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Current Concepts in Inguinal Hernia in Infants and Children

Jay L. Grosfeld, M.D.

Section of Pediatric Surgery, Department of Surgery, Indiana University School of Medicine, and the James Whitcomb Riley Hospital for Children, Indianapolis, Indiana, U.S.A.

Trends are changing in the management of infants and children with indirect inguinal hernias. Advances in neonatal intensive care have resulted in the survival of many small premature infants who have a high incidence of inguinal hernia. The rate of incarceration, strangulation, and gonadal infarction in these babies is twice that of the general pediatric age group. Respiratory immaturity, apnea, bradycardia, and associated neonatal conditions require special management at the time of hernia repair, usually performed just before discharge from the neonatal intensive care unit. New information concerning volume loss and depletion of germ cells beginning at 6 months of age in boys with undescended testes has stimulated the performance of orchiopexy when the patient is 1 year of age. More than 90% of boys with cryptorchid testes at the age of 1 year have an associated hernia that requires concomitant repair at the time of orchiopexy. The use of the peritoneal cavity for fluid absorptive purposes in hydrocephalus treated by venticuloperitoneal shunts or of peritoneal dialysis for renal failure and metabolic diseases such as hyperammonemia and lactic acidosis causes increased intraabdominal pressure and results in the appearance of a previously unrecognized hernia. Recognition of these and other conditions associated with a high incidence of hernial occurrence should allow early diagnosis and treatment before the development of complications. Most elective repairs of hernias are safely performed in the outpatient setting; however, some infants and children with concurrent illnesses are best managed in a "morning admissions" program, in which hospital admission occurs postoperatively.

Inguinal hernia is a common finding in infants and children and represents the condition most frequently requiring surgical repair in the pediatric age group [1, 2]. Changing concepts in the presentation and management of inguinal hernia have been influenced by a number of major considerations, including: the development of neonatal intensive care and the increased survival rates of seriously ill premature infants; early (when the child is 1 year of age) surgical repair of cryptorchid testis; the increasing use of the peritoneal surface for fluid absorption and exchange in infants with hydrocephalus, renal failure, or metabolic conditions; recognition of congenital and postoperative conditions that create a high risk for the development of an inguinal hernia; ambulatory surgical care; and government and insurance industry intrusion in the form of preoperative patient review and second-opinion examinations. This report will present details to clarify why these factors have an effect on the timing of treatment of inguinal hernia in infants and children.

Reprint requests: Jay L. Grosfeld, M.D., Department of Surgery, Indiana University School of Medicine, James Whitcomb Riley Hospital for Children, One Children's Square, Indianapolis, Indiana 46223, U.S.A.

Inguinal Hernia in Premature Infants

Rapid advances in the care of premature infants highlighted by the development of sophisticated neonatal intensive care facilities have resulted in an increased survival rate of seriously ill pre-term infants. Miniaturized equipment, a new generation of invasive and noninvasive monitors, jet-frequency ventilators, peritoneal dialysis systems for newborns, and extracorporeal membrane oxygenation (ECMO) have all played a role in the newly developed techniques of intensive care that have resulted in improved survival rates. Many of the tiny pre-term survivors present an inguinal hernia either during or soon after their hospitalization [3, 4].

Presentation

Congenital indirect inguinal hernia is related to persistence of the embryonic processus vaginalis. This process is a diverticulum of peritoneum that follows the gubernaculum and testis through the internal ring into the inguinal canal and, subsequently, down to the scrotum [1, 2, 5, 6]. Obliteration of the processus vaginalis is usually complete between the 36th and 40th weeks of gestation. Persistence of all or part of the processus vaginalis results in a variety of inguinal anomalies, including: scrotal hernia; distal obliteration of the processus with a proximal hernial sac; communicating hydrocele, which is a hernia with a small connection to the peritoneal cavity; hydrocele of the spermatic cord; and distal hydrocele of the tunica vaginalis (Fig. 1) [1, 5].

Incidence

The incidence of indirect congenital hernia in full-term newborn is 3.5–5.0% [1,2]. The incidence of inguinal hernia in pre-term infants is considerably higher and ranges from 9.0% to 11.0% [1, 4]. Inguinal hernia is much more common among boys than girls (9:1). Hernia presents more frequently on the right side because of a later descent of the right testis [6]. In pre-term infants, however, bilateral presentation is more commonly observed [1,

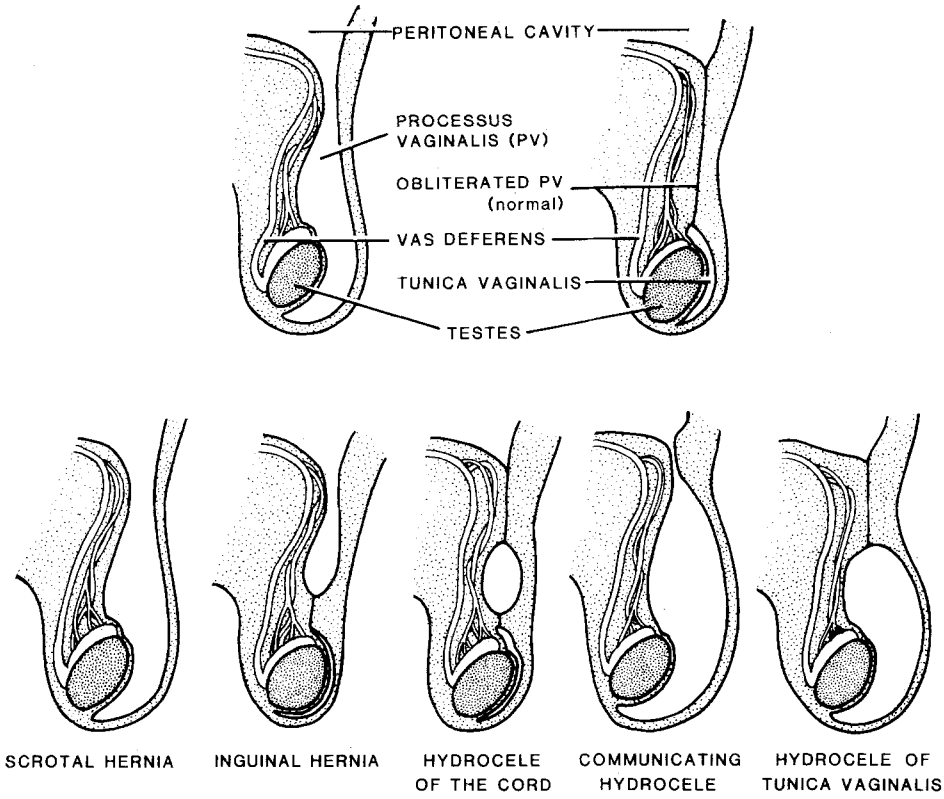

Fig. 1. Top: The fetal (left) patent processus vaginalis and its normal obliteration (right). Bottom: The 5 common anomalies of the inguinal canal. Reprinted with permission of publisher [1].

4, 7]. Harper and associates [7] noted a 55% incidence of bilateral inguinal hernias in low birth-weight infants, whereas Rescorla and Grosfeld [4] recorded a 44% incidence in premature infants. This compared to an 8–10% incidence of bilateral presentation in full-term infants noted by Rowe and co-workers [6].

Complications

The great risk in inguinal hernia is the development of intestinal incarceration and possible strangulation [8]. The complication rate in premature infants is significantly higher than in the general pediatric population. Rescorla and Grosfeld [4] reported an incarceration rate of 31% in 100 infants younger than 2 months of age with inguinal hernia. This observation is consistent with the findings of Puri and associates [9], who noted a similar 31% incarceration rate in patients younger than 1 year of age, indicating that this increased incidence of incarceration may extend for the entire first year of life. This higher rate of incarceration in small infants is 2–5 times that of the 6–18% rate reported in older children by several authors (Table 1) [4, 8–10]. Sloman and Mylius [11] reported a 30% rate of gonadal infarction in infants younger than 3 months of age. This compared to a 7–14% rate of gonadal infarction associated with irreducible incarceration in the general pediatric population [4, 12, 13].

The type of hernia most susceptible to gonadal infarction involves an undescended testis located just outside the internal inguinal ring. It is under these circumstances that compression of the gonadal vessels by an irreducible hernia has the greatest risk of vascular compromise and subsequent ischemic infarction. This situation has also been observed in small girls with a sliding hernia of the ovary and fallopian tube with either compression of the hernial sac or actual torsion of the gonadal structures, resulting in ischemic infarction of the ovary [1].

Table 1. Incarcerated inquinal hernia.

Author	Age	No. of patients	No. incarcerated (%)
DeBoer [10]	0–17 yr	2,100	380 (18.1)
Rowe and Clatworthy [8]	0–16 yr	2,764	351 (12.7)
Puri et al. [9]	<1 yr	511	158 (31.0)
Rescorla and Grosfeld [4]	<2 mo	100	31 (31.0)

A number of reports allude to the need for intestinal resection in 3–7% of infants with incarcerated hernias, further demonstrating an increased morbidity associated with incarceration [4]. Rescorla and Grosfeld reported an incidence of intestinal obstruction in 9% of instances of incarceration that could not be reduced (Fig. 2) [4]. It is often possible to safely reduce an incarcerated inguinal hernia in infants and convert an emergency problem that requires an immediate operation to a condition requiring an elective procedure. The success rate in reducing infant hernias is over 70% [1, 2, 4, 6, 8]. Rowe and Clatworthy [8] reported an overall complication rate of only 1.7% after elective repair as opposed to a 22.1% complication rate for emergency operations in children of all ages. Rescorla and Grosfeld [4] noted a slightly higher complication rate in the very low birth-weight infants younger than 2 months of age at

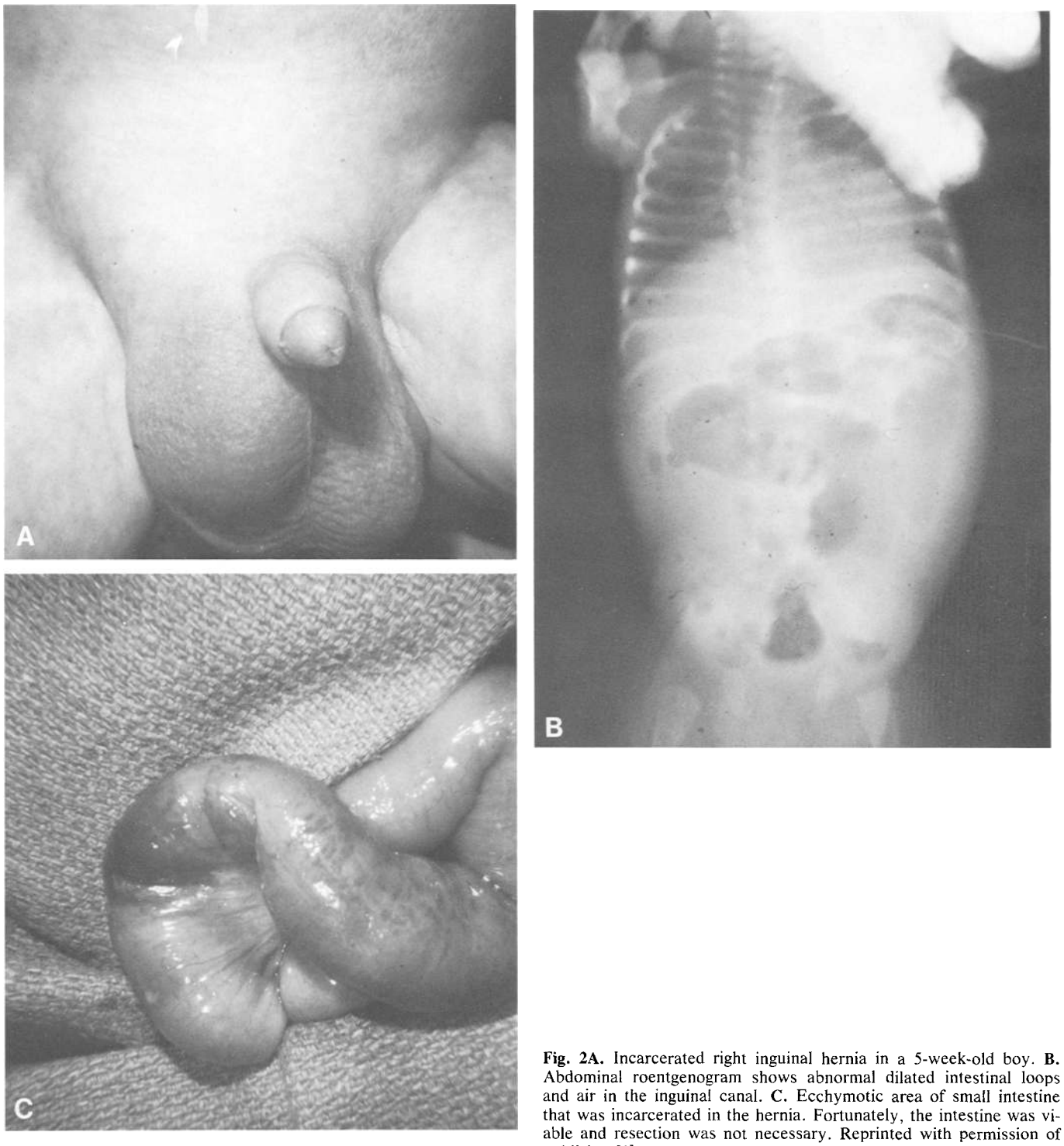

Fig. 2A. Incarcerated right inguinal hernia in a 5-week-old boy. **B.** Abdominal roentgenogram shows abnormal dilated intestinal loops and air in the inguinal canal. **C.** Ecchymotic area of small intestine that was incarcerated in the hernia. Fortunately, the intestine was viable and resection was not necessary. Reprinted with permission of publisher [1].

the time of their operation. The complication rate was 4.5% for incarcerated hernias that were reducible and 33% for those that were irreducible and required an emergency operation.

Treatment

Unlike adults with incarcerated hernias, infants can undergo safe reduction of inguinal hernias, in which case a potential emergency procedure is converted to an elective operation [5, 6]. Manual reduction of an inguinal hernia may be attempted in patients whose condition is not toxic. Toxicity is defined as severe tachycardia (pulse rate >160/min), leukocytosis (>15,000/mm^3) with a shift to the left on the differential smear, abdominal distention, bilious vomiting, an obstructive small-intestinal pattern on abdominal roentgenograms, and black or dusky blue discoloration of the entrapped viscera [1, 5]. Infants

with these findings require an emergency operation, and manual reduction should not be attempted because of the risk of intestinal perforation or of reducing necrotic intestine. Manual reduction should be attempted in all other patients.

For manual reduction, the infant may be sedated with a short-acting barbiturate (seconal or nembutal, 1.0 mg per kg intramuscularly) to reduce anxiety and diminish straining. Morphine sulfate and other opiates should be avoided because of their exaggerated effect on the respiratory center in the medulla oblongata in infants, particularly premature infants. The exception to this general rule concerning morphine is an infant already receiving respiratory support with mechanical ventilation at the time the hernia becomes incarcerated [4].

The infant should be placed in Trendelenberg position (when clinically feasible) to reduce edema by gravity. A coolpack positioned over a sheet of petroleum jelly gauze is placed over the inguinoscrotal area in boys and the inguinolabial region in girls. In premature infants, this may be done under an infant warmer to avoid hypothermia. When the infant seems relaxed and quiet, gentle taxis is applied in an attempt to reduce the incarceration and avoid the need for an emergency operation. Rescorla and Grosfeld [4] found this technique to be successful in 22 of 31 pre-term babies with inguinal hernia treated in a neonatal intensive care unit (NICU). Groff and associates [3] reported that almost all of their NICU patients had successful reduction of incarcerated hernia. The high rate of incarceration, intestinal obstruction, and gonadal infarction observed in small infants indicates that the highest risk of inguinal hernia occurs in the youngest patients. These data suggest that early elective hernia repair is preferred soon after a diagnosis is made.

A number of factors must be taken into consideration in the clinical management of inguinal hernias in small infants, many of whom are seriously ill. Pre-term infants are more susceptible to episodes of apnea and bradycardia after general anesthesia [14, 15]. Steward [15] observed pulmonary complications in 11 of 33 pre-term infants undergoing inguinal hernia repairs. Six of the 11 babies with complications had apneic episodes. This incidence was compared with only one instance of a pulmonary complication in 38 full-term infants evaluated in the same study. The actual cause of apnea in these infants was not entirely clear. Halogenated anesthetic agents may be implicated in the immediate postoperative phase; even low blood levels of these agents may cause depression of the chemoreceptor response to hypoxemia. The ventilatory muscles of pre-term infants fatigue easily. Muscle fatigue may be related to the relatively few high-oxidative, fatigue-resistant muscle fibers present in the diaphragm of small infants. Whatever the reason, pre-term infants undergoing an inguinal hernia repair should be carefully monitored and observed postoperatively for a 24-hour period within the hospital environment [1, 4].

General Recommendations for Care

In view of the increased incidence of complications observed, we have developed some recommendations for the care of pre-term or seriously ill newborns with inguinal hernias. In pre-term infants already in the hospital for birth asphyxia or other neonatal conditions that present with a clinically apparent but reducible inguinal hernia, the timing for the operative repair depends on the overall condition of the baby. It is reasonable to await improvement of the general status of the infant's underlying condition. Infants to receive this kind of care include those with hyaline membrane disease or other causes of respiratory distress syndrome receiving ventilator support, those with heart failure due to congenital cardiac defects, and those with meconium peritonitis or those recovering from peritonitis related to necrotizing enterocolitis or other causes.

Some delay in operative repair also seems indicated for very low birth-weight infants with reducible hernias. When the underlying condition improves, and the infant weighs more than 2,200 g, an elective hernia repair is carried out just before discharge from the NICU [3, 4]. Patients with a previous history of prematurity, especially those who required ventilator support, who are referred for an inguinal hernia that was first observed at home after hospital discharge, should be treated as inpatients through a morning admission program [1, 4]. These infants have an increased incidence of apnea and bradycardia following general anesthesia and should be observed overnight [1, 4, 14, 15]. This policy is followed in infants up to 6 months of age (corrected gestational age) [4].

Infants who require extended ventilator support after birth often have some degree of bronchopulmonary dysplasia and reactive airway disease. This type of patient may have bronchospasms and hypoxia after even the minor stress associated with a hernia repair and is also best managed as an inpatient. The morning admission program brings a patient into the system through the 1-day surgery facility as if he/she were an outpatient. The infant is then admitted to the hospital postoperatively for a 1-night stay for postanesthetic observation. A short hospital stay is also recommended for infants with congenital heart disease or other conditions that require prophylactic antibiotic administration. Rescorla and Grosfeld [4] reported that 4% of premature infants younger than 2 months of age at operation required overnight ventilator support after their repair, including 2 infants with periods of apnea and bradycardia, 1 with bronchopulmonary dysplasia associated with hypoxia, and 1 with lanoxin toxicity and an arrythmia. These observations have led some pediatric surgeons to recommend local or spinal anesthesia for repair, particularly if a skilled pediatric anesthesiologist is unavailable. Our institution has a superb group of pediatric anesthesiologists available; we, therefore, prefer general anesthesia for hernia repairs.

If appropriate precautions are followed, early elective hernia repairs can be done safely in newborns and other infants hospitalized for concurrent illnesses before their discharge from the hospital, or through a carefully monitored morning admission program for patients with previous illnesses whose hernias develop after discharge. Full-term infants with a normal uncomplicated perinatal history and most older infants and children can be operated on safely in an outpatient setting [1, 4, 16]. The low incidence of wound infection (1%) and hernia recurrence (1%) noted in this young age group is similar to that seen in the general pediatric hernia population (ages 1 year to 16 years) and less than that reported for adults [4].

The technical details of inguinal hernia repair in infants have been previously published [1, 2]. Most infants can be successfully managed by high suture ligation of the hernial sac at the level of the internal ring (Fig. 3). In some hernias with a large internal ring, the transversalis fascia inferior to the ring is snugged with interrupted nonabsorbable sutures to reduce the

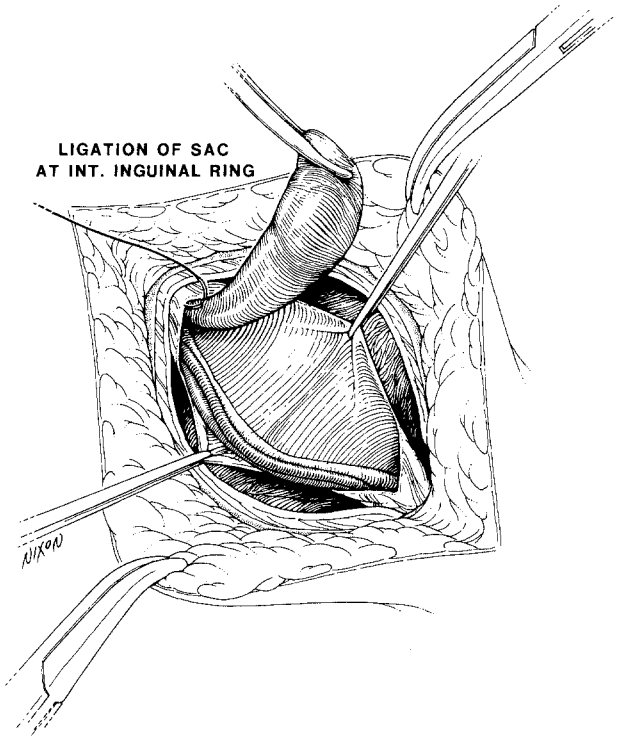

Fig. 3. Most indirect inguinal hernias in infants can be managed by high suture ligation of the sac at the level of the internal inguinal ring. Reprinted with permission of publisher [1].

size of the ring without compression of the spermatic vessels. Contralateral exploration is usually performed because of the high incidence of bilaterality in the first few months of life. Contralateral exploration is not done in instances of incarceration [1, 2, 4, 5, 6, 13].

Early Repair of Undescended Testis

Undescended testis is a common finding in newborns. The incidence of cryptorchidism varies widely with the gestational age of the baby. Two to three percent of full-term boys have an undescended testis [17, 18]; however, the prevalence increases considerably in premature infants. The lower the gestational age is, the higher is the incidence of cryptorchid testis [17–21]. Up to 30% of premature low birth-weight infants may have an undescended testis (Tables 2, 3) [17]. By the time an infant is 1 year of age, the incidence decreases to approximately 1% [18, 19]. Cryptorchidism is associated with both histologic and morphologic changes in the affected testis [17, 22, 23]. Loss of volume and progressive germ cell depletion characterize the natural history of a testis located in an extrascrotal location. Evidence suggests that the undescended testis in an XY 46 chromosome male is usually normal at birth and contains an appropriate number of germ cells [17, 18]. The number of germ cells remains normal up to 6 months of age; after that time, however, a progressive decrease is noted [17, 20]. Hadziselimovic [20] reported that 40% of undescended testes may be totally devoid of germ cells at the age of 2 years. Kogan [17] reported that 25–50% of testicular biopsies at the time of orchiopexy showed an absence of germ cells, although there was some variability in the histology.

Table 2. Incidence of cryptorchidism related to age and birth weight.

Age group	Weight (g)	Percent of instances
Premature	451–910	100.0
	911–1,810	62.0
	1,811–2,040	25.0
	2,041–2,490	17.0
Average		30.0
Full-term	2,491–2,720	12.0
	2,721–3,630	3.3
	3,631–5,210	0.7
Average		3.4
One year		0.7–0.8
School age		0.7–0.9
Adult		0.7–1.0

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Table 3. Incidence of undescended testis in premature infants.

Weight (g)	Percent incidence
<1,000	19.0
<1,850	9.9
>1,850[a]	2.0

[a]More than 32 weeks gestational age.
Table created from data in reference 21.

Other histologic changes are also observed in a cryptorchid testis. Atrophy of the Leydig cells, probably caused by lack of hormonal stimulation, results in reduced function and germinal atrophy. A decreased tubular diameter is noted. It worsens with time and is associated with a lower number of spermatogonia per tubule. In addition, interstitial fibrosis is also observed. In addition to the histologic changes observed, hormonal abnormalities have also been noted. Job and associates [24] reported a decreased luteinizing hormone (LH) response to gonadotropin releasing hormone (Gn-RH) in infants with both unilateral and bilateral undescended testes and decreased basal LH levels in older cryptorchid boys. Patients with undescended testes also fail to demonstrate the usual testosterone surge seen in healthy male infants at 2 months of age [25].

The depleted germ cell numbers observed in undescended testes appear early and may be irreversible [17]. Because many undescended testes initially noted in premature infants descend by the time the child is 1 year of age, we usually recommend observation until this time. Although some clinicians advocate therapy with human chorionic gonadotropin (HCG) in instances of undescended testis, the response is age-dependent and the poorest success rate is noted between the ages of 1 and 2 years, which is the most appropriate time for repair [17].

In double-blind studies evaluating Gn-RH, the response rate to intranasal administration of this medication 6 times daily for 4–6 weeks was disappointing (8–20%) [26, 27]. Furthermore, intranasal Gn-RH, which has the best hormonal response rate, is not approved for general use in the United States of America at the present time. A study evaluating buserelin, a Gn-RH analogue, indicated that this medication resulted in descent of cryptorchid testis in 8 of 48 prepubertal boys and also increased the mean germ cell count per tubule [28]. Additional investigation of this analogue is warranted as a possible preserver of germ cells before and after orchiopexy.

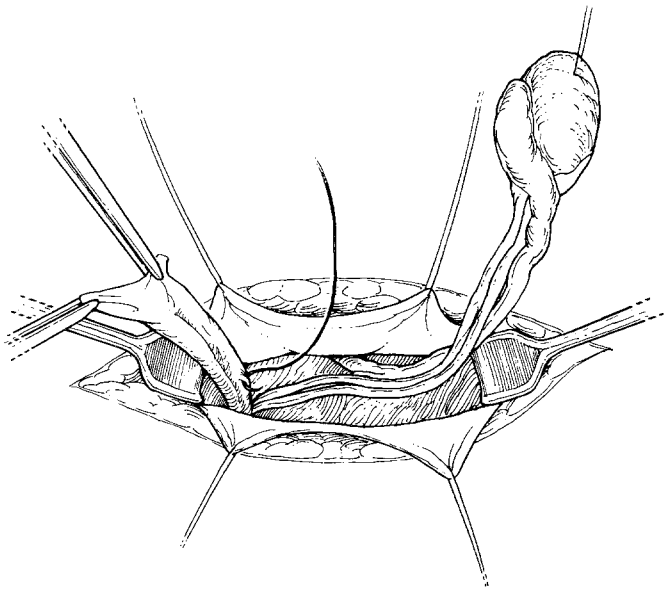

Fig. 4. Separation of the inguinal hernial sac from the spermatic vessels and division of the lateral spermatic fascia usually establishes adequate length for performance of an orchiopexy in instances of undescended testis. The illustration demonstrates suture ligation of the hernial sac and a traction suture in the testis just before passage into the scrotum for dartos fixation. Reprinted with permission of publisher [1].

The foregoing observations indicate that early orchiopexy should be performed when a patient is 1 year of age [17, 19, 29]. At the age of 1 year, the incidence of associated inguinal hernia in infants with undescended testis is higher than 90% [1]. In many patients, the hernial sac is asymptomatic and often goes unrecognized (patent processus vaginalis) until the time of orchiopexy. In undescended testis in which the associated hernia is symptomatic, both inguinal hernia repair and orchiopexy should be performed promptly at the time of diagnosis, even in infants less than 1 year of age, to avoid the complications of incarceration, strangulation, and testicular infarction [1, 24]. Testicular infarction is more commonly noted in instances of undescended testis.

At the time of repair, the sac of a hernia associated with cryptorchidism may be particularly thin and fragile. Gentle operative technique is essential in the separation of the hernial sac from the cord structures. Once the diverticular hernial sac is freed up and suture ligation is accomplished at the internal inguinal ring, a good length of the testicular vessels and cord is obtained (Fig. 4). Further dissection is usually necessary. Division of the lateral spermatic fascia in the retroperitoneal tissues within and just above the internal ring usually achieves adequate length to allow the testis to reach a normal position in the scrotal sac [1]. The testis is then placed in a dartos muscle pouch to prevent retraction.

Therapeutic Use of the Peritoneum for Absorption

In recent years, the peritoneum has been used as a site for fluid absorption, exchange purposes, and peritoneal irrigation in the management of patients with hydrocephalus, end-stage renal failure, metabolic conditions, or peritonitis. An increased incidence of inguinal hernia has been noted in these patients, probably because excess fluid in the peritoneal cavity causes increased intraabdominal pressure [30, 31]. This set of circumstances may convert a previously unrecognized patent processus vaginalis to a clinically apparent hernia [31].

Hydrocephalus and Ventriculoperitoneal Shunt

Ventriculoperitoneal (VP) shunt is a procedure commonly used in infants with hydrocephalus to divert cerebrospinal fluid (CSF) from the obstructed ventricle to the peritoneal cavity. This procedure has been a successful method of management and has generally replaced other shunt operations, such as ventriculoatrial shunt, as the procedure of choice in infants and children. After undergoing shunts in the first 3 months of life, 70% of infants with hydrocephalus have experienced reasonably normal intellectual development [31, 32]. The procedure is associated with a number of complications, including intraabdominal CSF cyst formation, adhesions and intestinal obstruction, intestinal perforation, shunt occlusion, and inguinal hernia [32]. Grosfeld and Cooney [30] described a 16% incidence of previously unrecognized inguinal hernias following VP shunts in patients with hydrocephalus. It is theorized that the production of CSF exceeds the peritoneal absorption rate, resulting in CSF ascites. The additional intraperitoneal fluid raises the intraabdominal pressure in infants at risk of having a patent processus vaginalis and converts this embryonic remnant into a clinically apparent hernia. The natural history of the processus vaginalis was described by Rowe and associates [6] in a report concerning more than 2,300 patients. Patency was 85–90% at birth, 70% at 3 months, 50% at 1 year, and 40% thereafter [6]. I reported [1, 31] an 80% incidence of bilaterality in patients with VP-shunt-related hernias and suggested that bilateral repair be routinely performed. These infants are given prophylactic antibiotics to protect the shunt from possible contamination at the time of the operation [30, 31]. Infants with VP shunts should be followed closely with periodic postoperative examinations in the first 2–3 years because of an increased incidence of hernial recurrence as a result of continued elevated intraabdominal pressure related to the ongoing presence of shunt fluid [30, 31].

End-Stage Renal Failure and Peritoneal Dialysis

In 1968, Tenckhoff and Schecter [33] described the use of a permanent indwelling silicone rubber catheter as a safe and reliable route of access to the peritoneal cavity. This event led to the development of peritoneal dialysis for patients with end-stage renal failure. The actual technique for continuous ambulatory peritoneal dialysis (CAPD) was described by Popovich and associates [34] in 1976. CAPD has more clinical, economic, and psychologic advantages than hemodialysis [35]. In infants and children, hemodialysis is often complicated by hypertension, arteriovenous shunt thrombosis, inadequate vascular access sites, and increased blood transfusion requirements. Stone and associates [35] reported that CAPD allows for greater patient mobility, decreased dietary restrictions, more effective control of fluid balance, more self reliance, and treatment at a lower cost. Ninety percent of children with end-stage renal failure are managed with CAPD in preference to hemodialysis until a successful renal transplant can be performed. Instances of renal dysplasia, glomerulonephritis and

obstructive uropathy represent the most common indications for CAPD [35]. Rigden and associates [36] noted that acute renal failure complicated cardiopulmonary bypass operations in 24 (5.3%) of 456 infants and children. Such patients represent an additional group of candidates for CAPD.

Peritonitis and other infectious complications related to an indwelling foreign body constitute the most common complications of CAPD. An increased number of associated abdominal wall hernias have also been observed [35–38]. These include ventral incisional hernias, umbilical hernias, and inguinal hernias. Stone and associates [35] reported the occurrence of 60 hernias in 93 children undergoing CAPD. Ventral hernias were noted in 36 patients, inguinal hernias in 17, and umbilical defects in 7. Francis and associates [39] and Rubin and coworkers [40] both noted a similar incidence of inguinal hernia in 14% of patients undergoing CAPD. Tank and Hatch [37] performed peritoneography in 19 pediatric patients undergoing insertion of a CAPD catheter and demonstrated a patent processus vaginalis in 7. These authors recommended simultaneous repair of the hernia at the time of diagnosis. At the time of insertion of the peritoneal dialysis catheter, the end is directed into the pelvis in the retrovesical or retrouterine position. Rapid infusion of dialysate into the pelvis as well as an increase in intraabdominal pressure may be responsible for filling the processus vaginalis with fluid and result in a clinically apparent hernia.

In the past few years at our institution, CAPD has also been used in selected newborns with hyperammonemia due to congenital metabolic disorders of the urea cycle, including: ornithine transcarbamylase deficiency, liver failure due to other inborn errors such as tyrosinosis, and lactic acidosis. One of 5 patients in this category had an inguinal hernia. Stone and associates [35] as well as Alexander and Tank [38] indicated that hernia repair can be safely accomplished while the infant or child affected is still undergoing CAPD. A higher rate of hernial recurrence is noted after simple high ligation of the hernial sac in patients undergoing CAPD. Tank and Hatch [37] recommended a snug closure of the transversalis fascia at the level of the internal ring just below the cord structures to reduce the incidence of recurrence.

Conditions Associated with a High Risk of Inguinal Hernia

A number of factors and conditions are associated with an increased incidence of congenital inguinal hernia (Table 4). Careful examination by parents and pediatric physicians is important in recognizing the presence of a hernia in these infants before the development of complications. There is a distinct tendency for hernias to occur in certain families. A positive family history for congenital indirect inguinal hernia was noted in 11.5% of patients reported by Holder and Ashcraft [2]. Although the occurrence of hernia has been observed in twins, no specific hereditary factors have been detected [1].

In addition to the increased rate of hernial occurrence in premature infants, in boys with cryptorchid testes, and in children who have had a VP shunt or CAPD, other conditions have an increased incidence of hernia. Conditions that result in increased abdominal pressure and place infants at risk for the development of a hernia include: prenatal intestinal perforation and meconium peritonitis [1], chylous ascites, ascites coincident to biliary atresia or other causes of cirrhosis of the liver, congenital hydrops, and tight closure of a relatively small abdominal cavity in infants with gastroschisis and omphalocele [41]. In addition, infants with associated genitourinary abnormalities have a high incidence of inguinal hernia. This includes patients with exstrophy of the bladder and cloaca (45%), hypospadias (45%), and epispadias (40%) [1, 4]. Husman and associates [42] reported that 45 of 100 children with bladder exstrophy had an inguinal hernia. Hernias occurred in 38 of 55 boys and 7 of 45 girls in that study.

Table 4. Conditions associated with an increased incidence of inguinal hernia.[a]

Prematurity
Positive family history
Hydrops
Meconium peritonitis
Chylous ascites
Liver disease with ascites
Abdominal wall defects
Ambiguous genitalia
Hypospadias, epispadias
Exstrophy of bladder, cloaca
Cryptorchid testes
Cystic fibrosis
Connective tissue disorders
Ventriculoperitoneal shunt
Continuous ambulatory peritoneal dialysis (CAPD)
Hunter–Hurler syndrome
Mucopolysaccharidosis

[a]Patients seen at the James Whitcomb Riley Hospital for Children, Indiana University Medical Center, Indianapolis, Indiana, U.S.A.

Infants with intersex problems frequently present with inguinal hernias, often containing a gonad. This is especially true for phenotypic girls with the testicular feminization syndrome who may have bilaterally palpable gonads (testes) in the inguinal canal or the canal of Nuck in the labia majora [43, 44]. These children should be screened with a buccal smear and appropriate genetic evaluation before the hernia repair. In the testicular feminization syndrome and other intersex disorders, such as mixed gonadal dysgenesis and selected pseudohermaphrodites, gonadectomy can often be accomplished by the inguinal approach at the time of the hernia repair, when indicated.

A considerable increase in the incidence of inguinal anomalies in infants and children with cystic fibrosis and their unaffected relatives has been observed by Holsclaw and Schwachman [45] and Wang and associates [46]. Whereas excessive coughing and straining may result in increased abdominal pressure and predispose the affected children with mucoviscidosis to a hernia, this would not explain the increased incidence among nonaffected family members. Poor appetite and recurring pulmonary infections and other exocrine abnormalities affecting biliary, pancreatic, and intestinal secretions may adversely affect nutrition and cause muscle wasting and weakness of the inguinal tissues. Many children with cystic fibrosis have poor nutrition and, in some, a weak posterior inguinal floor is observed at the time of indirect hernia repair [47]. These observations suggest that, in selected patients, a more formal herniorraphy procedure (e.g., Cooper ligament repair) should be performed to prevent recurrence. In addition, an increased rate of recurrent hernia is observed following simple high

ligation of the congenital indirect hernia in children with cystic fibrosis.

An increased incidence of inguinal hernia has also been observed in children with connective tissue disorders such as the Ehlers-Danlos syndrome or the Marfan syndrome [1, 2], with the Hurler-Hunter syndrome [48], with mucopolysaccharidosis, or with a variety of other hereditary conditions. An enhanced awareness of the relation between the aforementioned conditions and the increased risk of inguinal hernia will allow early detection of the hernia, prompt repair, and avoidance of complications.

Outpatient Surgical Treatment

All full-term infants and older children without underlying illness may undergo hernia repairs as outpatients [1, 2, 16]. Outpatient surgical facilities have become available in many communities across the country. Outpatient surgical intervention in infants and children requires the availability of appropriate pediatric anesthetic skills, nursing staff, a pleasant environment for children, appropriate-sized pediatric equipment and monitoring capability, and the ability to admit the baby postoperatively to a pediatric inpatient facility if necessary [1, 4]. Outpatient operations for inguinal hernias in children are safe, effective, and well tolerated. The benefits of 1-day surgical programs also include reduced psychologic trauma for the child by avoiding hospitalization, limited family separation, reduced costs related to hospitalization, and a lowered cross-infection rate because the patient has less exposure to hospital personnel. A preoperative visit and tour of the outpatient facility and acquisition of laboratory tests before the day of the procedure have been extremely useful in reducing anxiety related to the anticipated events of the day.

Outpatient repair of inguinal hernias has been well accepted by parents, children, physicians, nurses, administrators, and third-party insurance carriers. The fact that outpatient surgical care has become so popular suggests that adequate programs to evaluate the quality of care administered to patients in these facilities will be increasingly important in the future to assure patient safety.

Involvement of the Government and Third-Party Payors

Despite the current trend of cost-containment and the growing popularity of outpatient surgical care, there is still a need for some infants with symptomatic inguinal hernias to be admitted to the hospital. Unfortunately, both governmental and insurer intrusion into decision-making inpatient care often results in unnecessary delays in scheduling [4, 49]. Managed care programs that delay referral of infants for special care and that often limit the patient's parents' ability to choose both surgeon and facility may interfere with optimal care. The burden of arranging prior approval for hospital admission and unnecessary mandatory second opinions for infants with hernias further delay treatment. As previously stated, infants with bronchopulmonary dysplasia, congenital heart disease, severe seizure disorders, a history of prematurity, the need for ventilator support, or episodes of apnea and bradycardia should enter the hospital through a morning admission program following hernia repair. A 1-night stay to carefully monitor the cardiorespiratory status of infants at high risk during the postoperative period is the standard of care. Hospital administrators, government health care resources, managed care programs, and other insurance industry personnel must be made aware of these needs [1, 4]. Parents, pediatricians, family practitioners, nurses, and physician assistants in well-baby clinics and health care officials must become familiar with the message that the greatest risk for an infant with an inguinal hernia is encountered early in life.

Résumé

Le traitement des hernies inguinales obliques externes chez le bébé et l'enfant évolue. Les progrès accomplis dans les soins intensifs des nouveau-nés ont permis la survie d'un plus grand nombre d'enfants prématurés qui présentent une fréquence plus importante de hernies inguinales. Le taux d'engouement, d'étranglement, et d'ischémie gonadale chez cette population est deux fois celui de la population pédiatrique générale. Le développement respiratoire inachevé, l'apnée, la bradycardie, et d'autres conditions néonatales associées sont autant de facteurs qui nécessitent le travail d'une équipe spécialisée au moment du traitement de la hernie qui se situe juste avant la sortie de l'unité de soins intensifs. Certaines études ayant montré une perte de volume et une déplétion de cellules germinales à partir de l'âge de 6 mois chez le garçon avec une ectopie testiculaire, on préconise une orchidopexie tôt, à l'âge d'un an. Plus de 90% de ces enfants présentent une hernie associée qui doit être réparée en même temps. L'utilisation de la cavité péritonéale pour dériver l'hydrocéphalie par shunt ventriculopéritonéal ou pour dialyse péritonéale en cas d'insuffisance rénale ou autres maladies métaboliques comme l'hyperammonémie et l'acidose lactique sont des causes d'hyperpression intra-abdominale avec augmentation du nombre de cas de hernies jusqu'alors méconnues. Une meilleure connaissance de ces conditions propices à augmenter le nombre de hernies symptomatiques devrait permettre d'en faire le diagnostic plus tôt et de les traiter avant l'apparition des complications. La plupart des hernies non compliquées sont traitées sans hospitalisation. Cependant, quelques bébés et enfants ayant d'autres maladies concomitantes sont mieux traités avec un programme d'hospitalisation de jour, c'est-à-dire que l'enfant est hospitalisé pendant 24 heures après son opération.

Resumen

Este artículo se refiere a las tendencias en el manejo de lactantes y niños con hernias inguinales indirectas. Los avances logrados en el cuidado intensivo neonatal han resultado en la supervivencia de muchos pequeños prematuros, quienes exhiben una elevada incidencia de hernia inguinal. La tasa de incarceración, estrangulación, e infarto gonadal en estos pacientes es dos veces la de la población pediátrica general. La inmadurez respiratoria, apnea, bradicardia, y otras condiciones neonatales asociadas requieren un manejo especial con ocasión de la reparación herniaria, la cual generalmente se realiza inmediatamente antes de la salida de la unidad de cuidado intensivo neonatal. Nuevos conocimientos sobre pérdida de volumen y depleción de las células germinales, lo cual comienza a los 6 meses de edad en niños con testículos no descendidos,

ha estimulado la realización de orquidopexia cuando el paciente llegue a la edad de un año. Más del 90% de los niños con testículos criptorquídicos a la edad de un año tienen una hernia asociada que requiere reparación concomitante con la orquidopexia. El uso de la cavidad peritoneal para efectos de absorción de fluidos en el caso de hidrocéfalos tratados con la implantación de sistemas valvulares ventriculoperitoneales, o de diálisis peritoneal para falla renal y enfermedades metabólicas tales como hiperamonemia o acidosis láctica, causa un aumento en la presión intraabdominal y resulta en la aparición de una hernia previamente inaparente. La identificación de estas y otras condiciones asociadas con una elevada incidencia de hernia debe hacer posible el diagnóstico y tratamiento tempranos, antes de que se presenten complicaciones. La mayoría de las reparaciones herniarias pueden ser realizadas en forma adecuada como procedimientos ambulatorios. Sin embargo, algunos infantes y niños con enfermedades concurrentes pueden ser mejor manejados en un programa de admisión matinal, en el cual la hospitalización se produce en el postoperatorio.

References

1. Grosfeld, J.L.: Groin hernia in infants and children. In Hernia, L.M. Nyhus, R.E. Condon, editors, Philadelphia, J.B. Lippincott, 1989, pp. 81–96
2. Holder, T.M., Ashcraft, K.W.: Groin hernias and hydroceles. In Pediatric Surgery, T.M. Holder, K.W. Ashcraft, editors, Philadelphia, W.B. Saunders Co., 1980, pp. 594–608
3. Groff, D., Nagaraj, H.S., Pietsch, J.B.: Inguinal hernias in premature infants operated on before discharge from the neonatal intensive care unit. Arch. Surg. *120*:962, 1985
4. Rescorla, F.J., Grosfeld, J.L.: Inguinal hernia repair in the perinatal period and early infancy: Clinical considerations. J. Pediatr. Surg. *19*:832, 1984
5. Grosfeld, J.L.: Management of inguinal hernia and hydrocele in infants and children. Ind. St. Med. J. *68*:261, 1975
6. Rowe, M.I., Copelson, L.W., Clatworthy, H.W.: The patent processus vaginalis and the inguinal hernia. J. Pediatr. Surg. *4*:102, 1969
7. Harper, R.G., Garcia, A., Sin, C.: Inguinal hernia: A common problem of premature infants weighing 1000 grams or less at birth. Pediatrics *56*:112, 1975
8. Rowe, M.I., Clatworthy, H.W.: Incarcerated and strangulated hernias in children. Arch. Surg. *101*:136, 1970
9. Puri, P., Guiney, E.J., O'Donnell, B.: Inguinal hernia in infants: The fate of the testis following incarceration. J. Pediatr. Surg. *19*:44, 1984
10. DeBoer, A.: Inguinal hernia in infants and children. Arch. Surg. *75*:920, 1957
11. Sloman, J.G., Mylius, R.E.: Testicular infarction in infancy: Its association with irreducible inguinal hernia. Med. J. Aust. *1*:242, 1958
12. Menardi, F., Sauer, M.: Gangrene of the testis as a complication of incarcerated inguinal hernia in infancy. Z. Kinderchir. *16*:421, 1975
13. Rowe, M.I., Marchildon, M.G.: Inguinal hernia and hydrocele in infants and children. Surg. Clin. North Am. *61*:1137, 1981
14. Liu, L.M.P., Cote, C.J., Goudsouzian, N.G., Ryan, J.F., Firestone, S., Dedrick, D.F., Liu, P.L., Todres, I.D.: Life-threatening apnea in infants recovering from anesthesia. Anesthesiology *59*: 506, 1983
15. Steward, D.J.: Preterm infants are more prone to complications following minor surgery than are term infants. Anesthesiology *56*:304, 1982
16. Morse, T.S.: Pediatric outpatient surgery. J. Pediatr. Surg. *7*:283, 1972
17. Kogan, S.J.: The case for early orchiopexy. In Urologic Surgery in Neonates and Infants, L.R. King, editor, Philadelphia, W.B. Saunders Co., 1988, pp. 396–416
18. Elder, J.S.: The undescended testis: Hormonal and surgical management. Surg. Clin. North Am. *68*:983, 1988
19. Kogan, S.J.: Cryptorchidism. In Clinical Pediatric Urology, 2nd edition, P.P. Kelalis, L.R. King, A.B. Belman, editors, Philadelphia, W.B. Saunders Company, 1985, p. 866
20. Hadziselimovic, F.: Cryptorchidism. In Adult and Pediatric Urology, J.G. Gillenwater, J.T. Grayhack, S.S. Howard, editors, Chicago, Year Book Medical Publishers, 1987, pp. 1932–1947
21. Mosley, R., Lucas, A.: Undescended testis in low birth weight infants. Br. Med. J. *295*:753, 1987
22. Mengel, W., Heinz, H.A., Sippe, II, W.G., Hecker, W.C.: Studies on cryptorchidism: A comparison of histologic findings in the germinative epithelium before and after the second year of life. J. Pediatr. Surg. *9*:445, 1974
23. Muller, J., Skakkebaek, N.E.: Abnormal germ cells in maldescended testes: A study of cell density, nuclear size, and DNA content in testicular biopsies from 50 boys. J. Urol. *131*:730, 1984
24. Job, J.C., Gendrel, D., Safar, A., Roger, M., Chaussain, J.L.: Pituitary LH and FSH and testosterone secretion in infants with undescended testes. Acta Endocrinol. *85*:644, 1977
25. Hadziselimovic, F., Thommen, L., Girard, J., Herzog, B.: The significance of postnatal gonadotropin surge for testicular development in normal and cryptorchid testes. J. Urol. *136*:274, 1986
26. Rajfer, J., Handelsman, D.J., Swerdloff, R.S., Hurwitz, R., Kaplan, H., Vandergast, T., Ehrlich, R.M.: Hormonal therapy of cryptorchidism: A randomized double-blind study comparing human chorionic gonadotropin and gonadotropin releasing hormone. N. Engl. J. Med. *314*:466, 1986
27. Keizer-Schrama, S.M.P.F., Hazebroek, F.W.J., Drop, S.L.S., Matroos, A.W., Molenaar, J.C., Visser, H.K.A.: Double-blind, placebo-controlled study of luteinizing-hormone-releasing hormone nasal spray in treatment of undescended testes. Lancet *1*:876, 1986
28. Hadziselimovic, F., Huff, D., Duckett, J., Herzog, B., Elder, J., Snyder, H., Buser, M.: Long-term effect of luteinizing hormone releasing hormone (Buserelin) on cryptorchid testis. J. Urol. *138*: 1043, 1987
29. Ludwig, G., Potempa, J.: Der optimale zeitpunkt der behandlung des kryptochimus. Dtsch. Med. Wochenschr. *100*:680, 1975
30. Grosfeld, J.L., Cooney, D.R.: Inguinal hernia after ventriculoperitoneal shunt for hydrocephalus. J. Pediatr. Surg. *9*:311, 1974
31. Grosfeld, J.L.: Inguinal hernia and ventriculoperitoneal shunt for hydrocepalus. In Hernia, L.M. Nyhus, R.E. Condon, editors, Philadelphia, J.B. Lippincott Co., 1978, pp. 134–136
32. Grosfeld, J.L., Cooney, D.R., Smith, J., Campbell, R.L.: Intra-abdominal complications following ventriculoperitoneal shunt procedures. Pediatrics *54*:791, 1974
33. Tenckhoff, H., Schecter, H.: A bacteriologically safe peritoneal access device. Trans. Am. Soc. Artif. Intern. Organs *14*:181, 1968
34. Popovich, R.P., Moncrief, J.W., Decherd, J.F., Bomar, J.B., Pyle, W.K.: The definition of a portable/wearable equilibrium peritoneal dialysis technique. (Abstract). Trans. Am. Soc. Artif. Intern. Organs *5*:64, 1976
35. Stone, M.M., Fonkalsrud, E.W., Salusky, I.B., Takiff, H., Hall, T., Fine, R.N.: Surgical management of peritoneal dialysis catheters in children: Five-year experience with 1,800 patient-month follow-up. J. Pediatr. Surg. *21*:1177, 1986
36. Rigden, S.P.A., Barratt, T.M., Dillon, M.J., De Leval, M., Stark, J.: Acute renal failure complicating cardiopulmonary bypass surgery. Arch. Dis. Child. *57*:425, 1982
37. Tank, E.S., Hatch, D.A.: Hernias complicating chronic ambulatory peritoneal dialysis in children. J. Pediatr. Surg. *21*:41, 1986
38. Alexander, S.R., Tank, E.S.: Surgical aspects of continuous ambulatory peritoneal dialysis in infants, children and adolescents. J. Urol. *127*:501, 1982
39. Francis, D.M.A., Donnelly, P.K., Veitch, P.S., Proud, G., Taylor, R.M.R., Ramos, J.M., Ward, M.K., Wilkinson, R., Elliott, R.W., Kerr, D.N.S.: Continuous ambulatory peritoneal dialysis: 3 years experience. Br. J. Surg. *71*:225, 1984
40. Rubin, J., Raju, S., Teal, N., Hellems, E., Bower, J.D.: Abdominal

hernia in patients undergoing continuous ambulatory peritoneal dialysis. Arch. Intern. Med. *142*:1453, 1982
41. Grosfeld, J.L., Weber, T.R.: Congenital abdominal wall defects: Gastroschisis and omphalocele. Curr. Probl. Surg. *19*:159, 1982
42. Husman, D.A., McLorie, G.A., Churchill, B.M., Ein, S.H.: Inguinal pathology in its association with classical bladder exstrophy. Poster Session at the 19th Annual Meeting of the American Pediatric Surgery Association, Tucson, Arizona, May 11–14, 1988
43. Pergament, E., Heimler, A., Shah, P.: Testicular feminization and inguinal hernia. Lancet *2*:740, 1973
44. Punnett, H.H., Kistenmacher, M.L., Toro-Sola, M.: Testicular feminization and inguinal hernia. Lancet *2*:852, 1973
45. Holsclaw, D.S., Schwachman, H.: Increased incidence of inguinal hernia, hydrocele and undescended testicles in males with cystic fibrosis. Pediatrics *3*:442, 1971
46. Wang, C.I., Kwok, S., Edelbrock, H.: Inguinal hernia, hydrocele and other genitourinary abnormalities in boys with cystic fibrosis and their male siblings. Am. J. Dis. Child. *119*:236, 1970
47. Gross, K., DeSanto, A., Grosfeld, J.L., West, K.W., Eigen, H.: Intra-abdominal complications of cystic fibrosis. J. Pediatr. Surg. *20*:431, 1985
48. Coran, A.G., Eraklis, A.H.: Inguinal hernia in the Hurler-Hunter syndrome. Surgery *61*:302, 1967
49. Friedman, D., Schwartzbard, A., Velcek, F.T., Klotz, D.H., Kottmeier, P.K.: The government and the inguinal hernia. J. Pediatr. Surg. *14*:356, 1979