Surgery in Childhood

Cover: Drawing by Julia Havercorn van Rijsewijk
Printed by: Optima Grafische Communicatie, Rotterdam
Lay out: Margo Terlouw-Willebrand, Nieuwerkerk aan den IJssel

Surgery in Childhood
Thesis, Erasmus University Rotterdam
ISBN 90-8559-182-1

Surgery in Childhood

Chirurgie op de kinderleeftijd

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Erasmus Universiteit Rotterdam
op gezag van de rector magnificus
Prof.dr. S.W.J. Lamberts
en volgens besluit van het College voor Promoties

De openbare verdediging zal plaatsvinden op
donderdag 28 september 2006 om 16.00 uur

door

Esther Desirée van den Ende

geboren te Geldrop

PROMOTIECOMMISSIE

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I believe the children are our future
Teach then well and let them lead the way
Show them all the beauty they posses inside
Give them a sense of pride to make it easier
Let the children's laughter remind us how we used to be

Whitney Houston, The Greatest Love of All
March 1986

Aan mijn ouders

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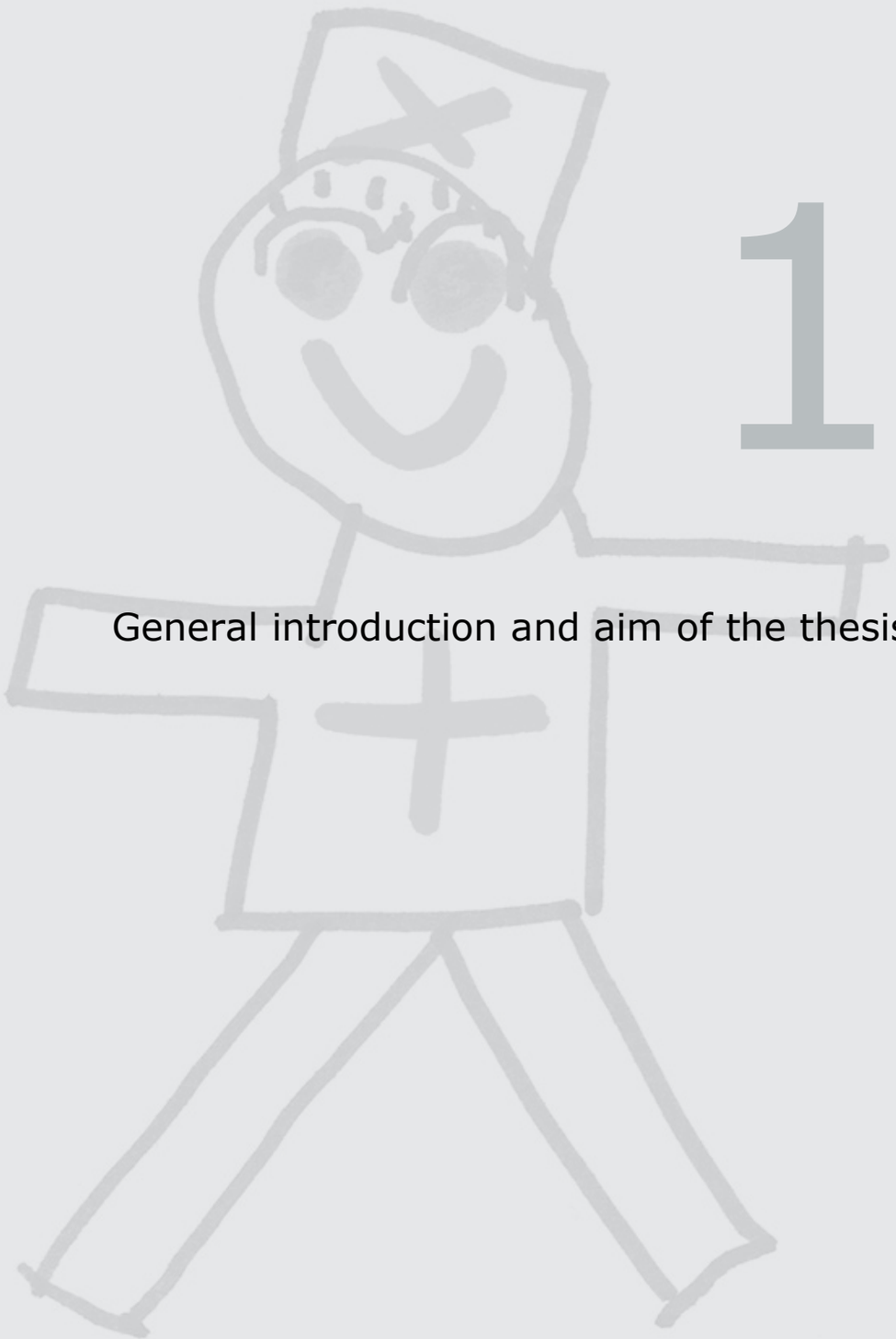

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General introduction and aim of the thesis

GENERAL INTRODUCTION

Surgery is the cure for many diseases in childhood. The second half of the 19th century saw the building of many hospitals for children. In those earlier days pediatric surgery was defined as the surgery performed in those hospitals and not by specific 'physiologic and technologic knowledge'. Following the Second World War advances in anesthesia and analgesia and better knowledge of metabolic processes enabled a move to longer operations in children. In 1974 an important step in the development of pediatric surgery in the Netherlands was the foundation of a pediatric working party of the Association of Surgeons of the Netherlands (Nederlandse Vereniging voor Heelkunde). This working party became officially known as 'The Netherlands Association of Pediatric Surgery' (Nederlandse Vereniging voor Kinderchirurgie) in 1981. The Health Council of the Netherlands provided a more specific definition of pediatric surgery in a recommendation to the Dutch Ministry of Health in 1989. Pediatric surgery was defined as the diagnostics and therapy, if necessary by means of surgical interference, of congenital malformations, solid tumors and surgical treatment of infections in children. Separate definitions were given for 'special pediatric surgery' and 'surgery in children'.[1-3]

Special pediatric surgery was defined as surgical treatment of rare and/or major congenital malformations, diseases, injuries and solid tumors. This type of surgery should be performed by pediatric surgeons in pediatric university centers. Also, all newborns under the age of seven days or prematurely born children under the age of six months were to be operated on by surgeons with pediatric surgical training. Following this advice, pediatric surgery in the Netherlands was concentrated in six university centers, of which four provided pediatric surgical training. Several years later the Association of Surgeons of the Netherlands raised the upper age limit for obligatory surgery in a pediatric university center to one month for full-term newborns and six months for premature infants, whereupon the Netherlands Association of Anesthesiologists (Nederlandse Vereniging voor Anesthesiologie) developed similar guidelines on anesthesia in children. It was agreed that full-term newborns under the age of one month and preterm infants under the age of sixty postconceptual weeks were to be treated by pediatric anesthesiologists.[4]

Notwithstanding the usefulness of guidelines, medical competence is a far better guarantee for quality of care and good medical treatment. Thorough medical training is necessary to achieve competence.

'Surgery in children', as the counterpart of 'special pediatric surgery' was defined by the Health Council of the Netherlands as the surgical treatment of common surgical diseases in children. This type of surgery can be performed by general surgeons.

Qualification for general surgical practice in the Netherlands requires residents to complete a six–year training program. Trainees are expected to perform a set number of operations over the six years. There are six categories of operations with increasing level of complexity, each corresponding with the year of training. The field of surgery includes the surgical disciplines that have not been officially recognized as separate specializations, such as gastro-intestinal surgery, surgical oncology, vascular surgery, transplantation surgery and trauma surgery.[5] Trainees perform at least thirty surgical procedures in children during the six years' general surgery training. An optional three to six months' training period in a pediatric surgical university center is recommended if the hospital of residency has no experience in surgery in children.

Two-year training programs for surgical oncology, gastro-intestinal surgery, trauma surgery, vascular surgery, lung surgery or pediatric surgery are optional to the 6-year general surgery training. Completion of this program for pediatric surgery is required for consultancy in a pediatric center.[6,7]

Training in pediatric surgery is structured in a very different way in most European countries. Duration of training in pediatric surgery is mainly seven years including a mean three-years' experience in general surgery. Only the Netherlands, Belgium and Denmark require surgeons to be a fully accredited general surgeon before specializing in pediatric surgery.[8-10]

Most European countries, with the exception of the three above-mentioned countries, recognize pediatric surgery as a separate specialisty.[8] Nevertheless, for the very reason that the Association of Surgeons of the Netherlands provided a very clear definition of special pediatric surgery, there is no need for pediatric surgeons in the Netherlands to establish a small specialisty of its own.

In 1985 pediatric surgeons in the Sophia Children's Hospital in Rotterdam and general surgeons in the Juliana Children's Hospital in the Hague started to collaborate. This collaboration with its dual infrastructure (university and general teaching hospital, respectively) made it possible to perform 'surgery in children' in the Juliana Children's Hospital. Thus, it now enables to review the quality of surgery in childhood in a general teaching hospital provided with an infrastructure and facilities adhering to the standards of the Netherlands Association of Pediatric Surgery as well as the Association of Surgeons of the Netherlands. The rationale for this thesis, therefore, was to review the outcomes of quality of care for common surgical diseases in childhood in both hospitals. This, then, would make it possible to define future guidelines regarding workload and distribution of surgery in childhood.

This thesis to this end examines several common surgical diseases in childhood, such as infantile hypertrophic pylorus stenosis (IHPS), intussusception, and acute appendicitis.

The incidences of the above-mentioned surgical diseases vary by age. The onset of symptoms caused by IHPS occurs on average within 3 to 5 weeks after birth, and vomiting starts at age three or four weeks in 50% of cases. The incidence of IHPS is approximately 2 - 5 per thousand live births.[11,12] Intussusception is the commonest cause of bowel obstruction in children under the age of two years. Most intussusceptions develop in the first year of life. While rare before two months of age, the incidence peaks in 5 to 7-month-old children, and then sharply declines.[13-16] The reported incidence varies over time. A Danish study reports a 55% reduction in incidence in children younger than 5 years from 1980 (16 cases per 10.000 person-years) to 2000 (8.5 cases per 10,000 person-years).[17] Appendicitis is a major cause of acute abdominal pain in childhood. It is most common among teenagers and rare under the age of three years. Its incidence is approximately 100 per 100,000 person-years in all age groups.[18]

These common surgical diseases in children mostly present with acute abdominal complaints. Attending physicians therefore face the challenge to differentiate between various causes of acute abdominal pain. Differentiation may be hampered in that many children have difficulty in voicing their symptoms and that the presentation is often a-specific. For example, only 13% of patients with an intussusception present with the

classical triad of symptoms; abdominal pain, currant jelly stools, and palpable abdominal mass.[19,20] Laboratory testing may cause even more confusion.[21-23] A special scoring system for acute appendicitis may be more helpful than a single investigation in identifying a correct diagnosis by combining medical history, physical examination and laboratory data.[24,25]

Additional imaging diagnostics can also improve diagnostic accuracy. If 'the pyloric olive' in pyloric hypertrophy is not palpable on physical examination (reported in 49 - 87% of cases) ultrasound study may provide accurate measurements of the pyloric muscular layers.[26-28] Ultrasound is the preferred diagnostic tool in suspected intussusception as well, with both its sensitivity and specificity approaching 100%. While the CT scan is the best imaging tool for diagnosing an intussusception in adults, it has no additional role in children. An invasive diagnostic imaging tool for intussusceptions is enema contrast study, which can be a therapeutic tool at the same time.[29-34] The diagnostic accuracy of ultrasound study for diagnosing an acute appendicitis in children varies from 90 to 100%. Accuracy is subject to the radiologist's experience.[35-40] Although ultrasound is easier, often more readily available and gives less radiation exposure, appendiceal CT scan may be required in selected cases to guide therapeutic decision making.[41-44]

Diagnostic laparoscopy is a possible tool for suspected appendicitis; if appendicitis is shown, one may proceed with laparoscopic appendectomy. Diagnostic delay can lead to a perforated appendix. This still causes the death of one child per year in the Netherlands.

Delays in the diagnosis of intussusception and initiation of treatment may lead to bowel ischemia, perforation and peritonitis, shock and even death.[45] Early reduction of the intussusception is vital in preventing a patient's further deterioration. It is still widely believed that hydrostatic reduction is less likely to be successful when symptoms have persisted for longer than 48 hours.[19,46,47] Other reported risk factors for unsuccessful reduction are age below 3 months or above 5 years, significant dehydration, rectal blood loss and small intestinal obstruction.[42,43,47]

The definitive treatment for IHPS is surgery. Conservative management of infants with IHPS has been described; i.e. continuous nasoduodenal feedings for several months, until the obstructive process becomes less

significant as the infant gains weight.[48,49] However, as surgery is safer and more efficacious, conservative treatment should be reserved for infants in whom a surgical approach is contraindicated. The classic operation for IHPS is a pyloromyotomy according to Ramstedt. This procedure uses longitudinal incision of the hypertrophic pylorus, with blunt dissection to the level of the submucosa.[11,50-52] Other operative approaches are Tan and Bianchi's circumumbilical approach and laparoscopic approaches.[53-60] There is still vigorous debate over where infants with IHPS should be treated; some researchers advocate centralization in specialist pediatric surgical centers, others suggest that this condition can be managed safely in district general hospitals.[61-63]

There are hardly any randomized controlled studies in children reporting the use of tissue adhesives for closure of surgical wounds in the operation room. Up till now tissue adhesives have mainly been used for the closure of traumatic lacerations in emergency departments.[64-66] Since inguinal hernia repair is routinely performed both in the Sophia Children's Hospital and in the Juliana Children's Hospital, we were in the position to perform a randomized controlled study evaluating the use of tissue adhesive for the closure of wounds after herniotomy.

AIM OF THIS THESIS

The aim of this thesis is to assess management and treatment outcomes of several common surgical diseases in childhood by comparing the results obtained in a specialized pediatric center and in a general teaching hospital. Three specific objectives were defined:

1. To analyze the distribution of common surgical diseases in childhood among pediatric university centers and general hospitals in the Netherlands.
2. To explore several common surgical procedures in childhood by identifying the value of various noninvasive diagnostic tools and by documenting treatment outcomes.
3. To propose a recommendation for the organization of 'surgery in childhood' in the Netherlands, based on the effects of the collaboration of a university pediatric surgical center and a general teaching hospital.

In **chapter 2** all surgical procedures performed in children under the age of sixteen in the Netherlands during a period of six years were analyzed. Data on three common surgical procedures, i.e. pyloromyotomy, appendectomy and correction of inguinal hernia or hydrocele, were extracted to evaluate the relative numbers of these operations in specialist pediatric centers and general hospitals.

Chapter 3 describes the diagnostic value of an ultrasound study for acute abdominal symptoms in children. Over a twelve-month period all children referred to the emergency department with abdominal pain existing for less than two weeks, were included. The 'clinical diagnosis' was based on the medical history, physical examination and laboratory tests results. A 'working hypothesis' was developed based on both clinical and ultrasound findings. Treatment was either observation or operation. The 'final diagnosis' was made on the basis of either a histological investigation after surgery or the child's condition at discharge. The clinical diagnosis, the working diagnosis and the definitive diagnosis were used to determine sensitivity, specificity, and predictive value of ultrasound as a diagnostic tool for acute abdominal pain in children.

Chapter 4 describes how a scoring system was devised and evaluated for children with suspected appendicitis. First we identified variables that correlated significantly with the prevalence of appendicitis, as shown by chi-square tests. Variables identified in this manner were age, sex, duration of symptoms, rectal temperature, rebound tenderness and white cell count. Regression analysis served to establish the extent to which individual variables contribute to the diagnosis appendicitis. Each variable was then given a score based on the regression coefficients. A sum score was computed by adding these scores. The model was subsequently tested on an independent data set from children who presented with suspected appendicitis in another hospital.

Chapter 5 reports a study evaluating the success rate of hydrostatic reduction in relation to duration of symptoms. Subjects were all children presenting with ultrasound proven intussusception over five years. Hydrostatic reduction of the intussusception was performed, regardless of duration of symptoms, unless there was clinical or radiological evidence of peritonitis or perforation. The latter conditions were managed surgically. Success rate, as well as recurrence and complication rates of hydrostatic reduction of intussusception were determined.

Chapter 6 compares incidences of peri-operative complications in patients with infantile hypertrophic pyloric stenosis over five years between the earlier mentioned specialist pediatric surgical center and general hospital. Pyloromyotomy was performed in all infants with an ultrasound proven hypertrophic pyloric stenosis, either by a resident supervised by a pediatric surgeon or a general surgeon. Diagnosing and treatment was by standard protocol. Data on age, sex, secondary referral status, family history of pyloric stenosis, prematurity, weight on admission, metabolic status, ultrasound findings, operative approach, operating time, intra- and postoperative complications, and length of hospital stay were retrieved from the hospital charts.

Chapter 7 reports a randomized controlled study comparing tissue adhesives with resorbable intracutaneous sutures for closure of surgical wounds in 100 consecutive children undergoing hernia repair. The primary endpoints of this study were wound closure and cosmesis.

In **Chapter 8** we discuss how the diagnostic and treatment outcomes of the reported studies create a recommendation for a quality-based, well-organized distribution of 'surgery in Childhood' in the Netherlands.

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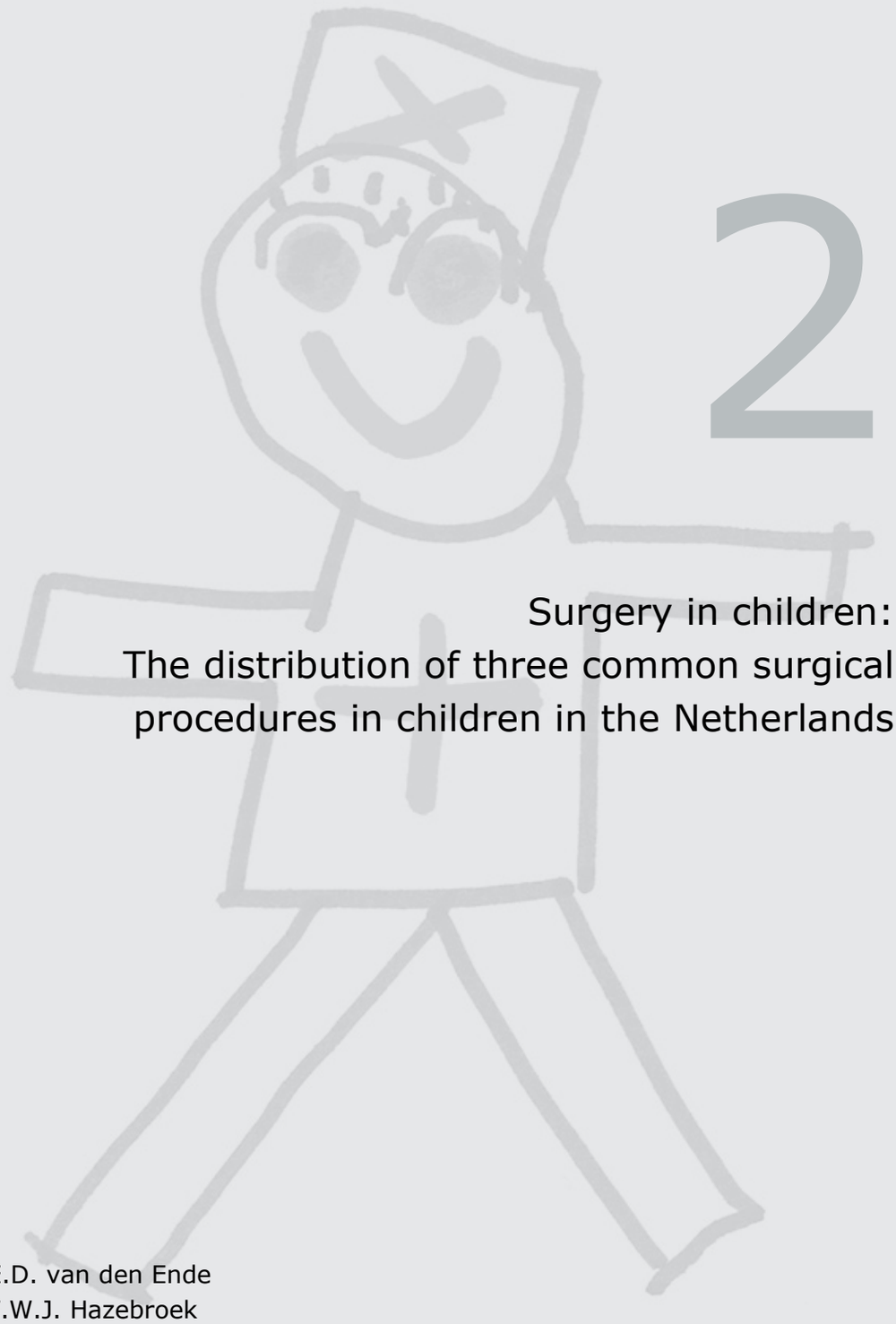

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Surgery in children: The distribution of three common surgical procedures in children in the Netherlands

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P.J. Breslau

Submitted

ABSTRACT

Introduction Annually more than 30.000 children (until age 17) are operated upon in the Netherlands. Two types of childhood operations can be distinguished; surgery as the treatment of rare, congenital diseases or solid tumors (specialized pediatric surgery) and surgery of common diseases during childhood, for example appendectomy, herniorraphy and treatment of fractures. Examples of common operations in very young children are pyloromyotomy and treatment of intussusceptions (surgery in children). 'Specialised pediatric surgery' is performed in the Netherlands, in one of the six pediatric university centers. 'Surgery in children' or as we call it 'Surgery in Childhood' can be performed in general hospitals by surgeons with a specific knowledge of surgery in children. We performed a study designed to get insight into the distribution of surgical procedures between pediatric surgical centers and general hospitals.

Methods Numbers and types of childhood operations during 1998 through 2003 were analyzed, broken down for pediatric surgical centers and general hospitals, and focusing on appendectomy, herniotomy and pyloromyotomy.

Results The yearly number of childhood operations in the Netherlands amounted to 32.790 and was stable over the study period. Of these, 23% were performed in the university centers and 77% in the general hospitals. This ratio also remained stable over the study period. The ratio of operations in the pediatric centers to operations in the general centers was 7% : 93% for appendectomy, 25% : 75% for herniotomy and 52% : 48% for pyloromyotomy. We observed a trend for more pyloromyotomies performed in the pediatric centers over the years; from 40% in 1998 to 60% in 2003.

Conclusion Our findings are consistent with stable distribution of numbers of appendectomies and herniotomies between pediatric surgical centers and general hospitals. As to pyloromyotomy, the shift in favor of the specialized surgical centers can be explained by age of patients and by recommendations issued in 1996 to the effect that treatment of very young children should be concentrated in pediatric surgical centers. It appears that most of the common surgical procedures in childhood are performed in general hospitals. We feel that this is a fair situation, enabling the pediatric surgical centers to focus on specialized pediatric surgery, such as neonatal surgery. We expect the cooperation between specialized medical centers and general hospitals – based on knowledge and skills – to intensify in the coming years, in analogy to the present collaborations between university medical centers and regional hospitals.

INTRODUCTION

Yearly more than 30.000 children under the age of 16 years in the Netherlands need to undergo surgery. Common operations in childhood are appendectomy, herniorraphy and treatment of fractures. Examples of common operations in very young children are pyloromyotomy and the treatment of intussusception.

Pediatric surgery is one of the fields of interest of general surgery. The Health Council of the Netherlands, in an advice to the Dutch Ministry of Health in 1989, proposed a dichotomy for surgery in children under the age of 16 years. There was to be a distinction between 'surgery in children' and 'specialized pediatric surgery'. The first, surgery in children and as we call it 'surgery in childhood', referred to the surgical treatment of common pathology in children; and the second, specialized pediatric surgery, to the treatment of rare diseases, congenital malformations and solid tumours.[1]

Specialized pediatric operations are performed by trained pediatric surgeons in six university medical centers in the Netherlands. The common pediatric operations are partly performed in the general hospitals by surgeons with a special interest in surgery in children.[2]

The recent public interest in quality of health care rightly calls for transparent organization of medical care in children with surgical diseases.

The aim of this analysis is to map the present distribution of several common surgical procedures in children over the six specialized pediatric centers and the other general hospitals in the Netherlands.

METHODS

Data on numbers and types of surgical procedures in children under the age of 16 years over the years 1998 through 2003 were obtained from the database of Prismant, Utrecht, the Netherlands, covering 99.9% of Dutch hospitals. The data were broken down for operations performed in the specialist pediatric surgical centers and the general hospitals. We extracted data on three common surgical procedures, i.e. infantile hypertrophic pyloromyotomy, appendectomy and correction of inguinal hernia or hydrocele.

RESULTS

The total number of surgical procedures in childhood in the Netherlands over the six-year period is 196.740, at a mean of 32.790 per year (range 31.000 – 34.000). In total 44.840 of these (23%) were performed in the university centers. The 93 general hospitals performed 77% of the surgical procedures in children. Yearly around 7500 procedures were performed in the university centers and around 25.300 yearly in the general hospitals. The distribution over the university centers and the general hospitals remained constant in this period. (*Table 2.1*)

Table 2.2 shows data on the three common surgical procedures we analyzed. The study period saw a total of 26.643 appendectomies at a mean of 4.440 per year. The university centers performed 7% of the appendectomies and the general hospitals 93%. This ratio had remained unchanged during the six years.

The university centers performed 25% of the herniorraphies over the study period and the general hospitals 75%; again, the ratio had remained constant. Yearly a mean of 6.151 herniorraphies are performed in the Netherlands.

The university centers performed 52% of the pyloromyotomies during the six year period; the general hospitals 48% of a total of 2417 pyloromyotomies in the Netherlands during six years. Regarding this operation we noted a shift in distribution over the years: in 1998 the university centers performed 40% of all pyloromyotomies in that year, and in 2003 as many as 60%.

Table 2.1 Numbers of total surgical procedures in childhood in the Netherlands from 1998-2003

Years	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Total**
University centers	7628	7356	7561	7649	7351	7259	44804
	23%	22%	23%	23%	23%	23%	23%
General hospitals	26222	25796	25144	25548	24705	24521	151936
	77%	78%	77%	77%	77%	77%	77%
Total	33850	33152	32705	33197	32056	31780	196740

Table 2.2 Numbers of three common surgical procedures in the Netherlands from 1998-2003

	1998	1999	2000	2001	2002	2003
University centers						
Appendectomy	284 (7%)	316 (7%)	303 (7%)	314 (7%)	315 (7%)	354 (8%)
Herniorraphy	1717 (25%)	1639 (26%)	1687 (27%)	1588 (26%)	1305 (23%)	1372 (24%)
Pyloromyotomy	166 (40%)	198 (50%)	257 (56%)	232 (58%)	190 (50%)	228 (62%)
General hospitals						
Appendectomy	4086 (93%)	4201 (93%)	4195 (93%)	4292 (93%)	3951 (93%)	4032 (92%)
Herniorraphy	5144 (75%)	4614 (74%)	4612 (73%)	4595 (74%)	4382 (77%)	4250 (76%)
Pyloromyotomy	249 (60%)	202 (50%)	200 (44%)	168 (42%)	190 (50%)	137 (38%)

Discussion

The year 1974 witnessed an important event in the history of pediatric surgery in the Netherlands with the foundation of the working group 'Surgery in children en newborn children' under the auspices of the Netherlands Association for Surgery. The first official sub-association, 'the Netherlands Association of Pediatric Surgery' was founded seven years later in 1981.[3] In 1989 the Health Council of the Netherlands issued a report 'Surgery in Children, the Need for Concentration'. This report recommended a distinction between 'special pediatric surgery' and 'surgery in children'. Following this advice, specialized pediatric surgery was concentrated in six pediatric surgical centers in the Netherlands.[1] These are centers with round the clock availability of medical specialists (such as pediatric surgeons, pediatricians an anesthesiologists) with expertise in the field of intensive peri-operative care in children until the age of 16 years. 'Surgery in children' was defined as the surgical treatment of common surgical diseases in children. This type of surgery can be performed by general surgeons with a special interest in surgical conditions in childhood. Following on the Health Council's recommendation the Netherlands Association for Surgery defined the categories of patients that should be treated in a pediatric surgical centre. (*Table 2.3*) The Netherlands Association of Anesthesiologists later took this up as well.[1,4]

Table 2.3 Categories of patients to be treated in a pediatric surgical centre, as defined by the Netherlands Association for Surgery

- All full-term children until the age of one month and preterm born children until the age of 6 months;
- Children whose conditions in view of severity, nature and rarity require treatment in a specialized centre at any age;
- Children whose conditions in view of treatment and complication risks require treatment in a specialized centre, e.g. polytrauma patients;
- Children with malignancies requiring surgical intervention;
- Children in need of organ transplantation.

The general hospitals for surgery in children should at least be staffed with surgeons with a special interest in this field and anesthesiologists with a special interest in pediatric anesthesiology. They should also have a children's ward providing for good peri-operative care. Furthermore, in a guideline issued in 1996 the Netherlands Association of Anesthesiologists recommended that full-term children until the age of one month en preterm born children until the age of sixty weeks postconception should be treated by pediatric anesthesiologists. (Website Netherlands Association of Anesthesiologists; www.anesthesiologie.nl)

The findings from our analysis over the years 1998 - 2003 show that a small part of the operations in the 'surgery in children' category are performed in the university centers. Only for the pyloromyotomy we observed a trend towards more pyloromyotomies in the university centers in recent years. A possible explanation is the fact that children undergoing this intervention are usually younger than 30 days. Consequently, as the Netherlands Association of Anesthesiologists recommended, a pediatric anesthesiologist in a specialized centre usually treats them. Yet these are interventions in the 'surgery in children' category, which in an appropriate setting could be performed, even in young children, by surgeons with a special interest in childhood. Collective data over the years 1998 through 2002 from the Haga Hospital, location Juliana Children's hospital, the Hague and the Sophia Children's hospital, Rotterdam showed that 55% of children presenting with infantile hypertrophic pyloric stenosis were under the age of one month. Within the framework of a collaboration established in 1985, pediatric trained surgeons from Rotterdam participate in the activities in Juliana Children's Hospital. This collaboration as well as the availability of pediatric anesthesiologists in the Juliana Children's Hospital

made it possible for children younger than 30 days to be treated in either hospital in their own region. Another example of results of treatment in hospitals with a 'collaborating infrastructure' is a recent study about children with a intussusception. This study showed that treatment outcomes of children with an intussusception did not differ significantly between a general teaching hospital and a specialized pediatric centre.[5] The treatment of childhood intussusception can be performed safely in a general teaching hospital by surgeons with experience in surgery in children.

Apart from the patient population aspect, extra attention should be paid to specific surgical skill. In the Netherlands general surgical residents must perform at least thirty surgical procedures in children under the age of 16 years. Residents may opt for a three to six month traineeship in a pediatric surgical university centre, especially if the hospital of residency has no or little experience in surgery in children.[6-8] (Website Netherlands Association of Surgery; www.heelkunde.nl) Specialist pediatric surgical training requires surgeons to complete two years of pediatric surgical training in one of the pediatric university centers, after their six years of general surgical education.[9]

We feel that a minimum of thirty surgical procedures in children over the first five years of residency seem inadequate for a career as a general surgeon with special interest in surgery in children. A differentiation year in pediatric surgery could add to the experience. The incorporation of an above named differentiation year is currently a matter of discussion within the 'Concilium Chirurgicum' of the Netherlands Association of Surgery.

In conclusion, a majority of the three described common surgical procedures in children is performed in the general hospitals in the Netherlands. This, to our opinion, correct distribution of common surgical procedures enables the pediatric university centers to concentrate on their core business, the specialised pediatric surgery. We expect that, in future the collaboration between pediatric university centers and general hospitals, on the basis of quality and expertise, will further develop and intensify, in analogy to the present collaborations between both named hospitals.

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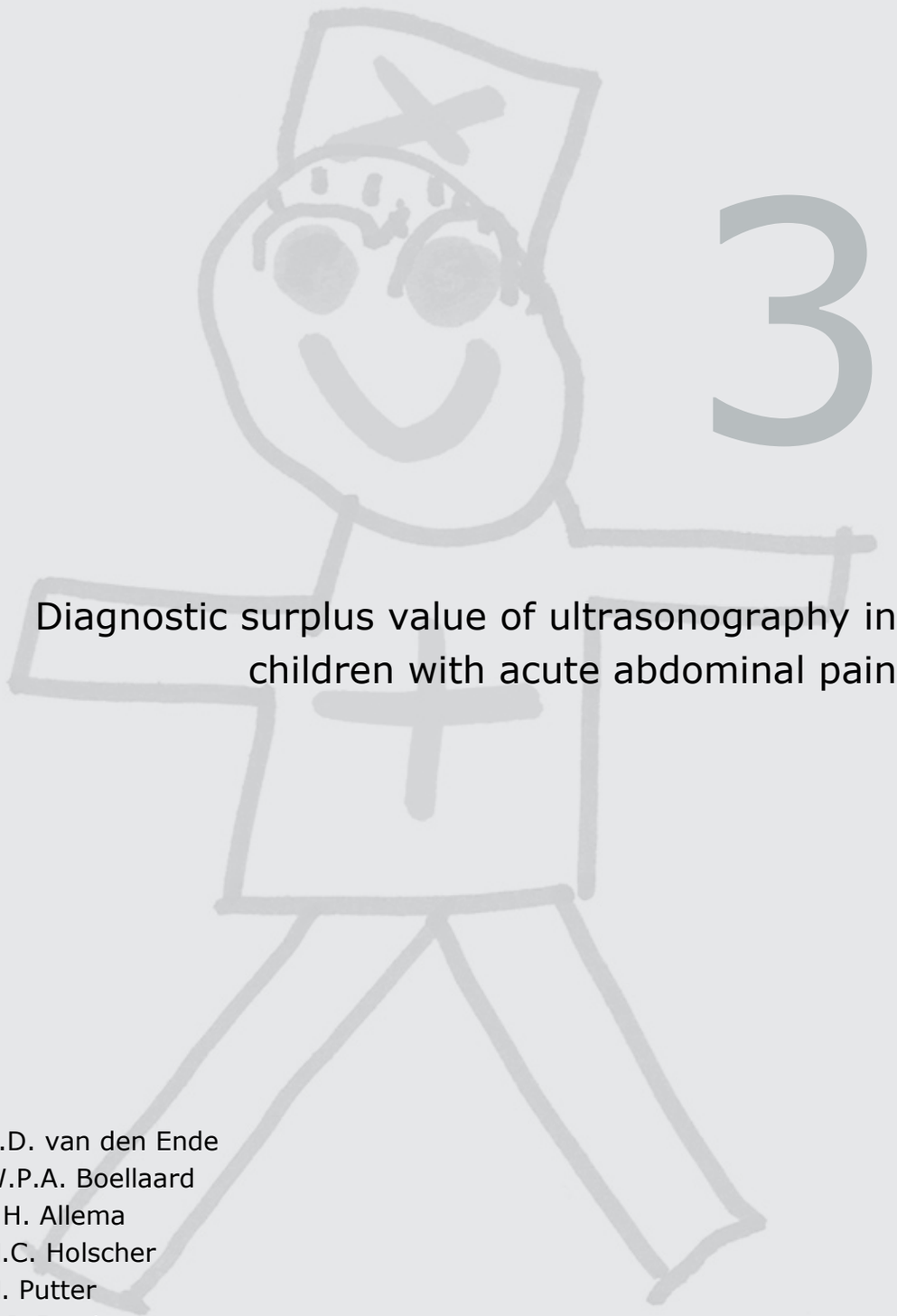

3

Diagnostic surplus value of ultrasonography in children with acute abdominal pain

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Nederlands Tijdschrift voor Geneeskd 2003;147:1174-1177

ABSTRACT

Objective To assess the role of ultrasound in the diagnosis of acute abdominal symptoms in children.

Design Prospective, descriptive.

Method During one year we performed abdominal ultrasound in all children with abdominal pain less than two weeks, who were referred to the emergency department. An initial clinical diagnosis was made on the basis of the medical history, physical examination and the results of laboratory tests. Subsequently, ultrasound was performed by a radiologist who was unaware of the clinical diagnosis. A working hypothesis was reached on the basis of the clinical findings and the results of ultrasound. Treatment was observation or operation. The final diagnosis was made on the basis of either a histological investigation after surgery or the condition at discharge.

Results We included 112 patients with mean age 9 years (54% boys). Acute appendicitis was ascertained in 48 children. The sensitivity of the clinical findings was 88% and the specificity 70%. The sensitivity of the clinical findings together with ultrasound was 88% and the specificity 91%. The positive predictive value of the clinical findings alone was 69% and of the clinical findings together with ultrasound 88%.

Conclusion Ultrasound has an additional role in the diagnosis of acute abdominal pain in children; it increases the specificity of the physical examination and reduces the number of negative laparotomies.

INTRODUCTION

Acute abdominal pain is a frequent problem in children, and making the correct diagnosis is quite a challenge for the attending physician. Though often caused by relatively harmless conditions that warrant conservative treatment (e.g. gastroenteritis, mesenteric lymphadenitis, constipation), it might as well result from more (life-) threatening diseases necessitating surgical intervention (e.g. acute appendicitis, ileocolic intussusception, infected Meckel's diverticulum).

At clinical presentation it is most important to differentiate between the diagnoses that either or not require surgical treatment: an overlooked appendicitis, for instance, may lead to diffuse peritonitis and abdominal sepsis. Notably the distinction between gastroenteritis/mesenteric lymphadenitis on the one hand and appendicitis on the other hand can be subtle in the early stage. Children are not always able to express their abdominal pain, and the physical examination is often aspecific for the different diagnoses. Laboratory testing of blood and urine as well is not very specific and may cause more confusion.[1,2]

Additional imaging diagnostics is possible using ultrasound or computed tomography. Ultrasound is easier, often more quickly available and gives less radiation exposure.[3] Studies in adults have indicated that ultrasonography allows to make the diagnosis of acute appendicitis with high sensitivity and specificity.[4,5] Other diagnoses as well can be made using ultrasound (intussusception, mesenteric lymphadenitis). In children with acute appendicitis a sensitivity of 90% and a specificity of 96% were reached.[6-9]

We investigated the role of ultrasound in children as an additional diagnostic means, primarily aiming at correct identification of the cause of acute abdominal pain, though also in view of preventing unnecessary (negative) laparotomies.

PATIENTS AND METHODS

The study population consisted of children aged from 6 months-15 years with abdominal pain less than two weeks previously, presenting in the Emergency Department of the Juliana Children's Hospital/Red Cross

Hospital from 1st June 1999 - 31st May 2000. Excluded were patients with abdominal pain on the basis of extra-abdominal pathology.

For each patient a medical history was taken, followed by physical examination and laboratory testing of blood collected in vacuette ® or minicollect ® capillary blood collection tubes (sedimentation, differential leukocytes count with differentiation) and urine (sedimentation). Sedimentation rate above 20 mm, and leukocyte count exceeding 12.0 x 10^9/l, were considered indications for an inflammatory process. Local peritonitis at physical examination in combination with elevated temperature and leukocytosis led to the clinical diagnosis of acute appendicitis. If one of these criteria was lacking the clinical diagnosis of acute appendicitis was rejected. A urinary tract infection was excluded if the sediment was negative. Frequent defecation was considered to be consistent with the diagnosis of gastroenteritis. On the basis of these data the clinical diagnosis was made (diagnosis I). The attending physician was asked to formulate a theoretical policy (policy I), i.e. opting between outpatient observation, clinical observation or laparotomy.

All patients were subjected to abdominal ultrasound within 1 hour after the clinical diagnosis had been made. The attending pediatric radiologist was not aware of the clinical diagnosis. A high-frequency transducer was used with the graded compression technique according to Puylaert.[3] Incompressibility of the appendix and/or the presence of an appendicolith, periappendicular fluid or infiltrate led to the ultrasound diagnosis of 'acute appendicitis'. The presence of lymph nodes next to a normal aspect of the appendix on ultrasound was reason for making the diagnosis mesenteric lymphadenitis. For the probable diagnoses 'enteritis' or 'urinary tract infection' ultrasound was of help in excluding other pathology. Frequent defecation or contaminated urine sediment was then decisive for the diagnoses mentioned above. Using the ultrasound findings the attending physician established the working diagnosis (diagnosis II) and on this basis decided on the policy to be pursued (policy II): outpatient observation, clinical observation or laparotomy. During observation the patient might recover or deteriorate, after which a laparotomy could still be decided upon.

The findings at laparotomy (in particular yes/no appendicitis) were recorded. The definitive diagnosis (diagnosis III) was based on histologic findings after laparotomy and after clinical or outpatient observation.

Diagnoses I and II with the proposed policies and diagnosis III for each patient were entered on a standard form. The value of ultrasound became evident by comparing the first policy with the second policy. The clinical diagnosis, the working diagnosis and the definitive diagnosis were compared to determine sensitivity, specificity, and predictive value.

RESULTS

We included 112 patients with a mean age of 9 years (8 months – 15 years). There were 60 boys and 52 girls. The most frequent clinical diagnosis was 'acute appendicitis' (61 patients, 54%) on the basis of a localized peritonitis with elevated temperature and leukocytosis, followed by 'enteritis' (26 patients) and 'lymphadenitis' (12 patients).

After making the clinical diagnosis (diagnosis I) it was decided (policy I) to operate upon 51 patients, to clinically observe 21 patients and to follow 40 patients as outpatients (*Figure 3.1*).

After ultrasound a second policy was established. The ultrasound-diagnosis was in 48 patients an appendicitis. Fifty-three patients were actually operated upon. Four patients were operated upon in spite of primary clinical observation. Three times an acute appendicitis was diagnosed, one time a Meckel's diverticulum. Four patients instead of outpatient follow up were operated upon as well, as indicated by the ultrasound. Of the latter, 3 patients appeared to have acute appendicitis and one a healthy appendix. In 45 patients ultrasound did not alter the proposed policy to perform laparotomy. Six of these appeared to have a healthy appendix. (in two cases the appendix was not visualized on ultrasound). In six patients (first singled out for laparotomy) after ultrasound it was decided not to perform laparotomy. One of these, however, later appeared to have an acute appendicitis, but in the five others a negative laparotomy was prevented.

The definitive diagnosis of 'acute appendicitis' was the most frequent (48 patients, 43%) followed by 'enteritis' and/or 'mesenteric lymphadenitis' (35 patients, 32%). 'Fecal impaction' was diagnosed in 9 patients, and 'urinary tract infection' in 8 patients. 'Postoperative ileus', 'Meckel's diverticulum' and 'intussusception' all occurred once. Per-operatively an appendix sana was found 7 times. Acute abdominal pain could be ascribed to ovarial cysts twice.

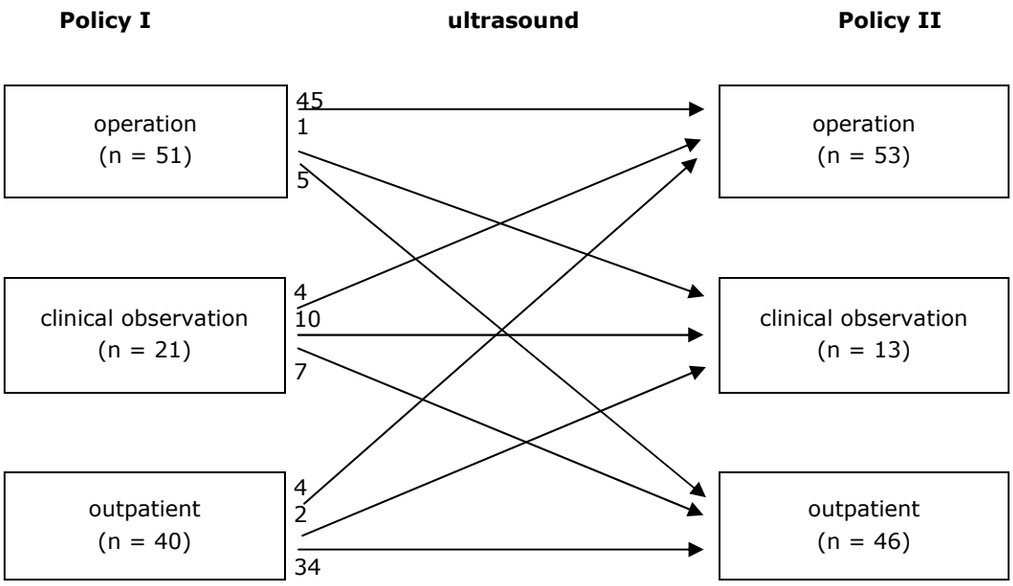

Figure 3.1 *Impact of ultrasound on policy pursued*

The clinical diagnosis (diagnosis I) was correct in 87 patients (78%), the working diagnosis after ultrasound (diagnosis II) was correct in 100 patients (89%). The clinical diagnosis and the ultrasound diagnosis for the whole patient population had similar sensitivity (88%). The specificity of ultrasound was higher than that of clinical diagnosis; 91% *vs*. 70%. The positive predictive value of the clinical diagnosis was 69% and that of the ultrasound diagnosis was 88%. (*Tables 3.1* and *3.2*)

Table 3.1 Sensitivity, specificity, predictive value of the clinical diagnosis in acute abdominal pain

Clinical diagnosis	**Definitive diagnosis***		**total**
	positive	negative	
positive	42	19	61
negative	6	45	51
total	48	64	112

Clinical diagnosis	*sensitivity 88%, specificity 70%*
Positive predictive value	*69%*
negative predictive value	*88%*

Table 3.2 Sensitivity, specificity, predictive value of the ultrasound diagnosis in acute abdominal pain

Utrasound	Definitive diagnosis*		total
	positive	negative	
positive	42	6	48
negative	6	58	64
total	48	64	112

Ultrasound *sensitivity 88%, specificity 91%*
Positive predictive value *88%*
negative predictive value *91%*
* *Diagnoses such as acute appendicitis, enteritis, mesenteric lymphadenitis, Meckel's diverticulum, urinary tract infection, ileus, intussusception and coprostasis. The diagnosis was definite when clinical or outpatient observation was ended or was based upon results of laparotomy (histologic findings).*

DISCUSSION

Establishing the correct diagnosis in children with acute abdominal pain within a short time is a challenge for the clinician. Acute abdominal pain occurs frequently in children. In one third to half of the cases of acute abdominal pain a viral infection, constipation, mesenteric lymphadenitis or the onset of gastroenteritis can explain the pain.[1,2] In children, an acute appendicitis often leads to the development of a local or diffuse peritonitis. Symptoms such as worsening of the abdominal pain, nausea, vomiting and diarrhea are significantly more often seen in case of local peritonitis. Also facial flushing, tachycardia, guarding and rebound tenderness are observed significantly more frequently in the case of either a local or diffuse peritonitis.[10] The term 'acute abdomen' should, therefore, only be used in the case of either a local or diffuse peritonitis. The physical-diagnostic examination of the abdomen points at peritonitis if guarding and rebound tenderness are present as well as muscular defense. Guarding and rebound tenderness are both expressions of the shifting of the inflamed parietal peritoneum in relation to the visceral peritoneum. Rebound tenderness would therefore be an unnecessary painful procedure for the patient.[11] Abdominal examination in children is often aspecific and its quality strongly depends on the assessor's experience. The more indistinct the symptoms are, the higher the value of ultrasound. Mesenteric lymphadenitis, acute appendicitis, intussusception, and intra-abdominal cysts can be visualized using ultrasound.[12]

Reported sensitivity and specificity of ultrasonography for acute appendicitis range from 82 to 90% and 96 to 100%, respectively.[10,11] Siegel *et al*. reported a sensitivity of 82 % and a specificity of 100% for the use of ultrasonography in the diagnostics of acute appendicitis.[9]
Another non-invasive diagnostic means is computed tomography (CT scan). Wilson *et al*. reported a sensitivity of 94% and a specificity of 92% for the use of CT scan in the diagnostics of acute appendicitis in patients aged from 4 to 81 years.[13] A noteworthy disadvantage of the use of CT scan is the radiation exposure to the patient. In addition, particularly children have difficulty in lying still during the procedure. Continuing uncertainty about the diagnosis has been mentioned as an indication for the use of the CT scan in the diagnostics of acute appendicitis.[14] Most important, however, are taking a thorough medical history, physical examination and ultrasonography.[15]

There are no literature reports of prospective studies evaluating the role of ultrasound in the diagnostics of acute pediatric abdominal pain. Although in our study the sensitivity of ultrasound did not exceed that of clinical examination (both 88%), the positive predictive value of the ultrasound diagnosis was much higher, 88% *versus* 69%. Additional ultrasound more often provided the correct diagnosis of the acute abdominal pain than did clinical examination only. Thus, ultrasound has either prevented negative laparotomies or has spared children from an unnecessary operation.

This prospective study once again confirmed that acute appendicitis is a highly frequent cause of acute abdominal pain in children referred to the emergency department for this reason (43%) and that other serious surgical diagnoses are rare. Thus almost any child with a "real" acute abdomen has an acute appendicitis until evidence to the contrary has been provided.

Ultrasound is a simple and child-friendly technique, and appeared to be of value in diagnosing acute appendicitis in children with an acute abdomen. Ultrasound more frequently assures the clinician that observation is rightly indicated rather than that it fails to notice an appendicitis. In addition, ultrasound more often identifies lymphadenitis next to a normal appendix and thus provides the clinician and the parents with an explanation for the complaints. Children under the age of two years will occasionally present with an invagination, which can be properly diagnosed using ultrasound.

Ultrasound has a distinct role in the assessment of acute abdominal pain in children. Ultrasound in addition to the clinical examination reduces the number of negative laparotomies. We, therefore, are of the opinion that ultrasound should be routinely used in the evaluation of acute abdominal pain in children.

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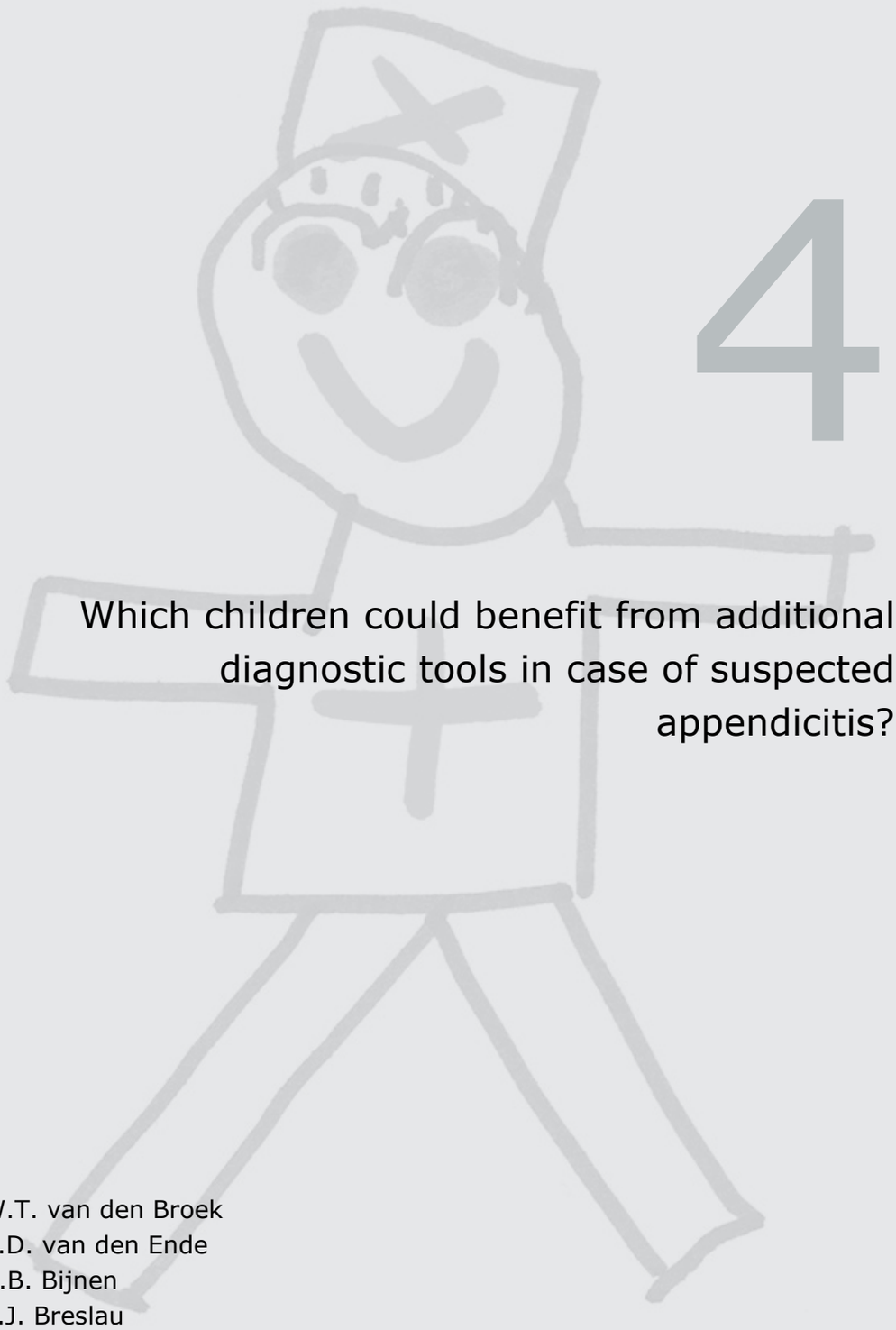

4

Which children could benefit from additional diagnostic tools in case of suspected appendicitis?

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Journal of Pediatric Surgery 2004;39:570-574

ABSTRACT

Background New diagnostic tools as ultrasound, CT-scan and diagnostic laparoscopy, have become available for children with suspected appendicitis, but should be reserved for equivocal cases in which it can contribute for diagnosis. The aim of this study is to develop a scoring system to identify this subgroup of children.

Methods Patients from 2 different periods: period 1, 99 consecutive children (group 1) and in period 2, 62 consecutive children (group 2) with suspected appendicitis were prospectively evaluated. Variables predicting appendicitis were obtained from group 1. By means of a regression analysis, a scoring system was created and applied to the patients of group 2. The clinical outcomes in terms of delayed and negative appendectomy rates obtained by clinical practice were compared with the results that would have been accomplished based on the scoring system. Thereafter the scoring system was applied and so externally validated in a group of children presented in another hospital (group 3, n = 114).

Results The variables: leukocytes count ≥ 10.10^9/l (2 points); rebound tenderness (2 points) and temperature ≥ 38°C (1 point) correlated significantly with the diagnosis appendicitis. The scoring system was used to categorize patients into three groups: appendicitis unlikely, doubtful appendicitis and suspected appendicitis. The specificity and sensitivity of the scoring system were respectively 85% and 89%. Applying the scoring system would lead to comparable negative appendectomy rates of 8% *versus* 6% using clinical judgement and a comparable number of performed laparoscopies: 26% *vs* 31%. However, it could lead to a lower missed appendicitis rate: (1% *vs* 6%) and a lower perforation rate (0% *vs* 11%). External validation showed comparable performed laparoscopies (32%) and delayed appendectomies (2%) rates but a higher negative appendectomy rate (19%), possibly due to a lower percentage of appendicitis in hospital 2 (47%) compared to hospital 1 (71%).

Conclusions Children can be observed if leukocyte count is less than 10.10^9/l and rebound tenderness is absent; a diagnostic laparoscopy should be performed if leucocyte count is more than 10.10^9/l or if renound tenderness is present, and if both are present one could perform an appendectomy.

INTRODUCTION

The clinical diagnosis acute appendicitis remains difficult in children.[1,2] To increase diagnostic accuracy new modalities as ultrasound, CT-scan , and diagnostic laparoscopy have been introduced.[3-7] Laparoscopic appendectomy is feasible in children and has shown subtle advantages (less postoperative pain and shorter hospital stay) over open appendectomy.[8-10] Diagnostic laparoscopy for acute abdominal pain however, has been used for many years.[11,12] Because of the relatively high costs and possible complications from this invasive diagnostic procedure, we reported previously that laparoscopy should be applied selectively on patients where it can most effectively contribute to obtain the diagnosis.[13] Therefore, a method should be developed to define the subgroup of children with a doubtful diagnosis of appendicitis that can benefit from diagnostic laparoscopy.

Several scoring systems have already been developed in adults, achieving negative appendectomy rates between 5 to 17.5% and false negative rates between 0 to 7%.[14-17] Applying these systems on patients in other hospitals however, lead to considerable higher negative appendectomy rates ranging between 13 to 37% and false negative rates ranging between 0,9 to 13% and are therefore not recommended as a standard tool for diagnostic decision making in suspected appendicitis.[18-20] This current study aims to define a new scoring system in an attempt to identify a group of children with a doubtful diagnosis of appendicitis that could optimally benefit from extra diagnostic tools such as diagnostic laparoscopy. The scoring system was tested in another group of patients and finally externally validated by the application on a group of children presented in another hospital.

MATERIALS AND METHODS

The study was performed in two hospitals with different referral areas from general practitioners: the Medisch Centrum Alkmaar (hospital 1), Alkmaar, The Netherlands and the Rode Kruis Ziekenhuis (hospital 2), The Hague, The Netherlands.

In hospital 1, consecutive children (age 11 years), referred to the hospital by general practitioners for suspected appendicitis, prospectively evaluated in a consecutive period of 4 years. The suspicion of appendicitis

was made by the general practitioners and based on clinical criteria (history, physical examination, and laboratory examination: white cell count and C-reactive protein). There were 2 groups created: Group 1 patients included in the first 2 years. Group 2, the patients included in the second period of 2 years.

Among others, the variables: age, sex, duration of symptoms, rectal temperature, rebound tenderness and white cell count (WCC) were collected. Based on clinical judgment, patients were categorized as unlikely (n = 35), doubtful (n = 45), or highly suspected (n = 65) having appendicitis, and accordingly they were observed, submitted to laparoscopy, or an open procedure was performed, respectively. Imaging techniques such as CT scan and ultrasound were not used.

Children were observed clinically or on an outpatient basis if this was socially and practically acceptable. In case of increasing symptoms they were re-evaluated immediately or otherwise routinely after one day at the emergency ward. Depending on the actual symptoms, these primarily observed patients (n = 35) were then discharged (n = 25), underwent diagnostic laparoscopy (n = 5), or an open appendectomy (n = 5). When observed patients did not have signs of acute appendicitis, and abdominal complaints were diminished, we assumed that they suffered from a self-limiting disease.

At laparoscopy, a normal appendix routinely was left in place; an inflamed appendix was removed laparoscopically or by muscle splitting incision, depending on the experience of the surgeon. During an open procedure the appendix was always removed irrespective of the macroscopic appearance. Histological examination was performed on all removed appendices.

Group 3 represents children (age 15 years) presented in hospital 2 who were prospectively evaluated for acute abdominal complaints as part of another study. The same variables as used in hospital 1 were collected. There were no diagnostic laparoscopies performed in hospital 2 but they all underwent an ultrasound, which determined further treatment.

Except for a lower percentage of patients with appendicitis in group 3, there were not differences between groups, as shown in *table 4.1*.

Table 4.1 Patient's characteristics

	Group 1*	Group 2+	Group 3#
No.	99	62	114
Age	9.3 (2.0)	9.1 (2.0)	9.0 (3.3)
Male	51 (51%)	35 (57%)	62 (54%)
Female	48 (49%)	27 (43%)	52 (46%)
Appendicitis	65 (66%)	50 (81%)	54 (47%) $P < .001$

* *Patients hospital 1 period 1994 - 1995*
\+ *Patients hospital 1 period 1996 to 1997*
\# *Patients hospital 2*

Data were analyzed with the use of the SPSS computer program. Negative appendectomy rates, missed appendicitis (ie, delayed operation), and perforation rates were calculated. In order to compare these results with the scoring system, the patients of whom we could retrieve all variables for the scoring system 143/161 (89%) in hospital 1 and 114/114 (100%) in hospital 2, were considered.

Creating the scoring system

From the children of group 1, variables were obtained that correlated significantly with the prevalence of appendicitis by using X square tests. Sensitivity and specificity rates of these variables were calculated.

Hereafter we performed a regression analysis to establish how strongly the individual variables contribute to the diagnosis appendicitis. Based on the regression coefficients, each significant variable was given a score. The final score was created by the sum of these scores, varying from 0 to 5.

Validation and clinical testing of the scoring system

The scoring system was validated by comparing odds ratios for score of group 1 with the independent patient group 2. To evaluate the clinical value of the scoring system, data of both group 1 and group 2 were combined.

By choosing 2 cut-off points in our scoring system, patients were divided into three groups: low probability, amenable to observation; intermediate probability, necessitating further diagnostic tools such as diagnostic laparoscopy; and high probability of appendicitis, justifying immediate appendectomy by muscle splitting incision. Because the final diagnosis in all cases is known, the sensitivity, specificity rates can be calculated.

Finally, the results that would have been obtained from applying the system were compared to the actual results of clinical practice, performed in the same series.

External validation of the scoring system

Thereafter the scoring system was applied to children from hospital 2. Number of performed laparoscopies, delayed appendectomies and negative appendectomy rates that would have been obtained if the scoring system was used in hospital 2 were calculated and compared with the results of hospital 1.

RESULTS

Creating the scoring system

The following 2 objective variables: temperature (≥ 38 °C) and White Cell Count (WCC ≥ 10.10^9/l) and the subjective variable: rebound tenderness, correlated significantly ($P \leq 0.01$) with appendicitis. The other variables were not significantly correlated. By means of a logistic regression model, these variables were allotted a certain weight by deriving them from the regression coefficients (RC) instead of using the exact RC, in order to make the scoring system workable in a practical setting (*table 4.2*).

Table 4.2 Variables predicting appendicitis in group 1 (n = 99) obtained by χ^2-Tests

	Sens	Spec	χ^2	*P* Value[1]	RC	*P* Value[2]	Score
Rebound tenderness	0.87	0.78	40.195	.001	2.8102	.001	2
Leukocyte count (≥ 10.10^9/l)	0.80	0.76	29.816	.001	2.1302	.001	2
Temperature (≥ 38 °C)	0.72	0.50	4.861	.024	0.5536	.3696	1
Duration symptoms (< 48 hr)	0.77	0.41	3.531	.051	-	-	-
Sex (male)	0.50	0.44	0.395	.339	-	-	-
Maximal score							5

Note: Score based on regression coefficient (RC) of variable in regression analysis
P Value[1] *P value obtained by χ^2-Tests*
P Value[2] *P value obtained in logistic regression analysis*

Validation of the scoring system

The incidence of appendicitis for each score is shown in *table 4.3*. As expected, the percentage of appendicitis increases with higher scores (score 0, 0% to score 5, 93% in group 1). The odds ratio of score was 2.4 in this group, which means that an increase of 1 point contributes to a 2.4

higher chance of having appendicitis. The odds ratio of score in group 2 was comparable, namely 3.2 which validates it as a reproducible scoring system in this setting. Because the findings in group 1 and group 2 do not differ they have been combined for further analysis to evaluate its efficiency in the clinical setting.

Table 4.3 Distribution of appendicitis among the different scores in group 1, 2, and 3

	Group1		Group 2		Group 3	
score	Normal	Appendicitis	Normal	Appendicitis	Normal	Appendicitis
0	11	0 (0%)	1	0 (0%)	22	1 (4%)
1	10	1 (9%)	1	0 (0%)	5	0 (0%)
2	4	8 (67%)	1	2 (67%)	5	0 (0%)
3	5	10 (67%)	0	7 (100%)	8	3 (27%)
4	2	10 (83%)	0	9 (100%)	7	19 (73%)
5	2	36 (95%)	2	21 (91%)	3	21 (88%)

Observed results

From 143 children, all evaluated variables could be retrieved and were amenable for comparing with the scoring system. The 18 remaining children were not amenable because the variable temperature was lacking. Clinical practice led to an overall 6% negative appendectomy rate and 6% missed appendicits rate. Thirty-one percent of the patients underwent primary diagnostic laparoscopy. In the 3 different groups created by clinical judgment the percentage appendicitis was respectively 17%, 82% and 97%, shown in *table 4.4*.

Table 4.4 Outcome of treatment of patients by clinical practice, patients group 1 and 2

	Patients	Appendectomy	Appendicitis	Normal Appendix removed	perforation
Observation	35	7 (20%)	6 (17%)	1 (3%)	4 (11%)
Laparoscopy	45	41 (91%)	37 (82%)	4 (9%)	4 (9%)
Open Operation	63	63 (100%)	61 (97%)	2 (3%)	9 (14%)
Total	143	111 (78%)	104 (73%)	7 (6%)	17 (12%)

Note: Missed appendicitis rate, 6 of 104 (6%); negative appendectomy rate, 7 of 111 (6%)

Clinical testing of the scoring system

The scoring system was used with 2 cut-off points to determine a treatment strategy: observation, laparoscopy, or appendectomy. The low

cut-off point will be determined by the sensitivity rate (indication for the capability of the test to rule out appendicitis), as the specificity rate (indication for the capability of the test to demonstrate appendicitis) will be useful in determining the level of the high cut-off point. A receiver-operator characteristic curve for the scoring system applied to all patients is presented in *Fig 4.1*.

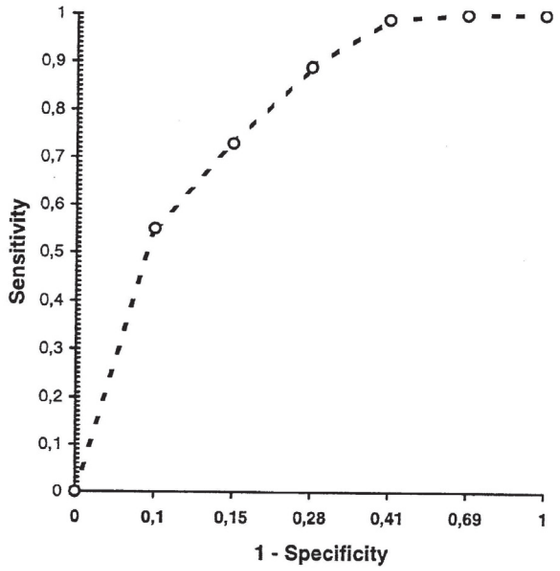

Figure 4.1 *Receiver-operator characteristic curve*

Varying the low and high cut-off points would affect the different numbers of delayed diagnosed appendicitis, performed laparoscopies and negative appendectomy rates. The optimal low cut-off point is located somewhere between 2 and 3, i.e. patients with the scores 0 and 1 would be observed (sensitivity rate 0.89), in combination with a high cut-off point of 3 (specificity rate 0.85), i.e. patients with scores 4 and 5 will undergo directly appendectomy by muscle splitting incision. This would (theoretically) lead to a delayed appendectomy rate of 1/104 (1%) and a negative appendectomy rate of 6/110 (5%). In this scenario 37 of 143 (26%) diagnostic laparoscopies would be performed (*table 4.4*). Because our series, after diagnostic laparoscopy, in 9% a normal appendix was incorrectly removed, the overall negative appendectomy rate might in practice be higher, namely (3 + 6)/(30 + 83) = 8%, shown in *table 4.5*.

Table 4.5 Theoretical results of outcome according to the scoring system using cut-off point 1 and 3 (Hospital 1, group 1 and 2)

	patients	**appendectomy**	**Appendicitis**	**Normal appendix removed**	**perforation**
Observation	24	1 (4%)	1 (4%)	-	0 (0%)
Laparoscopy	37	30 (81%)	27 (73%)	3 (9%)	5 (14%)
Open operation	82	82 (100%)	76 (93%)	6 (7%)	12 (15%)
Total	143	113 (79%)	104 (73%)	9 (8%)	17 (12%)

Note: Low cut-off point, 2: patients with scores 0 and 1 will be observed. High cut-off point, 4: patients with scores 4 and 5 will undergo directly appendectomy by muscle-splitting incision. Patients with score 2 and 3 will undergo diagnostic laparoscopy. Missed appendicitis, 1 of 104 (1%); negative appendectomy, 9 of 113 (8%).

In the 3 different groups created by our cut-off points 1 and 3, the percentage appendicitis was respectively 4%, 73% and 93%, shown in *table 4.5*.

External validation of the scoring system

Applying the scoring system on children from group 3 would lead to 2% delayed operation rate with 36 (32%) performed diagnostic laparoscopies. When an expected 9% negative appendectomy rate of the children who undergo diagnostic laparoscopy is taken into account, the overall negative appendectomy rate would be 13 of 67 (19%). In the 3 different groups created by the scoring system the percentage appendicitis was respectively 4%, 36%, and 80%, shown in *table 4.6*.

Although the variable temperature was significant in predicting appendicitis (P = 0.024) when using de univariate χ^2-test, in the multivariate analysis, temperature was not significant (P = 0.3696).

Table 4.6 Theoretical results of outcome of treatment according to the scoring system, using cut-off points 1 and 3 (Hospital 2, group 3)

	Patients	appendectomy	appendicitis	Normal appendix removed
Observation	28	1 (4%)	1 (4%)	-
Laparoscopy	36	16 (44%)	13 (36%)	3 (8%)
Open operation	50	50 (100%)	40 (80%)	10 (20%)
Total	114	67 (59%)	54 (47%)	13 (20%)

Note: Missed appendicitis, 1 of 54 (2%); negative appendectomy 13 of 67 (19%)

Therefore, temperature greater than 38 °C contributed for only 1 point in our scoring system. When using cut-off points 1 and 3, temperature does not contribute in determining the further strategy because patients with scores of 0 and 1 will be observed, patients with scores of 3 and 4 will undergo diagnostic laparoscopy, and patients with scores of 5 and 6 will undergo direct appendectomy. So the scoring system could be simplified by concluding that if both elevated leukocyte count and rebound tenderness are not present, the child can be observed; if 1 of the 2 variables is present a laparoscopy should be performed; and if both variables are present, one could directly proceed with an appendectomy.

Because of lack of the variable temperature, only 89% of our children could be evaluated. Our simplified scoring system could now be applied on all children (n = 161), which would lead to a missed appendicitis of 1 of 115 (1%), 45 (28%) performed laparoscopies, and a negative appendectomy rate of 7 of 122 (6%). Our clinical practice in all children led to 6 of 115 (5%) delayed appendectomies, 52 (32%) performed laparoscopies, and a negative appendectomy rate of 11 of 126 (9%). Because in 5 of 52 (10%) of children who underwent a laparoscopy, a normal appendix was removed, the corrected negative appendectomy by our simplified scoring system would be 11 of 126 (9%).

Discussion

The current study showed that improved results could be obtained by applying diagnostic laparoscopy selectively in case of clinical doubt in the diagnosis, because there are subsets of children in whom the diagnosis of appendicitis is almost certain and in some, very unlikely. This study shows that such subsets can be identified by good clinical judgment but even more effectively by a simple , reproducible scoring system because the scoring system would lead to lower missed appendicitis rates (1% *vs* 6 %) and lower perforation rates in the primary observed patient group (0% *vs* 11%) as shown in *tables 4.3* and *4.4*. Because using the scoring system would also reduce the number of performed laparoscopies (26% *vs* 31%), it would lead to lower costs for children with suspected appendicitis. Negative appendectomy rates (8% *vs* 6%) will not improve by using the scoring system. Scoring could be of help in the preclinical setting and for less experienced physicians by preventing unnecessary delay in applying further diagnostic tools on these children.

Unfortunately, a relatively large number of normal appendices (9%) were removed in the laparoscopy group for unclear reasons, and this was taken into account in evaluating the scoring system. The overall negative appendectomy rate of 8% could, therefore, considerably be improved, namely, to 5%, if the indication for appendectomy after laparoscopy would be more thoughtfully imposed.

The outcome of scoring systems could depend on the prevalence of appendicitis in the referred patient population, which depends on different referral policies by general practitioners. Therefore, it was also applied on children referred to another hospital by other general practitioners. The percentage of appendicitis was higher in hospital 1 (71%) compared with hospital 2 (47%). As a result, applying the scoring system led to a comparable missed appendicitis rate (1%) and comparable performed laparoscopies (35%) but also to a relative high negative appendectomy rate of 19%. So, the scoring system performed well for excluding appendicitis but performed less for showing appendicitis. Therefore, the current scoring system was not validated under different conditions. A possible cause for the high negative appendectomy rate that would have been obtained using the scoring system in hospital 2 might be that children in hospital 2 differ in age (15 years *v* 11 years) and because in hospital 2 all acute abdominal complaints were evaluated instead of only patients with suspected appendicitis.

Scoring systems for adults have previously been devised by others to decide whether to operate. In the current study, the scoring system is used to define a group of patients in whom addition laparoscopy or other diagnostic tools can be helpful. The correlation between score and likelihood of appendicitis allows us to choose cut-off points to increase the diagnostic yield of addition diagnostic tests. The number of needed diagnostic laparoscopies will be determined by the percentage of negative appendectomies that is regarded acceptable. Cost-efficiency studies (laparoscopies *v* perforation risk and negative appendectomies) should optimally determine the choice of those points but are not yet available.

The subset of patients in which laparoscopy can contribute in obtaining the diagnosis appendicitis can be identified by our clinical judgment or by a simple scoring system.

ACKNOWLEDGEMENT

The authors thank E.S.M. de Lange from the bio-statistics department of the Free University Hospital, Amsterdam, The Netherlands, for her contribution in the statistical analysis.

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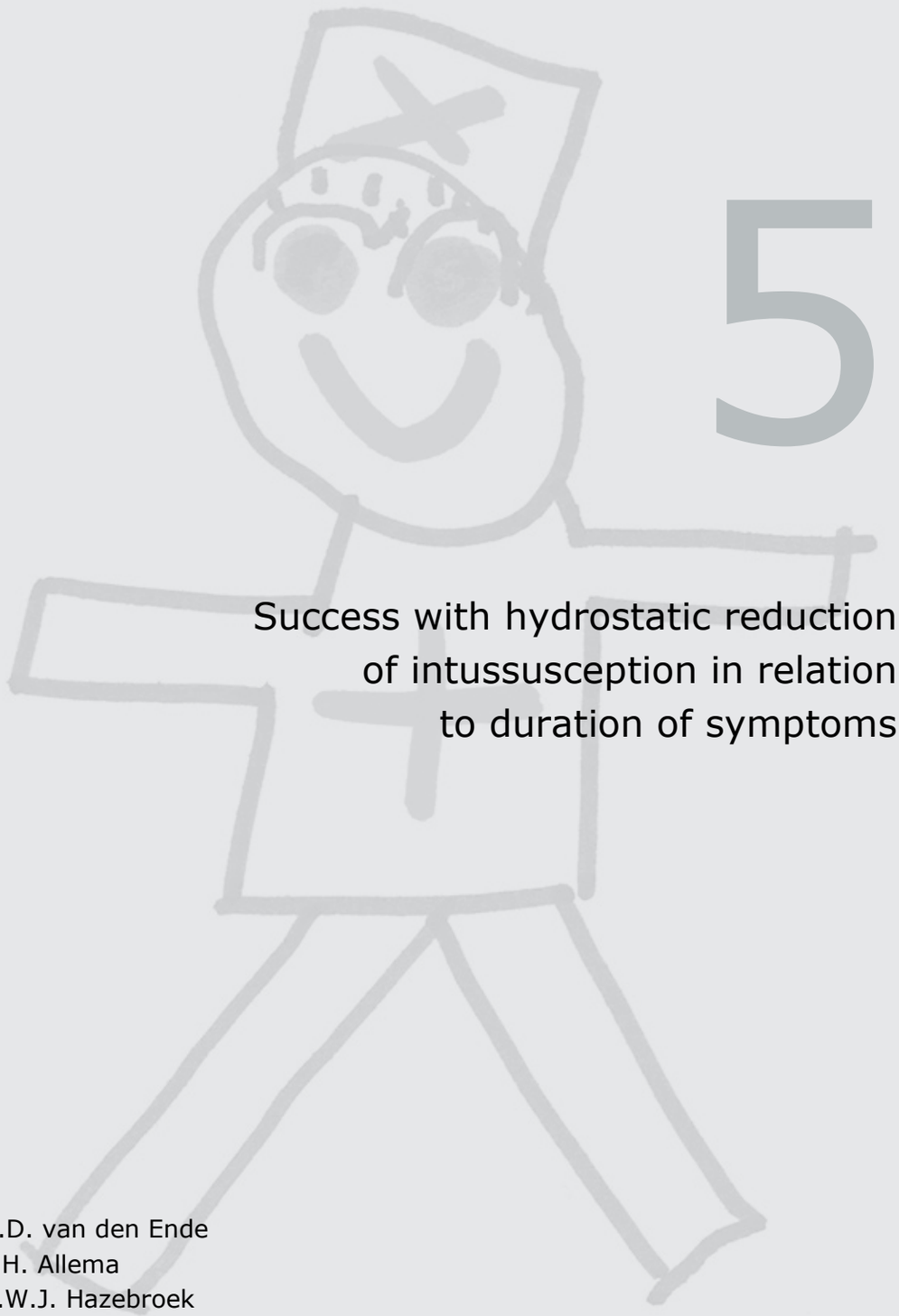

5

Success with hydrostatic reduction of intussusception in relation to duration of symptoms

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Archives of Disease in Childhood 2005;90:1071-1072

ABSTRACT

Background It is widely believed that hydrostatic reduction of intussusception is less successful in children with prolonged symptoms prior to presentation.

Aim To prospectively evaluate success in relation to duration of symptoms.

Methods Prospective study in which children, regardless of the symptom duration, underwent an attempt at hydrostatic reduction.

Results Of 113 children presenting with intussusception, 16 had peritonitis and required immediate laparotomy. A hydrostatic reduction was attempted in 97 and was successful in 77 (79%). There were 26 successful reductions with symptoms < 12 hours (81%); 30 with symptoms for 12 - 24 hours (81%), and 21 with symptoms > 24 hours (75%).

Conclusion The success rate with hydrostatic reduction was not significantly influenced by symptom duration.

INTRODUCTION

Intussusception is the most common abdominal emergency in early childhood, particularly in children younger than 2 years of age.[1]

It has been reported that successful hydrostatic reduction may be less likely in patients with symptoms for more than 48 hours, and consequently patients with prolonged symptoms are nowadays likely to undergo operative reduction as the first line treatment.[1-3] Since there is little evidence to support this policy we undertook a prospective study to examine our success with hydrostatic reduction in relation to duration of symptoms.

METHODS

All children presenting to the Sophia Children's Hospital, Rotterdam or the Juliana Children's Hospital, The Hague, with ultrasound proven intussusception from January 1998 to December 2002 were included. A hydrostatic reduction was performed unless there was clinical or radiological evidence of peritonitis or perforation. Patient details, including nature and duration of symptoms, physical findings, laboratory results, and the findings on abdominal x-ray and ultrasound were prospectively recorded.

Hydrostatic reduction was performed using a standard protocol in which a 40 ml balloon catheter was positioned in the rectum, and a reservoir containing water-soluble contrast medium was positioned 100 cm above the patient and contrast then instilled into the colon. If reduction did not occur the contrast reservoir height was increased to 120 cm. If this was unsuccessful the patient underwent a laparotomy.

Ethical approval for the study was obtained in both participating hospitals.

RESULTS

A total of 113 patients presented with an intussusception, 55 to the Juliana Children's Hospital and 58 to the Sophia Children's Hospital. There was a male dominance (3:2) and 84% were under 2 years of age.

Presenting symptoms included vomiting (86%), abdominal pain (67%), and rectal blood loss (63%). An abdominal mass was palpable in 35%.

The most commonly identified lead point appeared to be lymphoid hyperplasia, but in five cases a Meckel's diverticulum was responsible.

Peritonitis was present in 16. Of these, bowel resection was necessary in seven, the other nine undergoing manual reduction. Of the seven requiring resection, six had presented with symptoms for more than 24 hours. However, of the nine in whom the intussusception could manually be reduced; six had symptoms for more then 24 hours.

Hydrostatic reduction was attempted in 97 (86%), and was successful in 77 (79%). There were 26/32 successful reductions with symptoms less than 12 hours, 30/37 with symptoms for between 12 and 24 hours, and 21/28 with symptoms for more than 24 hours (*Table 5.1*). In the latter group 62% had symptoms for more then 48 hours, and the mean duration was 57 hours. In nine cases there was a recurrence of the intussusception within 12 hours of successful hydrostatic reduction. In four of these this was treated successfully by repeat hydrostatic reduction. The other five underwent laparotomy, and three required bowel resection (Figure 5.1)

In 20 hydrostatic reduction was unsuccessful, including one case in which a bowel perforation occurred during the procedure. In 15 of these, resection of the intussusception was required; five of them had symptoms for more than 24 hours. In five of the 20, manual reduction was possible.

Table 5.1 Duration of symptoms and results of hydrostatic reduction

	< 12 hours	**12 - 24 hours**	**> 24 hours**	**total**
Successful hydrostatic reduction	26 (81%)	30 (81%)	21 (75%)	77
Unsuccessful hydrostatic reduction	6 (19%)	7 (19%)	7 (25%)	20
total	32	37	28	97

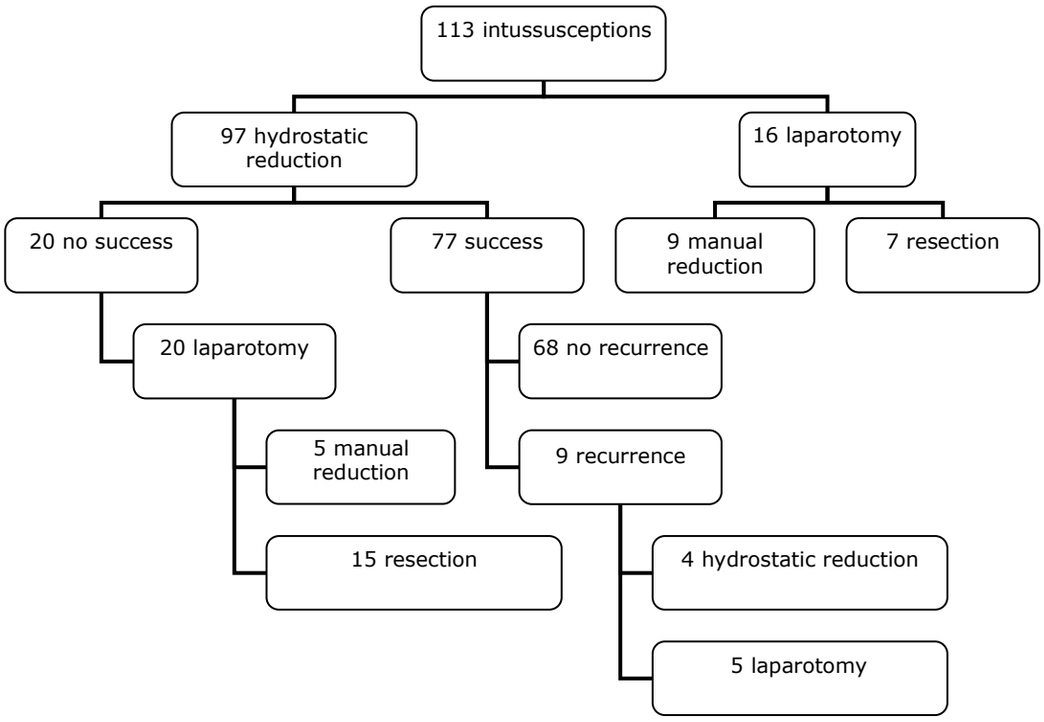

Figure 5.1 *Summary of results*

DISCUSSION

The symptoms of intussusception are non-specific.[4-6] In our population only 13% of the children presented with classical symptoms. Ultrasound is a reliable diagnostic tool with a sensitivity and a specificity close to 100%.[7-11] The role of the abdominal radiograph is more controversial, and its main value may be in excluding the presence of free air in the abdomen.[12,13]

Non-operative reduction using barium or air contrast techniques is successful in about 75 – 90% of patients.[11] In this study the success rate with hydrostatic reduction was 79%. Several authors have reported that the success rate of hydrostatic reduction is lower and the risk of perforation risk higher in patients with symptoms for more than 48 hours,[1-3] while others have reported that although the likelihood of hydrostatic reduction may be reduced, the risk of complication is no greater in patients with a longer duration of symptoms.[14] In this study we did not find that the likelihood of successful hydrostatic reduction was less in those with more prolonged symptoms at presentation.

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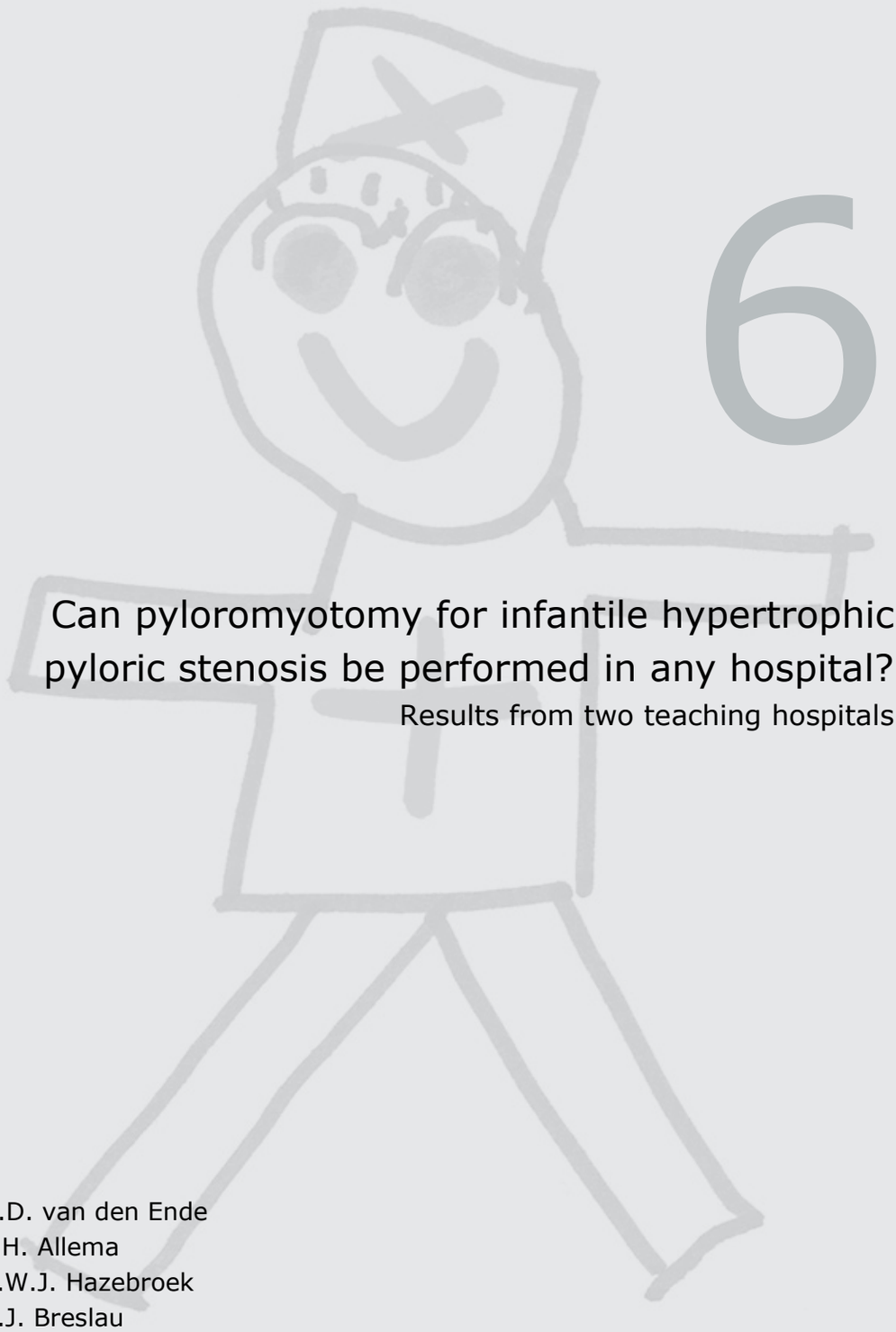

6

Can pyloromyotomy for infantile hypertrophic pyloric stenosis be performed in any hospital?

Results from two teaching hospitals

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European Journal of Pediatrics, in press

ABSTRACT

Background In order to document the incidence of peri-operative complications in patients with infantile hypertrophic pyloric stenosis a descriptive cohort study was performed in two teaching hospitals in the Netherlands, one hospital specialized in pediatric surgery and the other in general surgery.

Methods All consecutive infants who underwent pyloromyotomy for the diagnosis hypertrophic pyloric stenosis in both hospitals between 1998 and 2002 were included. All children were diagnosed according a standard protocol. From all charts complications durante and post-operationem were recorded.

Results A total of 256 pyloromyotomies were performed. Registered per-operative complications were duodenal mucosal perforation (n = 6; 2%). Per-operatively unrecognized duodenal mucosal perforation occurred four times (1%). Once a re-operation was performed for an incomplete pyloromyotomy (0.3%). Persistent vomiting after the operation occurred in 18 children (7%). A large majority of post-operative complications were wound infections (n = 16; 6%); most of them were treated with antibiotics and/or incision for drainage of an abscess. An incisional hernia occurred four times. Prolonged vomiting was the only post-operative complication that differed significantly between the two teaching hospitals.

Conclusion The overall percentage of complications were equal to complication rates in literature and since there were no significant differences in major complications between the two teaching hospitals in this study, we can conclude that pyloromyotomy can be performed safely in specialized centres and in general centres provided with a multidisciplinary team.

INTRODUCTION

Infantile hypertrophic pyloric stenosis (IHPS) is the second commonest indication for surgical correction in children, following inguinal herniorrhaphy.[1] The classic presentation of hypertrophic pyloric stenosis is the three- to six-week-old-baby who develops immediate postprandial, often projectile vomiting and on physical examination has a palpable mass in the upper abdomen.[2] The diagnosis should be confirmed by ultrasound.[3]

The current surgical procedure of choice is the pyloromyotomy according to Ramstedt.[4] Intra-operative complications, such as duodenal perforation occur in 4% of patients operated for IHPS and in 6% of the patients the post-operative period is complicated with one or more of the following unfavorable entities; wound infections, incisional hernia, incomplete pyloromyotomy, and persistent vomiting.[1]

Some authors have suggested that the pyloromyotomy, irrespective of the approach, should always be performed by pediatric surgeons to prevent unnecessary complications.[13,14] But others are certain that a good cooperation between pediatricians, anesthesists, and surgeons is seen as the key to the low complication rates.[15]

In order to document the incidence of peri-operative complications in patients with IHPS treated in a pediatric university center compared to a general teaching hospital, a descriptive cohort study was performed in two teaching hospitals in the Netherlands; the Erasmus MC-Sophia Children's Hospital in Rotterdam, a specialized pediatric surgical center, and the Juliana Children's Hospital in The Hague, a regional teaching hospital.

PATIENTS AND METHODS

All consecutive infants in both hospitals who underwent pyloromyotomy for the diagnosis IHPS from 1998 through 2002 were included. Patients had been referred by general practitioners directly as well as secondarily from other community hospitals. They were diagnosed according a standard protocol. The clinical diagnosis was confirmed with ultrasound in all cases. After metabolic correction, the infants were operated upon, by teams consisting of a pediatric anesthesiologist, a general or pediatric surgeon, and most of the time a resident. In the general teaching hospital the procedure was supervised by a general surgeon, in the pediatric

university center by a pediatric surgeon. In the pediatric center the umbilical incision was increasingly used from 2000 onwards. The pyloromyotomies were not performed by laparoscopy but with an open extramucosal procedure in both centers according Ramstedt. The pyloromyotomy is established by a sero-muscular incision of the enlarged pylorus; the incised layers are spread with a blunt dissector, until the mucosa is free to bulge into the split muscle. Antibiotic prophylaxis was not used routinely. Postoperative feeding protocols were only changed in case of persisting emesis. The fisher exact test was used to calculate statistical difference.

Age, sex, secondary referral status, a family history of pyloric stenosis, prematuritas, weight on admission, metabolic status, ultrasound findings, operative approach, operating time, intra- and postoperative complications durante and post-operationem, and length of hospital stay were retrieved from the hospital charts. Length of hospital stay included the preoperative period, for correction of metabolic disorders, and the postoperative period, for initializing oral feeding. Complications analyzed from follow up data after discharge from hospital were recorded.

RESULTS

A total of 256 infants had undergone pyloromyotomy in de study period, i.e. 176 (male: female 151:25) in the pediatric center and 80 (male: female 68:12) in the regional hospital. Secondary referrals were 131 to the pediatric center and 36 to the regional hospital. A total of 56 infants had been born prematurely (< 37 weeks gestation), 40 of whom were treated in the pediatric center. A positive family history for hypertrophic pylorus stenosis was documented in 58 families, 21 children were one of twins. (*Table 6.1*)

The children had been hospitalized after a period of vomiting with an overall mean length of 8.6 days ± 8.8. The pre-admission period for patients in the pediatric center was 9.9 ± 9.7 days and in the regional hospital 5.5 days ± 5.1.

Metabolic alkalosis was present in most of the patients. The pH was elevated (> 7.45) in 92 patients (36%) and 161 patients (63%) had base excess over 2.5. Hypochloraemia was found in 62 patients (24%) (*Table 6.2*).

Table 6.1 Patient data

	Regional hospital (n = 80)	**Pediatric center** (n = 176)	**Total** (n = 256)
age (days ± SD) *	38 ± 22	36 ± 22	37 ± 15
sex (M : F)	68 : 12	151 : 25	219 : 37
secondary referral (n)	36	131	167
prematuritas (n)**	16	40	56
birth weight (g ± SD)	3362 ± 599	3224 ± 739	3239 ± 724
family history IHPS*** (n)	15	43	58
one of twins (n)	8	13	21
concomittant congenital disorder (n)	1	10	11

* *age on admission*
** *prematuritas is defined as a pregnancy of less than 37 weeks.*
*** *A family history of IHPS (infantile hypertrophic pyloric stenosis) was considered present if a first or second degree relative had been operated on for IHPS.*

Table 6.2 Patient data and laboratory results on admission

	Regional hospital (n = 80)	**Pediatric center** (n = 176)	**Total**
Duration complaints (days, mean)	5.5 ± 5.1	9.9 ± 9.7	8.6 ± 8.8
Clinical signs of dehydration (n)	2	21	23
Weight on admission (grams, mean)	3820	3720	3770
pH (mean)	7.42 ± 0.06	7.44 ± 0.07	7.43 ± 0.06
BE > 2.5 (n)	45	116	161
Serum chloride < 98 (n)	29	33	62
Muscle layer (mm, mean)	4.9 ± 0.9	4.3 ± 1.4	4.4 ± 1.5

In all patients an ultrasound had confirmed the clinical diagnosis. Eight patients did not fulfill the ultrasonic definition of a duodenal muscular layer thickness exceeding three millimeter. Their operation had been postponed, but when clinical symptoms persisted it was decided to let the clinical diagnosis prevail. In all eight a hypertrophic pylorus was found intra-operatively. Umbilical incision was used in 109 patients, all in the pediatric center. Overall mean length of hospital stay was 6.9 days (SD ± 5.0): 6.0 ± 3.3 days in the regional center and 7.1 ± 5.6 days in the pediatric center (*Table 6.3*).

Documented intra-operative complications were per-operatively recognized duodenal mucosal perforation in 6 patients (2%). These perforations occurred 3 times after a right upper quadrant incision and 3 times after an umbilical incision. These duodenal mucosal perforations had

been closed without further implications, except in one infant who was administered antibiotics for 5 days postoperatively.

Per-operatively unrecognized duodenal mucosal perforation occurred in 4 patients (1%), in 2 after right upper quadrant incision and in 2 after an umbilical incision. They all were re-operated.

One patient was re-operated for an incomplete pyloromyotomy (0.3%). Persistent vomiting after the operation (> 5 days) was documented in 18 children (7%), in 10 of these 18 children the pyloromyotomy was done through the umbilical incision. Two of these children underwent repair of an accidental per-operative duodenal mucosal perforation and had longer hospital stay as a matter of course. Prolonged vomiting was the only post-operative complication, that was significantly different between the two hospitals in this study.

Wound infection was found to be the most frequent postoperative complication (n = 16; 6%); most of them were treated with antibiotics and/or incision for drainage of an abscess. Most wound infections occurred after right upper quadrant incision of the abdomen (n = 12; 8%). 4 times a wound infection was seen after an umbilical incision (n = 4; 4%).

An umbilical incision was complicated by an incisional hernia three times; an incision in the right upper quadrant was once complicated by an incisional hernia. In *table 6.4* an overview of complications is illustrated and the number of complications in both hospitals are presented separately.

Table 6.3 Clinical parameters

	Regional hospital (n = 80)	**Pediatric center** (n = 176)	**Total**
Hospital stay (days, mean)	6.0 ± 3.3	7.1 ± 5.6	6.9 ± 5.0
Right upper quadrant incision (n)	80	67	147
Umbilical incision (n)	0	109	109
Weight on discharge (grams, mean)	3954	3789	3806

Table 6.4 Peri-operative complications

	Regional hospital (n = 80)	**Pediatric center** (n = 176)	**Total** (n = 256)	***P*-value** (< .05 = significant)
Duodenal perforation*	0 (0%)	6 (3%)	6 (2%)	0.18
Duodenal perforation**	1 (1%)	3 (2%)	4 (1%)	1.0
Incomplete pyloromyotomy	0 (0%)	1 (0.5%)	1 (0.3%)	1.0
Persistent vomiting (> 5 days)	1 (1%)	17 (10%)	18 (7%)	0.01
Wound infection	8 (10%)	8 (5%)	16 (6%)	0.1
Incisional hernia	1 (1%)	3 (2%)	4 (1%)	1.0
Total	11 (14%)	38 (21%)	49 (19%)	0.17

* *Duodenal mucosal perforation recognized intra-operatively*
** *Duodenal perforation un-recognized intra-operatively, second operation for repair*

DISCUSSION

Pyloromyotomy is the commonest surgical procedure performed in infants (< 12 months) after the inguinal herniorrhaphy.[1] Although few, the pyloromyotomy is not without complications. Most recent reports about pyloromyotomy concern the differences between the procedures through the umbilical route[4-7,16] or the laparoscopic technique.[8-12,20] Up till now a debate is going on if this procedure can be safely performed in general hospitals with special interest in surgery in children. The present study was undertaken to analyze the peri-operative complication rates of the pyloromyotomy, both in a specialized pediatric university hospital and in a pediatric surgical department of a regional teaching hospital.

Duodenal perforations recognized during operation occurred in 6 patients (2%). Repair was immediately and had no further implications. The overall (recognized and unrecognized) duodenal perforation rate of 3% is consistent with the literature in which rates vary from 0.8% to 4%.[1,4]

The semi-circumumbilical incision introduced by Tan and Bianchi had its first publication in 1986. To deliver a large pyloric tumor into the umbilical wound to perform a pyloromyotomy is by some considered fairly difficult and time consuming. The gastric or duodenal serosa can be damaged by tearing.[17] We found no difference in intra-operative mucosal duodenal tears between the two different operation techniques. We documented unrecognized duodenal perforation in four children in our study (1%); 2 after umbilical and 2 after right upper quadrant incision.

The frequency of persistent postoperative vomiting reported in the literature ranges from 36% to 90%[1]. In the present study almost one third (n = 18; 7%) of the total number of complications could be ascribed to persistent postoperative emesis, defined as persistent vomiting over more than five days.[1] Prolonged postoperative vomiting occurred in 1 patient in the regional hospital and in 17 patients in the pediatric center. We used a feeding protocol which was adapted only in case of persistent emesis. Others have reported that a consistent postoperative feeding regimen for patients with hypertrophic pyloric stenosis decreases length of hospitalization and hospital costs without adverse effects.[18] An ad libitum feeding scheme was reported to result in even shorter hospital stays and lower costs.[19] As reported by others,[1] we found that patients with persistent vomiting had slightly longer pre-admission emesis periods and lower weights on admission compared with the other patients. Interestingly, the significantly larger number of patients with post operative vomiting in the pediatric center can be explained by the fact that most secondary referrals were hospitalized in the pediatric center; secondary referrals had longer pre-admission emesis periods.

Wound infections constitute another major category of postoperative complications (6%). The wound infection rate after the right upper quadrant incision reported in the literature is 0.3 to 7%.[1] 10% of the wound infections were seen in the regional hospital and 5% in the pediatric center. There has been some concern that the umbilical approach is associated with higher infection rates. The incidence of wound infection after umbilical incision ranges from 4.2 to 20%.[4,6] A study of wound infections showed incidences of wound infections for the right upper quadrant and umbilical incision of 6.7% and 1.2%, respectively, which dropped to 4.5% and 0% when prophylactic antibiotics were used.[4] We found 3.7% wound infections after the umbilical approach and 8.1% after the right upper quadrant incision. The lower incidence of infections after the umbilical approach is probably due to the use of prophylactic antibiotics in almost all of these procedures. The umbilical approach was only performed in the pediatric center, and as a consequence their infection rate was lower. Our protocol did not provide for the use of antibiotics for the right upper quadrant incision.

An incisional hernia was documented two times after a right upper quadrant incision and two times after an umbilical incision. One of these patients also had an infection of the wound. All incisional hernias were

operatively repaired. Theoretically a transverse incision of the linea alba produces a stronger closure with fewer incisional hernias.[6] The umbilical incision we used was a modification on the technique proposed by Tan-Bianchi. A supra umbilical incision of the skin is made and successively the abdominal wall is transversally dissected about 1 cm proximal of the umbilical incision.
Most patients in the pediatric center had been referred by other hospitals, as a consequence of a national anaesthesiologist's agreement to refer children under the age of one month or when premature under the age of six months to a paediatric anaesthesiologist. Some have taken the position that if a non-specialist team cannot attain the current standards of care, it should not be doing this procedure.[14] Others have argued that if adequate experience is available, there is no need to refer these children to tertiary referral centres or those who have special interest in paediatric surgery.[15]

In our series, with one third of patients treated in a regional teaching hospital and two thirds in a specialized paediatric surgery university department, complication rates did not differ significantly between hospitals. They also did not differ significantly from the rates reported by other specialized centres. From a surgical point of view it seems to make no difference whether pyloromyotomy is performed in a general or specialized centre, provided the frequency in the former is such that a cooperating multidisciplinary team is available. Furthermore the workload will be smaller in the tertiary centres, so that these may concentrate on procedures that demand an academic paediatric approach.

In conclusion a pyloromyotomy can be performed safely in both specialized pediatric centres and in general hospitals provided with a multidisciplinary team, with special interest in surgery in children.

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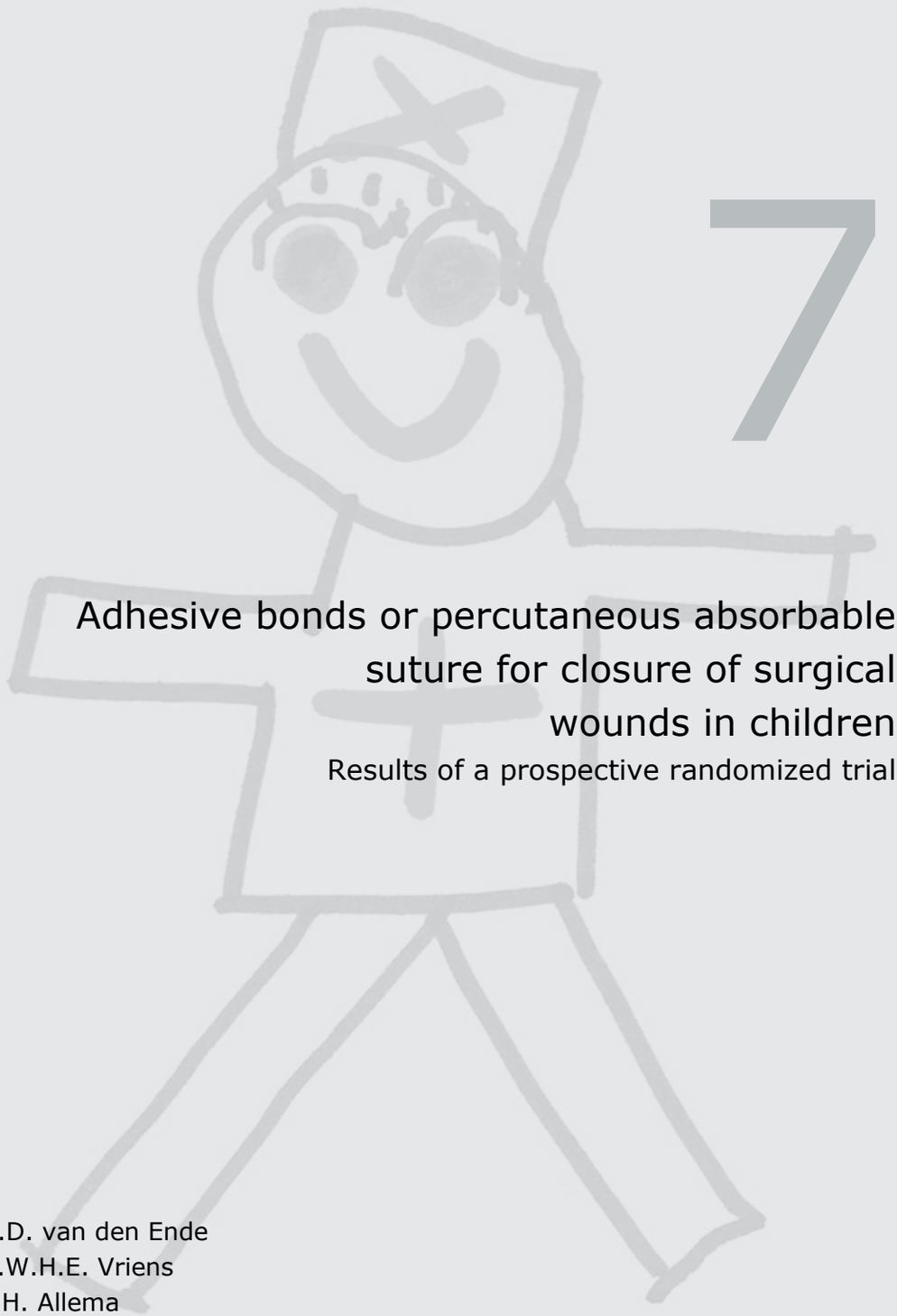

7

Adhesive bonds or percutaneous absorbable suture for closure of surgical wounds in children

Results of a prospective randomized trial

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Journal of pediatric surgery 2004;39:1249-1251

ABSTRACT

Background Surgeons have become increasingly interested in replacing conventional sutures by means of adhesive bonds for the closure of skin wounds. There are several advantages to the use of adhesive bonds compared with the conventional sutures.

Methods Between January and August 2001, all the wounds in children after groin surgery were closed with an adhesive *N*-butylcyanoacrylate (Indermil, Locite Corp, 's-Hertogenbosch, The Netherlands), or with a suture, polyglactin 5-0 (Vicryl), intracutaneously. Fifty inguinal wounds were treated with Indermil and 50 with Vicryl. Wounds were evaluated for hematoma, infection, dehiscence, or formation of granuloma. A scale from 1 to 10 expressed the cosmesis by patient and surgeon.

Results The most remarkable difference in wound healing was dehiscence of the wound in 26% of cases in the adhesive group and no dehiscence in the suture group. The cosmesis of the wounds was marked with an 8.5 in the suture group and in the adhesive group with a 6.8.

Conclusion Wound dehiscence was seen significantly more frequent in the patients whom the wound was closed with *N*-butylcyanoacrylate. The cosmesis of wounds closed with tissue glue was significantly lower then the cosmesis after suturing. Therefore, the authors advice on the basis of this prospective randomised trial, that surgical wounds in children should be closed with a intracutaneous absorbable suture.

INTRODUCTION

In the last 20 years, surgeons have become increasingly interested in replacing and augmenting conventional sutures by means of adhesive bonds in the closure of surgical wounds. Cyanoacrylate tissue adhesives have been used for a number of medical applications including bronchopleural fistula repair, endoscopic treatment of ulcers, high-risk intestinal anastomoses and middle ear surgery, and mesh fixation for inguinal hernia repair.[1-3] The most extensive use of adhesive bonds is, however, for the repair of traumatic lacerations in the emergency department. There are several advantages in the use of adhesive bonds compared to the conventional sutures. First, tissue union can be achieved rapidly.[4] Second, the need to remove sutures is eliminated. Third, application of adhesive bonds is significantly less painful than suturing, and the cyanoacrylate adhesives have a significant antimicrobial effect against Gram-positive organisms.[5] Furthermore, until now, there is no cosmetic difference between standard suturing and adhesive bond closure reported.[2,6-10] Early wound dehiscence is the most common complication of tissue adhesive closure and occurs in 1% to 5% of cases.[2] Most research has been done in the use of adhesives for the closure of traumatic lacerations; the use of these agents for closure of surgical wounds has been reported to a lesser extent.[6,8-14] Studies described in the literature compare the tissue adhesives with the conventional nondissolving sutures. A comparison of tissue adhesives and absorbable intracutaneous sutures for closure of surgical wounds in children has not been made yet.

Therefore, we started a prospective randomized study to compare tissue adhesives with standard suturing in closure of surgical wounds in the groins of 100 consecutive children The primary end-point of this study was that if tissue adhesives led to the same cosmetic result as suturing and fewer postoperative outpatient visits, tissue adhesives should be the first choice for skin closure.

MATERIALS AND METHODS

With an estimated difference in outcome variables of 5%, we calculated a needed number of 100 patients. Between January 2001 and August 2001 all wounds of 100 consecutive children after hernia inguinalis surgery, including repair of a hydrocele or orchidopexy, were closed with

N-butylcyanoacrylate (Indermil) or polyglactin 5-0 (Vicryl) intracutaneously. Patients were selected randomly to receive wound adhesive or suture on the basis of 100 previously prepared and sealed envelopes containing slips for either suture closure or the use of Indermil (50 of each). We enrolled 100 children after a herniotomy or orchidopexy, single or double sided. During the operation, we documented the total time of surgery, the time needed for wound closure, and the length of the wound. We scored the use of a subcutaneous suture and the facility of application of the tissue adhesive, the latter in terms of easy, unhandy, and difficult. Wounds closed with Indermil were manually approximated with skin hooks, and the adhesive was applied sparingly along the wound edges. The wound was held together for 30 seconds to allow for polymerization. Sutured wounds were closed with Vicryl 5-0 intracutaneously. Patients were reviewed in the outpatient department 10 days after surgery for wound inspection. Wounds were evaluated for hematoma, evidence of infection, dehiscence or formation of granuloma. The cosmesis was expressed by a mark (analogue scale 1 to 10) given by the parent or patient and the observing doctor at the outpatient clinic. A wound registry data sheet was completed prospectively for all patients. The data were entered in Microsoft Excel. Patient characteristics were compared using paired *t* tests; *P* value less than .05 was scored as statistically significant. The follow-up period was up to sex weeks after surgery.

RESULTS

Prospectively, we randomly divided 100 patients; 50 patients were treated with *N*-butylcyanoacrylate and 50 patients were treated with standard wound closure technique (polyglactin, 5-0 intracutaneous). The 2 treatment groups were similar with respect to age, gender, and operation indication (*Table 7.1*).The mean age in the tissue adhesive group was 2.5 years and in the suture group 3.0 years. The population in the tissue adhesive group consisted of 74% boys, and in the suture group this percentage was 82%. In the tissue adhesive group, 45 herniotomies, of which, 3 operations for correction of a hydrocele and 5 orchidopexies, were performed, and in the suture group this was, respectively, 41, 2, and 9. Wound characteristics were similar between the groups. There were no significant differences between the groups.

Table 7.1 Results of a comparison of adhesive bond with absorbable suture for closure of surgical wounds in children

	Indermil	**Vicryl**	***P* Value**
Wound length* (cm)	2.5	2.5	.4
Time of wound closure* (min)	1.7	2.2	< .001
Time of surgery* (min)	19	22	.04
Dehiscence	13	0	< .001
Hematoma	2	1	.1
Infection	4	2	.08
Granuloma	3	0	.04
Pain	3	0	.04
Cosmesis†			
Doctor*	7.1	8.5	< .001
Patient*	6.8	8.5	< .001
Costs	€ 12.15	€ 2.30	< .05

* *Values are means*
† *Cosmesis is expressed according an analogue scale from 1 to 10*

The time needed for wound closure with the use of an adhesive was 1.7 minutes, and when a suture was used it took 2.2 minutes to close the wound. This was significantly different ($P < 0.001$) The total time of surgery for correction of a hernia inguinalis with closure of the inguinal wound with an adhesive was 19 minutes and for the suture group 22 minutes ($P = 0.04$). All but 1 patient received a subcutaneous suture (*Table 7.1*). The ease in applying an adhesive was expressed as "easy" in 42 wound closures. In 6 cases, applying the tissue glue was "unhandy", and in 2 cases was noted to be "difficult".

Inspection of wounds after 10 days in the outpatient clinic showed that 1 patient in the suture group had a local wound hematoma and 2 patients had a redness of the wound without elevation of the body temperature. None of the wounds showed a dehiscence. Two patients in the adhesive group had a wound hematoma one local and one with swelling of the scrotum and the upper leg. In 4 cases there was a redness of the wound without fever (8%). A dehiscence of the wound was observed in 13 cases (26%, $P < .001$) The wound was dehiscent for more than half of the wound length in 3 patients. Three wounds showed formation of granuloma (*Table 7.1*).

After 6 weeks, all but 1 wound healed without surgical intervention. One wound needed secondary closure in the emergency department because of dehiscence of the wound. In the suture group, the cosmesis of the

wounds was marked with an 8.5 (analogue scale, 1 to 10) by the doctor and by the patient or her or his parent. In the suture group, the cosmesis was marked by the doctor with a 7.1 ($P < .001$) and by the patient or parent with a 6.8 ($P < .001$). The costs of a vial of adhesive bond were € 12.15, and 1 package of polyglactine suture costs € 2.30, both enough for closure of a 1-sided or double-sided surgical inguinal wound.

Discussion

Many advantages can be ascribed to the tissue adhesives, especially if these glues are used for the repair of traumatic lacerations in the emergency department. One of these advantages is, for example, a rapid and easy realization of tissue union.[4,15,16] We calculated in our study a duration of 1.7 minutes for wound closure with a tissue adhesive. This was significantly faster than the 2.2 minutes needed for an intracutaneous closure of the wound with suture. This time difference is clinically irrelevant, because the total operation time was not influenced significantly by this time difference ($P = .04$). A second important advantage of the tissue adhesives, especially when used for repair of pediatric lacerations, is that closure of the wound with glue is almost painless. This advantage is irrelevant when the adhesives are used under general anaesthesia, as is the case in our study setting.

The third advantage of tissue adhesives described in literature is the antimicrobial effect of the glue. Quinn *et al*.[5] contaminated wounds in pigs with 10^5 Staphylococcus Aureus and randomly assigned the wounds to be closed with either octylcyanoacrylate tissue adhesive or percutaneous 5-0 polypropylene suture.[1,5] Five wounds in the tissue adhesive groups were sterile after 5 days, whereas all sutured wounds had positive cultures ($P < .05$).

The operations in our study were performed under sterile conditions. The adhesive bond is a sterile sealed unit terminally sterilized by gamma-radiation.[4] Redness of the wounds in our study was seen in both groups without significant difference. Wounds treated with a tissue adhesive or standard wound closure, like non-dissolving sutures, have similar cosmetic appearances.[2,6-10,18] The cosmesis of tissue glue has not yet been compared with dissolvable sutures in literature. We found a wound dehiscence after 10 days of wound closure with an adhesive bond in 26%

of the patients. In one patient, the wound needed secondary closure with sutures. None of the wounds closed with sutures showed a dehiscence. Granuloma formation was seen 3 times after the use of glue. However, despite these bad results of short-term cosmetic appearance, we found better cosmetic results after 6 weeks. However, displeasure and anxiety on behalf of the parents in the first period after operation is an important factor in disadvantage of the tissue glue. Singer *et al*.[13] and Osmond *et al*.[17] performed an economic comparison between glue and suturing and found that glue was substantially cheaper than nondissolving sutures if the glue vial was used for at least 10 patients. Under sterile conditions, 1 vial of glue cannot be used in several patients, so if we compare the costs of 1 vial of glue (€ 12.15) with the costs of 1 polyglactin suture (€ 2.30), we can conclude that suturing is 4 times cheaper. Other costs as operation time, necessity to remove sutures, and number of outpatient visits is the same for both groups.

The cosmesis of wounds closed with tissue glue was considered significantly worse than the cosmesis after suturing by the parents and observing doctor ($P < .001$). Furthermore, the costs of a vial glue was 4 times more expensive then a suture. So closure of sterile surgical wounds in children with absorbable suture results in a cosmetic nicer appearance after 10 days and is less expensive than tissue glue for wound closure. Therefore, we advise, as a result of this prospective randomized trial, closure of surgical wounds in children with intracutaneous absorbable sutures.

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8

General Discussion

Children can not be seen as small equivalents of adults. Often they are unable to precisely express their complaints. Especially in very young children symptoms may be vague and misleading. Physical examination may be hampered in the anxious and crying child. Establishing the correct diagnosis is a challenge for the clinician; furthermore the diagnosis guides the decision if and when operative or non-operative therapy should be initiated. Acute abdominal pain is extremely common in children and may reflect a variety of conditions, intra-abdominal and extra-abdominal.[1] In one third to half of cases of acute abdominal pain a non-surgical cause can explain the pain, such as a viral infection, pneumonia, constipation, mesenteric lymphadenitis or the onset of gastroenteritis.[2,3] Facial flushing, tachycardia and rebound tenderness are observed significantly more frequently in the case of either a local or diffuse peritonitis, which are indicators of a surgical cause.[4] Acute appendicitis is the prevailing indication for emergency abdominal surgery in childhood, especially after three years of age.[5] Under one year of age intussusception and infantile pylorus hypertrophy are much more common.[6-8] Delay in diagnosis of appendicitis can lead to perforation, which will increase morbidity and mortality.[9-13] These unfavorable outcomes will also occur if intussusception reduction is postponed. A late reduction may increase the risk of bowel ischemia, perforation and peritonitis.[14,15] Besides physical examination, additional tools in resolving the diagnostic dilemma are available. Various clinical and computer-assisted scoring systems, with varying clinical benefit, have been developed. The use of scoring systems in diagnosing appendicitis has increased the diagnostic accuracy from 58 to 71% with a drop in appendiceal perforation rate from 27.0 to 12.5%. For example, the 'pediatric appendicitis score' is a simple diagnostic tool that can be used for repeated structured reevaluation during active observation.[16-18]

Progression of operative therapy of diseases in childhood culminated after World War II, when developments in anesthesia and analgesia provided safer and longer narcosis. In 1981 the Netherlands Association of Pediatric Surgery was founded. Specific interest in children with surgical disease led to refinement of diagnostic strategies and operative and non-operative treatment. In an advice of the 'Health Council of the Netherlands' to the Dutch Ministry of Health in 1989 separate definitions were given for 'special pediatric surgery' and 'surgery in children'. 'Special pediatric surgery' was defined as surgical treatment of rare and/or serious congenital malformations, diseases, injuries and solid tumors in children. Also, all children under the age of seven days or premature born children

under the age of six months should be operated by a surgeon with pediatric surgical training. 'Surgery in children' was defined as the surgical treatment of common surgical diseases in children; this surgery can be performed by general surgeons. The Association of Surgeons of the Netherlands altered the seven days' and six months' age limits for surgery in a pediatric surgical center into one month for a-term born children and six months for premature born children, respectively. Additionally, more recent guidelines on anesthesia in children issued by the Netherlands Association of Anesthesiologists advised that children before the age of one month en preterm born children before the age of sixty weeks post conceptual should be treated by pediatric anesthesiologists.

In pursuance of the Health Council's advice in 1989, which mainly focused on 'special pediatric surgery', the rationale of the present thesis was to explore its counterpart 'surgery in children', also known as 'surgery in childhood'.

In 1985 a collaboration was established between the pediatric surgeons of the Sophia Children's Hospital, a university hospital in Rotterdam and the general surgeons of the Juliana Children's Hospital, a general teaching hospital in The Hague. This collaboration, as well as the availability of pediatric anesthesiologists and pediatric trained nursing staff, made it possible to treat children with common surgical diseases in the Juliana Children's Hospital. The diagnostic modalities used and the treatment outcomes of several common surgical diseases in both hospitals made it possible to look into the quality of common surgery in childhood. Besides this assessment of present medical technology in diagnosis and surgical decision-making, we described the present infrastructure of pediatric surgery in the Netherlands. The developments in anesthesia, radiology and surgery necessitate ongoing reflection on new diagnostic and (operative) treatment strategies in pediatric surgery. The specific issues and insights related to the diagnosis and treatment of children with a surgical disease, as well as ongoing developments in this field, require surgeons taking care of these children to have a specific interest in these matters. This may call for concentration of the expertise and experience in surgery in childhood.

The results from the analysis of pediatric surgical procedures in the Netherlands in the period from 1998 to 2004 showed that the six pediatric surgical centers perform 23% of all surgical procedures in children in the

Netherlands. The majority of two common surgical procedures in childhood, the appendectomy and herniorraphy, are performed in general hospitals, respectively 93% and 75%. This distribution enables the pediatric surgical centers to focus on specialized pediatric surgery. For the pyloromyotomy, we see a trend towards more pyloromyotomies in the university centers in recent years, probably due to guidelines of the Netherlands Association of Anesthesiologists.

In this thesis we developed a scoring system to identify groups of patients with different levels of likelihood of having appendicitis. Identifying the a priori chance of having an inflamed appendix led to lower delayed operation rates (1 *vs*. 6%) and lower perforation rates (0 *vs*. 11%). Nevertheless, negative appendectomy rates did not improve (8% *vs*. 6%) by the use of this scoring system. The system performed well for excluding appendicitis but performed less satisfactorily for demonstrating appendicitis.

Other non-invasive diagnostic means for the diagnosis of acute appendicitis are ultrasound and computed tomography (CT scan).

As an additional imaging modality, ultrasound should be the tool of choice in children with acute abdominal complaints; it reduces the negative laparotomy rate. Furthermore, in contrast to computed tomography it does not expose the growing child to radiation. As acute appendicitis is the most frequent underlying cause of acute abdominal complaints, a scoring system can aid in identifying a subgroup of children with acute abdominal complaints who are likely to suffer from acute appendicitis.

Ultrasound has a reported sensitivity and specificity range from 82 to 90% and 96 to 100%, respectively. Wilson *et al*. reported a sensitivity of 94% and a specificity of 92% for the use of CT scan in the diagnostics of acute appendicitis in patients aged from 4 to 81 years. A noteworthy disadvantage of the use of CT scan is the radiation exposure to the patient. Continuing uncertainty about the diagnosis has been mentioned as an indication for the use of the CT scan in the diagnostics of acute appendicitis.[19-22] In this thesis, specificity of clinical examination alone in children with acute abdominal pain was 70%. The use of ultrasound added to the clinical examination raised the specificity to 91%. The positive predictive value of the clinical findings alone was 69% and of the clinical findings together with ultrasound 88%. Ultrasound has an additional role

in establishing the correct diagnosis of acute abdominal pain in children; it increases the specificity of the physical examination and reduces the number of negative laparotomies. Ultrasound is also helpful as a noninvasive diagnostic image tool for intussusception in children, its reported sensitivity and specificity approaching 100%.[23,24]

Contrast enemas can serve as an invasive diagnostic tool for intussusception and at the same time as a treatment modality.[25-27] Non-operative reduction using water-soluble or air contrast techniques is successful in about 75 to 90 percent of patients.[23] Others have reported that the success rate of hydrostatic reduction is lower and the risk of perforation risk higher in patients with symptoms for more than 48 hours.[28-30] We did not find any relation between an unsuccessful hydrostatic reduction and patients with more prolonged symptoms at presentation. Therefore, a hydrostatic reduction should be the first choice of treatment of intussusception, except when patients show signs of peritonitis.

Infantile hypertrophic pyloris stenosis is more common in children under the age of one year. Pyloromyotomy is the second most commonest surgical procedure in this age group.[31] We performed a study to analyze the peri-operative complication rates of the pyloromyotomy, both in a specialized pediatric surgical center and in a pediatric surgical department of a general teaching hospital. In our series, with one third of patients treated in a general hospital and two thirds in a specialized pediatric center, complication rates did not differ extensively between hospitals. No differences in major complications were found. Some have taken the position that if a non-specialist team cannot attain the current standards of care, it should not be doing this procedure.[32] Others have argued that if adequate experience is available, there is no need to refer these children to tertiary referral centres or those who have a special interest in pediatric surgery.[33] As a consequence of a national anesthesiologist's agreement to refer children under the age of one month or when prematurely born under the age of 60 weeks post conceptual to a pediatric anesthesiologist, most of the operations and especially pyloromyotomy, would be performed in a pediatric surgical center. We showed comparable treatment outcomes of pyloromyotomy and its pre- and postoperative care between a general and a specialized center, provided that frequency of this operative procedure is such that a multidisciplinary team is available.

Herniorraphy is a frequent surgical procedure in childhood. The operative technique is uniform, but closure of the incision may differ. Absorbable, non-absorbable, intracutaneous sutures are all operator dependent possibilities. We were interested in the results of using skin glue as a wound closing modality after herniorraphy. Most studies described in the literature compare tissue adhesives with the conventional non-absorbable sutures; the use of adhesives for closure of incisions in elective surgery is reported in lesser extent than the use of adhesives for the closure of traumatic lacerations.[34-41] We prospectively randomized wounds closed with tissue glue and wounds closed with absorbable sutures, and concluded that the cosmesis of the wounds closed with tissue glue was significantly lower than that after suturing. Therefore we recommend to close surgical wounds with an absorbable suture.

The analysis of the distribution of surgical procedures in childhood in the Netherlands among pediatric surgical centers and the general hospitals showed that, pyloromyotomy is most frequently performed in pediatric surgical centers, in recent years. The peak incidence of pylorus hypertrophy is between three and five weeks of age. Due to the necessity of specialized anesthesiological care for these young children, they are treated in pediatric surgical centers, conform the guidelines of the Netherlands Association of Anesthesiologists. A general surgeon with extra education and attention for surgery in childhood, the one who ideally performs common surgical procedures, can maintain a high level of experience, as many patients will present for surgery. Collaboration between a pediatric surgical center and surrounding general hospitals provides for safe performance of these procedures in general hospitals, as described in this thesis. These general hospitals should maintain a multidisciplinary setting including pediatric anesthesiologists, pediatric trained staff and facilities sufficient for care of children and in accordance with the quality guidelines of the Netherlands Association of Pediatric Surgery and the Association of Surgeons of the Netherlands. An expansion of the described collaboration-network between pediatric surgical centers and surrounding general hospitals will help to maintain or even improve the distribution of surgical procedures in childhood between hospitals in the Netherlands.

A collaboration between pediatric surgical centers and general hospitals not only provides an opportunity to operate on children with common surgical diseases based on high-qualitative and safe standards, but also

creates an environment for clinical studies. First of all important for ongoing optimalization of patient care, clinical studies will also lead to critical self-reflection of outcome of given care.

Recommendations

The studies in this thesis all focus on surgery in childhood. Modern developments in anesthesiology, radiology and surgery necessitate ongoing reflection on new strategies in diagnosis and (operative) treatment in pediatric surgery. Ongoing differentiation in surgical disciplines has improved quality of care, but the availability of modern technology and skills, as well as the dissemination of rapidly changing knowledge is a matter of concern.

This thesis explores the results of contemporary pediatric surgical diagnosis and treatment and recent developments in the distribution of pediatric surgical procedures.

Treatment outcomes of common surgical diseases in childhood in a center for 'surgery in childhood' were found to be the same as those in a pediatric surgical center. Centers for 'special pediatric surgery' may thus focus on their core business as described in the advice of the Dutch Ministry of Health in 1989. It seems advantageous to create a balanced distribution of patients between hospitals on the basis of knowledge and skills. If the pediatric centers and surrounding general hospitals with special interest in surgery in children were to make relevant agreements, the pediatric centers could focus on rare and/or major congenital malformations, diseases and solid tumors in children and additionally surgery in children under the age of one month or prematurely born children until postconceptual age sixty weeks, whereas quality of care for common surgical procedures in children could be provided by centers for surgery in childhood.

The recent special interest in quality of outcome of medical care induces a transparency in the medical organization of surgical care in childhood. Many common surgical diseases in childhood can be managed in a surgical department of a general hospital which takes a special interest in surgery in childhood. This special interest in combination with a close cooperation with a neighboring specialist pediatric surgical department ensures a high quality of care and up-to-date diagnostic and treatment strategies. Availability of at least pediatricians and nursing staff with experience in

children with surgical pathology, pediatric anesthesiologists and a dedicated radiological department completes the picture of a center for 'surgery in childhood'. The infrastructure of such a center should provide for 24-hour care. A least one surgeon with expertise in surgery in children should be available in such a hospital. We are convinced that a minimum of thirty surgical procedures in children over the first five years of residency, as formulated in the present surgical resident training guidelines, is inadequate for a career as a general surgeon with special interest in surgery in children.

It is only *optional* to incorporate a learning period with a minimum of three months and a maximum of six months in a pediatric surgical university center, when the hospital of residency has no experience in surgery in children.

Ideally, incorporation of a differentiation year as the final training year, in which the resident is pre-dominantly involved in activities related to pediatric surgery, could be a solid basis for a career as a general surgeon with a special interest in surgery in childhood.

In summary, the organization of pediatric surgery and surgery in childhood should be based on transparency and quality of care. This may best be achieved by a balanced distribution of patients, based on knowledge and skills in the available centers for pediatric surgery and surgery in childhood. Specialized pediatric surgery can best be concentrated in the university hospitals where specialized pediatric surgeons are based, with five years of general surgical training, optionally a differentiation year in pediatric surgery and a two-year post-surgical pediatric training program. These centers should establish close cooperation with appropriately equipped general training hospitals in which surgery in childhood is performed by a surgeon with (at least) a differentiation year in pediatric surgery.

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9

Summary
Samenvatting

SUMMARY

The aim of this thesis was to assess the management and treatment outcomes of surgery in childhood by comparing the results obtained in a specialized pediatric center and in a general teaching hospital. More precisely, we analyzed the distribution of common surgical diseases in childhood among pediatric university centers and general hospitals in the Netherlands. Furthermore, we explored several common surgical procedures in childhood by identifying the value of various noninvasive diagnostic tools and by documenting treatment outcomes. Finally, we proposed a recommendation for the organization of 'surgery in childhood' in the Netherlands, based on the effects of the collaboration of a university pediatric surgical center and a general teaching hospital.

In 1989, separate definitions were given for 'special pediatric surgery' and 'surgery in children' in an advice of the 'Health Council' to the Dutch Ministry of Health. 'Special pediatric surgery' performed by pediatric surgeons, is defined as the surgical treatment of rare and/or major congenital malformations, diseases and solid tumors in children. Also, all full-term children under the age of seven days or prematurely born children under the age of six months should be operated on by a surgeon with pediatric surgical training. On the other hand, 'surgery in children', also referred to as 'surgery in childhood', was defined as the surgical treatment of common surgical diseases in childhood. This type of surgery can be performed by general surgeons.

The Association of Surgeons of the Netherlands, later raised the age-limit for full-term born children to one month. Next, the Netherlands Association of Anesthesiologists issued a guideline on anesthesia in children recommending that children before the age of one month and preterm born children before the age of sixty weeks post conceptual should be treated by pediatric anesthesiologists.

Chapter 2 provides an analysis of all surgical procedures in children until the age of seventeen from 1998 to 2004 in the Netherlands. Data on three common surgical procedures – hypertrophic pyloromyotomy, appendectomy and the correction of inguinal hernia or hydrocele – were extracted to evaluate relative numbers of these operations in specialist pediatric surgical centers and general hospitals. Over this period the six specialized pediatric surgical centers in the Netherlands performed 23% of

all surgical procedures in children. These centers performed 7% of appendectomies and 25% of herniotomies, percentages that remained stable during the research period. They performed overall 52% of pyloromyotomies, the rate of which increased from 40% in 1998 to 60% in 2003. This increase can be explained by the age of the patient group and the above-mentioned recommendation of the Dutch Association of Anesthesiology in 1996. It appears that most of the common surgical procedures in childhood are performed in general hospitals. We feel that this is a fair situation, enabling the pediatric surgical centers to focus on specialized pediatric surgery. We expect cooperations between specialized medical centers and general hospitals to intensify in the coming years, in analogy to the present collaborations between university medical centers and regional hospitals.

Chapter 3 describes the diagnostic value of ultrasound study for acute abdominal complaints in children. Over a twelve-month period we included all children referred to the emergency department with abdominal pain existing for less than two weeks. Excluded, however, were patients with abdominal pain on the basis of extra-abdominal pathology. A clinical diagnosis was derived from the medical history, physical examination and the results of laboratory tests. A working hypothesis was then reached on the basis of the clinical findings and the results of ultrasound study. Management was either observation or operation. The final diagnosis was based on either histological investigation after surgery or the child's condition at discharge. The clinical diagnosis, the working diagnosis and the definitive diagnosis were compared with each other to determine sensitivity, specificity, and predictive value of ultrasound study as a diagnostic tool in acute abdominal pain in children. Sensitivity of the clinical findings was 88%, the specificity 70%. Sensitivity of the clinical findings together with ultrasound study was 88%, the specificity 91%. The positive predictive value of the clinical findings alone was 69% and of the clinical findings together with ultrasound study 88%. We concluded that ultrasound has an additional role in the diagnosis of acute abdominal pain in children; it increases the specificity of the physical examination and reduces the number of negative laparotomies.

Apart from ultrasonography, other diagnostic tools such as CT scan and diagnostic laparoscopy are available for children with acute abdominal complaints. In **chapter 4** a scoring system for children with suspected appendicitis was created and evaluated. We prospectively evaluated 99

consecutive children in the years 1994 and 1995 (group 1) and 62 children in the years 1996 and 1997 (group 2) with suspected appendicitis. For developing a scoring system we collected the following variables from group 1: age, sex, duration of symptoms, rectal temperature, rebound tenderness and leukocyte count. Regression analysis revealed that the variables leukocyte count ≥ 10.10^9/l, rebound tenderness and temperature ≥ 38°C correlated significantly with the diagnosis appendicitis. These formed the basis for the scoring system we then applied to the patients of group 2. The clinical outcome, in terms of delayed and negative appendectomy rates, were compared with the results that would have been accomplished based on the scoring system. Next, this scoring system was externally validated in a group of 114 children presenting in another hospital. (group 3) Specificity and sensitivity of the scoring system were respectively 85% and 89%. Applying the scoring system led to negative appendectomy rates of 8% *vs*. 6% using clinical judgment and 26% performed laparoscopies *vs*. 31%. The scoring system lowered the delayed appendectomy rate from 6% to 1% and the perforation rate from 11% to 0%. External validation showed comparable rates for performed laparoscopies (32%) and delayed appendectomies (2%) but a higher negative appendectomy rate (19%). The latter is possible due to lower occurrence of appendicitis in group 3, i.e. in the external hospital. We conclude that the scoring system would allow for more selective use of laparoscopy.

Hydrostatic reduction of intussusception is believed to be less successful in children with prolonged symptoms prior to presentation. In **chapter 5** the success rate of hydrostatic reduction in relation to duration of symptoms was assessed in children with ultrasound proven intussusception. The study period was five years. Hydrostatic reduction was performed unless there was clinical or radiological evidence of peritonitis or perforation. Children with peritonitis or perforation underwent surgery. Of the 113 children presenting with intussusception, 16 had signs of peritonitis and required immediate laparotomy. A hydrostatic reduction was attempted in the remaining 97 and was successful in 77 (79%). Reduction was successful in 26 cases associated with symptoms < 12 hr (81%); in 30 with symptoms for 12 - 24 hr (81%) and in 21 with symptoms > 24 hr (75%). In 62% of the latter group symptom duration had been more than 48 hours, with a mean duration of 57 hour. We concluded that the success rate of hydrostatic reduction is not significantly influenced by symptom duration.

In **chapter 6** we assessed peri-operative complication rates in 256 children with ultrasound proven hypertrophic pyloric stenosis treated in a specialist pediatric center or in a general teaching hospital. The study period was 5 years. Treatment was pyloromyotomy, and was performed 176 times in the specialist centre and 80 times in the general hospital. Operations were done by a resident supervised by a pediatric surgeon or by a general surgeon. The children had been diagnosed by standard protocol. Age, sex, secondary referral status, a family history of pyloric stenosis, prematuritas, weight on admission, metabolic status, ultrasound findings, operative approach, operating time, intra- and postoperative complications and length of hospital stay were retrieved from the hospital charts. In our series, with one third of patients treated in a general teaching hospital and two thirds in a specialized pediatric surgery department, complication rates did not differ significantly between hospitals. Duodenal mucosal perforation was observed in 4% (n = 10), incomplete pyloromyotomy in 0.3% (n = 1), persistent vomiting (> 5 days) in 7% (n = 18), wound infection in 6% (n = 16) and incisional hernia in 1% (n = 4). The overall complication rate in the specialized centres was 21% and that in the general hospital 11%. The complication rates do not differ significantly from rates reported by other specialized centres. We concluded that pyloromyotomy can be performed safely both in specialized centres and in general teaching hospitals provided with a multidisciplinary team with special interest in surgery in children.

In **chapter 7** a prospective randomised controlled study compared tissue adhesives with absorbable sutures for closure of surgical wounds. The study period was eight months. Incisions after herniorraphy in children were closed with either n-butylcyanoacrylate (Indermil®) (n = 50) or polyglactin 5-0 (Vicryl) intracutaneously (n = 50). Wounds were evaluated for hematoma, infection, dehiscence or formation of granuloma. The patient's parents and surgeon both rated cosmesis on a scale from 1 to 10. The most remarkable difference in wound healing was dehiscence in 26% of cases in the Indermil group *versus* none in the Vicryl group. Wound cosmesis was appreciated with a mean value of 8.6 in the Vicryl group, and 6.8 in the Indermil group. On the basis of the findings from this prospective randomised trial we recommend the use of intracutaneous absorbable suture for the closure of surgical incisions in children.

In **Chapter 8** we discuss the difference between 'specialized paediatric surgery' and 'surgery in children'. Surgery in children deals with the

diagnostics and treatment of common surgical diseases in children. Acute abdominal complaints are common in childhood and the pathology underlying these complaints frequently calls for surgery. Establishing the correct diagnosis of acute abdominal complaints is a challenge for the attending physician. Additional diagnostic tools, such as scoring systems and ultrasound studies are helpful in resolving the diagnostic puzzle of acute abdominal complaints in childhood. Intussusception can be treated by hydrostatic reduction of the intussuscepted bowel, also in children with symptoms persisting for longer than 48 hours. Children with hypertrophic pyloric stenosis can safely be treated in a general teaching hospital provided that a multidisciplinary team with special interest in surgery in children is available. Another common disease in childhood is inguinal hernia. Groin incisions should preferably be closed with absorbable sutures and not with skin glue. Common diseases such as appendicitis, inguinal hernia and pylorus hypertrophy constitute a vast majority of all conditions requiring surgery in childhood. These procedures can be safely performed in general hospitals provided with a multidisciplinary team with special interest in childhood surgery and which collaborate with nearby tertiary centres.

A 'center of childhood' should ideally be equipped with a multidisciplinary team with special interest in childhood surgery. A general surgeon, as a member of this team, should be trained accordingly. Adequate training for a surgeon with special interest in surgery in childhood could be provided, for example, by incorporation of a differentiation year as the final training year, in which he or she is pre-dominantly involved in activities related to pediatric surgery. Availability of at least pediatricians and nursing staff with experience in children with surgical pathology, pediatric anesthesiologists and a dedicated radiological department completes the picture of a center for 'surgery in childhood'. Efforts should be directed at a balanced distribution of childhood surgical procedures in the Netherlands over the specialised pediatric centers and the affiliated centers for 'surgery in childhood'.

Collaborations as outlined above can also create an environment for clinical studies. First of all important for ongoing optimalization of patient care, clinical studies will also lead to critical self-reflection of outcome of given care.

SAMENVATTING

Het doel van dit proefschrift was om de diagnostiek naar en resultaten van de chirurgische behandeling van veel voorkomende ziekten op de kinderleeftijd in de kinderchirurgisch centra en de algemene ziekenhuizen van Nederland te analyseren. Om dit doel te bereiken hebben wij gekeken naar de verdeling van drie veel voorkomende ingrepen op de kinderleeftijd tussen algemene ziekenhuizen en de universitaire kinderchirurgische centra in Nederland. Voor enkele veel voorkomende chirurgische ingrepen op de kinderleeftijd hebben wij de waarde van non-invasieve diagnostiek en de behandelingsresultaten onderzocht. Tenslotte deden wij een aanbeveling ten aanzien van 'chirurgie op de kinderleeftijd' gebaseerd op de samenwerking tussen een universitair kinderchirurgisch centrum en een algemeen (opleidings)ziekenhuis.

In een advies van de Gezondheidsraad in 1989 werden chirurgische ingrepen bij kinderen onderverdeeld in twee aandachtsgebieden: 'gespecialiseerde kinderchirurgie' en 'chirurgie bij kinderen'. Het betreffende advies omschreef 'gespecialiseerde kinderchirurgie', idealiter uit te voeren door kinderchirurgen, als de chirurgische behandeling van zeldzame en/of congenitale misvormingen, ziekten en solide tumoren op de kinderleeftijd. Het advies luidde om alle kinderen jonger dan een week en prematuur geboren kinderen onder de leeftijd van zes maanden te laten opereren door kinderchirurgen. Daarnaast werd de term 'chirurgie bij kinderen' of zoals wij het noemen 'chirurgie op de kinderleeftijd', gedefinieerd als de chirurgische behandeling van veelvuldig voorkomende ziekten op de kinderleeftijd. Deze chirurgie kan worden uitgevoerd door algemeen chirurgen. Later veranderde de Nederlandse Vereniging voor Heelkunde de leeftijdslimiet voor de à terme geboren kinderen van een week naar een maand. Vervolgens bracht de Nederlandse Vereniging van Anesthesiologen de richtlijn 'Anesthesie bij kinderen' uit, met het advies kinderen onder de leeftijd van een maand en prematuur geboren kinderen tot de leeftijd van 60 weken postconceptie te laten behandelen door kinderanesthesiologen.

In **hoofdstuk 2** wordt een analyse gepresenteerd van alle, in Nederland uitgevoerde, chirurgische ingrepen bij patiënten op de kinderleeftijd, over een periode van zes jaar. Van drie vaak gedane chirurgische ingrepen – de pyloromyotomie, de appendectomie en de inguinale herniotomie – wordt de verdeling van deze operaties tussen de universitaire kinderchirurgische centra en de algemene ziekenhuizen geëvalueerd. De

zes kinderchirurgische universitaire centra in Nederland verrichtten 23% van het totale aantal chirurgische ingrepen bij kinderen. Van de pyloromyotomieën werd 52% in de kinderchirurgische centra verricht, van de appendectomieën 7% en van de herniotomieën 25%. Wij zagen wat betreft aantallen pyloromyotomieën een verschuiving in de kinderchirurgische centra van 40% in 1998 naar 60% in 2003. Deze verschuiving zou verklaard kunnen worden door de leeftijden in deze patiëntengroep en de adviezen die de Nederlandse Verenigingen voor Heelkunde en Anesthesiologie in 1996 hebben uitgebracht om de zeer jonge kinderen in kinderchirurgische centra te concentreren.

Wanneer gespecialiseerde kinderchirurgische ingrepen daadwerkelijk in de zes kindercentra zouden worden verricht, en chirurgie bij kinderen in de algemene 'omringende' ziekenhuizen, dan zou een groter percentage van de genoemde ingrepen in de algemene ziekenhuizen kunnen worden verricht. Dientengevolge zou de werklast van de tertiaire centra verminderen en kunnen deze centra zich in toenemende mate concentreren op chirurgische procedures die een academische aanpak vergen.

Hoofdstuk 3 beschrijft de diagnostische meerwaarde van de echografie bij kinderen met acute buikklachten. Over een heel jaar werd echografie verricht bij kinderen die waren verwezen naar de spoedeisende hulp met acute buikklachten. De echografie werd echter alleen gedaan als de klachten korter dan twee weken bestonden en kinderen met buikklachten door een extra-abdominale oorzaak werden ook uitgesloten. Op basis van de anamnese, lichamelijk onderzoek en laboratoriumgegevens werd een klinische diagnose gesteld. Vervolgens werd echografie van het abdomen verricht, waarbij de echografist niet op de hoogte was van de klinische diagnose. De klinische en echografische diagnosebevindingen leidden tot de werkdiagnose. De definitieve diagnose werd gesteld op basis van histologisch onderzoek na operatie of op de klinische toestand bij ontslag. De klinische diagnose, werkdiagnose en definitieve diagnose werden met elkaar vergeleken om zo de sensitiviteit, de specificiteit en de positief voorspellende waarde van de echografie voor de diagnostiek bij acute buikklachten bij kinderen te bepalen. De sensitiviteit van de klinische bevindingen was 88% en de specificiteit 70%. De sensitiviteit van de echografie was 88% en de specificiteit 91%. De positief voorspellende waarde van de klinische bevindingen alleen was 69% en die van de combinatie van klinische en echografische bevindingen 88%. Echografie

bij kinderen met acute buikklachten heeft een additionele rol; het verhoogt de specificiteit van het klinisch onderzoek. Het aantal negatieve laparotomieën daalde door gebruik van echografisch onderzoek.

Naast echografie zijn andere middelen voorhanden om acute buikklachten bij kinderen te diagnosticeren, zoals scoringssystemen, computer-tomografie en diagnostische laparoscopie. **Hoofdstuk 4** beschrijft de ontwikkeling van een scoringssysteem en de toepassing ervan bij kinderen met een verdenking op een appendicitis. Zo wordt geëvalueerd of hiermee de waarschijnlijkheid van een appendicitis als werkelijke oorzaak van klachten kan worden verhoogd. In twee verschillende perioden werden de bevindingen bij kinderen met een verdenking op een appendicitis prospectief geëvalueerd: eerst 99 kinderen (groep 1) en vervolgens 62 kinderen (groep 2). We verzamelden de volgende variabelen uit groep 1: leeftijd, geslacht, duur van de symptomen, lichaamstemperatuur (rectaal) $\geq 38^{\circ}C$, loslaatpijn en aantal leucocyten $\geq 10.10^{9}/l$. Op grond van de chi-square test bleken drie daarvan significant te correleren met de diagnose appendicitis: het aantal leucocyten, de loslaatpijn en de lichaams-temperatuur. Vervolgens werd door toepassing van regressieanalyse het scoringssysteem ontwikkeld, en toegepast bij groep 2. De resultaten van het klinisch onderzoek, in termen van uitgestelde appendectomie of negatieve appendectomie, werden vergeleken met de resultaten met toepassing van het scoringssysteem. Als laatste werd het systeem extern gevalideerd door gebruik bij 114 kinderen uit een ander ziekenhuis. De specificiteit en de sensitiviteit van het scoringssysteem waren respectievelijk 85% en 89%. Bij gebruik van het scoringssysteem was het percentage negatieve appendectomieën 8% in tegenstelling tot 6% bij klinisch onderzoek alleen. Het percentage verrichte laparoscopieën was 26% met het scoringssysteem en 31% zonder. Het scoringssysteem verlaagde het aantal uitgestelde appendectomieën (6% *versus* 1%) en het aantal geperforeerde appendectomieën (11% *versus* 0%) De externe validatie gaf eenzelfde aantal te verrichten laparoscopieën (32%) en uitgestelde appendectomieën (2%), maar een hoger aantal negatieve appendectomieën, waarschijnlijk als gevolg van een lager percentage appendicitis in de populatie van het externe ziekenhuis. Laparoscopie kan selectiever worden toegepast als een scoringssysteem wordt gebruikt, zo luidt de conclusie.

Als oorzaak van een niet geslaagde hydrostatische repositie van een invaginatie van de darm bij kinderen wordt nog veelal het langdurig

bestaan van symptomen (> 48 uur) beschouwd. In **hoofdstuk 5** werd de kans op geslaagde hydrostatische repositie van een echografisch bewezen invaginatie van de darm bij kinderen geëvalueerd. De onderzoeksperiode was 5 jaar. In alle gevallen werd een hydrostatische repositie ondernomen, tenzij er klinische of radiologische aanwijzingen waren voor een peritonitis of perforatie. Bij vermeende peritonitis of vrij lucht op een buikoverzichtsfoto werd direct geopereerd. Zestien van de 113 kinderen werden direct geopereerd, aangezien lichamelijk onderzoek wees op een peritonitis. De hydrostatische repositie bij de overige 97 kinderen had succes in 77 gevallen (79%). Uitgesplitst naar duur van de symptomen was deze succesvol bij 81% van de invaginaties die korter dan 24 uur symptomen hadden gegeven, eveneens bij 81% met symptomen gedurende 12 - 24 uur en bij 75% met symptomen langer dan 24 uur. In deze laatste groep had 62% symptomen langer dan 48 uur, met een gemiddeld aantal van 57 uur. Het slagen van de hydrostatische repositie van invaginatie bij kinderen hangt derhalve niet af van de duur van de symptomen.

In **hoofdstuk 6** beschrijven wij hoeveel peri-operatieve complicaties optraden bij behandeling van pylorushypertrofie in een universitair kindercentrum en een algemeen opleidingsziekenhuis over een periode van vijf jaar. De behandeling bestond uit een pyloromyotomie volgens Ramstedt. Deze werd in totaal 256 keer uitgevoerd: 176 keer in het universitaire kindercentrum en 80 keer in het algemene opleidings-ziekenhuis. De operaties werden verricht door een arts-assistent in opleiding onder supervisie van een kinderchirurg dan wel een algemeen chirurg met speciale interesse voor chirurgie bij kinderen. Alle kinderen werden volgens protocol behandeld. We verzamelden gegevens over leeftijd, geslacht, familieanamnese, prematuriteit, verwijzing uit ander ziekenhuis, gewicht bij opname, metabole status, plaats van incisie, operatieduur, intra- en postoperatieve complicaties en opnameduur. Het totale percentage complicaties, respectievelijk 21% en 11%, verschilde niet significant tussen het universitaire kindercentrum (2/3 van de patiënten) en het algemene ziekenhuis (1/3 van de patiënten). Duodenumperforaties kwamen voor bij 4% van de patiënten (n = 10), een incomplete pyloromyotomie bij 0,3% (n = 1), persisterend braken (> 5 dagen) bij 7% (n = 18), wondinfecties bij 6% (n = 16) en een littekenbreuk bij 1% (n = 4). Deze complicatiepercentages verschillen niet significant van percentages gerapporteerd in de literatuur. Wij kunnen concluderen dat de pyloromyotomie een veelvoorkomende ingreep is, die

verantwoord kan worden verricht in een algemeen ziekenhuis dat beschikt over een multidisciplinair team.

In **hoofdstuk 7** beschrijven wij een prospectief gerandomiseerd onderzoek waarin huidlijm vergeleken werd met oplosbare intracutane hechtingen voor het sluiten van incisies in de lies na herniachirurgie bij kinderen. Gedurende een periode van 8 maanden werd bij 50 patiënten n-butylcyanoacrylaat (Indermil®) gebruikt, en bij 50 andere polyglactin 5-0 (Vicryl) intracutaan. De wonden werden beoordeeld op hematoom, infectie, dehiscentie of granulatieweefsel. De cosmetiek werd gewaardeerd op een schaal van 1 tot 10 door ouders en chirurg. Het opvallendste verschil in wondgenezing tussen beide groepen betrof de wonddehiscentie. Die trad op in 26% van de gevallen in de huidlijmgroep, maar werd in het geheel niet gezien in de Vicrylgroep. Voor de cosmetiek van de wonden in de huidlijmgroep werd gemiddeld 6,8 gescoord en in de Vicrylgroep gemiddeld 8,6. Op basis van de resultaten uit deze prospectief gerandomiseerde studie adviseren wij chirurgische incisies bij kinderen te sluiten met een intracutaan resorbeerbare draad.

In **hoofdstuk 8** geven wij een beknopte uiteenzetting over de onderwerpen in dit proefschrift. We bediscussiëren het verschil tussen 'gespecialiseerde kinderchirurgie' en 'chirurgie bij kinderen'. Chirurgie bij kinderen behelst de diagnostiek en behandeling van veelvuldig voorkomende ziekten op de kinderleeftijd. Ziekten, welke ten grondslag liggen aan acute buikklachten vormen een voorbeeld daarvan. Het stellen van de correcte diagnose bij acute buikklachten is een uitdaging voor de behandelende arts. Aanvullende diagnostiek, zoals een scoringssysteem en echografie kunnen hulp bieden bij het oplossen van dit diagnostische dilemma.

Invaginaties kunnen worden behandeld door middel van hydrostatische repositie, ook wanneer de symptomen passende bij de invaginatie langer dan 48 uur bestaan. Kinderen met een aangeboren pylorushypertrofie kunnen verantwoord worden behandeld in een algemeen ziekenhuis dat beschikt over een multidisciplinair team met speciale interesse in chirurgie. Een eveneens vaak voorkomende aandoening op de kinderleeftijd is de liesbreuk. Na de ingreep dient de incisie bij voorkeur gesloten te worden met een resorbeerbare intracutane hechtdraad en niet met huidlijm. Veelvuldig voorkomende ziekten op de kinderleeftijd welke een chirurgische behandeling behoeven kunnen verantwoord worden

uitgevoerd in algemene ziekenhuizen die beschikken over een multidisciplinair team met speciale interesse voor deze chirurgie bij kinderen. Een centrum voor chirurgie bij kinderen zal over een dergelijk multidisciplinair team dienen te beschikken, in ieder geval met een chirurg die getraind is op het aandachtsgebied 'chirurgie bij kinderen'. Een differentiatiejaar, als het laatste jaar van de opleiding tot chirurg, in welke de chirurg in opleiding zich hoofdzakelijk bezig houdt met activiteiten gericht op de kinderchirurgie, zou een basis kunnen zijn voor een chirurg met speciale interesse in chirurgie bij kinderen. Daarnaast omvat dit team idealiter kinderartsen, kinderanesthesiologen, verpleegkundigen en een afdeling radiologie, geschoold in de zorg voor, c.q. aanvullende diagnostiek bij kinderen. In een centrum voor chirurgie bij kinderen is het eveneens mogelijk klinische studies uit te voeren, bij wijze van constante toetsing van eigen handelen. In de toekomst zal gestreefd moeten worden naar een diepgaandere uitbalancering van de verdeling van de chirurgische ingrepen op de kinderleeftijd tussen universitaire kinderchirurgische centra en de geaffilieerde 'centra voor chirurgie bij kinderen'.

List of publications

Surgery in children; analysis of the distribution of surgical procedures in children in the Netherlands.
Esther D. van den Ende, Frans W.J. Hazebroek, Paul J. Breslau
Submitted for publication.

[Diagnostic surplus value of ultrasound in children with acute abdominal pain].
Esther D. van den Ende, Willem P.A. Boellaard, Jan-Hein Allema, Herma C. Holscher, Hein Putter, Paul J Breslau
Nederlands Tijdschrift voor Geneeskunde 2003;147:1174-1177.

Which children could benefit from additional diagnostic tools in suspected appendicitis?
Wim T. van den Broek, Esther D. van den Ende, A. Bart Bijnen, Paul J. Breslau, Dirk J. Gouma.
Journal of Pediatric Surgery 2004;39:570-574.

Success with hydrostatic reduction of intussusception in relation to duration of symptoms.
Esther D. van den Ende, Jan-Hein Allema, Frans W.J. Hazebroek Paul J. Breslau
Archives of Disease in Childhood 2005;90:1071-1072.

Pyloromyotomy for Infantile Hypertrophic Pyloric Stenosis; Results in two teaching hospitals.
Esther D. van den Ende, Jan-Hein Allema, Frans W.J. Hazebroek, Paul J. Breslau
European Journal of Pediatrics, in press.

Adhesive bonds or percutaneous absorbable suture for closure of surgical wounds in children. Results of a prospective randomized trial.
Esther D. van den Ende, Patrick W.H.E. Vriens, Jan-Hein Allema, Paul J. Breslau
Journal of Pediatric Surgery 2004;39:1249-1251.

Dankwoord

In 1991 begon ik de studie geneeskunde met de gedachte aan de eindstreep een *'dokter voor kinderen'* te worden. Met de neus op de praktijk gedrukt tijdens mijn co-assistentschappen besefte ik mij terdege dat een specialisatie in de snijdende vakken mijn voorkeur had boven een beschouwend vak, dat de kindergeneeskunde is. De periode als agnio heelkunde in het Rode Kruis Ziekenhuis & Julianakinderziekenhuis bevestigde mijn keuze voor de chirurgie. Met veel plezier heb ik in het Julianakinderziekenhuis kennis gemaakt met het fenomeen *'chirurgische dokter voor kinderen'*. De geestdrift voor dit proefschrift 'Surgery in Childhood' is hier ontstaan.

Geestdrift heb je nodig, maar nog veel meer andermans hulpvaardige geestdrift. Met de hulp van velen is dit boekje tot stand gekomen, een aantal daarvan wil ik in het bijzonder bedanken.

Frans Hazebroek, uw enthousiasme voor het onderhouden en versterken van de samenwerking van het Sophiakinderziekenhuis en het Julianakinderziekenhuis heeft onder andere dit proefschrift mogelijk gemaakt. Gezamenlijk hebben we de beschreven studies kunnen opzetten en uitvoeren. Uw inzichten waren vanuit de 'gespecialiseerde kinderchirurgie' onontbeerlijk voor het eindresultaat.

Paul Breslau, ik had dit alles niet geschreven als u niet de 'voorzet' had gegeven. Niet alleen de opzet tot, maar veel belangrijker de voortgang, welke u elke week (!) weer door middel van telefoon of e-mail hoog wist te houden, resulteerde in een manuscript, welke uiteindelijk dit verdedigbaar proefschrift is geworden. Een constante aanmoediging is met name onmisbaar, wanneer men zich specialiseert tot algemeen chirurg en 'ondertussen' een proefschrift schrijft.

Prof. dr. H. Obertop, prof. dr. A.J. van der Heijden, prof. dr. H.A. Heij, hartelijk dank voor uw interesse in dit proefschrift en mede door uw advies, zelfs tijdens vakanties, is dit proefschrift geworden tot wat nu voor u ligt.

Jan-Hein Allema, tijdens mijn agnio-periode in het Rode Kruis Ziekenhuis / Julianakinderziekenhuis heeft u door uw enthousiasme voor de 'Chirurgie bij kinderen' mijn interesse voor dit aandachtsgebied aangewakkerd. In meerdere opzichten zijn de hoofdstukken in dit proefschrift door uw hulp tot stand gekomen. Samen met de verpleegkundigen van het

Julianakinderziekenhuis, de operatieverpleegkundigen, de kinderartsen en kinderanesthesiologen heb ik genoten en ervaren, hoe leuk het is om in een centrum voor 'Surgery in childhood' te werken.

Herma Holsher, ik besef dat een 'kinderradioloog' van onbeschrijfelijke waarde is voor de aanvullende diagnostiek bij kinderen. Hartelijk dank voor je gedetailleerde uitleg over röntgenfoto's van supracondylaire humerus fracturen, abdominale echografie en hydrostatische repositie van invaginaties bij kinderen.

Een proefschrift is geen proefschrift zonder medeauteurs, hartelijk wil ik alle auteurs danken voor hun advies, inzet en ondersteuning.

Jaap Hamming, Bob van Rijn en collega arts-assistenten in het LUMC en in het Bronovo Ziekenhuis, heel veel dank voor de extra tijd die ik gekregen heb om dit boekje af te ronden. In die extra tijd, kon ik mij volledig op het schrijven richten van 's ochtends tot 's avonds en dat heeft zoveel meer vruchten afgeworpen, dan de (beperkte) tijd 's avonds na het werk.

Marie-Louise, Carla, Yvonne, Esther en Evelien, secretaresses Sophiakinderziekenhuis en Rode Kruis Ziekenhuis, enorm veel dank voor het opvragen van statussen, het organiseren van afspraken (in overvolle agenda's) en voor een versterkend kopje koffie met koek.

Medewerkers van het archief van het Sophia- en Julianakinderziekenhuis hartelijke dank voor het opzoeken en klaarleggen van alle klinische en poliklinische statussen van alle patiëntjes. Vele uren heb ik bij jullie in het archief gespendeerd, achter de computer met een hoge stapel statussen, die zich van mijn rechterzijde naar links verplaatste, dank voor jullie hulp!

Ko Hagoort en Margo Terlouw-Willebrand, zonder jullie was mijn schrift geen boekwerk geworden. Ko, ware 'edit-king', mijn engels is door jou leesbaar geworden. Margo, ik heb enorm genoten van onze e-mailcorrespondentie, waarin je naast de continue stroom aan gereviseerde teksten, mij ook met korte zinnen een hart onder de riem hebt gestoken. Zo heb ik tijdens de hittegolf (!) van 2006, veel plezier gehad (vanachter mijn computerscherm), om je advies 'met de voeten in een bak met ijsklonten te gaan zitten'.

Mijn paranimfen, M. Cramer en E.J.C. Vriens-Nieuwenhuis. Monique en Eline, al voordat de eerste letter op papier stond, wist ik dat ik jullie wilde vragen mijn paranimfen te zijn. Beide arts en zeer dierbare vriendinnen. Ik ben ongelooflijk blij dat jullie dit met zoveel enthousiasme hebben geaccepteerd en enorm trots om jullie aan mijn zijde te hebben op de dag van de verdediging.

Jos, veel te veel achter de schermen, maar daarom niet minder aanwezig. Altijd een luisterend oor met daarop volgend jouw advies en hulp…. zelfs nu je eigen werkzaamheden alle aandacht en inzet vergen.

Joke en Theo, lieve ouders. In de vierde klas van de middelbare school kon ik 'toch over' door de stap van gymnasium-β naar atheneum-A te maken. Jullie hebben mij geadviseerd, dat niet te doen en gymnasium-β af te maken. Tijdens de studie geneeskunde hebben jullie vele weken op jullie tenen door het huis gelopen, als ik weer eens binnen een week de tentamenstof probeerde te bevatten. En niet te vergeten alle verhuizingen tijdens de studie en erna, steeds maar weer op komen draven met verhuiswagen en nieuwe gordijnen. Ik ben enorm dankbaar voor jullie continue hulp en advies. Ik heb ontzettend veel bewondering en waardering voor jullie. Het is vooral door jullie liefdevolle steun en doorzettingsvermogen, dat ik tot hier ben gekomen.

Lieve Julia, mijn petekind, fantastisch, hoe je zo je best hebt gedaan om de tekeningen voor de omslag te maken. Het is een prachtige weergave van hoe jij, bijna 7 jaar oud, verschillende zaken met betrekking tot een ziekenhuis interpreteert. Daarnaast hoop ik dat wij nog vaak samen 'op pad' gaan.

Curriculum vitae

The author of this thesis was born on August 6, 1972 in Geldrop, the Netherlands. She grew up in Beek en Donk. She followed her secondary school at the Lorentz Lyceum in Eindhoven. After having graduated from the gymnasium in 1991, she started medical school at the University of Leiden in the same year. During college years she worked as an allocation-coordinator for Eurotransplant in Leiden.

In 1997 the author received her master's degree having completed her graduation project at the University of Edinburgh, Scotland. Her six months graduation project included 'Spectral and Fractal analysis of heart rate variability in near misses and age matched controls' and was supervised by Professor Dr. N. McIntosh, at the department of Child, Life and Health of the Royal Infirmary, Edinburgh. In 1999 she obtained her medical degree. In the same year she started working as a junior resident at the department of trauma and emergency surgery of the University Medical center in Utrecht (Prof. Dr. Chr. van der Werken). In 2000 she continued working as a junior resident at the surgical department of the Red Cross hospital and Juliana Children's hospital (Dr. P.J. Breslau) in The Hague. The studies described in this thesis were initiated at this time and were performed in collaboration with the pediatric surgical department of the Sophia Children's hospital (Prof. Dr. F.W.J. Hazebroek) in Rotterdam. She started as a registrar in surgery in October 2002 at the Bronovo hospital (Dr A.B.B. van Rijn) in The Hague and continued at the Leiden University Medical center (Prof. Dr. J.F. Hamming) in 2004, where she is currently working. In October 2006 the author will return to the Bronovo hospital (Dr. H.J. Smeets) and continue her last two years of surgical residency.

The publication of this thesis was financially supported by:

Biomet Nederland BV
Johnson and Johnson Medical BV
Astra Zeneca