Urogenital tract anomalies in children with congenital anorectal malformations

Afwijkingen in de tractus urogenitalis bij kinderen met een congenitale anorectale misvorming

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Proefschrift
ter verkrijging van de graad van doctor
aan de Erasmus Universiteit Rotterdam
op gezag van de rector magnificus
Prof.Dr. C.J. Rijnvos
en volgens het besluit van het College van Dekanen.
De openbare verdediging zal plaatsvinden op

woensdag 23 januari 1991 om 13.45 uur

door

Johannes Wytze Hoekstra
geboren te 's-Gravenzande

Promotiecommissie

Promotoren:	Prof.dr. R.J. Scholtmeijer
	Prof.dr. J.C. Molenaar
Overige leden:	Prof.dr. F.H. Schröder
	Prof.jhr.dr. J.W. Wladimiroff

Dit proefschrift werd bewerkt op de Afdelingen Kinderurologie en Kinderheelkunde van het Academisch Ziekenhuis Rotterdam, Sophia Kinderziekenhuis.
De statistische bewerkingen werden uitgevoerd door Drs. P.G.H. Mulder van het Instituut voor Epidemiologie en Biostatistiek der Erasmus Universiteit Rotterdam.
De Engelse vertaling werd verzorgd door Drs. J. Hagoort.

Aan de kinderen met deze afwijking
en hun ouders

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1

Introduction and aims of the study

1.1 Introduction

The term 'imperforate anus' covers a variety of congenital anorectal malformations ranging in severity from anal stenosis to cloacal exstrophy. The clinical picture of the anorectal malformation has been known for thousands of years, during which many attempts have been made to find an effective treatment.

In the days of Assurbanipal, king of Assyria from 668 to 627 B.C., the library of Ninive contained a cuneiform tablet with a text about a child born without an anus (Schärli 1978, van Putten 1969). The ancient Greek, Roman and Arabic physicians were familiar with the imperforate anus as well. They considered it a 'lusus naturae', the treatment of which was beyond their abilities. Paul of Aegina, a Byzantine physician (A.D. 625-690), performed the first recorded treatment of a child with imperforate anus by making a blind plunge with a bistoury into the perineum as far as the rectum and maintaining the opening by frequent dilatation. The next thousand years this blind method remained the only treatment for the malformation. Whenever a child survived this operation, complications such as perforations, infections, development of fistula, and stenosis of the newly made opening often occurred.

Ever since the 18th century new ideas were suggested and new methods of treatment introduced. An extensive study of the embryology, pathology, and treatment of congenital malformations of anus and rectum was published in 1860 by Bodenhamer. He described nine 'species' of malformation, mainly on the basis of anatomical variations found in obductions. Bodenhamer described some anomalies of the urogenital tract and warned against possible damage of the bladder or urethra caused by surgical treatment of the anorectal malformation (Bodenhamer 1860).

Various classification systems for the congenital anorectal malformations have been proposed. In general a distinction is made into 'high', or supralevator, and 'low', or infralevator, anorectal malformations, a distinction based on the position of the 'blind-ending' anorectum relative to the pelvic floor. High and low malformations are treated in different ways. Ever since Bodenhamer, numerous theories about the pathogenesis of imperforate anus have been developed. At present the congenital anorectal malformations are considered to be caused by impaired development of the cloacal plate and its surrounding structures (van der Putte and Neeteson 1984).

Although in the past the literature mainly focussed on the study and the treatment of the congenital anorectal malformation itself, in the last few decades attention has also been paid to associated anomalies in other organ systems. Combinations of anomalies are described as VA(C)TER(L) association (V = vascular or vertebral, A = anorectal, C = cardiac, TE = tracheoesophageal, R = renal, and L = limb abnormalities (Quan and Smith 1973, Kaufman 1973, Barnes and Smith 1978), caudal regression syndrome (Duhamel 1961), caudal mesodermal pattern of anomalies (Kallen and Winberg 1974), or axial mesodermal dysplasia syndrome (Russel et al. 1981). Of the anomalies that may present in combination with the congenital anorectal malformation, those of the urogenital tract occur most frequently (Moore and Lawrence 1952, Hasse 1976, Hoekstra et al. 1983).

Systematic approaches to the management of the urogenital tract problems have not been reported in the literature so far. Some reports do contain a non-structured enumeration of anomalies, complications and later consequences. In other publications an arbitrary distinction is made between primary and secondary, anatomical and functional, or symptomatic and asymptomatic anomalies.

It is clear, however, that urogenital tract anomalies, no matter how they are described, can lead to high morbidity and mortality.

The lack of a systematic approach in the field of patient study and treatment is responsible for vagueness, whereas a good survey of the available data may lead to a classification of the congenital anomalies, which is mandatory for adequate treatment of the children concerned. Consensus about checkups and follow-up of the patients with a congenital anorectal malformation is lacking in literature as well. The vagueness referred to above induced a retrospective study into the anomalies and complications of the urogenital tract in patients with a congenital anorectal malformation.

1.2 Aims of the study

First, to find answers to the following questions:

1. What kind of anomalies of the urogenital tract occur in children with a congenital anorectal malformation, and how frequently do they occur?
2. How may these anomalies and their consequences be evaluated and classified?
3. Taking into account the data obtained from 1 and 2, which recommendations may be given for examination, treatment, and follow-up of patients with a congenital anorectal malformation?

Second, to formulate a protocol for the management of the urogenital tract anomalies in children with a congenital anorectal malformation and to formulate guidelines for evaluation and follow-up through which improvement of the quality of life of these children may be accomplished.

2

Embryology and pathogenesis

A study of the association of urogenital tract anomalies and congenital anorectal malformations raises the question whether they are related. Is the association due to coincidence or is it a matter of causality? A conclusive answer to this question requires some insight into both the normal and abnormal development of the caudal part of the embryo.

2.1 Anorectum and bladder

Various theories about the normal development of the anorectum in humans have been proposed. To study the congenital anorectal malformations one should have the disposal of a series of human embryos with consecutive stages of these anomalies. Such a series is not available however. Therefore attempts have been made to elucidate the malformations by a synthesis of the known data about the normal embryologic development, of the knowledge about the malformations found in newborns, and of data from comparative anatomy. These attempts resulted in a number of different theories, but only a few of these were based on well conducted studies.

Several clinical researchers described the anomalies in newborns with a congenital anorectal malformation as an arrest in the normal developmental process and searched for a known or supposed stage in normal development with which the anomaly could be compared. This view led to theories founded on fragmentary knowledge of embryology.

The majority of theories interpret a high congenital anorectal malformation as an interference in an early stage of embryonic development, and a low congenital anorectal malformation as a later interference.

In their book on anorectal malformations, Stephens and Smith describe the normal division of the cloaca as being the result of an actively descending urorectal septum and the fusion of this septum with the cloacal membrane. According to these authors the urogenital membrane would then rupture first, and the anal membrane one or two weeks later. An interference or arrest in the formation of the urorectal septum would give rise to the congenital anorectal malformation (Stephens and Smith 1971). Many researchers have adopted these interpretations, and for a long time they formed the basis for classification systems of the anorectal malformations and the methods of treatment.

Bill and Johnson considered most congenital anorectal malformations as being the result of an interference in the migration of the anal opening. They argued that as a result of the formation of the urorectal septum the orifice of the hindgut and the cloaca shifts along the dorsal wall of the cloaca into the direction of the perineum. Should an arrest occur during this 'migration', the orifice does not reach its normal position, thus leading to an ectopic anal opening (Bill and Johnson 1958).

According to Duhamel, normal development is characterized by regression of the tailgut during which process mesenchymal tissue migrates from the tail bud, and then gives rise to the urorectal septum, the perineum, and the pelvic floor

muscles. Should regression of the tailgut advance too far, the mesenchymal tissue would extend too far into the direction of the cloacal membrane, prohibiting normal development (Duhamel 1966). Excessive regression of the tailgut and its surrounding structures would also be the cause of abnormalities of the lumbosacral spine, lower limbs and urogenital tract (Duhamel 1966, van Horn 1979).

Other theories about the division of the cloaca into the primitive rectum and the urogenital sinus have been formulated as well. Several embryologists studied the normal development in consecutive series of human embryos, but they did not observe active growth of the urorectal septum and its fusion with the cloacal membrane (Politzer 1931, Blechschmidt 1961, Wijnen 1964, and Ludwig 1965).

These findings are supported by recent research into pig embryos. Several researchers reported that the normal basic development of the anorectum in humans is comparable to that in pigs (Van der Putte and Neeteson 1983, Lambrecht and Lierse 1987). The basic process of the normal division of the cloaca in anorectal and urogenital part is a shift of the dorsal cloaca and its mesenchymal components towards the tail groove (Fig. 1). The nature of the anorectal anomalies presenting in pigs and the concomitant communications between rectum and urogenital tract can be compared with the human situation as well (Van der Putte 1986).

Van der Putte and Neeteson described a series of pig embryos with consecutive stages of congenital anorectal malformation. They found that the first noticeable abnormality consisted of the absence of part of the cloacal plate (Van der Putte and Neeteson 1984). In this situation the normal shift of the dorsal cloaca cannot take place, resulting in the formation of an ectopic anal canal (Fig. 2). The size of the cloacal plate defect determines the type of the congenital anorectal malformation.

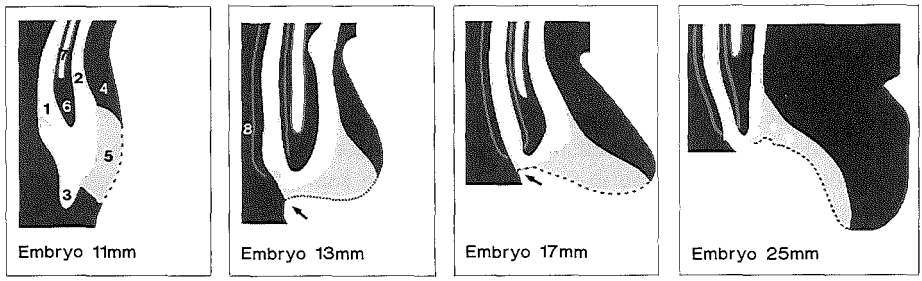

Fig. 1 Normal development of the anorectum in the pig.
The graphical reconstructions show regression of the tailgut, growth of the ventral part of the genital tubercle and a shift of the dorsal cloaca towards the tailgroove.
1: Hindgut 2: Allantois 3: Tailgut 4: Genital tubercle 5: Cloacal plate 6: Urorectal septum 7: Coelom 8: Muscle layer of intestine.

The explanation of abnormalities in human embryos on the basis of data from animal studies is not without risk. The normal development of the anorectum in human and in pig embryos, however, does not show essential differences. Besides, the results from the study of Van der Putte and Neeteson, which were obtained experimentally, fit into the gaps in the knowledge of the pathogenesis in human embryos. Therefore we think there are reasonable arguments to consider the abnormalities in human embryos likewise as largely being due to interferences in the development of the cloacal plate.

Taking into account the results of the human embryo studies by Politzer, Blechschmidt, Ludwig, and Wijnen, and adding to these the observations of Van der Putte and Neeteson, and Lambrecht and Lierse in pigs, the normal and abnormal development of the human anorectum may be summarized as follows:

By the 30th day after conception the cloaca is a relatively large chamber into which empty the hindgut (cranially), the tailgut (caudally), and the allantois (ventrocranially). Ventrocaudally the cloaca is bordered by the cloacal membrane. By ingrowth of mesodermal tissue in the region between allantoic stalk and cloacal membrane on the one hand, and a difference in growth between the formation of the dorsal muscles and the vertebral column on the other hand, the embryo unrolls. The level of the umbilical cord descends from the thoracic to the lumbal somites. Meanwhile, the tailgut and the region around the dorsal part of the cloaca undergo regressive changes. The genital tubercle, and especially its ventral part, shows marked growth. As a result of these processes the dorsal portion of the cloaca undergoes a shift in position towards the tail groove. In the course of this development the dorsal part of the cloaca becomes thinner and thinner, and ruptures. Next, an orifice for the urogenital sinus and an orifice for the rectum develop simultaneously. After the cloacal plate has ruptured, the uroenteric region shifts to the body surface.

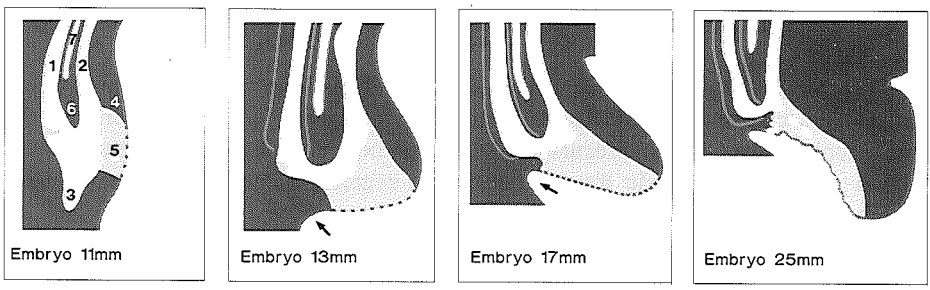

Fig. 2 Pathogenesis of congenital anorectal malformation in the pig. A part of the cloacal plate is missing, preventing the shift of the dorsal cloaca.
1: Hindgut 2: Allantois 3: Tailgut 4: Genital tubercle 5: Cloacal plate 6: Urorectal septum 7: Coelom 8: Muscle layer of intestine.

At this stage we may distinguish a widened portion of the ventral cloaca, the future bladder, and a narrow portion, the urogenital sinus. In the human embryo the allantois undergoes regressive changes so that usually only a fibrous cord remains.

When part of the cloacal membrane is absent, the shift of position of the dorsal cloaca into the direction of the tail groove cannot take place, and thus the hindgut opening remains at a higher level than normal. The so-called fistula between rectum and urogenital tract of perineum should be considered an ectopic anal canal. The type of the congenital anorectal malformation and the position of the ectopic anal canal are dependent on the size of the defect in the cloacal plate.

2.2 Kidneys

Another segment of the urogenital tract originates from the intermediate mesoderm and the nearby celomic epithelium. By longitudinal fusion of tissue in the intermediate mesoderm the nephrogenic cord develops, giving rise to pronephros, mesonephros, and metanephros.

The pronephros is of little importance in the human embryo. More caudally, a tubular structure, the mesonephric duct develops by fusion and lumen formation in the nephrogenic cord. At the medial side of this tube a pearl-chain-like series of small vesicles forms. Ingrowth of capillaries into the wall of the vesicles gives rise to glomeruli. The tubular portion of the vesicles, out of which tubuli and collecting ducts are to develop later, forms a communication with the mesonephric duct.

The mesonephric duct develops in caudal direction and by the 26th day a communication is made with the widened part of the hindgut, which is called cloaca from then on. Around the 30th day a protuberance develops in the mesonephric duct at the place where it opens into the cloaca. This protuberance, the ureteric bud, grows in dorsal direction and comes into contact with the metanephrogenic blastema. Next, an extensive system of bifurcations develops from the distal segment of the ureteric bud, and renal pelves and collecting ducts develop.

The anchor-shaped, epithelium-lined far ends of the bifurcated collecting system induce the metanephrogenic blastema to form nephrons. In the male embryo the mesonephric duct is the precursor of the vas deferens. The greater part of the tubuli of the mesonephric duct are bound to regress. Some tubuli remain intact and become the efferent ducts of the testes at a later stage.

Initially the mesonephric duct and the ureter have a common excretory duct. This structure is then incorporated into the dorsal wall of the cloaca, thus providing separate openings. In later development the ureteric orifices shift to more cranial and lateral positions, whereas the orifices of the mesonephric duct will be positioned more caudally and in the midline (Blechschmidt 1961).

2.3 Urethra

The urethra in girls and the proximal part of the urethra in boys originate from the urogenital sinus. When the cloacal membrane ruptures, the orifice of the urogenital sinus becomes visible. The urethral plate between the genital tubercle and the orifice of the urogenital sinus transforms into a groove.

There is no consensus about the formation of the distal urethra in boys. According to some authors the urethral folds close over the urogenital sinus and fuse in the midline (Spaulding 1921, Hamilton et al. 1959). This seam would be visible as the raphe of the penis. Others assume that the orifice of the urogenital sinus shifts to the glans by ventral expansion of the perineum (Van der Putte 1986). According to Politzer the raphe of the penis is not a line of fusion; its development rather resembles that of the perineal crest (Politzer 1931).

2.4 Uterus and vagina

The formation of the uterus and the vagina can be outlined as follows. In the 6th week (12 mm crown-rump length) protuberances in the mesenchyme, lateral to the mesonephric duct, originate from the celomic epithelium. On both sides these protuberances form a paramesonephric duct which grows in caudal direction conducted by the mesonephric duct. The paramesonephric duct intersects the mesonephric duct on the ventral side and fuses with its partner on the other side. By further caudal growth they reach the urogenital sinus by the 8th week and form Müller's tubercle there. Around the 10th week a septum in the fused Müllerian ducts desintegrates, thus forming the uterovaginal tract.

At the level of Müller's tubercle, paired protuberances in the urogenital sinus, the sinovaginal bulbs, proliferate to form a solid cord, the vaginal plate. In the 16th week this plate is canalized into a tubular structure. Probably four fifths of the vagina originate from the Müllerian ducts (the uterovaginal tract), while one fifth originates from the urogenital sinus (sinovaginal bulbs). The sinovaginal bulbs also contribute to the formation of the hymen. Eventually the vestibule remains in existence as a remnant of the urogenital sinus (Gruenwald 1941, Johnson et al. 1972, Griffin et al. 1976, Marshall 1978).

During normal embryonic development there is never a communication between rectum and vagina. In the 7th week of normal development of the male embryo the production of the so-called Müller inhibiting factor begins. This agent with androgenic characteristics causes a regression of the Müllerian ducts. During normal development, only the appendices of the testes and the utriculus of the prostate will remain in existence as remnants (Jost 1972).

The defect in the cloacal plate and the abnormal development of the dorsal cloaca may cause complications in the formation of the mesonephric duct and the ureteric bud.

A range of anomalies of kidneys, ureters, and bladder may result from this defective formation.

There is a correlation between the size of the defect in the cloacal plate and the position of the orifice of the ectopic anus (Van der Putte 1986). There is also a correlation between the position of the communication between rectum and urogenital sinus and the severity of the urogenital tract anomalies (Magnus 1974, Stephens 1983). The defect of the cloacal plate may also cause interferences in the development of the external genitalia. Possible malformations are: stenosis, agenesis or duplication of urethra and penis, hypospadias, epispadias, bladder exstrophy or cloacal exstrophy (Van der Putte 1986). Displacement and dysplasia of the penis and scrotum have been reported as well (Apold et al. 1976). A disorder in the mesonephric duct in the female embryo may be the cause of malformations in vagina, uterus or tubae (Gruenwald 1941, Griffin et al. 1976, Marshall and Beisel 1978, Marshall 1978, D'Alberton et al. 1981).

2.5 Discussion

From the embryologic knowledge it is evident that the normal development of the urogenital tract is inextricably bound up with that of the anorectum. Van der Putte and Neeteson make a reasonable case for the theory that most of the congenital anorectal malformations are caused by impaired development of the cloacal plate. The urogenital tract anomalies should be considered as associated anomalies. The correlation between urogenital tract anomalies and anorectal malformations has consequences for the diagnostic examinations and treatment of patients with a congenital anorectal malformation.

The following chapter deals with the available data in the literature about urogenital tract anomalies and examination of the urogenital tract in children with a congenital anorectal malformation.

3

Urogenital tract anomalies in children with a congenital anorectal malformation (data from the literature)

One of the earliest works about congenital anorectal malformations already mentioned that urogenital tract anomalies frequently coincide with a malformation of the anorectum (Bodenhamer 1860). Diagnostic procedures and treatment in the past, however, were principally aimed at the anorectal malformation, because it was a matter of life and death to provide an opening of the intestinal tract to the body surface through which meconium could be passed. Anomalies or complications of the urogenital tract were considered less important and often went unrecognized. A fistula was usually operated upon at a later age or not at all, and therefore a permanent fistula between the intestinal and urinary tracts was frequently found. When evacuation of urine and feces could take place, some patients were not operated upon at all. Only a few decades ago a 41-year-old man was described who was born with a cloacal opening through which both urine and feces were evacuated. He was never treated for his congenital malformation (Spence 1954).

From the 1950's onwards more attention was paid to the occurrence and treatment of urogenital tract anomalies. In the preceding chapter a direct link between anomalies of the anorectum and of the urogenital tract was pointed out. When studying the literature one should ask oneself whether the associative connection between the anomalies has been taken into account. This should be expressed in the clinical studies that were undertaken and the description and classification of the urogenital tract anomalies.

3.1 Examination of the urogenital tract in children with a congenital anorectal malformation

In the past few decades X-ray studies played a major role in the examination of the urogenital tract in children with a congenital anorectal malformation. Some authors especially recommended performing an IVP and voiding cystourethrogram (vcug) in these patients. Other tests were performed less frequently.

a. Intravenous pyelogram

In a series of 323 patients reported by Partridge and Gough, an IVP was performed in only 21 percent of the children with a high congenital anorectal malformation and in only 6 percent of the children with a low malformation (Partridge and Gough 1963). From other studies, too, it appears that IVPs were mainly performed in children with a high malformation (Munn and Schillinger 1983). Both in patients with a high malformation and patients with a low malformation many anomalies were found. In a group of 120 children reported by Puchner and co-workers, an abnormal IVP was found in 29 cases (Puchner et al. 1975). Parrot and Woodard found an anomalous IVP in 48 percent of the children with a high malformation and in 20 percent of the children with a low malformation (Parrot and Woodard 1979).

Consequently many authors recommend an examination of shape and position of the kidneys. In the past few years ultrasound study has replaced the IVP as a screening test for the kidneys. According to Parrot it is essential to carry out this test at an early stage, before a possible colostomy is performed (Parrot 1985).

b. Voiding cystourethrogram

Formerly a voiding cystourethrogram was only made on indication and especially in children with a high malformation (Parrot and Woodard 1979, Puchner et al. 1975). After it was found that vesicoureteral reflux often occurs, systematic performing of a voiding cystourethrogram was considered to be indicated for all children with a congenital anorectal malformation (Rickwood and Spitz 1980). Several authors consider it necessary to perform this test before any surgical treatment (Stephens and Smith 1971, Churchill et al. 1978).

c. Cloacagram

Parrot and Woodard state that in cloacal abnormalities the nature of the abnormality should be investigated by means of a cloacagram (Parrot and Woodard 1979). A supplementary method is endoscopy with introduction of small catheters in the bladder, vagina, and rectum, and X-ray examination in various directions, if necessary after injection of a radiopaque solution (Hendren 1982, Tank 1979).

d. Urodynamic studies

Urodynamic studies to examine functional disorders of the bladder were performed in some cases, usually at a later age, after the definitive reconstruction of the anorectum (Parrot 1985). But a postoperative urodynamic study at a later age does not establish whether it concerns a primary or secondary bladder dysfunction. This is why at present in several clinics urodynamic studies are performed at an early stage, before the definitive reconstruction of the anorectum. However, there is still no clarity about the necessity of routine urodynamic studies.

3.2 Congenital urogenital tract anomalies in children with a congenital anorectal malformation

In the literature urogenital tract anomalies are reported in 19 to 59 percent of children with a congenital anorectal malformation (Table 1). Children with a high malformation have a greater chance of anomalies than children with a low malformation, the chances ranging from 30 to 78 percent, and from 10 to 55 percent respectively. The urogenital tract anomalies in children with a high congenital anorectal malformation are generally more severe than those in children with a low malformation (Stephens and Smith 1971).

Berdon and co-workers did not find anomalies in girls with a low congenital anorectal malformation (Berdon et al. 1965, Berdon et all 1968), but this finding could not be confirmed by other authors (Thomson and Grossman 1973, Puchner et al. 1975).

Anomalies in children with 3 or more characteristics of the VATER association occur frequently. In a series of 30 patients with a VATER association, anomalies in the kidneys were found in 67 percent of them (Weber et al. 1980)

Table 1: Incidence of congenital urogenital tract anomalies in children with a congenital anorectal malformation

	N	Percentage anomalies	Malformation High	Low
Belman and King (1972)	143	51%	54%	16%
Churchill et al. (1978)	1509	26%	43-67%	16-18%
Cook (1978)	384	25%		
Duhamel (1961)	76	19%		
Garret and Yurdin (1958)	174	45%		
Hall et al. (1970)	88	47%		
Hasse (1976)	1420	19%		
Hoekstra et al. (1983)	150	47%	70%	34%
Moore and Lawrence (1952)	120	37%		
Obeid and Corkery (1974)	40	32%	46%	26%
Parrot and Woodard (1979)	51	52%		
Pellerin and Bertin (1967)	212	22%	30%	10%
Santulli et al. (1971)	1166	26%	50%	14%
Scott (1969)	50	46%	56%	37%
Singh et al. (1974)	113	59%	61%	55%
Smith (1968)	195	29%	38%	34%
Tank (1970)	100	42%	50%	15%
Wendelken et al. (1977)	64	54%	78%	38%
Wiener and Kiesewetter (1973)	200	40%		

The most frequent anomalies of the anatomy of the urogenital tract are:
- Agenesis of kidney(s)
- Dysplasia/hypoplasia of kidney(s)
- Polycystic kidneys
- Ectopic kidney(s)
- Horseshoe kidney
- Agenesis of ureter(s)
- Stenosis of ureter(s)
- Ectopic ureter(s)
- Ureterocele
- Agenesis of the bladder
- Bladder duplication
- Vesical/cloacal exstrophy
- Agenesis of urethra
- Urethral stenosis
- Urethral valves
- Hypospadias
- Cryptorchidism
- Persistent urogenital sinus
- Persistent cloaca
- Agenesis of vagina
- Vaginal duplication
- Bicornate uterus

The frequency of these anomalies ranges widely in various series and is also determined by the extent of the study. It is known that many of the anomalies listed above are associated with high morbidity and mortality. In the past, children with a congenital anorectal malformation often presented with severe renal damage before it was realized that the cause was to be found in the associated urogenital tract anomalies (Spence 1954). The consequences of untraced urogenital tract anomalies are more severe than those of the congenital anorectal malformation itself (Thompson and Grossman 1973).

3.3 Functional disorders of the urogenital tract (Disorders at X-ray examination and urodynamic study)

The most frequent functional urogenital tract disorders in children with a congenital anorectal malformation are:

- Hydronephrosis and hydroureteronephrosis
- Vesicoureteral reflux
- Neurogenic bladder dysfunction

3.3.1. Hydronephrosis and hydroureteronephrosis

A congenital hydronephrosis is reported in up to 17 percent of children with a congenital anorectal malformation (Table 2). These are mainly cases of a pelviureteric junction obstruction or vesicoureteral reflux. Some cases have been reported in which the hydronephrosis disappeared spontaneously after a colostomy had been established (Rickwood 1978, Munn and Schillinger 1983). This kind of hydronephrosis might result from compression of the ureters by the dilated colon (Parrot 1985).

Table 2: Incidence of hydronephrosis in children with a congenital anorectal malformation

	N	Hydronephrosis	%
Belman and King (1972)	143	3	2%
Cook (1978)	384	41	11%
Denton (1982)	94	3	3%
Garret and Yurdin (1958)	174	29	17%
Hall et al. (1970)	88	2	2%
Hasse (1976)	1272	18	1%
Moore and Lawrence (1952)	120	18	15%

3.3.2. Vesicoureteral reflux

a. Vesicoureteral reflux in general

The incidence of vesicoureteral reflux is determined by the age of the children, the patient population, and the technique of the voiding cystourethrogram (Smellie et al. 1975). A primary reflux is characterized by the occurrence of a congenital defect in the submucous part of the ureter. A secondary reflux is considered to be the result of a dysfunction of the bladder and/or pelvic floor, or the result of infections (Nielsen

et al. 1984, Scholtmeijer 1986, Griffiths and Scholtmeijer 1987, Scholtmeijer and Griffiths 1988). Vesicourethral reflux is found in 30 to 50 percent of children with urinary tract infections.

The International Reflux Study Committee distinguishes 5 grades of reflux (IRSC 1981):

grade 1. Reflux in the ureter only.

grade 2. Reflux in ureter, renal pelvis and calices.
No dilatation, normal caliceal fornices.

grade 3. Mild to moderate dilatation and/or tortuosity of ureter, and light to moderate dilatation of renal pelvis, but no or slight blunting of the fornices.

grade 4. Moderate dilation and/or tortuosity of the ureter, and moderate dilatation of renal pelvis and calices. Complete obliteration of sharp angle of fornices but maintenance of papillary impressions in majority of calices.

grade 5. Gross dilatation and tortuosity of the ureter.
Gross dilatation of renal pelvis and calices.
Papillary impressions are no longer visible in majority of calices.

Children with vesicoureteral reflux grades 1 to 3 rarely develop renal damage. In case of a more severe form of reflux a high percentage of inital and progressive renal damage is encountered (Rolleston et al. 1970). Damage to the renal tissue is especially seen in infants and young children, and the presence of intrarenal reflux is an important contributing factor (Hodson 1978, Ransley and Risdon 1979).

In 40 to 50 percent of the children the vesicoureteral reflux disappears with conservative treatment (unilateral reflux in 65 percent, bilateral reflux in non-dilated ureters in 50 percent, and bilateral reflux in dilated ureters in 9 percent) (Lenaghan et al. 1976).

If the kidneys have already been damaged, an increase of lesions occurs in 60 percent of children, in spite of adequate treatment of the vesicoureteral reflux (Filly et al. 1974, Lenaghan et al. 1976).

b. Vesicoureteral reflux in children with a congenital anorectal malformation.
In children with a congenital anorectal malformation both primary and secondary vesicoureteral reflux may occur.

Defective cloacal development may lead to an anatomical abnormality of the vesicoureteral junction and consequently a primary reflux. Dysfunctions of the bladder and pelvic floor, and infections may give rise to a secondary reflux.

The data from the literature are incomplete, confusing, and not uniform. As appears from Table 3, some reports do not mention in how many children a voiding cystourethrogram was performed. Moreover, the severity of the vesicoureteral reflux is described in different ways. In Table 3 the percentages are only given for the children in whom a voiding cystourethrogram was made.

Table 3: Vesicoureteral reflux in children with a congenital anorectal malformation

	N	Vcug	Reflux
Belman and King (1972)	143	?	5
Hoekstra et al. (1983)	150	84	34 (40%)
Narasimharao et al. (1983)	36	36	17 (47%)
Parrot and Woodard (1979)	51	39	10 (26%)
Puchner et al. (1975)	120	91	32 (35%)
Rickwood and Spitz (1980)	33	26	12 (46%)
Smith (1968)	195	?	13
Uehling et al. (1983)	21	?	9
Wendelken (1977)	64	?	7
Wiener and Kiesewetter (1973)	200	?	11

In a group of 120 children with a congenital anorectal malformation, Puchner and co-workers found 32 cases of vesicoureteral reflux. Only 4 children needed surgical treatment. In the others the reflux disappeared with conservative treatment (Puchner et al. 1975).

Parrot and Woodard reported 51 children with a congenital anorectal malformation. In 39 of them a voiding cystourethrogram was made. Vesicoureteral reflux was found in 10 out of 39 children and was 'moderate to severe' in 75 percent of the refluxing ureters (Parrot and Woodard 1979).

In a group of 33 children reported by Rickwood and Spitz, a voiding cysto-urethrogram was made in 26 of them. In 12 out of these 26 children vesicoureteral reflux was shown, in most cases grade 3. The reflux was mainly found in girls. There was no correlation between the reflux and the type of congenital anorectal malformation (Rickwood and Spitz 1980). Wendelken and co-workers discovered vesicoureteral reflux in 4 out of 27 children with a high congenital anorectal malformation and in 3 out of 37 children with a low one (Wendelken et al. 1977).

In a group of children from the Sophia Children's Hospital in whom a voiding cysturethrogram was made, we found vesicoureteral reflux in 47 percent of the children with a high congenital anorectal malformation, and in 35 percent of the children with a low malformation (Hoekstra et al. 1983).

Narasimharao and co-workers reported vesicoureteral reflux in 47 percent of children with a congenital anorectal malformation. They found that reflux mainly occurred in high malformations (8 out of 12 with a high malformation, 4 out of 10 with an intermediate malformation, and 1 out of 10 with a low malformation). There was no difference of incidence between boys and girls. The reflux was generally moderate and disappeared spontaneously (Narasimharao et al. 1983).

Finally, Ueling and co-workers reported a series of 23 children with a VATER syndrome. Urogenital tract anomalies were found in 21 of them. 'Severe' reflux was seen in 9 children (Ueling et al. 1983).

3.3.3 Neurogenic bladder dysfunctions in children with a congenital anorectal malformation

A neurogenic bladder dysfunction in children with a congenital anorectal malformation may be primary or secondary, and is reported in 6 to 18 percent of these children (Table 4).

Table 4: Neurogenic bladder dysfunctions in children with a congenital anorectal malformation

	N	Neur. bladder dysfunction
Belman and King (1972)	143	10%
Hall et al. (1970)	88	6%
Puchner (1975)	120	14%
Tank (1970)	100	8%
Wiener and Kiesewetter (1973)	200	18%

A primary congenital bladder dysfunction due to impaired innervation is seen in children with spina bifida and/or sacral abnormalities (Williams and Nixon 1957, Koontz and Prout 1968, Mariani et al. 1979).

Table 5: Sacral abnormalities in children with a congenital anorectal malformation

	N	Description	Abnormalities
Carlton et al. (1973)	74	Sacral anomalies	4 (5%)
Carson et al. (1984)	92	Sacral dysplasia	28 (30%)
Cook (1978)	384	Sacral agenesis	25 (6%)
Denton (1982)	94	Sacral deformity	30 (32%)
Fleming et al. (1986)	115	Sacral abnormalities	28 (24%)
Pellerin et al. (1966)	212	Sacral agenesis	30 (14%)
Puchner et al. (1975)	120	Abnormal sacrum	49 (41%)
Singh et al. (1974)	67	Anomalies sacrum	24 (36%)
Tunell et al. (1987)	106	Sacral abnormalities	37 (35%)

Table 5 shows the reported numbers of sacral abnormalities in children with a congenital anorectal malformation. The terminology is not uniform, since the terms anomalies, dysplasia, agenesis, deformities, and abnormalities are used. While the incidence ranges from 5 to 41 percent, the incidence of sacral abnormalities in girls appears to be as high as that in boys (Denton 1982, Tunell et al. 1987). In children with a high congenital anorectal malformation, sacral abnormalities occur 2 or 3 times more frequently than in children with a low malformation (Berdon et al. 1968, Pellerin and Bertin 1967, Carson et al. 1984, Tunell et al. 1987).

Carson and co-workers reported a group of 97 children with a congenital anorectal malformation, in 30 percent of whom a sacral abnormality was found. In a number of patients the neurologic deficits were progressive rather than static. Neurosurgical corrections were performed for tethered cord syndrome, dural sac stenosis and intradural mass. They concluded that in all children with sacral abnormalities routine

screening for spinal cord lesions is recommended (Carson et al. 1984). This can be done by means of myelography, CT-scan, or magnetic resonance imaging (MRI) (Tunell et al. 1987, Karrer et al. 1988).

Several authors describe secondary, acquired neurogenic bladder dysfunctions as complications following treatment of the congenital anorectal malformation. This problem may arise due to an inexpertly performed pull-through procedure, extended dissections or multiple operations in the pelvic region. The incidence is unknown and it is usually diagnosed when other causes for a neurogenic bladder dysfunction are absent (Williams and Grant 1969, Stephens and Smith 1971, Tank et al. 1972, Carlton et al. 1973, Wiener and Kiesewetter 1973, Nixon and Puri 1977, Smith et al. 1978).

3.4 Urogenital tract anomalies resulting from surgery for the congenital anorectal malformation

During and after surgery for the congenital anorectal malformation complications in the urogenital tract may occur. In the 18th and 19th centuries already the literature reported lesions of the bladder or the urethra caused by attempts to create a communication between the bowel and the body surface (Heister 1776, Bodenhamer 1860).

Problems in identifying and managing the communication between rectum and urinary tract may lead to a relapse of the fistula (Carlton et al. 1973, Churchill et al. 1978, Parrot 1977, Williams 1969, Tank et al. 1972, Scott 1972).

A lesion or a complete transection of the urethra is reported by several authors. The hazard is especially present at perineal exploration for a high congenital anorectal malformation (Persky et al. 1974, McGill et al. 1978, Thomas and Molenaar 1979)

When the fistula is transected too far from the urethra, a pseudo-diverticulum will form, which may give rise to voiding disorders, urinary tract infections, or stone formation (Williams and Grant 1969, Persky et al. 1974, Shashikumar et al. 1974, Churchill et al. 1978).

Damage to the bulbar urethra may lead to urethral strictures (Partridge and Gough 1963, Carlton et al. 1973, Tank et al. 1972, Scott 1972, Churchill et al. 1978).
Extended dissection in the pelvic region may cause impaired innervation of the bladder, which might result in a bladder dysfunction (refer to 3.3.3).

3.5 The clinical consequences of urogenital tract anomalies in children with a congenital anorectal malformation

The urogenital tract anomalies described in the preceding sections may result in:
1. impaired renal function
2. voiding disorders and incontinence
3. urinary tract infections
4. impaired genital functions

3.5.1. Impaired renal function

A number of children will die in the postnatal period due to agenesis of both kidneys (Wendelken et al. 1977, Wiener and Kiesewetter 1973, Cook 1978). Other bilateral anomalies may cause neonatal renal insufficiency.

Anatomical and functional abnormalities, concomitant with stasis of urine, urinary tract infections, and vesicoureteral reflux, may give rise to cicatrization and delayed kidney growth. The risk of death from renal failure was established at 6.4 percent in children with a high congenital anorectal malformation, and 1.1 percent in children with a low malformation (McLorie et al. 1987)

Data about long-term renal function are scarce. Fleming and co-workers described 66 girls with a congenital anorectal malformation and a follow-up of over 15 years. In 39 of them the renal function was assessed, and in 6 of those patients impaired renal function was found. (Fleming et al. 1986).

3.5.2 Voiding disorders and incontinence

Voiding disorders, enuresis, incontinence, and other symptoms are not clearly defined in the literature. Moreover, in many series the follow-up period is not long enough, and not all children have been included in the evaluation. Therefore the percentages of children with voiding complaints and incontinence range widely.

Scott and Swenson evaluated 38 patients from a group of 63. Seven out of 19 children with a high congenital anorectal malformation were fully incontinent, and 2 others had voiding complaints (Scott and Swenson 1959).

Swenson and Grana report bed-wetting, incontinence of urine, and other symptoms. Four out of 21 children with a high congenital anorectal malformation were fully incontinent, and 4 out of 23 children with a low malformation had voiding problems (Swenson and Grana 1962).

In a group of 76 children, Cozzi and Wilkinson found 7 fully incontinent patients and 5 partly incontinent patients (Cozzi and Wilkinson 1968).

Wiener and Kiesewetter reported incontinence in 12 percent of the children with a congenital anorectal malformation, i.e. in about three quarters of the children with a neurogenic bladder disorder (Wiener and Kiesewetter 1973).

According to Nixon and Puri, continence of urine may still be obtained later in life. Sixteen out of 47 children with a high congenital anorectal malformation were incontinent of urine. After 10 to 14 years, eight of these 16 children became continent (Nixon and Puri 1977).

3.5.3 Urinary tract infections

Urinary tract infections comprise the most frequent complications of the urogenital tract in children with a congenital anorectal malformation (Partridge and Gough 1963). They occur in 20 to 48 percent of the patients (McLorie et al. 1987). This high incidence may be explained by the frequently occurring communication between rectum and urinary tract, and by urogenital tract anomalies. In a group of 200 children, Wiener and Kiesewetter found serious infections in 25 percent of the

patients with a fistula. Children with a fistula and a urogenital tract anomaly all had a urinary tract infection (Wiener and Kiesewetter 1973).

Singh and co-workers reported urinary tract infections in 21 out of 24 children with a fistula between rectum and urinary tract. After surgery of the congenital anorectal malformation, including removal of the fistula, 18 children had no new infections (Singh et al. 1974).

In the presence of a fistula between rectum and urinary tract and/or an anatomical or functional urogenital tract anomaly, prophylactic anti-microbial therapy is advised from birth until after the pull-through procedure and treatment of the fistula (Parrot 1985). If necessary, temporary measures (e.g.ureterocutaneostomy) or definitive operations (e.g. nephrectomy) should be carried out to prevent urinary tract infections in the future (Stephens and Smith 1971).

3.5.4 Impaired genital functions in patients with a congenital anorectal malformation

Due to the small number of reports about adults with a congenital anorectal malformation, only sporadic data are available about sexual function and fertility in patients with a congenital anorectal malformation.

a. Sexual function

In boys, disorders may occur as a result of the congenital anomalies (agenesis of penis, micropenis, duplicated penis, vesical exstrophy, cloacal exstrophy) or of surgical treatment. Hardly any research has been done into the possible consequences.

In girls, anomalies of the paramesonephric duct may give rise to abnormalities of vagina and uterus. They may go unnoticed until puberty, and may cause hydrosalpinx, pyosalpinx, hydrocolpos, or hematocolpos (Mollitt et al. 1981, Marshall et al. 1979). In girls there is also the hazard of vaginal scarring after a pull-through procedure or vaginoplasty (Hall et al. 1985).

Fleming reported 162 girls with a congenital anorectal malformation. In 17 of them the vagina was assessed during follow-up. Eight girls had moderate to serious scarring, and in 5 surgery was necessary (Fleming et al. 1986).

Karkowski and co-workers reported 22 patients with a congenital anorectal malformation and a follow-up period ranging from 18 to 30 years. All men experienced normal erections and ejaculations. The women who had partners mentioned a normal sexual function (Karkowski et al. 1973).

Also from other reports discussing sexual function hardly any conclusions can been drawn because of the low numbers of patients and the incomplete data (Nixon and Puri 1977, Iwai et al. 1979).

b. Fertility

Only few data are available about fertility in female patients with a congenital anorectal malformation. Disorders of the uterus involve a high risk of abortus or premature birth (Buttram 1983). Abdominal surgery may cause adhesions in the

pelvic region with adverse consequences for fertility. At term delivery of a pregnant congenital anorectal malformation patient by means of cesarean section might be necessary (Karkowski et al. 1973).

3.6 Discussion

A survey of the literature reveals that in general the urogenital tract anomalies are only described, and that little attention is paid to classification, assessment, treatment, and checkups.

Some of these issues need further elucidation:

1. Nature and incidence of the anomalies

a. Nearly all reports deal with retrospective studies
b. The patient groups vary considerably in composition, for example with regard to the type of the congenital anorectal malformation or the division into sexes.
c. Some groups were skewed because a minimal evaluation is required (e.g. performing an IVP).
d. In many series the patients were examined incompletely, unsystematically, and often at a late stage. From several series it appears that the number of anomalies found is increasing with the degree of thoroughness of the examination.
e. The terminology is not uniform.

Examples:

1. In some series the 'R' in 'VATER' indicates 'renal', merely including renal anomalies. In other series 'R' indicates 'renal tract', thus including the entire urogenital tract.
2. Sometimes normal variants such as 'bifid pyelum' are considered to be malformations.
3. In some series an arbitrary distiction is made into:
   - Anatomical and functional anomalies
   - Anomalies of the upper urinary tract, lower urinary tract, and genital tract.

2. Evaluation of the different parts and functions of the urogenital tract

Usually the urogenital tract is not evaluated. In case it is evaluated it is sometimes combined with the evaluation of function of the anorectum. The evaluation is usually not based on well-described, objective, and reproducible criteria.

Examples:

a. The distinction between serious and less serious anomalies (Wiener and Kiesewetter 1973, Rich et al. 1988)
b. The distinction between symptomatic and asymptomatic anomalies (Scott 1969)

c. Evaluation of renal function:
   - Good : normal renal function
   - Moderate: renal function worse than normal, but no renal failure.
   - Bad : renal failure (Fleming et al. 1986)

d. Evaluation of bladder function:
   - Good : always continent
   - Moderate: urine loss every now and then
   - Bad : no control at all (Trusler and Wilkinson 1962)

   - Good : excellent control
   - Moderate: some control of voiding
   - Bad : voiding disorders caused by a lack of control, resulting in continuous urine loss (Swenson and Grana 1962)

It should be evident that these evaluations are open to different interpretations.

3. Examination of patients

There are great differences in the examination of patients and in most reports the connection between the congenital anorectal malformation and the urogenital tract anomalies has not been accounted for adequately.

4. Treatment of patients

Although the concepts of the treatment of the congenital anorectal malformation and the urogenital tract anomalies have always been liable to changes, one gets the impression that in the past symptomatic approaches were more common than approaches according to protocol. In general, attention was paid first and foremost to the more striking anorectal malformations. Little attention was paid to the nature and time of treatment of urogenital tract anomalies.

5. Follow-up of patients

No recommendations are made or guidelines given for follow-up of patients on the basis of the nature and treatment of the anomalies.

3.7 Conclusion

From the literature it appears that there are still many uncertainties with regard to nature and the incidence of urogenital tract anomalies in children with a congenital anorectal malformation. It also appears that no good guidelines are provided for diagnostic procedures and treatment of these anomalies. In many cases the anomalies, which may lead to high morbidity, have even been disregarded.

In order to provide answers to the questions posed in the introduction to this thesis, we carried out a retrospective study of 153 children who were treated for a congenital anorectal malformation in the Sophia Children's Hospital, Rotterdam, the Netherlands, in the period from 1970 to 1980.

4

Patients and methods

4.1 Patients

The study group consisted of 153 children who were born after 1 January 1970 and were hospitalized for the first time in the Sophia Children's Hospital in the period 1970 to 1980 under the diagnosis group atresia and stenosis of rectum and anus (code 751.3). The study group included 84 boys and 69 girls.

Seventy five children were admitted for the first time between 1970 and 1975 and 78 between 1975 and 1980. A classification in high malformations, low malformations and cloacal extrophy is shown in 5.2. Patients with cloacal extrophy are included in the high malformation group, unless stated otherwise.

4.2 Methods

The study included the following aspects:

1. Evaluation of medical records

The evaluation of medical records, letters, X-rays, and other relevant data took place in 1980 (Hoekstra et al. 1983) and again in 1985. The follow-up data up to 1 January 1986 were incorporated.

2. Survey.

In 1984 a questionnaire was drawn up with questions on the function of anorectum and urogenital tract and sent to the parents of all surviving children (Appendix). The parents and patients were also invited to participate in a follow-up examination.

3. Follow-up examination.

Apart from an extensive interview, the follow-up examination included a physical examination, simple laboratory tests (urinalysis and serum creatinine), and ultrasonographic determination of residual volume after voiding.

4. Telephone survey.

A number of parents did not deem it necessary to participate in the follow-up examination, because there were no complaints and/or they objected to their child's renewed confrontation with the hospital. A number of children were still under medical supervision, in which cases the parents did not deem it desirable to have an extra examination take place. The parents of the children who did not want to participate in the follow-up examination were approached by telephone, in which cases an extensive interview took place similar to that for the children participating in the follow-up examination. It proved not to be possible to reach all parents in this manner.

4.3 Patient groups and response

The total group consisted of 153 children, 27 of whom have died. Consequently 126 children should have been available for the survey and examination. Four children could not be reached since they moved abroad. A total of 117 completed question-

naires were returned (a response of 117/126 = 93 percent). Subsequently the actual situation in 1986 could be assessed from the medical record data of another three children. These three children were under medical supervision of both the department of pediatric surgery and the department of pediatric urology, but did not return the questionnaire or participate in the follow-up examination. Seventy-six patients did participate in the follow-up examination, and additional data on 28 patients were obtained by telephone survey.

The description of the urogenital tract anomalies is based on data from three groups:

1. The overall group of 153 children.
In collecting the data at least the medical record data from 1980 or earlier were used.
2. The group of 120 children with a follow-up till 1986.
The data are based at least on the results of the questionnaire and telephone survey and/or medical record data with a urological follow-up to 1986.
3. A group of 76 children who participated in the follow-up examination. For this group medical record data and data from questionnaires and follow-up examination were used.

This subdivision into three groups makes it possible to determine to what extent the values and percentages found in the group of children participating in the survey and follow-up examination differ from those in the overall group.

4.4 Schematic representation:

group 1: 153 children, the complete study group
- 27 died
- 117 survey by questionnaire
- 4 emigration
- 5 no response

group 2: 120 children, follow up to 1986
- 117 survey by questionnaire
- 3 follow-up in Sophia Children's Hospital

group 3: 76 children participating in the follow-up examination.

First of all it was verified if the composition of the patient groups from the Sophia Children's Hospital is comparable to that of groups of children with a congenital anorectal malformation reported in the literature.

5

Some general characteristics of the patient group

In chapter 3 it was pointed out that there are major differences in the composition of the series patients with a congenital anorectal malformation described in the literature. In many groups a selection has probably been made. Before describing data on the urogenital tract of the children from the Sophia Children's Hospital, it must first be assessed to what extent this group is comparable to other groups described in the literature. For that reason a number of general characteristics are discussed and the results are compared to the known data from the literature.

5.1 Incidence of congenital anorectal malformations and sex ratio

From 1970 to 1980, 153 children with a congenital anorectal malformation were hospitalized for the first time in the Sophia Children's Hospital, 75 children between 1970 and 1975, and 78 between 1975 and 1980. There were 84 boys and 69 girls (resp. 55 percent and 45 percent).

Discussion:

Congenital anorectal malformations are found more frequently in boys than in girls (Santulli et al. 1971, Stephens and Smith 1971, Spouge and Baird 1986). Although a variation in incidence for congenital anorectal malformation is reported of 1 in 1,800 in South Africa to 1 in 10,000 in France, an incidence of 1 in 3,000/5,000 is generally assumed for most European and North American countries (Schärli 1971). On the basic assumption of 150,000 births per year in the Netherlands, 30 to 50 percent of the children who were born between 1970 and 1980 with a congenital anorectal malformation were treated in the Sophia Children's Hospital in Rotterdam.

5.2 Type of the congenital anorectal malformation

For the classification in high (supralevator) malformations, low (infralevator) malformations, and cloacal exstrophy the data furnished by the attending physician or surgeon were taken as a starting point, whether or not corroborated by X-ray examination. It was not possible to re-evaluate these data (Table 6).

Table 6: Nature of the congenital anorectal malformation (Sophia Children's Hospital)

	N	Percentage
High (supralevator) malformation :	59	39%
Low (infralevator) malformation :	90	59%
Cloacal exstrophy :	4	2%

Discussion:

There is no consensus of opinion in the literature as to the manner in which the congenital anorectal malformations should be classified. The first classifications were

purely descriptive (Bodenhamer 1860, Ladd and Gross 1934). Later classifications were made on the basis of the location of the malformation in relation to the pelvic floor (Browne 1955, Partridge and Gough 1963).

The international classification is based on the sex, the location of the anomaly relative to the pelvic floor and the presence or absence of a fistula (Santulli et al. 1970).

In addition to the high and low malformations a new group with intermediate malformations was introduced. This international classification was widely criticized.

According to Gans the terminology is incorrect, the classification too complicated and difficult in everyday practice (Gans 1970). In particular the group with intermediate malformations causes confusion. Some authors regard an intermediate lesion as a high malformation (Churchill 1978), others include the patients with intermediate lesions in the low malformation group (Belman 1975).

The classification into high and low malformations applied in the Sophia Children's Hospital since 1975 is a clinical classification (Schreeve et al. 1981, McGill et al. 1978).

An anomaly is considered to be low:

1. when meconium can be seen on the perineum or shows through a membrane.
2. when in girls the hymen is constructed normally and the ectopic anus opens into the vestibule.

All other anomalies are considered to be high.

In the recent literature a classification into high and low malformations is often used as well (Boe et al. 1973, Singh et al. 1974, Smith et al. 1978, Parrot and Woodard 1979, Hecker et al. 1980, Munn and Schillinger 1983).

The composition of the patient series in the literature shows great differences, the number of children with a high malformation ranging from 25 to 58 percent. In the description of the malformations and the assessment of results the composition of the group of patients should be taken into account.

5.3 The VATER association

Included in the VATER association are: vertebral defects, vascular abnormalities, anal atresia, tracheoesophageal fistula with esophageal atresia, and radius and renal dysplasia. The number of anomalies from the VATER association in the children from the Sophia Children's Hospital is shown in Table 7.

Table 7: Number of anomalies vater association (Sophia Children's Hospital)

	N	Percentage
< 3 anomalies	108	71%
3 anomalies	25	16%
4 anomalies	14	9%
5 anomalies	6	4%

Discussion:

The acronym VATER was introduced as a name for a spectrum of anomalies occurring quite frequently (Quan and Smith 1973). Some uncertainty has arisen because a few characters of VATER are also used for other anomalies (Tentamy and Miller 1974, Say 1975). The original acronym VATER was later extended to VACTERL (Kaufmann 1973), ARTICLE or ARTICLE V (Barnes and Smith 1978), or VATERS (Jones 1988). The full spectrum rarely occurs, whereas three or four anomalies often coincide (Quan and Smith 1973, Barry and Auldist 1974, Fournier et al. 1979).

5.4 Associated congenital anomalies

In 49 out of the 153 children the congenital anorectal malformation was the only known congenital anomaly. In 104 (68 percent) there were more anomalies. The location of the anomalies and the incidence is shown in table 8.

Table 8: Associated congenital anomalies with the anorectal malformation (Sophia Children's Hospital)

	N	Percentage
urogenital tract	81	53%
spinal column	31	20%
extremities	30	20%
cardiovascular system	23	15%
face	22	14%
esophageal atresia and tracheoesophageal fistula	15	10%
gastrointestinal tract elsewhere	12	8%
central nervous system	9	6%
other	9	6%

Discussion:

In the literature anomalies associated with the congenital anorectal malformation are reported in 26 to 72 percent of the children (Ladd and Gross 1934, Mayo and Rice 1950, Moore and Lawrence 1952, Santulli 1962, Partridge and Gough 1963, Kiesewetter et al. 1964, Hasse 1976, Wendelken et al. 1977).

Anomalies in the spinal column are found in 6 to 40 percent, (Thompson and Grossman 1974, Denton 1982, Carson et al. 1984). Cardiovascular anomalies present in 7 to 16 percent (Greenwood et al. 1975, Teixeira et al. 1983), esophageal atresia in 6 to 12 percent (Stephens and Smith 1971, Piekarski and Stephens 1976), and central nervous system anomalies in 4 percent.

The differences in incidence of anomalies in various patient groups can be explained by differences in the composition of the patient groups. Differences can also be explained by a special interest of the researcher, or by the degree of thoroughness with which the study was carried out.

5.5 Mortality

The mortality for the children from the Sophia Children's Hospital is 18 percent (27 children). Twenty-two of them died within three months after birth. The other 5 died at an age between 7 months and 7 years. Twelve of the children who died at an early age were born prematurely and/or had a low birth weight.

Of equal importance is the fact that 18 of the 22 children who died within 3 months had congenital anomalies in four or more organ systems. The location of the anomalies and the incidence are shown in Table 9.

Table 9: Mortality: number of children with anomalies in different organ systems (Sophia Children's Hospital, N = 27)

	N
urogenital tract	21
extremities	14
face	13
cardiovascular system	9
central nervous system	8
esophagus and trachea	6
other	7

Because of the great number of anomalies it is not always possible to indicate the exact cause of death. The causes of death are shown in table 10.

Table 10: Cause of death (Sophia Children's Hospital)

Early death (younger than 3 months) (N = 22)

	N
complex cause	6
renal insufficiency or renal agenesis	6
pulmonic cause	2
cardiac cause	2
meningitis	3
esophageal atresia	1
enterocolitis	1
sepsis	1

Died at an age between 7 months and 7 years (N = 5)

	N
renal insufficiency	1
esophageal atresia	1
enterocolitis	1
meningitis	1
unknown cause	1

Discussion:

The mortality of the children with a congenital anorectal malformation in the Sophia Children's Hospital is mainly determined by other congenital anomalies, prematurity and/or low birth weight. Although in many cases death is determined by a number of factors, renal anomalies are the major cause of death (see also Chapter 6).

The overall mortality in the study group was 18 percent, and thus falls within the range of 12 to 35 percent reported in the literature.

5.6 Conclusion

The composition of the groups of children with a congenital anorectal malformation in the literature is varied. The group of children from the Sophia Children's Hospital which is described in this study falls within the wide margins of the characteristics set forth in this chapter.

The next step is to make a more detailed inventory of the anomalies and the complications of the urogenital tract that were found.

6

Urogenital tract anomalies in patients with a congenital anorectal malformation from the Sophia Children's Hospital

In the previous chapter it was established that the composition of the group of children with a congenital anorectal malformation from the Sophia Children's Hospital corresponds to that in a number of large series reported in the literature. A few general characteristics also correspond to the data from the literature.

In this chapter an inventory of the data on the urogenital tract will be made and these data will be compared to those from the literature.

The data are described for three groups:

1. the total group of 153 children
2. the group of 120 children with a follow-up to 1986
3. the group of 76 children participating in the follow-up examination.

The following aspects are taken into account:

1. examination of the urogenital tract;
2. anatomical abnormalities;
3. functional abnormalities;
4. surgery of the urogenital tract;
5. complications of the urogenital tract as a result of the treatment of the congenital anorectal malformation;
6. results of survey and follow-up examination:
   a. renal function;
   b. bladder function;
   c. urinary tract infections.

6.1 Examination of the urogenital tract

a. Intravenous pyelogram

In principle an IVP was performed in all children in the stated period. Table 11 shows the number of IVPs that were made and the number of anomalous IVPs for the different groups. In total anomalous IVPs were found in 34 children. In 17 children it concerned anatomical abnormalities only, in 11 children functional abnormalities, and in 6 children a combination thereof (Table 12).

In the 153 children of group 1, abnormalities on the IVP were found in 17 percent (12/69) of the girls and 26 percent (22/84) of the boys. Of the children with a high anomaly, 34 percent (22/63) had an anomaly, whereas for the children with a low anomaly this was 13 percent (12/90).

In group 2, twenty-four abnormal IVP's were found, in 19 percent (10/53) of the girls and 21 percent (14/67) of the boys. The IVP was anomalous in 33 percent of the children with a high and in 13 percent of the children with a low congenital anorectal malformation.

The percentages of the abnormalities in the children of group 3 in relation to sex and the type of the congenital anorectal malformation are similar to those of group 2.

Table 11: IVP (percentages abnormalities)

	N	Percentage
group 1 (153 children)		
IVP performed:	132	86%
no abnormalities	98	64%
abnormalities	34	22%
IVP not performed:	21	14%
no treatment	16	11%
reason unknown	5	3%
group 2 (120 children)		
IVP performed:	115	96%
no abnormalities	91	76%
abnormalities	24	20%
IVP not performed:	5	4%
group 3 (76 children)		
IVP performed:	73	96%
no abnormalities	57	75%
abnormalities	16	21%
IVP not performed:	3	4%

Table 12: IVP (nature of the abnormalities)

		N
Anatomical	horseshoe kidney	5
	hypoplasia	5
	ectopia	4
	agenesis (unilateral)	3
Functional	hydronephrosis	9
	megaureter	2
Combined	ectopia, aplasia or polycystic kidney and hydronephrotic contralateral kidney	6

b. Voiding cystourethrogram

A voiding cystourethrogram (vcug) was performed in 87 children. Surprisingly the number of children in whom a voiding cystourethrogram was made was larger in the period 1970-1975 (namely 82 percent) than in the period 1975-1980 (47 percent). This holds good for both boys and girls. The numbers of voiding cystourethrograms and the numbers of abnormalities for the different groups are shown in table 13.

In group 1 abnormalities on the voiding cystourethrogram were found in 19/69 of the girls (28 percent). For the boys the number was 31/84 (37 percent). Of the children with a high anorectal malformation the voiding cystourethrogram was anomalous in 30/63 (47 percent). In the children with a low malformation abnormalities were found in 20/90 (22 percent).

In group 2 the voiding cystourethrogram was anomalous in 32 percent of the girls and in 36 percent of the boys. Abnormalities were found in 58 percent of the children with a high malformation and 23 percent of the children with a low malformation.

Table 13: Voiding cystourethrogram (percentages abnormalities)

	N	Percentage
group 1 (153 children)		
Vcug performed:	87	57%
no abnormalities	37	24%
abnormalities	50	33%
Vcug not performed:	66	43%
group 2 (120 children)		
Vcug performed:	75	62%
no abnormalities	34	28%
abnormalities	41	34%
Vcug not performed:	45	38%
group 3 (76 children)		
Vcug performed:	51	67%
no abnormalities	20	26%
abnormalities	31	41%
Vcug not performed:	25	33%

Thirty-three percent of the girls and 40 percent of the boys from group 3 had abnormalities on the voiding cystourethrogram. This applied for 62 percent of the children with a high anorectal malformation and 30 percent of the children with a low malformation.

The percentages of abnormalities increase when they are calculated for the children in whom a voiding cystourethrogram was performed only.

Table 14 shows the nature of the abnormalities that were found.

Table 14: Voiding cystourethrogram (nature of the abnormalities) (in 2 children multiple abnormalities were found)

	N
vesicoureteral reflux	38
fistula rectum – lower urinary tract	6
urethral stenosis / valves	4
diverticulum of urethra	2
duplicated or segmented bladder	2

c. X-ray examination of the spinal column

X-rays of the spinal column were not taken in all children. In some cases abnormalities were found on special X-rays taken of the lumbosacral spine. Abnormalities were also found on X-rays of the thorax or on IVPs.

Of the total group of 153 patients (group 1) abnormalities of the spinal column were found in 31 patients (20 percent). The percentage was the same for boys and girls. What could be demonstrated was the fact that an anomaly of the spinal column was found in more children with a high malformation than in children with a low malformation (resp. 29 percent and 13 percent).

In group 2 and 3 respectively 19 percent and 18 percent of the children showed abnormalities of the spinal column. In children with a high congenital anorectal malformation the percentage of abnormalities is twice as high as in children with a low malformation.

Sacral abnormalities were described in 14 children and will be dealt with more specifically in chapter 6.3.

Table 15: Abnormalities spinal column (6 children had multiple abnormalities)

	N
wedged vertebrae, hemivertebrae or lumbar block vertebrae	15
sacral malformation	9
agenesis of sacrum	5
agenesis of os coccygis	5
spina bifida	3

d. Urodynamic examination

A urodynamic examination was only carried out in case of suspected neurogenic bladder dysfunction. This concerned 11 children, in general at an older age (range 1 to 14 years, mean 7 years); 7 children had a high congenital anorectal malformation and 4 had a low malformation.

e. Ultra-sound studies and nuclear imaging
Ultra-sound studies and radionuclide scans were not used as screening tests in the study period. These studies were only carried out at checkups and additional evaluation of patients with problems.

Discussion

In the past, tests for the urogenital tract were only carried out in the case of children with problems or complications. At a later stage tests were carried out for certain groups (e.g. only in the case of children with a high congenital anorectal malformation). Eventually systematic screening was indicated for all children.

The data from the Sophia Children's Hospital confirm the data from the literature that an IVP and voiding cystourethrogram in children with a congenital anorectal malformation reveal many abnormalities. The view of Berdon and co-workers, that girls with a low congenital anorectal malformation do not show any abnormalities cannot be confirmed (Berdon et al. 1965).

Both the study of the Sophia Children's Hospital and the reports in the literature provide sufficient arguments to perform an IVP (or ultra-sound study of the kidneys and bladder) and voiding cystourethrogram at all times. Opinions differ as to the point of time on which these tests should take place. The following arguments argue in favour of a test at an early stage, that is to say prior to the construction of the neo-anus or the first examination under anaesthesia:

1. severe abnormalities in the kidneys or urinary tract may alter the treatment plan with respect to the congenital anorectal malformation;
2. the voiding cystourethrogram should be performed when the urine is still sterile;
3. when an obstruction is demonstrated in the urogenital tract treatment on the short term may be necessary and possibly be combined with the first examination under anaesthesia or treatment for the congenital anorectal malformation.

Not in all cases X-rays were taken of the lumbosacral spine, neither in the series from the literature nor in the children from the Sophia Children's Hospital. Nevertheless is has become clear that many children have an abnormality of the lumbosacral spine. Detecting occult bladder dysfunctions at an early stage is just as important as demonstrating anatomical abnormalities (Tank 1970). For this reason an X-ray of the lumbosacral spine should also be taken in all children. It is not clear if this should also apply for the more invasive urodynamic or video-urodynamic studies. These studies should certainly be carried out in children with an abnormality of the lumbosacral spine, vesicoureteral reflux and/or suspected bladder dysfunction on the basis of a neurogenic abnormality.

In order to distinguish between primary and secondary abnormalities it is recommended to have the studies take place at a point of time prior to the definitive correction of the congenital anorectal malformation. At present urodynamic studies

are carried out in all children with a high congenital anorectal malformation in a number of clinics. The necessity and value of these studies should be elucidated in a prospective study. At present there are no sufficient arguments to carry out urodynamic or video-urodynamic examination as routine screening for all children with a congenital anorectal malformation.

6.2 Anatomical abnormalities

a. Kidneys
The numbers and percentages of renal abnormalities for the different groups are shown in Table 16.

In total 39 children showed renal abnormalities (25 percent). This held good for 48 percent of the children with a high anorectal malformation, but for only 10 percent of the children with a low malformation.

Table 16: Renal abnormalities

	N	Percentage
group 1		
no abnormalities	108	71%
abnormalities	39	25%
unknown	6	4%
group 2		
no abnormalities	100	83%
abnormalities	20	17%
group 3		
no abnormalities	64	84%
abnormalities	12	16%

Table 17: Renal abnormalities (numbers and percentages for sex of patients and type of congenital anorectal malformation)

		Number of children with renal abnormalities	Percentage
anorectal malformation high			
boys	(n = 47)	22	47%
girls	(n = 16)	8	50%
anorectal malformation low			
boys	(n = 37)	3	8%
girls	(n = 53)	6	11%

The numbers of abnormalities for the children with a high respectively low congenital anorectal malformation are shown in Tables 17 and 18.

Table 18: Nature of renal abnormalities (subdivided according to the type of the congenital anorectal malformation)

	N
anorectal malformation high:	
agenesis bilateral	3
horseshoe kidney	6
agenesis unilateral	5
hypoplasia unilateral	6
hypoplasia bilateral	3
ectopic kidneys	3
pelvi-ureteric junction obstruction	2
polycystic kidneys	2
anorectal malformation low:	
horseshoe kidney	2
agenesis unilateral	2
ectopic kidneys	2
hypoplasia unilateral	1
pelvi-ureteric junction obstruction	1
polycystic kidneys	1

b. Ureters

Abnormalities of the ureters were found in 12 patients of the total group. Table 19 shows the number and the percentages of the abnormalities in the different groups. The nature of the abnormalities is presented in Table 20.

Table 19: Abnormalities of the ureters

	N	Percentage
group 1		
no abnormalities	134	88%
abnormalities	12	8%
unknown	7	4%
group 2		
no abnormalities	115	96%
abnormalities	5	4%
group 3		
no abnormalities	73	96%
abnormalities	3	4%

Table 20: Nature of abnormalities of the ureters

	N
agenesis ureters	4
ectopic ureter	4
hypoplasia (without lumen)	2
ureterocele	1
primary megaureter	1

c. Bladder

Anatomical abnormalities of the bladder were found in 13 children of the total group. In Table 21 the number and the percentages are shown for the different groups.

Of the 13 children of group 1 with abnormalities of the bladder, twelve fell into the group of children with a high congenital anorectal malformation or cloacal exstrophy, and only one child had a low malformation. There were 7 boys and 6 girls. Table 22 shows the nature of the abnormalities.

Table 21: Abnormalities of the bladder

	N	Percentage
group 1		
no abnormalities	134	88%
abnormalities	13	8%
unknown	6	4%
group 2		
no abnormalities	114	95%
abnormalities	6	5%
group 3		
no abnormalities	73	96%
abnormalities	3	4%

Table 22: Nature of abnormalities of the bladder

	N
cloacal exstrophy	4
agenesis	3
duplicated/segmented bladder	2
malformation trigone/bladder neck	2
patent urachus	1
vesical exstrophy	1

d. Urethra

In the total group abnormalities were found in 37 children (24 percent). The number and percentages are shown in table 23. As appears from Table 24 this applies mainly to boys with a high congenital anorectal malformation. Some children had multiple abnormalities. In total 41 abnormalities were found (Table 25).

The high percentage of boys with hypospadias (11/84, or 13 percent) is striking.

Table 23: Abnormalities of the urethra

	N	Percentage
group 1		
no abnormalities	110	72%
abnormalities	37	24%
unknown	6	4%
group 2		
no abnormalities	95	79%
abnormalities	25	21%
group 3		
no abnormalities	60	73%
abnormalities	16	27%

Table 24: Abnormalities of urethra (number and percentages for sex of patients and type of congenital anorectal malformation)

		N	Percentage
anorectal malformation high			
boys	(n = 47)	22	47%
girls	(n = 16)	6	38%
anorectal malformation low			
boys	(n = 37)	7	19%
girls	(n = 53)	2	4%

Table 25: Nature of abnormalities of urethra

	N
hypospadias (boys)	11
stenosis (stricture)	9
epispadias (exstrophy)	5
persistent fistula	5
urethral valves	4
agenesis	3
diverticulum	2
hypospadia (girls)	2

e. Penis

In 7 of the total of 84 boys an abnormality of the penis was found. The numbers are shown in Table 26, and the nature of the abnormalities in Table 27.

Table 26: Abnormalities of the penis

		N	Percentage
group 1	(n = 84)		
	no abnormalities	77	
	abnormalities	7	8%
group 2	(n = 67)		
	no abnormalities	64	
	abnormalities	3	4%
group 3	(n = 40)		
	no abnormalities	37	
	abnormalities	3	8%

Table 27: Nature of abnormalities of the penis

	N
duplication	2
short, broad penis in case of exstrophy	2
micropenis	2
isolated chordee	1

f. Testes

Abnormalities of the testes were found in 14 boys (17 percent). Tables 28 and 29 respectively show the numbers and the nature of the abnormalities.

Table 28: Abnormalities testis

		N	Percentage
group 1	(n = 84)		
	no abnormalities	62	
	abnormalities	14	17%
	unknown	8	
group 2	(n = 67)		
	no abnormalities	56	
	abnormalities	11	16%
group 3	(n = 40)		
	no abnormalities	31	
	abnormalities	9	22%

Table 29: Nature of abnormalities of testes

	N
undescended testes bilateral	10
undescended testis unilateral	3
agenesis unilateral and undescended testis contralateral	1

g. Vagina

In 6 of the 69 girls an abnormality of the vagina was found. The number and the nature of the abnormalities are shown in Tables 30 and 31.

Table 30: Abnormalities of the vagina

		N	Percentage
group 1	(n = 69)		
	no abnormalities	63	
	abnormalities	6	9%
group 2	(n = 53)		
	no abnormalities	50	
	abnormalities	3	6%
group 3	(n = 36)		
	no abnormalities	33	
	abnormalities	3	8%

Table 31: Nature of abnormalities of the vagina

	N
vaginal duplication	2
stenosis with hydrometrokolpos	2
agenesis of vagina	2

h. Uterus or Fallopian tube

Six girls had abnormalities of the uterus or Fallopian tube. The abnormalities of the uterus or Fallopian tube were found during operation or autopsy. The number and nature of the abnormalities are shown in Tables 32 and 33.

Table 32: Abnormalities of uterus or Fallopian tube

		N	Percentage
group 1	(n = 69)		
	no abnormalities	63	
	abnormalities	6	9%
group 2	(n = 53)		
	no abnormalities	51	
	abnormalities	2	4%
group 3	(n = 36)		
	no abnormalities	35	
	abnormalities	1	3%

Table 33: Nature of abnormalities of uterus or Fallopian tube

	N
bicornate uterus	3
uterus duplication	2
hydrosalpinx	1

Table 34 gives a recapitulation of the percentages of anatomical abnormalities in the different groups.

Table 34: Percentages anatomical abnormalities

	group 1	group 2	group 3
kidneys	25	17	16
ureters	8	4	4
bladder	8	5	4
urethra	24	21	27
penis	8	4	8
testes	17	16	22
vagina	9	6	8
uterus	9	4	3

Discussion

In the literature a large number of different urogenital tract anomalies presenting in children with a congenital anorectal malformation have been reported. The types of

abnormalities found in the children at the Sophia Children's Hospital correspond to those in the literature. The numbers reported range widely. This is probably due to the degree of extensiveness of the various studies.

The group of children from the Sophia Children's Hospital shows a surprisingly high number of renal abnormalities. The mortality in the group with renal abnormalities is high (see chapter 6.6). The high percentage of boys with hypospadias (13 percent of the total group) is surprising as well. In the literature an incidence of 3 to 5 percent is reported for boys with an anorectal malformation (Hasse 1976, Adkins and Kiesewetter 1976, Cook 1978). Puchner and co-workers found a high percentage of hypospadias too (Puchner et al. 1975). Undescended testes were found in 17 percent of the boys. This percentage is considerably higher than that in children without a congenital anorectal malformation (Hirasing et al. 1982).

The abnormalities of the uterus were either found at surgery or autopsy. The actual incidence will probably be higher considering the number of children with renal abnormalities and the relation between congenital abnormalities of the kidneys and the uterus. In order to ascertain the correct incidence, research in a series of adult patients with a congenital anorectal malformation is mandatory.

6.3 Functional abnormalities found at radiologic or urodynamic examinations

a. Hydronephrosis

Hydronephrosis of one or both kidneys was found in 15 children of the total group, 9 girls and 6 boys. Seven of these 15 patients had a high anorectal malformation and 8 a low malformation. The numbers of children with hydronephrosis in the different groups are shown in Table 35.

Table 35: Hydronephrosis

		N	Percentage
group 1	no hydronephrosis	116	76%
	hydronephrosis	15	10%
	unknown	22	14%
group 2	no hydronephrosis	107	89%
	hydronephrosis	13	11%
group 3	no hydronephrosis	68	89%
	hydronephrosis	8	11%

b. Vesicoureteral reflux

A voiding cystourethrogram was performed in 87 of the 153 children. Vesicoureteral reflux was found in 38 children, 16 girls and 22 boys. Twenty-one of them had a high anorectal malformation and 17 a low malformation.

The percentages of the vesicoureteral reflux were calculated for those children in whom a voiding cystourethrogram was made. Reflux was found in 41 percent (16/39) of the girls and 46 percent (22/48) of the boys, in 53 percent (21/40) of the children with a high and in 36 percent (17/47) with a low congenital anorectal malformation. The numbers and percentages of the children with vesicoureteral reflux in group 1, 2 and 3 are shown in Table 36.

Table 36: Vesicoureteral reflux

		N	Percentage
group 1	no reflux	49	32%
	reflux	38	25%
	unknown	66	43%
group 2	no reflux	45	37%
	reflux	31	26%
	unknown	44	37%
group 3	no reflux	30	40%
	reflux	23	30%
	unknown	23	30%

c. Neurogenic bladder dysfunction

1. Primary functional disorder. Fourteen out of the 153 children, nine boys and 5 girls had a sacral abnormality or lumbosacral meningomyelocele. Of these 14 children 8 had a neurogenic bladder dysfunction (see Table 37).
2. A secondary neurogenic bladder dysfunction as a result of surgery for the congenital anorectal malformation could not be ascertained in this study of children of the Sophia Children's Hospital.

Table 37: Neurogenic dysfunction of the bladder

		N	Percentage
group 1	no abnormalities	117	
	neurogenic bladder	8	5%
	unknown	28	
group 2	no abnormalities	112	
	neurogenic bladder	8	7%
group 3	no abnormalities	71	
	neurogenic bladder	5	7%

Discussion

a. The numbers of children with hydronephrosis correspond to those reported in the literature. With the introduction of ultrasound studies as the initial method of

examination for the kidneys an increase in the number of children with an early detected hydronephrosis may be expected. It is an important detail that in a number of children hydronephrosis is caused by compression of the ureters as a result of a dilated colon.

b. The high percentage of vesicoureteral reflux in children with a congenital anorectal malformation has only become apparent in the past decade (Rickwood and Spitz 1980, Narasimharao et al. 1983, Hoekstra et al. 1983). The data from the Sophia Children's Hospital correspond to those of Narasimharao and co-workers, who did not find a difference in incidence between boys and girls, but did find differences between children with a high and a low congenital anorectal malformation.

In our study group grades II, III or IV of vesicoureteral reflux were preponderant. Also in children with a low anorectal malformation the incidence of a vesicoureteral reflux is so high that it is recommended to perform a voiding cystourethrogram in all children with a congenital anorectal malformation.

c. Neurogenic bladder dysfunction. The incidence of children with a neurogenic bladder dysfunction in our study group was 5 percent. This is slightly below the range of 6 to 18 percent reported in the literature. A sacral anomaly was found in 9 percent of the children of the Sophia Children's Hospital. Sacral anomalies were found in particular in boys with a high congenital anorectal malformation. The percentages reported in the literature of children with a sacral anomaly associated with a congenital anorectal malformation range from 5 to 40 percent. Both from the literature and this study it appears that not all children with a sacral abnormality have a neurogenic bladder dysfunction.

6.4 Surgery of the urogenital tract

Of the total group of 153 children 29 underwent one or more operations in the Sophia Children's Hospital for anomalies or complications of the urogenital tract. The percentage of children operated upon is for group 1, 2 and 3 respectively, 19, 23 and 24 percent. Thirteen children underwent one operation, in 16 children multiple operations were performed.

In order to give an impression of the often complicated nature of the anomalies the operations performed are described separately:

1. Boy 7 months: transurethral resection for posterior urethral valves.
2. Boy 1 year: transurethral resection for posterior urethral valves.
3. Boy 2 years: hypospadias correction.
4. Boy 4 years: transurethral resection for posterior urethral valves.
5. Girl 12 years: removal hydrosalpinx.
6. Boy 4 years: suprapubic cystostomy in a case of persistent rectourethral fistulae.
7. Boy neonatal period: correction accidental lesion of the urethra at perineal operation for congenital anorectal malformation.
8. Girl 1 year: nephroureterectomy for a non functioning kidney due to pelviureteric junction stenosis.

9. Girl 1 month: dilatation urethral stenosis in a case of neurogenic bladder dysfunction.
10. Boy 6 years: orchidopexy unilaterally.
11. Boy 5 years: orchidopexy unilaterally.
12. Boy 5 years: orchidopexy unilaterally.
13. Boy 1 month: closure cloacal exstrophy.
14. Girl 4 years: bilateral ureterocutaneostomy in connection with neurogenic bladder dysfunction, bilateral hydronephrosis and bilateral vesicoureteral reflux. At the age of 7 years the ureterocutaneostomy was closed at one side and one year later this procedure was performed at the other side.
15. Girl 1 year: bilateral reimplantation of the ureters in connection with vesicoureteral reflux grade IV. Five years later again reimplantation at one side in connection with re-occurrence of vesicoureteral reflux.
16. Girl 3 weeks: nephroureterectomy for extreme hydronephrosis due to pelviureteric junction stenosis. One year later a reimplantation was performed for a vesicoureteral reflux grade III of the other ureter. One year later again reimplantation in connection with persistent vesicoureteral reflux.
17. A boy was treated for congenital anorectal malformation in the neonatal period by a perineal approach. A rectourethral fistula persisted. Two years later a diverting colostomy and a perineal urethrostomy were made and the fistula excised. The urethrostomy was closed at a later stage. Three years later a transurethral treatment followed for an urethral stricture.
18. Boy 10 years: orchidopexy, at first unilaterally, later also at the other side.
19. Girl 1 year: reimplantation of a ureter in connection with a vesicoureteral reflux grade III. One year later reimplantation of the other ureter.
20. A boy with a cloacal exstrophy underwent an ureterocutaneostomy after birth, and later a nephroureterectomy at one side. At the age of five years a cystectomy and colostomy were performed and an ureterocutaneostomy was made for the other ureter.
21. A girl underwent a nephroureterectomy in the neonatal period in connection with a neurogenic bladder dysfunction and severe reflux. At the age of three an ureteroileocutaneostomy according to Bricker was performed. Five years later an undiversion took place. As from that time intermittent catheterization is being applied.
22. In a girl with vesical exstrophy the bladder was closed at the age of one month. A complicating vesicocutaneous fistula was closed in a later stage. At the age of four reconstruction of the external genitalia took place. At the age of seven she underwent a urinary diversion by means of a colon conduit. One year later a stomal correction of the colon conduit was necessary.
23. A boy with a duplicated rectum, duplicated bladder and duplicated penis underwent multiple operations at the age of four. After removal of one bladder a reimplantation of one ureter was performed into the other bladder. The second penis was removed. He also underwent an orchidopexy for bilaterally un-

descended testes. Finally a hypospadias correction was performed.

24. Boy 2 years: pyeloplasty in connection with a pelviureteric junction stenosis. At the age of seven a bilateral orchidopexy was performed.
25. A girl was born with a congenital anorectal malformation and a bilateral ureteric duplication. At the age of one month a unilateral reimplantation of the ureters was performed and later a heminephrectomy at that side. At the other side a ureteropyelostomy was made and a ureterocutaneostomy. At the age of two the ureterocutaneostomy was closed and a reimplantation performed. Later she had several transurethral resections for a nephrogenic adenoma of the bladder.
26. In a girl with a cloaca drainage of a hydrometrocolpos was performed in the neonatal period. In a later stage she underwent a vaginoplasty. At the age of seven an internal urethrotomy was performed for a stenotic, hypospadiac urethra.
27. A boy with persistent urethral strictures underwent an internal urethrotomy three times in connection with persistent urethral strictures at the ages of respectively 11 months, 12 months and 3 years. He underwent a nephroureterectomy for a hypoplastic kidney and vesicoureteral reflux at the age of four years. At the age of six a hypospadias correction was performed.
28. A boy was born with congenital anorectal malformation, sacrum agenesis and agenesis of one kidney. In connection with persistent urethral strictures he underwent an internal urethrotomy twice, at the ages of 7 months and one year. At the age of eighteen months a perineal urethrostomy was constructed, which needed several revisions. He underwent a reimplantation and later a ureterocutaneostomy for his single ureter. The ureterocutaneostomy was closed at the age of three years and the perineal urethrostomy was closed at the age of 4.
29. A girl underwent a vaginoplasty for a cloacal anomaly at the age of one year. At the age of eleven an internal urethrotomy was performed for a meatal stenosis of a hypospadic urethra.

Discussion

Nineteen percent of the children from our study group underwent one or more operations of the urogenital tract. The enumeration given above shows a great diversity in nature, severity and number of operations performed. Some are minor operations. On the other side of the spectrum there are extensive reconstructions for the treatment of complicated disorders with a marked morbidity, with consequences for the quality of life and with the risk of later complications. The indications for the operations are in almost all cases the same as for children without a congenital anorectal malformation. The timing of operations for urogenital tract anomalies can be affected by the congenital anorectal malformation or other associated congenital anomalies. In the assessment of the urogenital tract during the follow-up period the operations performed should be taken into consideration.

6.5 Urogenital tract anomalies as a complication of the treatment of the congenital anorectal malformation

In the period to 1975 no clearly defined protocol was used in the treatment of the congenital anorectal malformation. When the nature of the congenital anorectal malformation was not entirely clear, an initial perineal exploration was often performed. As from 1975, therapeutic management was based on the clinical classification into low and high malformations (Schreve 1981). From that time on children with a low malformation were treated by means of perineal surgery.

In children with a high malformation a colostomy was constructed and at a later stage a pull-through procedure was performed.

In the entire period from 1970 to 1980, 19 children were given a treatment that did not correspond to this policy. In these children a perineal exploration was performed for a high malformation or a colostomy was constructed erroneously in case of a low malformation. Complications in the urogenital tract were seen in particular in the perineal treatment for a high congenital anorectal malformation. The complications are listed below separately.

1. In a boy the urethra was damaged during a neonatal perineal procedure for a high anorectal malformation.
2. In a boy a pseudo-diverticulum of the urethra (a remnant of the old communication with the rectum) remained after a pull-through procedure.
3. In a boy a recurrent urethral stricture was encountered, which had to be treated three times, respectively one and two months and three years after the pull-through procedure.
4. In a boy a perineal pull-through procedure was performed during the neonatal period. This procedure was complicated by a persistent fistula. After performing a colostomy two operations were required for a definitive treatment of the fistula.
5. In a boy a perineal operation was performed for a high malformation. A persistent fistula arose, as a result of which a new exploration had to take place twice after the construction of a colostomy.
6. A boy with a high congenital anorectal malformation was treated in the neonatal period with a perineal operation. A persistent fistula arose. At the age of two he was given an colostomy and a perineal urethrostomy. After closure of the fistula the colostomy and urethrostomy could be discontinued. At the age of five he underwent a transurethral treatment for an urethral stricture.
7. A boy underwent a perineal operation for a high congenital anorectal malformation. A persistent fistula arose, after which a colostomy was constructed. At the age of one the fistula was exciseded by means of a perineal exploration. At the age of ten a new small fistula was treated surgically.
8. For a boy with a high or intermediate malformation a perineal pull-through procedure was performed. Although initially a persistent fistula was shown this has healed spontaneously with conservative treatment.

Discussion

All complications of the urogenital tract resulting from the treatment of the congenital anorectal malformation found in the Sophia Children's Hospital have also been described in the literature. Damage to the urethra or bladder during an operation has been known for centuries. Persistent fistula should be considered from a historical point of view. The method of a perineal exploration for a congenital anorectal malformation of which the nature was not yet entirely clear was regularly applied during the stated period. By this approach the communication between the rectum and urethra can easily be overlooked and there is a considerable chance of persistence of the fistula. Nixon and Puri even described 8 patients with a persistent fistula in 47 children with a high malformation (Nixon and Puri 1977). At present, in case of doubt on the type of the congenital anorectal malformation an examination under anesthesia will take place in all cases. Contiguous construction of a colostomy takes place when indicated, in which case the definitive correction of the congenital anorectal malformation is performed at a later stage. The cause of strictures in the urethra is not always clear in retrospect. In a number of children there is a congenital stenosis of the urethra. In others a stricture is caused by cicatrization after manipulations to or in the urethra. In order to detect congenital stenoses at an early stage and to distinguish them from secondary strictures a voiding cystourethrogram should be made in the postnatal period.

6.6 Results follow-up examination and survey

a. Kidney function

a.1 mortality

In 7 children of the total group of 153 the absence of the kidneys or a renal insufficiency was the demonstrable cause of death. In a number of other children with multiple congenital abnormalities the poor renal function contributed to death. In Table 38 the mortality is shown for the children with renal abnormalities. A subdivision is made with respect to the type of the congenital anorectal malformation and the sex of the patients.

Table 38: Mortality and renal abnormalities

	N	Renal abnormalities	Deaths
Boys (high malformation)	47	22	11
Girls (high malformation)	16	8	4
Boys (low malformation)	37	3	0
Girls (low malformation)	53	6	1

a.2 kidney function in 1986
The serum creatinine is known for 72 children who participated in the follow-up examination or who were still under medical supervision in 1986. The values obtained varied from 35 to 90 mmol/l. Correlated to the age, none of these children had impaired renal function.

Discussion

In our study group mortality as a result of renal insufficiency or absence of kidneys is 9 percent (6/63) for children with a high anorectal malformation and 1 percent (1/90) for children with a low malformation. The death risk reported in the literature as a result of renal insufficiency in children with a congenital anorectal malformation is 6 percent for children with a high malformation and 1 to 4 percent for children with a low malformation (Cook 1978, McLorie et al. 1987).

There are few reports in the literature on the renal function on the long term. Fleming and co-workers found an impaired renal function in 15 percent in a group of 39 girls (Fleming et al. 1986). This percentage could not be corroborated in the children of the Sophia Children's Hospital. Both in Flemming's study and in our study the data were not complete. The long term follow-up of renal function in children with a congenital anorectal malformation requires further investigation in prospective studies.

b. Bladder function
Dysfunctions of the bladder manifest themselves by involuntary loss of urine, abnormal voiding frequency, deviating voiding pattern or incomplete voiding.

Involuntary loss of urine should be distinguished into incontinence and enuresis. Incontinence of urine is loss of urine which is not the result of a normally performed voiding. In case of enuresis the loss of urine is the result of a normally performed voiding. Enuresis may occur both in the daytime and at night. Nocturnal enuresis is defined as bed-wetting by children over six years of age with a frequency of at least one time per month (McKeith 1973, Smith 1981, Baldew 1981). In spite of the fact that many authors do not consider nocturnal enuresis as a bladder dysfunction in the restricted sense, in these children voiding disorders often occur during the daytime as well.

The bladder function was assessed for 120 children with a follow-up to 1986 from the medical records, questionnaire, telephone survey and follow-up examination. The results are presented in Table 39.

Table 39: Bladder dysfunction (urinary diversion, loss of urine and voiding complaints)

	N
urinary diversion	2
bladder dysfunction with complete incontinence	4
bladder dysfunction for which int. catheterization	4
nocturnal enuresis (older than 6 years)	15
nocturnal enuresis + voiding complaints during daytime	11
voiding complaints (frequency, urgency or difficulty in voiding with an impaired urinary flow)	4

	N	Bladder dysfunction	Percentage
Boys (high malformation)	32	17	53%
Girls (high malformation)	11	4	36%
Boys (low malformation)	35	9	25%
Girls (low malformation)	42	10	23%

Discussion

With respect to bladder dysfunction in the literature attention is being paid in particular to incontinence of urine. The results are very diverse as a result of differences in the assessment criteria. In most cases no objective criteria were used. From the data of the Sophia Children's Hospital it appears that one third of the children with a congenital anorectal malformation had voiding disorders and/or loss of urine on the moment of examination. Because of the different criteria it is difficult to compare our results with those reported in literature.

It is recommended to carry out further research into the bladder function in children with a congenital anorectal malformation. It is necessary to define bladder dysfunctions in a better way and to classify them prior to proceeding with the evaluation. Assessment of bladder function should be related to the age of the children.

c. Urinary tract infections

In the period stated there was no examination and no treatment plan according to protocol for urinary tract infections. The presence, severity and nature of urinary tract infections are difficult to ascertain scientifically from the patients' medical records.

From the questionnaire, survey and follow-up examination it appeared that 41 of the 120 children with a follow-up to 1986 were treated for urinary tract infections. Thirty one children had been treated in the past for urinary tract infections and 10 children were suffering from urinary tract infections at the time of the follow-up examination (Table 40).

Table 40: Urinary tract infections

	N
infections in the past	31
urinary tract infections 1986	10
no infections	79

	N	Infections	Percentage
Boys (high malformation)	32	14	44%
Girls (high malformation)	11	5	45%
Boys (low malformation)	35	3	8%
Girls (low malformation)	42	19	45%

Discussion

It is well known from the literature that there is a strong connection between the incidence of urinary tract infections and the presence of anatomical abnormalities in the urogenital tract, fistulae between rectum and urinary tract, and bladder dysfunctions. One third of the children from our study group underwent treatment for urinary tract infections.
Urinary tract infections occurred more often in girls (24/53 = 45 percent) than in boys (17/67 = 25 percent) and more often in children with a high malformation (19/43 = 44 percent) than with a low malformation (22/77 = 29 percent).

The combination of urinary tract infections and vesicoureteral reflux increases the risk of renal damage, in particular in young children. For this reason prophylaxis with an antimicrobial agent is indicated for children with a fistula between rectum and urinary tract, children with vesicoureteral reflux and children with a bladder dysfunction.

The duration of prophylaxis with antimicrobial agents, the implementation of routine urine tests and the treatment of urinary tract infections in children with a congenital anorectal malformation should be investigated in prospective studies.

6.7 Conclusion

In this chapter an account is given of the nature and the results of the examinations and diagnostic techniques. Next the anatomical and functional abnormalities, the operations performed and the complications of the urogenital tract are described. Finally the results of the questionnaire, survey and follow-up examination are reported.

The retrospective character of the study carries with it that the available information is not always complete and in some cases not clear. Differences in nomenclature and assessment criteria make comparison to the literature sometimes difficult and in some cases even impossible.

The data from the literature and this study reveal that a number of specific questions need to be answered by means of prospective studies. Such studies should be based on uniform nomenclature and assessment criteria.

In the following chapter a new system is introduced for the classification and assessment of a number of characteristics of the urogenital tract in children with a congenital anorectal malformations: the status praesens of the urogenital tract.

The data from the literature and this study do make it possible to give recommendations for examination, treatment and follow-up of the congenital anorectal malformation in general, and of the urogenital tract in children with a congenital anorectal malformation in particular. On the basis thereof a protocol is formulated in Chapter 8.

7

Status praesens of the urogenital tract

An evaluation and scoring system can be used to:

1. Follow invidual patients who will be examined, treated, and checked according to an established protocol.
2. Compare studies of different patient groups.
3. Establish risk factors with the inherent consequences for examination and check-up.
4. Provide a prognosis to patients and parents.

7.1 Assessment of anus and rectum

In the literature evaluation of the anorectal function or fecal continence is based on anamnestic, physical-diagnostic, radiologic, and manometric data (Schärli 1971, Kelly 1972, Smith et al. 1978, Ito et al. 1981, Templeton and Ditesheim 1985). In many cases the situation is assessed according to the categories good, moderate, and poor.

It is difficult to assess data from medical history and physical examination concerning anorectal funtion in an objective way. One cannot escape the impression that often an indication is given of the degree to which patients have adapted themselves to their handicap and that it is not a matter of an objective rendering of the function.

7.2 Assessment of urogenital tract

In the literature only few aspects of the urogenital tract are evaluated, such as renal function (Fleming et al. 1986), continence of urine (Swenson and Grana 1961, Cozzi and Wilkinson 1968, Trusler and Wilkinson 1962), or scarring of the vagina (Fleming et al. 1986).

Fleming and co-workers consider renal function as mildly impaired when it is less than normal but short of renal failure. Vaginal scarring is mildly impaired when it does not need future surgical correction (Fleming et al. 1986).

These characteristics ought to be assessed with objective, reproducible criteria and/or criteria determined beforehand.

The status praesens

The actual situation of the urogenital tract in children with a congenital anorectal malformation can be ascertained from the following characteristics:

1. Anatomy of the urogenital tract
2. Operations performed, and their results
3. Renal function
4. Vesicoureteral reflux
5. Bladder function
6. Urinary tract infections

Each of these items may be assigned to the categories good, moderate, or bad, and given a numeric value of 2, 1, or 0 points respectively. Evaluation of the characteristics of the status praesens can be made according to the scheme below:

Status praesens urogenital tract

Score 1. Anatomy

0 points: Agenesis both systems, polycystic kidneys, cloacal/vesical exstrophy.
1 point : Unilateral renal agenesis, horseshoe kidney, pelvi-ureteric junction stenosis, urethral valves, duplicated penis, duplicated vagina, epispadias, hypospadias.
2 points: Bifid scrotum, undescended testis, ectopic kidney, or no anomalies.

2. Operations

0 points: Cystectomy and urinary diversion, reoperations in case of imminent renal failure, reoperations in unilateral system.
1 point : Unilateral nephrectomy, ureterocutaneostomy, reimplantation, TUR-valves, partial nephrectomy, surgical intervention for epispadias or hypospadias.
2 points: Orchidopexy, circumcision, meatotomy, or no operations.

3. Renal function

0 points: Creatinine higher than twice the normal level
1 point : Creatinine between 1.25 and twice the normal level
2 points: Creatinine lower than 1.25 times the normal level

4. Vesicoureteral reflux

0 points: Reflux grade IV and V
1 point : Reflux grade I, II and III
2 points: No reflux, or cured

5. Bladder function

0 points: Urinary diversion, neurogenic bladder dysfunction (sacral agenesis, spina bifida), complete incontinence, voiding frequency of higher than ten times a day, residual urine for which intermittent catherisation is necessary.
1 point : Diurnal/nocturnal enuresis at an age over six years, residual urine after voiding, urgency, voiding frequency of six to ten times a day.
2 points: Normal voiding frequency, no urine loss.

6. Infections

0 points: Infection more frequently than once in six months, prophylaxis with antimicrobial agents.
1 point : Infection once in six months to once in two years, infection present but frequency unknown.
2 points: No infections or last infection more than two years ago.

The scores calculated for the patient group 3 of the Sophia Children's Hospital are presented in Table 41.

Table 41: Status praesens in group 3 (76 children of follow-up examination)

	N	Percentage
Anatomy		
poor (0)	7	9.2%
moderate (1)	11	14.5%
good (2)	58	76.3%
total	76	100.0%
Operations		
poor (0)	5	6.6%
moderate (1)	7	9.2%
good (2)	64	84.2%
total	76	100.0%
Kidney function		
good (2)	65	85.5%
unknown (9)	11	14.5%
total	76	100.0%
Vesicoureteral reflux		
poor (0)	0	0.0%
moderate (1)	6	7.9%
good (2)	47	61.8%
unknown (9)	23	30.3%
total	76	100.0%
Bladder function		
poor (0)	6	7.9%
moderate (1)	28	36.8%
good (2)	41	53.9%
unknown (9)	1	1.3%
total	67	100.0%

Urinary tract infections		
poor (0)	7	9.2%
moderate (1)	6	7.9%
good (2)	62	81.6%
unknown (9)	1	1.3%
total	76	100.0%
Status praesens		
poor	4	5.3%
moderate	15	19.7%
good	56	73.7%
unknown	1	1.3%
total	76	100.0%

Table 42: Status praesens in 76 children (distribution according to sex of patients)

	Girls	Boys	Total
poor	3	1	4
moderate	6	9	15
good	26	30	56
unknown	1	0	1
total	36	40	76

Table 43: Status praesens in 76 children (distribution according to time of first treatment)

First treatment	1970-1975	1975-1980	Total
poor	4	0	4
moderate	6	9	15
good	23		56
unknown	1	33	1
total	34	42	76

Table 44: Status praesens in 76 children (distribution according to type of the congenital anorectal malformation)

	High	Low	Extr. cloacae	Total
poor	0	3	1	4
moderate	11	4	0	15
good	19	37	0	56
unknown	1	0	0	1
total	31	44	1	76

7.3 Discussion

This chapter describes the desirability of systematic evaluation of a number of characteristics of the urogenital tract. It provides a scoring system based on evaluation of these characteristics. This scoring system was applied retrospectively to the patient group from the Sophia Children's Hospital.

The ages in this group ranged from 6 to 16 year, so that it was not possible to study the influence of the age of the patient. As to prospective studies, it is advisable to establish the status praesens at fixed ages, for instance at the ages of 1, 2, 5, 10, and 15 years.

For the evaluation of adult patients the status praesens could be supplemented with data on sexual function and fertility, for which objective evaluation criteria have to be established.

8

Conclusions and recommendations

8.1 General

Congenital anorectal malformations are rare. Given an incidence of 1 in 3.000 to 5.000, it is estimated that 30 to 40 children are born with this malformation in the Netherlands every year. A large majority of those have associated congenital abnormalities and complications in other regions. For this reason it is necessary to treat children with a congenital anorectal malformation in centers with specific knowledge and possibilities in the fields of pediatric surgery, pediatric urology, pediatric cardiology and cardiac surgery, pediatric neurology and neurosurgery, orthopedics, plastic surgery, etc. Examination and management should be carried out by a multidisciplinary team. It is recommended to consider the formation of congenital anorectal malformation teams, in analogy to, for example, spina bifida teams.

Several stages may be distinguished in the examination and management of children with a congenital anorectal malformation:

1a. Acute stage

The first examination should take place as soon as possible after birth. If multiple and/or serious congenital malformations are found a consultation with regard to the best management should be held immediately. The next step is a therapy for life-threatening conditions (construction of an artificial anus, treatment of esophageal atresia, relief of obstruction of bladder or kidneys, etc.).

1b. Diagnostic stage

The various tracts should be examined extensively in order to obtain a complete inventarisation of possible associated anomalies. Part of the diagnostic examinations should be carried out in the acute stage already.

1c. Treatment stage

From the diagnostic procedures it becomes evident what operations ought to be performed. In several anomalies (e.g. cardiac, spinal, and urogenital tract anomalies) the operation and/or treatment for the respective anomalies is fixed. The order in which operations or combinations of operations are performed should be determined in multidisciplinary consultation.

1d. Evaluation and checkup stage

Evaluation and checkup should be directed anyhow at children with known and treated anomalies. Moreover a routine follow-up should be carried out for all patients at the ages of 1, 2, 5, 10 and 15 years.

8.2 Urogenital tract

From the literature and this study it appears that of the anomalies associated with the congenital anorectal malformation, those of the urogenital tract occur most frequently. The number and severity of the anomalies are higher in children with a supralevator congenital anorectal malformation than in children with an infralevator malformation.

The study in the patient group from the Sophia Children's Hospital has provided more clarity about the results of the examinations of the patients and the nature of the urogenital tract anomalies. These anomalies may lead to high morbidity and mortality.

Moreover, problems and complications of the urogenital tract may also occur as a result of the treatment of the congenital anorectal malformation. These problems cannot always be predicted. Therefore it is necessary to carry out examination and checkups according to a protocol in all children with a congenital anorectal malformation.

Pediatric-urologic assessment in children with a congenital anorectal malformation should take place at an early stage, so that it is possible to determine the original anomalies.

On the basis of data from the literature and the results of the study in the patient group from the Sophia Children's Hospital it is possible to formulate a protocol for examination, treatment, and evaluation of the urogenital tract. The protocol should be applied together with that for the congenital anorectal malformation.

In analogy to the congenital anorectal malformation and other anomalies we may distinguish 4 stages in the examination and treatment of the urogenital tract:

1. Acute stage.
2. Diagnostic stage.
3. Treatment stage.
4. Evaluation and checkup stage.

Urogenital tract protocol in children with a congenital anorectal malformation

2.1. Acute stage (immediately after birth)

Aim: 1. To obtain an general picture of the congenital anomalies.
2. Treatment of life-threatening conditions.

2.1.1. History and observation

The most important question is whether the child passed urine. If voiding did not take place an ultrasound study of kidneys and bladder should be performed immediately, before any examination under anesthesia for the congenital anorectal malformation takes place.

2.1.2. Physical examination

- Renal regions (in case of palpable kidney ultrasound study of kidneys and bladder is mandatory).
- Bladder (in case of palpable bladder ultrasound study of kidneys and bladder is mandatory).
- External genitals of girls:
  Inspection vulva/vestibule,
  Inspection position of urethra (cloaca, urogenital sinus).
- External genitals of boys:
  Inspection penis and urinary meatus (chordee, epispadias, hypospadias, meatus stenosis).
  Palpation of scrotum and inguinal canal (undescended testes).

2.1.3
- Rule out agenesis of kidneys (oligohydramnion, lung hypoplasia and characteristic features).
- Rule out hydrometrocolpos (in case of urogenital sinus or cloacal anomalies).
- Rule out urinary tract obstruction (refer also to 2.1.2.).

2.2. Diagnostic stage

Aim: Inventarisation of urogenital tract anomalies.

During the first hospitalization:

1. Registration of voiding pattern.
2. Physical examination as in acute stage.
3. Urinalysis. General tests and microscopic examination, if necessary urine culture.
4. Blood tests. Serum creatinine, if necessary serum electrolytes.
5. Kidney ultrasound study. In case of anomalies perform IVP, if necessary renal scintigram.
6. Bladder ultrasound study.
7. X rays of lumbosacral spine and os sacrum.
8. Voiding cystourethrogram.

Before the definitive reconstruction of the congenital anorectal malformation:

9. Endoscopy in case of urogenital sinus or cloacal malformation.
10. Video-urodynamic study, possibly indicated for all children with a high congenital anorectal malformation, certainly for children with bladder abnormalities, lumbosacral spine abnormalities, and/or anomalies found at voiding cystourethrogram.

2.3. Treatment stage

Aim: For all children:
1. Prevention and treatment of urinary tract infections.
2. Protection of upper urinary tract.
3. Treatment of bladder dysfunction.

For older children:
4. Obtaining continence.

2.3.1. Prophylaxis with antimicrobial agents:
In boys with a communication between intestinal tract and urinary tract, in girls with a cloacal anomaly, and in all children with a vesicoureteral reflux and/or recurrent urinary tract infections.

2.3.2.
If surgical treatment to the urogenital tract is necessary, it may in general be performed as in children without a congenital anorectal malformation. A schedule for the order of the operations is essential. It is advisable to perform reconstructions of the kidneys or urinary tract before or simultaneously with the definitive treatment for the anorectal malformation.

2.4. Evaluation and checkup stage

Aim: 1. Evaluation and checkup of known and treated anomalies.
2. Routine checkups.

2.4.1.
Three weeks postoperatively:
1. voiding pattern.
2. urinalysis.

Three months postoperatively:
1. voiding pattern.
2. urinalysis.

3. ultrasound study of bladder and kidneys.
4. IVP, in the event of kidney or ureters having been corrected operatively.
5. voiding cystourethrogram, in case voiding cystourethrogram before the operative correction was abnormal.

Six months postoperatively:

1. voiding pattern.
2. urinalysis.
3. serum-creatinine test.
4. ultrasound study of bladder and kidneys.
5. kidney scintigram, in the event of kidneys or ureters having been corrected operatively, or in the event of hydronephrosis or vesicoureteral reflux.

2.4.2. At the ages of 1 and 2 years:

1. voiding pattern (when abnormal perform bladder ultrasound study).
2. urinalysis (culture in case of abnormalities).
3. serum-creatinine test.
4. ultrasound study of kidneys

In case of residual urine after voiding or positive urine culture: voiding cystourethrogram.

In case of abnormal voiding cystourethrogram: endoscopy and/or video-urodynamic examination.

If necessary, renal scintigram (refer to 8.2.4.1.)

At the ages of 5, 10, and 15 years:

1. voiding pattern/flow measurement.
2. urinalysis.
3. serum-creatinine test.
4. ultrasound study kidneys.

In case of abnormalities: refer to section above (1 and 2 years).

At the age of 15 years and older:

Evaluation of sexual functions and, if necessary, fertility in patients with genital tract anomalies. If necessary specific tests and treatment.

8.3 Future studies

This report raises more questions than can be answered.

The present study has the disadvantages of a retrospective study, viz. incomplete research data, inconsistent nomenclature in medical records, treatment not according to protocol, and incomplete follow-up. Nevertheless it is possible to formulate a number of conclusions that may be drawn from this study in children with a

congenital anorectal malformation from the Sophia Children's Hospital, and to answer the questions posed in the introduction:

1. The nature and incidence of the anomalies and complications were discussed.
2. A classification and scoring system was developed for a number of important characteristics and applied to the study group.
3. A protocol was drawn up for examination, treatment, and checkup of the urogenital tract in children with a congenital anorectal malformation.

Nevertheless, there remain some big gaps in the knowledge of the subject of this thesis. Further study is mandatory. In order to answer unsolved and new questions prospective, controlled studies with concretely specified questions should be undertaken.

Some subjects for future study are:

1. The value of systematic examination of the lumbosacral spine in children with a high congenital anorectal malformation by means of MRI.
2. The value of routine urodynamic or video-urodynamic studies in all children with a high congenital anorectal malformation.
3. Research into the development of voiding complaints and bladder dysfunctions in correlation with age.
4. Further research into hydronephrosis and vesicoureteral reflux in connection with the congenital anorectal malformation.
5. The significance of prophylaxis with antimicrobial agents, and of screening and treatment of urinary tract infections in children with a congenital anorectal malformation.
6. Investigation of sexual function and fertility in patients with a congenital anorectal malformation.

It is recommended to carry out new studies on a multicenter level, and if possible on an international level.

8.4 Consensus

As was mentioned in the aims of this thesis, improvement of the quality of life of patients with a congenital anorectal malformation should be the main target. This can only be achieved by common effort of a group of experts attempting to solve existing problems and to answer new questions.

In the past there was no uniformity with regard to nomenclature, classification, and evaluation of anomalies, complications, and problems of the urogenital tract in children with a congenital anorectal malformation. It is advisable to strive for more clarity. Agreements should be reached on a national and international level, in order

to obtain consensus about a number of important points in the field of the urogenital tract in these children. This thesis gives an initial impetus to the issue.

Bearing the children with a congenital anorectal malformation in mind, it is appropriate to conclude with a statement by Bodenhamer, dating from as early as 1860:

> 'Whatever may be said with regard to either the merits or the demerits of this work, all will admit that the subject of it is of the highest importance.'

Summary

Chapter 1 contains a brief introduction to the history, management and classification of congenital anorectal malformations. In the last few decades attention has also been paid to associated anomalies. In children with an anorectal malformation associated urogenital tract anomalies occur most frequently, but nevertheless the literature does not show consensus of opinion with regard to the correct approach. This ensues lack of clarity.

The study reported in this thesis was aimed at making an inventory of the anomalies and complications, at establishing criteria for classification and evaluation, and at formulating a protocol for examination, treatment and follow-up of children with a congenital anorectal malformation.

Chapter 2 examines the normal and abnormal development of anorectum and urogenital tract. In the literature there is no unanimous opinion about the embryogenesis and pathogenesis of the caudal part of the body. Some authors consider congenital anorectal malformations as the result of an arrest in the normal division of the cloaca by an actively growing urorectal septum.

From observations in pig embryo's, however, it appears that a disturbance in the normal development of the cloacal plate is the cause of most congenital anorectal malformations. It is argued that this concept can be applied to the human embryo as well.

The urogenital tract anomalies are directly interrelated with the anorectal malformation.

Chapter 3 discusses the data from the literature with regard to urogenital tract anomalies in children with a congenital anorectal malformation. There is a wide variety with regard to the description of the anomalies, the patient studies, the evaluation of the functions and the recommendations given for examination and treatment.

The design of the study of the children from the Sophia Children's Hospital is explained in Chapter 4. The study group consists of 153 children, who were evaluated on the basis of medical records, interview and re-examination.

Chapter 5 gives a number of general data about the patient group in relation to the data from the literature. With regard to the division into sexes, type of the congenital anorectal malformation, the VATER association, concomitant congenital abnormalities, and mortality, the patient group from the Sophia Children's Hospital is comparable to groups reported in the literature.

Chapter 6 contains the results of the patient study, the anatomical and functional anomalies of the urogenital tract, the operations performed, the complications of the urogenital tract resulting from treatment of the anorectal malformation, and the results of re-examinations.

The most frequently occurring anatomical abnormalities are those of the kidneys (25%), urethra (24%), and testes (17%). A high percentage of hypospadias in boys contributes to the urethral abnormalities. The mortality in the group of children with renal abnormalities is high. A high percentage of vesicoureteral reflux was found as well, both in boys and in girls. Vesicoureteral reflux is more often seen in association with a high malformation than with a low malformation.

About 20 percent of the children underwent one or more operations for urogenital tract anomalies. The nature, severity, and number of necessary operations range widely.

Complications of the urogenital tract arose in a small number of children at treatment for the congenital anorectal malformation. It concerned mainly recurrent fistulas in children who underwent a perineal approach of a high anorectal malformation.

In the children who were re-examined, no cases of impaired renal function were found. About one third of the children had voiding disorders and/or loss of urine. One third of the children had urinary tract infections.

In chapter 7 an evaluation and scoring system is proposed. The status praesens of the urogenital tract is evaluated on the basis of a number of characteristics. Scores are calculated for anatomy, operations performed, renal function, vesicoureteral reflux, bladder function, and urinary tract infections. The evaluation was applied retrospectively to the patient group from the Sophia Children's Hospital.

Chapter 8 contains the conclusions and recommendations. Apart from the shortcomings of this study, a number of positive results are mentioned. The nature, frequency, and severity of the urogenital tract anomalies in children with a congenital anorectal malformation have been elucidated. An evaluation and scoring system was introduced. A protocol for examination, management and follow-up of these children is proposed. Finally, future studies are advocated: they should be prospective, according to protocol, and if possible on a multi-centre basis.

Samenvatting

In hoofdstuk 1 wordt een korte inleiding gegeven over geschiedenis, behandeling en indeling van de congenitale anorectale misvormingen. In de laatste decennia is ook aandacht geschonken aan de samengaande afwijkingen. Alhoewel de afwijkingen in de tractus urogenitalis bij deze kinderen het meest frequent zijn, bestaat in de literatuur geen eensluidende mening over de juiste aanpak. Dit is de oorzaak van onduidelijkheid.

De doelstelling van het onderzoek omvat het inventariseren van de afwijkingen en problemen, het opstellen van criteria voor indeling en beoordeling en het opstellen van een protocol voor onderzoek, behandeling en controle van de tractus urogenitalis bij kinderen met een congenitale anorectale misvorming.

In het volgende hoofdstuk wordt een uiteenzetting gegeven over de normale en abnormale ontwikkeling van anorectum en tractus urogenitalis. In de literatuur bestaat geen eensluidende mening over de embryogenese en pathogenese van het caudale lichaamsgedeelte. Door sommigen worden de congenitale anorectale misvormingen beschouwd als een arrest in de normale verdeling van de cloaca door een actief groeiend septum urorectale. Uit observaties bij varkensembryo's blijkt echter dat een stoornis in de normale ontwikkeling van de cloacale plaat de oorzaak is van de meeste congenitale anorectale misvormingen. Er zijn argumenten, waarom deze opvatting ook voor het menselijke embryo moet worden geaccepteerd.

De afwijkingen in de tractus urogenitalis hebben een directe relatie met de anorectale afwijking.

In hoofdstuk 3 worden de literatuurgegevens betreffende de afwijkingen in de tractus urogenitalis bij kinderen met een congenitale anorectale misvorming beschreven. Er bestaat een grote diversiteit in de beschrijving van de afwijkingen, het uitgevoerde patientenonderzoek, de beoordeling van de functies en de adviezen voor onderzoek en behandeling.

De opzet van de studie van de kinderen uit het Sophia Kinderziekenhuis wordt uiteengezet in hoofdstuk 4. Het betreft 153 kinderen, die worden beoordeeld op basis van statusgegevens, enquete en naonderzoek.

Hoofdstuk 5 vermeldt een aantal algemene gegevens over de patientengroep in relatie tot de literatuurgegevens. Wat betreft geslachtsverdeling, aard van de congenitale anorectale afwijkingen, de VATER associatie, samengaande aangeboren afwijkingen en mortaliteit is de groep patienten uit het Sophia Kinderziekenhuis vergelijkbaar met de literatuurgegevens.

In hoofdstuk 6 worden de resultaten beschreven van het uitgevoerde patientenonderzoek, de gevonden anatomische en functionele afwijkingen in de tractus urogenitalis,

de uitgevoerde operaties, de complicaties in de tractus urogenitalis als gevolg van de behandeling van de anorectale misvorming en de resultaten van het naonderzoek.

De meest frequente anatomische afwijkingen zijn die in de nieren (25%), urethra (24%), waartoe een hoog percentage hypospadieen bij jongens bijdraagt en testikels (17%).

De mortaliteit in de groep van kinderen met nierafwijkingen is hoog. Tevens werd een hoog percentage vesico-ureterale reflux geconstateerd, zowel bij jongens als bij meisjes.

Bij een hoge congenitale anorectale misvorming is de kans op een vesico-ureterale reflux groter dan bij een lage afwijking. Ongeveer 20% van de kinderen onderging een of meer operatieve ingrepen voor afwijkingen in de tractus urogenitalis. De aard, ernst en het aantal noodzakelijke operaties zijn sterk uiteenlopend. Bij een klein aantal kinderen ontstonden complicaties in de tractus urogenitalis bij de behandeling voor de anorectale misvorming. Het betrof vooral recidiverende fistels en andere complicaties bij kinderen, voor wie een perineale benadering voor een supralevatore anorectale misvorming was toegepast.

In het naonderzoek werden bij de onderzochte kinderen geen nierfunctiestoornissen aangetroffen. Ongeveer een derde van de kinderen had mictiestoornissen en/of urineverlies.

Een derde van de kinderen had urineweginfecties doorgemaakt.

In hoofdstuk 7 wordt een beoordelings- en scoresysteem voorgesteld. De actuele toestand van de tractus urogenitalis wordt weergegeven door een aantal onderdelen en kenmerken.

Er wordt een score berekend voor anatomie, uitgevoerde operaties, nierfunctie, vesico-ureterale reflux, blaasfunctie en urineweginfecties. De beoordeling werd retrospectief toegepast op de groep kinderen uit het Sophia kinderziekenhuis.

Hoofdstuk 8 omvat de conclusies en aanbevelingen. Naast de tekortkomingen van deze studie worden een aantal positieve resultaten vermeld. Er is meer duidelijkheid gekomen in de aard, frequentie en ernst van de afwijkingen in de tractus urogenitalis bij kinderen met een congenitale anorectale afwijking.

Een beoordelings- en scoresysteem werd geïntroduceerd. Er wordt een protocol voorgesteld voor onderzoek, behandeling en controles van deze kinderen.

Tenslotte wordt gepleit voor verdere studies, welke een prospectief, protocollair en zomogelijk multicentrisch karakter dienen te hebben.

Appendix

Vragenlijst enquete

Naam:
Geboren:
Werd in het Sophia Kinderziekenhuis behandeld in:

Is uw kind sindsdien gecontroleerd en behandeld?
○ Ja, n.l. in het ..... ziekenhuis door Dr. .....
○ Ja, in het Sophia Kinderziekenhuis behandeld.
○ Nee, geen verdere behandeling gehad.

Is uw kind momenteel nog onder controle?
○ Ja, in het ..... ziekenhuis, bij Dr. .....
○ Ja, in het Sophia Kinderziekenhuis
○ Nee

Hoe is momenteel volgens u de functie van de anus?
○ Goed
○ Matig
○ Slecht

Hoe vaak wordt ontlasting geproduceerd?
○ 1-3 maal per week
○ 1-3 maal per dag
○ Meer dan drie maal per dag
○ Anders, namelijk .....

Worden medicijnen gebruikt voor de ontlasting?
○ Altijd
○ Af en toe
○ Nooit

Is er verlies van ontlasting?
○ Dagelijks
○ Alleen bij inspanning of drukke bezigheden
○ Alleen bij diarree
○ Zelden of nooit

Moeten speciale broekjes of luiers worden gebruikt?
○ Ja
○ Neen
○ Zelden

Weet uw kind wanneer de ontlasting komt?
○ Ja
○ Neen

Kan de ontlasting worden opgehouden wanneer er aandrang is?
○ Ja
○ Neen

Kan het onderscheid worden gemaakt tussen winden, dunne en normale ontlasting?
○ Ja
○ Neen

Zijn er verdere bijzonderheden? Indien ja, s.v.p. vermelden .....

Wat is uw indruk over de functie van nieren, blaas en urinewegen?
○ Goed
○ Matig
○ Slecht

Zijn er blaas- en/of nierontstekingen geweest?
○ Neen
○ Ja, namelijk ○ Minder dan een maal per jaar
○ Een maal per jaar
○ Meerdere malen per jaar
○ Vrijwel voortdurend

Is er ongewenst urineverlies?
○ Neen
○ Ja, namelijk ○ Altijd en volledig nat
○ s'Nachts
○ Overdag
○ Zelden
○ Anders, namelijk .....

Zijn er bijzonderheden bij het plassen?
○ Te vaak, ... maal per dag
○ Pijn bij het plassen
○ Kan het slecht ophouden bij aandrang
○ Anders, namelijk .....

Worden medicijnen gebruikt voor blaas, nieren en urinewegen?
○ Neen
○ Zelden
○ Ja, namelijk .....

Zijn er verdere bijzonderheden voor de blaas, de nieren en urinewegen? Indien ja, s.v.p. vermelden .....

Hoe ernstig is uw kind gehandicapt door de aangeboren afwijking(en) in vergelijking met zijn/haar leeftijdgenoten?
○ Niet gehandicapt
○ Matig gehandicapt
○ Ernstig gehandicapt

Gaat uw kind naar school?
○ Ja, ... klas van de ... (soort school)
○ Neen
○ Anders, namelijk .....

Bestaat er een achterstand op school ten opzichte van de leeftijdgenoten als gevolg van de aangeboren afwijking(en) en de ziekenhuisopnamen?
○ Ja
○ Neen

De kinderen zullen worden opgeroepen voor een na-onderzoek.
Bent u bereid daaraan mee te werken?
○ Ja
○ Neen, omdat .....

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Nawoord

Het schrijven van een proefschrift is teamwork.
Op deze plaats wil ik dan ook een ieder van harte bedanken die mij daarbij direct of indirect heeft geholpen:

- De promotoren, Prof.Dr. R.J. Scholtmeijer (aan wie ik tevens veel dank verschuldigd ben voor het kinderurologische gedeelte van mijn opleiding) en Prof.Dr. J.C. Molenaar, die mij in de gelegenheid stelden dit onderzoek op hun afdelingen uit te voeren en mij daarbij op een geweldige manier hebben begeleid en gesteund.

- Dr. Richard Langemeijer voor zijn stimulerende adviezen en opbouwende discussies. Zonder zijn hulp zou dit werk onmogelijk zijn geweest.

- De overige leden van de promotiecommissie, Prof.Dr. F.H. Schröder (van wie ik leerde dat perfectie misschien niet haalbaar is, maar wel nagestreefd dient te worden) en Prof.Jhr.Dr. J.W. Wladimiroff voor het beoordelen van het manuscript.

- Wil Smit-Naastepad, Edith van der Ham, Tiny Schulp-van Aggelen en Annelies Slaghek, die in de verschillende fasen het typewerk hebben verzorgd.

- Marianne Feijen-Korink, Carla Freund en opnieuw Tiny Schulp-van Aggelen voor de secretariele werkzaamheden.

- Drs. Paul Mulder voor zijn adviezen en hulp bij de verwerking van de patiëntengegevens.

- Drs. Ko Hagoort, die in een recordtempo de Engelse tekst heeft verzorgd.

- De paranymfen Olav van Aubel en Tom Schiphorst voor de psychologische begeleiding, ondersteuning en organisatie van de laatste fase.

- Annechien en Douwe, die eigenlijk het meest verdienen dat dit proefschrift nu af is.

- En alle anderen, die hier misschien ten onrechte niet zijn genoemd, maar wier bijdragen evenzeer gewaardeerd werden.

Curriculum vitae

De schrijver van dit proefschrift behaalde in 1964 zijn diploma Gymnasium B aan het Professor ter Veen Lyceum in Emmeloord.

Van 1964-1970 studeerde hij Geneeskunde aan de Rijksuniversiteit te Groningen. Na co-assistentschappen in Deventer werd in 1972 het artsexamen afgelegd.

Als voorbereiding op een verblijf in de tropen werd vervolgens een jaar als agnio gewerkt op de afdeling Heelkunde van het Gasthuis in Middelburg (Chirurgen Dr. J.P. Rijken en H. Harms).

Na de tropencursus in Amsterdam volgde uitzending naar de provincie Tigre in Ethiopie, aanvankelijk in dienst van het Ministerie van Buitenlandse Zaken in Den Haag, later in dienst van het Ethiopische Ministery of Public Health (1973-1976).

Vervolgens werd de chirurgische vooropleiding gevolgd ten behoeve van de specialisatie Urologie in het St. Jozef Ziekenhuis te Deventer (Opleider Dr. S.G. Rinsma).

In 1977 werd het E.C.F.M.G. examen behaald.

De urologische opleiding vond plaats in het Academisch Ziekenhuis te Rotterdam, op de afdeling Urologie (Hoofd Prof.Dr. F.H. Schröder) en de afdeling Kinder-urologie (Hoofd Prof.Dr. R.J. Scholtmeijer).

Op 1 april 1982 volgde inschrijving in het specialisten-register.

Sindsdien is hij als uroloog werkzaam in het Groot Ziekengasthuis en Willem Alexander-Ziekenhuis te 's-Hertogenbosch in associatie met Dr. R.A. Janknegt (tot diens vertrek in 1987), L.H.M. Schreinemachers, A.J. Smans en Dr. A.P.M. van de Meijden (sinds 1988).

Hij is corresponding member of the American Urological Association, lid van de Societe Internationale d'Urologie, active member van de E.O.R.T.C. GU Group, lid van de Nederlandse Vereniging van Urologie en associate member of the European Society of Pediatric Urology.