierik *et al.*, 2005; Preiksa *et al.*, 2005) and six of the 46 articles (13%) excluded high scrotal testes (Drake, 1934; Harris & Steinberg, 1954; Ward & Hunter, 1960;

Table 1. Incidence rates of undescended testes according to age (modified after Toppari & Kaleva, 1999)

Study population	No. of boys	Incidence (%)	References	Years of examination	Country	Primary examiner	Study design	Definitions	Previous testicular position
Newborns									
All	2793	0.5	McIntosh *et al.* (1954)	1946–1953	USA	3	1	4	–
	4474	1.5	Harris and Steinberg (1954)	1944–1950	USA	3	1	3	–
	1590	0.1	McDonald (1958)	1952–1955	UK	3	2	4	–
	20 068	5.4	Buemann *et al.* (1961)	1950–1961	Denmark	2 and 3	4	2	–
	3612	4.2	Scorer (1964)	Unknown	UK	3	1	1	–
	4500	4.6	Villumsen and Zachau-Christiansen (1966)	Unknown	Denmark	3	1	2	+
	1283	5.3	Halevi (1967)	1959–1960	Israel	1 and 3	1	4	–
	2850	1.6	Mital and Garg (1972)	1967–1968	India	3	1	1	–
	100	3.0	Allen *et al.* (1972)	Unknown	USA	4	1	4	–
	14 489	0.8	Beard *et al.* (1984)	1943–1973	USA	4	1	4	–
	7350	0.5	Seddon *et al.* (1985)	1978–1983	USA	3	4	4	–
	1208	1.7	Hsieh and Huang (1985)	1983–1984	Taiwan	4	1	4	–
	11 161	0.3	Choi *et al.* (1989)	1986	Korea	3	4	2	–
	7990	0.7	Choi *et al.* (1989)	1987–1988	Korea	3	1	2	–
	56 037	0.2	Correy *et al.* (1991)	1981–1989	Australia	3	5	4	–
	7400	5.0	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	6935	3.7	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	1002	4.8	Thong *et al.* (1998)	1993–1994	Malaysia	3	1	2	–
	10 730	6.9	Ghirri *et al.* (2002)	1978–1997	Italy	3	3	2	–
	390 034	0.6	Biggs *et al.* (2002)	1987–1996	USA	4	4	4	–
	1068	9.0	Boisen *et al.* (2004)	1997–2001	Denmark	5	1	1	–
	1204	5.7	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+
	9511	2.3	Kaleva *et al.* (2005)	1997–2001	Finland	3 and 5	1	2	–
<2.5 kg/ premature	310	4.2	Harris and Steinberg (1954)	1944–1950	USA	3	1	3	–
	473	1.1	Buemann *et al.* (1961)	1957–1960	Denmark	3	4	2	–
	1668	45.3	Buemann *et al.* (1961)	1950–1959	Denmark	2	4	2	–
	396	17.2	Buemann *et al.* (1961)	1959–1961	Denmark	3	1	2	–
	300	21.0	Scorer (1964)	Unknown	UK	3	1	1	–
	97	4.1	Hsieh and Huang (1985)	1983–1984	Taiwan	4	1	4	–
	368	22.8	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	575	19.8	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	120	22.5	Thong *et al.* (1998)	1993–1994	Malaysia	3	1	2	–
	1387	30.1	Ghirri *et al.* (2002)	1978–1997	Italy	3	3	2	–
	69	24.6	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+

Table 1. (Continued)

Study population	No. of boys	Incidence (%)	References	Years of examination	Country	Primary examiner	Study design	Definitions	Previous testicular position
>2.5 kg/term	4164	1.3	Harris and Steinberg (1954)	1944–1950	USA	3	1	3	–
	6317	1.0	Buemann *et al.* (1961)	1957–1960	Denmark	3	4	2	–
	8909	1.8	Buemann *et al.* (1961)	1950–1959	Denmark	2	4	2	–
	2305	1.8	Buemann *et al.* (1961)	1959–1961	Denmark	3	1	2	–
	3312	2.7	Scorer (1964)	Unknown	UK	3	1	1	–
	1781	2.0	Hirasing *et al.* (1982)	1977–1979	Netherlands	3	1	3	–
	1111	1.4	Hsieh and Huang (1985)	1983–1984	Taiwan	4	1	4	–
	7032	4.1	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	6360	2.2	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	882	2.4	Thong *et al.* (1998)	1993–1994	Malaysia	3	1	2	–
	9343	3.4	Ghirri *et al.* (2002)	1978–1997	Italy	3	3	2	–
	1135	4.6	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+
1 month									
All	2850	1.0	Mital and Garg (1972)	1967–1968	India	3	1	1	–
	7292	1.2	Pierik *et al.* (2005)	1998–2000	Netherlands	3	1	2	–
3 months									
All	3600	1.0	Scorer (1964)	Unknown	UK	3	1	1	–
	2850	0.7	Mital and Garg (1972)	1967–1968	India	3	1	1	–
	2048	1.9	van Gelderen and Vermeer-de Bondt (1986)	1977–1979	Netherlands	3	5	2	+
	7400	1.8	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	6935	1.0	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	1068	1.9	Boisen *et al.* (2004)	1997–2001	Denmark	5	1	1	–
	9511	1.1	Kaleva *et al.* (2005)	1997–2001	Finland	5	1	2	–
<2.5 kg/premature	288	1.7	Scorer (1964)	Unknown	UK	3	1	1	–
	368	5.2	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	575	1.9	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
>2.5 kg/term	3312	0.9	Scorer (1964)	Unknown	UK	3	1	1	–
	7032	1.6	John Radcliffe Hospital Cryptorchidism Research Group. (1992)	1984–1988	UK	1 and 3	1	1 and 2	–
	6360	0.9	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
6 months									
All	2850	0.6	Mital and Garg (1972)	1967–1968	India	3	1	1	–
	5969	2.3	Ghirri *et al.* (2002)	1988–1997	Italy	3	3	2	–
<2.5 kg/premature	949	9.3	Ghirri *et al.* (2002)	1988–1997	Italy	3	3	2	–
>2.5 kg/term	5020	1.2	Ghirri *et al.* (2002)	1988–1997	Italy	3	3	2	–
9 months									
All	1887	3.3	Mau and van Schnakenburg (1977)	Unknown	Germany	4	1	3	–
	3600	0.8	Scorer (1964)	Unknown	UK	3	1	1	–

Table 1. (Continued)

Study population	No. of boys	Incidence (%)	References	Years of examination	Country	Primary examiner	Study design	Definitions	Previous testicular position
<2.5 kg/premature	288	1.7	Scorer (1964)	Unknown	UK	3	1	1	–
>2.5 kg/term	3312	0.7	Scorer (1964)	Unknown	UK	3	1	1	–
1 year									
All	3015	1.5	Villumsen and Zachau-Christiansen (1966)	Unknown	Denmark	3	1	2	+
	2038	2.1	van Gelderen and Vermeer-de Bondt (1986)	1977–1979	Netherlands	3	5	2	+
	6935	1.1	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	1002	1.1	Thong *et al.* (1998)	1993–1994	Malaysia	3	1	2	–
	10 730	1.4	Ghirri *et al.* (2002)	1978–1997	Italy	3	3	2	–
	1204	1.4	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+
<2.5 kg/premature	575	1.9	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	438	7.3	Ghirri *et al.* (2002)	1978–1987	Italy	3	3	2	–
	949	3.1	Ghirri *et al.* (2002)	1988–1997	Italy	3	3	2	–
	69	4.4	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+
>2.5 kg/term	6360	1.0	Berkowitz *et al.* (1993)	1987–1990	USA	1	1	1	–
	4323	1.5	Ghirri *et al.* (2002)	1978–1987	Italy	3	3	2	–
	5020	1.2	Ghirri *et al.* (2002)	1988–1997	Italy	3	3	2	–
	1135	1.2	Preiksa *et al.* (2005)	1996–1997	Lithuania	5	1	2	+
1.5 years									
All	1887	2.9	Mau and van Schnakenburg (1977)	Unknown	Germany	4	1	3	–
<1.850 kg/premature	355	9.9	Morley and Lucas (1987)	1982–1984	UK	5	1	2	–
2 years	986	1.4	van Gelderen and Vermeer-de Bondt (1986)	1977–1979	Netherlands	3	5	2	+
3 years	2250	1.2	Villumsen and Zachau-Christiansen (1966)	Unknown	Denmark	3	1	2	+
	1887	2.5	Mau and van Schnakenburg (1977)	Unknown	Germany	4	1	3	–
	820	0.8	van Gelderen and Vermeer-de Bondt (1986)	1977–1979	Netherlands	3	5	2	+
4 years	727	0.2	van Gelderen and Vermeer-de Bondt, 1986	1977–1979	Netherlands	3	5	2	+
5 years	2174	2.3	Ward and Hunter (1960)	1957	UK	3	1	3	–
	2965	1.2	Ward and Hunter (1960)	1958	UK	3	1	3	–
	1568	0.8	Cour-Palais (1966)	Unknown	UK	3	1	3	–
	509	4.1	Simpson *et al.* (1985)	1972–1973	New Zealand	5	1	4 (RT included)	–
	527	1.9	Smith *et al.* (1990)	1981	UK	4	4	4	+
	21	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
6 years	3521	0.8	Hsieh and Huang (1985)	1983–1984	Taiwan	4	1	4	–
	77	2.6	Panayotou (1965)	Unknown	Greece	4	1	4	–
	71	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
7 years	184	4.3	Panayotou (1965)	Unknown	Greece	4	1	4	–
	449	13.3	Simpson *et al.* (1985)	1972–1973	New Zealand	5	1	4 (RT included)	–
	124	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
8 years	2	0.0	Smith and Camb (1941)	1937 and 1940	UK	3	1	4	–

Table 1. (Continued)

Study population	No. of boys	Incidence (%)	References	Years of examination	Country	Primary examiner	Study design	Definitions	Previous testicular position
	2166	6.3	Ward and Hunter (1960)	1957	UK	3	1	3	–
	2038	2.4	Ward and Hunter (1960)	1958	UK	3	1	3	–
	209	4.8	Panayotou (1965)	Unknown	Greece	4	1	4	–
	1460	1.0	Cour-Palais (1966)	Unknown	UK	3	1	3	–
	222	1.4	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
9 years	10	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	20	5.0	Smith and Camb (1941)	1940	UK	3	1	4	–
	207	4.3	Panayotou (1965)	Unknown	Greece	4	1	4	–
	218	0.9	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
10 years	12	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	28	3.6	Smith and Camb (1941)	1940	UK	3	1	4	–
	311	2.9	Panayotou (1965)	Unknown	Greece	4	1	4	–
	250	1.6	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
11 years	31	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	45	6.6	Smith and Camb (1941)	1940	UK	3	1	4	–
	2304	5.4	Ward and Hunter (1960)	1957	UK	3	1	3	–
	2666	2.7	Ward and Hunter (1960)	1958	UK	3	1	3	–
	198	3.5	Panayotou (1965)	Unknown	Greece	4	1	4	–
	65	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
12 years	63	1.6	Smith and Camb (1941)	1937	UK	3	1	4	–
	49	4.0	Smith and Camb (1941)	1940	UK	3	1	4	–
	268	2.2	Panayotou (1965)	Unknown	Greece	4	1	4	–
	81	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
13 years	76	4.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	125	1.6	Smith and Camb (1941)	1940	UK	3	1	4	–
	28	0.0	Okeke and Osegbe (2001)	Unknown	Nigeria	3	1	2	–
14 years	187	1.6	Smith and Camb (1941)	1937	UK	3	1	4	–
	157	0.0	Smith and Camb (1941)	1940	UK	3	1	4	–
15 years	185	2.2	Smith and Camb (1941)	1937	UK	3	1	4	–
	183	1.6	Smith and Camb (1941)	1940	UK	3	1	4	–
16 years	196	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	165	0.0	Smith and Camb (1941)	1940	UK	3	1	4	–
17 years	157	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
	138	0.0	Smith and Camb (1941)	1940	UK	3	1	4	–
18 years	63	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–
1–2 years	1369	0.5	Mital and Garg (1972)	1967–1970	India	3	1	1	–
2–10 years	1615	2.5	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
2–3 years	255	1.6	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
3–4 years	240	2.9	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–

Table 1. (Continued)

Study population	No. of boys	Incidence (%)	References	Years of examination	Country	Primary examiner	Study design	Definitions	Previous testicular position
3–5 years	1977	0.5	Mital and Garg (1972)	1967–1970	India	3	1	1	–
4–5 years	222	2.7	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
4–15 years	2500	11.0	Borghans-Delvaux *et al.* (1976)	1959–1960	Netherlands	3	4	4 (RT included)	+
5–6 years	320	2.2	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
5–15 years	1255	9.8	McCutcheon (1938)	1922	Australia	4	4	4	–
	2131	9.0	McCutcheon (1938)	1937	Australia	4	4	4	–
6–7 years	161	4.3	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
6–8 years	1658	0.4	Mital and Garg (1972)	1967–1970	India	3	1	1	–
6–12 years	2200	0.5	Onuora and Evbuomwan (1989)	Unknown	Nigeria	3	1	4	–
6–15 years	10 109	0.9	Yücesan *et al.* (1993)	1986	Turkey	3	1	4	–
6–16 years	2516	7.0	Blom (1984)	1940–1966	Denmark	3	1	2	–
7–8 years	153	2.0	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
7–14 years	6381	1.4	Simsek *et al.* (1995)	1990–1991	Turkey	3	1	4	–
7–17 years	31 609	1.7	Johnson (1939)	1931–1937	USA	4	1	4	–
8–9 years	122	2.5	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
8–15 years	2104	2.8	Williams (1936)	Unknown	UK	3	4	4	–
	268	6.0	King (1934)	Unknown	USA	4	1	4	–
9–10 years	39	7.7	Adeoti *et al.* (2004)	Unknown	Nigeria	3	1	4	–
9–12 years	1239	0.3	Mital and Garg (1972)	1967–1970	India	3	1	1	–
9–19 years	260	4.2	Drake (1934)	1928–1934	UK	3	1	3	–
11 years and	1552	0.6	Cour-Palais (1966)	Unknown	UK	3	1	3	–
>14–17 years	1716	0.4	Ward and Hunter (1960)	1957	UK	3	1	3	–
	2995	0.2	Ward and Hunter (1960)	1958	UK	3	1	3	–
15–18 years	590	0.2*	McCutcheon (1938)	1922	Australia	4	4	4	–
	1066	1.1	McCutcheon (1938)	1937	Australia	4	4	4	–
18–19 years	62	1.6	Smith and Camb (1941)	1940	UK	3	1	4	–
18–37 years	10 000	0.8	Baumrucker (1946)	1944	USA	4	1	4	–
19–20 years	2	0.0	Smith and Camb (1941)	1937	UK	3	1	4	–

Examinations performed by: 1, nurses; 2, midwives; 3, doctors; 4, unknown; 5, researchers.

Study design: 1, cohort; 2, records/cohort; 3, cohort/admission; 4, record charts; 5, separate forms.

Definitions: 1,Scorer (1964); 2, by position, high scrotal testes included; 3, by position, high scrotal testes excluded; 4, unknown.

Previous testicular position: '–', unknown; '+', known.

RT, retractile testis.

*Study population 15–18 years. Correction added after online publication 31 May 2007: Incidence (%) should be 0.2.

Cour-Palais, 1966; Mau & van Schnakenburg, 1977; Hirasing *et al.*, 1982).

Previous testicular position in the first year of life or later

Five of the 46 included studies (11%) took the previous testicular position into account (Villumsen & Zachau-Christiansen, 1966; Borghans-Delvaux *et al.*, 1976; van Gelderen & Vermeer-de Bondt, 1986; Smith *et al.*, 1990; Preiksa *et al.*, 2005). Villumsen & Zachau-Christiansen (1966) reported a previous testicular position at birth, Borghans-Delvaux *et al.* (1976) from the age of 4 years, van Gelderen & Vermeer-de Bondt (1986) from the age of 3 months, Smith *et al.* (1990) from 6 weeks of age and Preiksa *et al.* (2005) from 1 or 2 days after birth.

Incidence

Table 1 shows the incidence rates of UDT, according to age, as reported in various studies. From the analysed studies, the following data were obtained: in premature and/or birth weight <2.5 kg infants there is an UDT rate at birth varying from 1.1 to 45.3%, at 3 months of age the UDT rate ranged from 1.7 and 5.2% and at 1 year from 1.9 to 7.3%. In term and/or birth weight >2.5 kg infants, the rate at birth varies from 1.0 to 4.6%. At 3 months of age an incidence of 0.9–1.6% was found and at the age of 1 year the incidence was 1.0–1.5%. In premature and/or birth weight <2.5 kg and term and/or birth weight >2.5 kg infants (=All), the UDT rate at birth ranges from 0.1 to 9.0%; at 1 month of age from 1.0 to 1.2%; at 3 months of age from 0.7 to 1.9% and at 1 year from 1.1 to 2.1%. After the age of 1 year, data became increasingly difficult to interpret: at 3 years of age, the incidence varied from 0.8 to 2.5%. At 6 years of age, UDT was seen in 0.0–2.6% of the boys, at 8 years in 0.0–6.3%, at 10 years in 0.0–3.6%, at 11 years in 0.0–6.6% and at 13 years in 0.0–4.0%. At 15 years of age, the incidence varied from 1.6 to 2.2%, whereas at an older age UDT became rare. UDT rates based on a cohort of more than 1 year are shown in Table 1.

Discussion

According to the analysed studies, the UDT rate at birth in term and/or birth weight >2.5 kg infants ranges from 1.0 to 4.6%, at 3 months of age from 0.9 to 1.6% and at 1 year from 1.0 to 1.5%. At 6 years of age, UDT is seen in 0.0–2.6%, at 11 years in 0.0–6.6% and at 15 years in 1.6–2.2% of the boys. At an older age, UDT becomes rare.

The data concerning the UDT rate from birth to adolescence vary and are mainly based on newborn infants and boys <1 year of age. Data after the age of 1 year become increasingly scarce. For example, 57% (26/46) of the studies, including 591593 infants, reported UDT rates in boys <1 year of age. In addition, in elder boys, most studies are based on a cohort of more than 1 year, which are probably less reliable and difficult to interpret. The variability in UDT rate may in part be explained by the different sources of data and study designs, genetic differences (Boisen *et al.*, 2004), geographical differences, studied cohort years, secular trends, seasonal variability (John Radcliffe Hospital Cryptorchidism Research Group, 1992; Berkowitz *et al.*, 1995) and selection of the studied population (premature, term, all). As the diagnosis of UDT appears to be a subjective one, experience of the examiner and different definitions and classifications are likely to also influence this rate. For instance, Buemann *et al.* (1961) analysed (in series 1) retrospective medical charts, whereas Preiksa *et al.* (2005) performed prospective studies including physical examination of the boys. Berkowitz *et al.* (1993) had an ethnically heterogeneous population, while the Oxford study (John Radcliffe Hospital Cryptorchidism Research Group, 1992) and Preiksa *et al.* (2005) were limited to a homogeneous population. Despite that there are geographical differences in the incidence of male reproductive disorders, a possible interaction between genetic, environmental and/or lifestyle-related factors making individuals more susceptible to adverse exogenous exposures is still an unresolved issue (Toppari *et al.*, 1996; Giwercman *et al.*, 2006).

Additionally, in the studies of Cour-Palais (1966) and Hirasing *et al.* (1982), 'high scrotal testes' were explicitly excluded, whereas, for example, Preiksa *et al.* (2005) included these forms. At present, the high scrotal testis is regarded as part of the spectrum of either congenital or acquired UDT (Hack *et al.*, 2007a). An additional compounding factor in explaining the variability in UDT rate may be inclusion of retroctile testis (Borghans-Delvaux *et al.*, 1976; Simpson *et al.*, 1985) [correction added after online publication 31 May 2007: duplicate sentence deleted].

The 'proposed' increasing frequency of UDT (Buemann *et al.*, 1961; Scorer, 1964; John Radcliffe Hospital Cryptorchidism Research Group, 1992; Paulozzi, 1999; Boisen *et al.*, 2004) should be interpreted with caution. There are very few reliable studies that allow any temporal analysis mainly because of the lack of precise methodology.

Well-established risk factors for UDT include low birth weight, being born small for gestational age and a short gestation period (Scorer, 1964; John Radcliffe Hospital Cryptorchidism Research Group, 1992; Ghirri *et al.*, 2002). Our study shows that the UDT rate in premature

newborns, 2.5 kg or less, varies from 1.1 to 45.3%. This broad range might indicate a wide variation in various studies, methods and quality. It should be noted that maturity and birth weight might not be congruent. A sliding scale of measurements would be ideal, as weight for gestational age is a better predictor for the risk of cryptorchidism, but is difficult to adopt. In most of the previous studies, premature and birth weight <2.5 kg were often used synonymously. However, majority of the UDT rates in premature newborns, 2.5 kg or less, is above 20%, which is in agreement with the consideration that low birth weight and a short gestational period are consistently associated with UDT. Therefore, the number of premature and low birth weight infants included in the study population will likewise influence the overall UDT rate.

The variable reported UDT rates might also be attributed to lack of distinction between congenital and acquired UDT. A congenital UDT is an UDT which has never been descended from birth, in contrast to an acquired UDT which has previously been scrotal (Hack *et al.*, 2003). It is likely that a testis is truly a congenital UDT if the testis from birth till the age of 1 year cannot be manipulated into a stable scrotal position in its most caudal position. A truly acquired UDT is a previously intra-scrotal testis which can no longer be manipulated into a stable scrotal position. Currently, acquired UDT is commonly accepted and it occurs in young infants and older children. Probably, 1–3% of previously descended testes ascend (Agarwal *et al.*, 2006; Hack *et al.*, 2007b); some of the 'early ascents' have already been described at the age of 1 year and might also be congenital UDTs with spontaneous descent followed by ascent (Villumsen & Zachau-Christiansen, 1966; Docimo, 1996). Previous authors have suggested a number of mechanisms, including a remnant of the processus vaginalis preventing normal elongation of the spermatic cord, which causes testicular ascent (Clarnette *et al.*, 1997). In addition, cremaster muscle spasticity has been suggested (Smith *et al.*, 1989). The cremasteric reflex peaks in boys 5–8 years old (Bingöl-Kologlu *et al.*, 2001) and it is generally accepted that retractile testis might represent hyperactivity of the cremasteric reflex (Farrington, 1968; Tanyel, 2004). Before the age of 6 months and with the onset of puberty, the reflex is not sufficiently active to retract the testis out of the scrotum. Spontaneous descent at these ages might be explained by surges of luteinizing hormone and testosterone. Recently, Agarwal *et al.* (2006) showed that retractile testes have a 32% risk of becoming an acquired UDT, which is therefore expected to be higher in boys 5–8 years old. Consequently, the relatively high UDT rates as reported in some school and army surveys (King, 1934; Ward & Hunter, 1960; Blom, 1984; Simpson *et al.*, 1985) might be explained by the acquired form. For example, although retractile testes were included, acquired UDT might be a conceivable explanation for the 13.3% UDT rate in boys 7 year old as described by Simpson *et al.* (1985). Nevertheless, prevalence rates at older ages can also be dependent on timing of the treatment of congenital UDT. In the analysed studies, only 5/46 (11%) studies took previous testicular position into account, which is necessary to differentiate between congenital and acquired UDT. Therefore, in most studies, congenital and acquired UDT were not identified separately.

The determination of the UDT rate has gained special interest because of the 2–3% ORP rates recorded in different countries (Simpson *et al.*, 1985; Steeno *et al.*, 1988). There is a discrepancy between the 2–3% ORP rate and the 1% UDT rate at 1 year of age. The figures of early UDT rates correspond very closely with early ORP rates. This is in accordance with the age of election for operation of congenital UDT before the second year of life (American Academy of Pediatrics, 1996). Later in childhood, however, there is a 1–2% ORP rate but this study shows that there are scarcely any studies describing UDT rates in that particular period. There is increasing evidence that this 1–2% ORP rate might be caused by acquired UDT. This form, however, has a definite and constant tendency to spontaneous descent in the peripubertal period, rendering ORP redundant in three out of four cases (Sijstermans *et al.*, 2006). Nevertheless, the health consequences, like the fertility potential and the malignancy status of acquired UDT are still largely unknown.

This study demonstrates that the incidence of UDT shows variable figures in the literature, which might be explained by the difficulties encountered, when comparing the various publications. Especially the rate of acquired UDT remains an enigma because of shortage of studies performed at older ages and of studies reporting on previous testicular position.

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