Very low birth weight is an independent risk factor for emergency surgery in premature infants with inguinal hernia

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ABSTRACT

Background: Common surgical knowledge states that inguinal hernia repair in premature infants should be postponed until they reach a certain weight or age. Optimal management, however, is still under debate. The objective of this study was to collect evidence for the optimal management of inguinal hernia repair in premature infants.

Study Design: In the period between 2010 and 2013, data for all premature infants with inguinal hernia who underwent hernia correction within 3 months after birth in the Erasmus MC – Sophia Children's Hospital, Rotterdam were analyzed. Primary outcome measure was the incidence of incarceration and subsequent emergency surgery. In a multivariate analysis, Cox proportional hazards model served to identify independent risk factors for incarceration requiring an emergency procedure.

Results: A total of 142 premature infants were included in the analysis. The median follow-up was 28 months (range 15 to 39 months). Seventy-nine premature infants (55.6%) presented with a symptomatic inguinal hernia; emergency surgery was performed in 55.7%. Complications occurred in 27.3% of emergency operations versus 10.2% after elective repair; recurrences occurred in 13.6% versus 2.0%, respectively. Very low birth weight (≤ 1,500g) was an independent risk factor for emergency surgery, with a hazard ratio of 2.7 in the Cox proportional hazards model.

Conclusion: More than half of premature infants with an inguinal hernia have incarceration. Those with very low birth weight have a 3-fold greater risk of requiring an emergency procedure than heavier premature infants. Emergency repair results in higher recurrence rates and more complications. Elective hernia repair is recommended, particularly in premature infants with a very low birth weight.

INTRODUCTION

Inguinal hernia repair is the most frequently performed surgical procedure in neonates, especially in children born preterm. Up to 9.0% of children born preterm will undergo inguinal hernia repair before the age of 7 years, of whom more than half in the first year of life.[1,2] Factors that contribute to the increased risk of inguinal hernia in premature infants include a persistent processus vaginalis, male sex, gestational age, low birth weight, and prolonged mechanical ventilation.[2,3]

The optimal timing of inguinal hernia repair in premature infants is not clear. Common surgical knowledge is that it should be postponed until a certain weight or age is reach, because of technical challenges (particularly in very low birth weight [VLBW] premature infants), comorbidities, and potential anesthetic and surgical complications.[4-7] Conservative treatment, however, can be complicated by incarceration, followed by ischemia of the bowel and ovarian or testicular atrophy necessitating emergency repair in these fragile newborns, who are probably at even greater risk of complications in an emergency setting compared with an elective repair. In addition, delaying repair could increase the difficulty of the procedure because repeated herniation and reduction might result in a thickened hernia sac and fibrous adhesions between the hernia sac and the spermatic cord.[2,8]

The objective of this study was to collect evidence for the optimal management of inguinal hernia repair in premature infants by comparing the outcomes of emergency procedures with the outcomes of elective repair, and by identifying the risk factors for inguinal hernia in premature infants who become acutely symptomatic.

METHODS

A retrospective cohort study was performed at the Erasmus MC – Sophia Children's Hospital, a tertiary academic paediatric hospital in Rotterdam, The Netherlands. The Sophia Children's hospital is 1 of 6 referral hospitals for premature infants (*ie,* gestational age less than 37 weeks) in the Netherlands. Each referral hospital has its own unique region; Erasmus MC – Sophia Children's Hospital covers a population of >4.5 million inhabitants.

All premature infants operated on for an inguinal hernia within 3 months after birth between January 2010 and December 2013 were included. They were identified from the electronic hospital data systems and medical charts using Centraal Orgaan Tarieven Gezondheidszorg codes (unilateral inguinal hernia repair, CTG335700; bilateral inguinal hernia repair, CTG335701; incarcerated inguinal hernia repair without bowel resection, CTG335702; incarcerated inguinal hernia repair with bowel resection, CTG334639; recurrent inguinal hernia repair, CTG335710).

According to the hernia management chosen, two groups were distinguished: premature infants who underwent elective inguinal hernia repair and premature infants who needed an emergency procedure because of incarceration of contents in the hernia sac. Premature infants that presented with a symptomatic inguinal hernia at our emergency department that could not be manually reduced were operated on within 24 hours, and were defined as cases of incarcerated hernia with subsequent emergency surgery. A pediatric surgeon examined all premature infants at time of first presentation. In our hospital, an open technique was used for all primary inguinal hernia repairs; in case of a recurrence, hernia repair was performed using a laparoscopic approach. Time at risk was calculated from the date of first presentation at our hospital until the date of either elective repair or emergency procedure. Prolonged mechanical ventilation was defined as mechanical ventilation that was continued after the initial procedure was completed. Patient characteristics and clinical data were collected retrospectively in the search for potential risk factors. They included:

- Patient's demographics (ie, sex, gestational age, and weight at birth).
- Preoperative comorbidities associated with the pulmonary system (i.e. history of apnea, Infant Respiratory Distress Syndrome [IRDS], bronchopulmonary dysplasia, preoperative mechanical ventilation); cardiovascular system (ie, history of bradycardia, cardiac anomalies [atrial septal defect, ventricular septal defect, valve abnormalities, Tetralogy of Fallot], intraventricular haemorrhage); and digestive system (ie, GERD and necrotising enterocolitis).

§ Factors associated with the inguinal hernia (ie, palpable testis, hydrocele, incarceration, emergency procedure, other concurrent hernia such as umbilical hernia); hernia characteristics (ie, type of hernia such as uni-/bilateral; hernia side, ie, right, left, or bilateral); and presence of a contralateral hernia or orchidopexy during procedure).
§ Perioperative data (ie, gestational age at repair; weight at repair; type of procedure, ie, open or laparoscopic; duration of procedure; type of anaesthesia; duration of anaesthesia; type of ventilation; duration of ventilation; and re-intubation).
§ Postoperative data (ie, major complications, such as bowel resection, recurrence, testicular atrophy, spermatic cord injury; minor complications, such as haematoma, hydrocele, wound infection, high testicle; length of postoperative hospital stay; length of postoperative neonatal ICU stay, and prolonged mechanical ventilation).

Statistical analysis

SPSS software, version 21.0 (IBM Corp) was used for all statistical analyses. Chi-square and Mann-Whitney U tests were used to compare risk factors for emergency repair and elective repair in premature infants. Univariate regression analyses were performed to determine the relationship of incident cases of incarceration requiring emergency surgery with risk factors by analysing each potential risk factor separately. Multivariate regression analyses were performed using a Cox proportional hazards model to control for effects of multiple potential risk factors. Potential risk factors that were related to cases of incarceration requiring an emergency procedure or that were known in literature (ie, male sex, gestational age, weight of birth, pulmonary comorbidities, and mechanical ventilation) were included in the Cox proportional hazards model. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Between 2010 and 2013, one hundred and forty-two premature infants underwent inguinal hernia repair within 3 months after birth. One hundred and twenty-two (83.6%) were male, mean gestational age was 33 weeks + 4 days (SD 20 days), mean birth weight was 1,859g (SD 589g), and median time to follow-up was 28 months (interquartile range 15 to 39 months). Preoperatively, 43 (29.5%) patients had a history of apnea of prematurity, 29 (19.9%) had IRDS, 53 (36.3%) required mechanical ventilation, and 12 (8.2%) had bronchopulmonary dysplasia. Nineteen (13%) patients had a cardiac anomaly and 21 (14.4%) had a history of bradycardia. Of all premature infants, 11 (7.5%) had GERD, necrotizing enterocolitis developed in 4 (2.7%), 8 (5.5%) had intraven-

tricular haemorrhage, and 22 (15.1%) patients presented with a concurrent umbilical hernia. Mean duration of herniotomy was 29 min (SD 15 minutes), mean duration of anaesthesia was 82 min (SD 32 minutes), and 13 (9.2%) premature infants were operated on after the initial procedure for an inguinal hernia on the contralateral side. During follow-up, two premature infants died after 13 and 14 months, respectively. None of the deaths were related to the procedure for inguinal hernia repair.

Emergency repair

A total of 79 (55.6%) premature infants presented with a symptomatic inguinal hernia at our emergency room, 35 (43.3%) of those hernias could be reduced manually and 44 (55.7%) could not be reduced and required an emergency procedure. Mean time between first presentation at our hospital and emergency surgery was 2.5 days (SD 5.7 days) compared with 18.2 days (SD 11.0 days) for elective repair. Potential risk factors for emergency surgery and elective repair after univariate analysis are presented in Table 1. The postoperative complications rate for emergency surgery was 27.3% vs only 10.2% for elective repair (P = 0.013), and recurrence rates of inguinal hernia were significantly higher after emergency surgery (13.6% vs 2.0%; P = 0.011). Data on postoperative complications are presented in Table 2. Univariate regression analysis showed that gestational age (hazard ratio [HR] = 0.98; P = 0.003), IRDS (HR = 2.1; P = 0.027), and preoperative mechanical ventilation (HR = 2.5; P = 0.006) were associated with an emergency procedure. Premature infants with a very low birth weight (VLBW, ≤ 1,500g) had a 3-fold greater risk of incarceration with a subsequent emergency setting (HR = 3.0, 95% CI, 1.7 – 5.5; P < 0.001). The risk was 70.0% in the VLBW group compared with 23.7% in the group premature infants above 1,500g (Fig. 1). When we controlled for possible confounding variables in the multivariate regression analysis (male sex, gestational age, birth weight, IRDS, preoperative mechanical ventilation), VLBW remained an independent risk factor for incarceration requiring an emergency procedure (HR = 2.7; 95% CI, 1.1 – 6.4, P = 0.027). None of the other variables included in the multivariate regression analysis were found to be statistically significant.

Table 1. *Patient and hernia characteristics and comorbidities of premature infants with inguinal hernia who underwent hernia correction within 3 months after birth at the Erasmus MC – Sophia Children's Hospital, Rotterdam, The Netherlands between 2010 and 2013.*

	Emergency procedure (n = 44)	*Elective repair* (n = 98)	*p-value*
Patient characteristics			
Birth weight, g, mean (SD)	1638 (584)	1977 (561)	0.003*
Gestational age at birth, wk, mean (SD)	32.3 (3.5)	34.2 (2.3)	0.005*
Male sex, n (%)	41 (93.2%)	81 (82.7%)	0.120
Comorbidities, n (%)			
Cardiac anomalies	8 (19.5%)	11 (12.1%)	0.290
Bradycardia	11 (26.8%)	10 (11.0%)	0.037*
IVH	4 (9.8%)	4 (4.4%)	0.254
IRDS	14 (34.1%)	15 (16.5%)	0.039*
BPD	9 (22.0%)	3 (3.3%)	0.001*
Apneas	19 (46.3%)	24 (26.4%)	0.028*
Preoperative MV	14 (56.1%)	11 (33.0%)	0.004*
NEC	2 (4.9%)	2 (2.2%)	0.588
GERD	5 (12.2%)	6 (6.6%)	0.316
Umbilical hernia	6 (14.3%)	16 (17.0%)	0.804
Hernia characteristics, n (%)			
Left side	12 (27.3%)	35 (35.7%)	0.600
Right side	21 (47.7%)	40 (40.8%)	
Bilateral	11 (25.0%)	23 (23.5%)	
Palpable Testes	27 (61.4%)	67 (68.4%)	0.447
Hydrocele	10 (22.7%)	15 (15.3%)	0.342

**Statistically significant. P-values are 2-sided. For dichotomous variables chi-square test was performed and for continuous variables Mann-Whitney U test was performed. IVH, intraventricular haemorrhage; IRDS, infant respiratory distress syndrome; BPD, bronchopulmonary dysplasia; MV, mechanical ventilation; NEC, necrotising enterocolitis.*

Table 2. *Peri- and postoperative data and complications of premature infants with inguinal hernia who underwent hernia correction within 3 months after birth at the Erasmus MC – Sophia Children's Hospital, Rotterdam, The Netherlands between 2010 and 2013.*

	Emergency procedure (n = 44)	*Elective repair* (n = 98)	*p-value*
Peri- and postoperative data			
Gestational age at repair, wk, mean (SD)	39.6 (4.0)	43.8 (2.9)	< 0.001*
Weight at repair, g, mean (SD)	3021 (883)	3889 (862)	< 0.001*
NICU stay, d, mean (SD)	4.7 (9.0)	2.2 (4.8)	0.085
Hospital stay, d, mean (SD)	6.8 (16.3)	3.5 (6.7)	0.210
Prolonged MV, n (%)	11 (25.0%)	2 (2.0%)	< 0.001*
Reintubation, n (%)	5 (11.4%)	2 (2.0%)	0.030*
Orchidopexy during initial repair, n (%)	5 (11.4%)	6 (6.1%)	0.316
Contralateral repair after initial repair, n (%)	8 (18.2%)	5 (5.1%)	0.023*
Duration of anaesthesia, min, mean (SD)	95 (35)	76 (28)	0.001*
Time of herniotomy, min, mean (SD)	34 (16)	26 (14)	0.005*
Major complications, n (%)	**8 (18.2%)**	**4 (4.1%)**	**0.009***
Bowel resection	2 (4.5%)	-	0.094
Recurrence repair	6 (13.6%)	2 (2.0%)	0.011*
Testicular atrophy	2 (4.5%)	2 (2.0%)	0.588
Spermatic cord injury	-	2 (2.0%)	1.000
Minor complications, n (%)	**8 (18.2%)**	**8 (8.2%)**	**0.092**
Haematoma	2 (4.5%)	4 (4.1%)	1.000
Hydrocele	6 (13.6%)	4 (4.1%)	0.070
Wound infection	-	-	-
High testicle	2 (4.5%)	2 (2.0%)	0.588
Total complications, n (%)	**12 (27.3%)**	**10 (10.2%)**	**0.013***

**Statistically significant. P-values are 2-sided. For dichotomous variables chi-square test was performed. The number of premature infants with one or more complications are presented in bold type for the different sub-categories (minor, major, and total). MV, mechanical ventilation; NICU, neonatal ICU.*

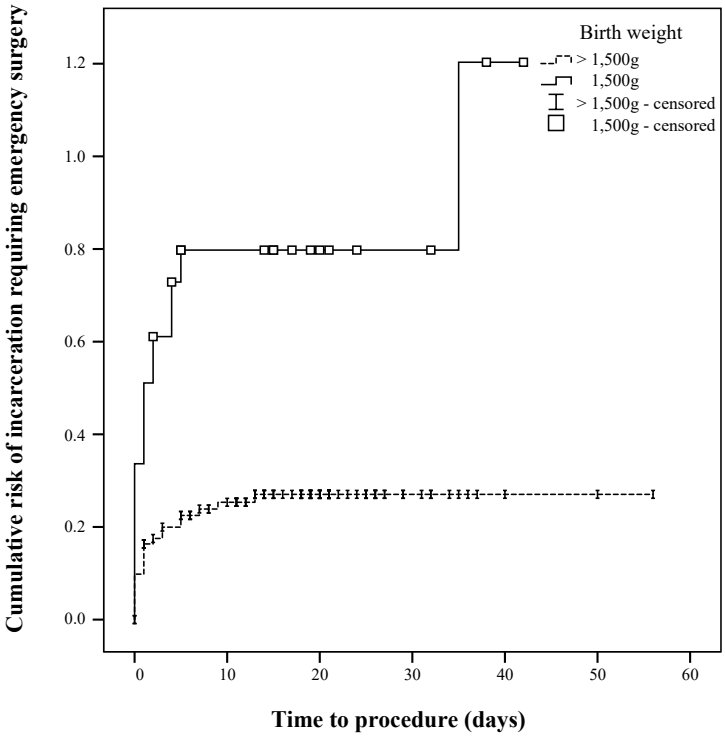

Figure 1. *Hazard function. Risk of incarceration requiring emergency surgery by weight of birth (≤1,500g or >1,500g) among premature infants. VLBW, very low birth weight.*

DISCUSSION

The current study reports that elective inguinal hernia repair is safe and successful in most premature infants and is associated with fewer complications. It also reports that postponing inguinal hernia repair in premature infants results in an incarceration requiring emergency correction in one-third of patients, and that emergency surgery in those premature infants is associated with a significantly higher incidence of postoperative complications as compared with elective repair. This appears to be particularly true for VLBW premature infants, as they were found to have a 3-fold greater risk of incarceration.

These are relevant results in the light of the fact that conflicting published data have made it hard to draw definite conclusions on the optimal management of inguinal hernia in premature infants. Although the levels of prematurity and dysmaturity are associated with high incidence of inguinal hernia, it is the technical challenges and risk of perioperative complications in these fragile newborns make us reluctant to per-

form early elective repair.[9,10] Many pediatric surgeons prefer to perform herniotomy when infants born prematurely reach a certain weight or age. Although this more conservative approach can minimize the risk of surgical and anaesthetic complications, it might also increase the risk of incarceration forcing an emergency procedure with potentially more negative sequelae compared with early elective repair.[2,11,12]

Earlier research on this issue resulted in contradictory outcomes.[2,4-6,9,10,12] However, none of the earlier studies performed a multivariate regression analysis to identify independent risk factors. In 2011, Lautz et al[2] compared premature neonates who presented with an incarcerated or non-incarcerated inguinal hernia and they provided data on timing for inguinal hernia repair. In this retrospective study they found a 2-fold greater risk of incarceration when repair is delayed beyond 40 weeks of gestational age. This result, however, was not corrected for multiple factors and, therefore, a gestational age beyond 40 weeks cannot be considered as an independent risk factor for incarceration.

The incarceration rate in the current study population is one of the highest described in literature.[2,3,10] This can be explained by the fact that the Erasmus MC – Sophia Children's Hospital is a tertiary academic pediatric hospital. It covers a population of >4.5 million inhabitants and is the only hospital of its region that is allowed to perform inguinal hernia repair in premature infants – both in the emergency setting and for the elective operation. More than half of all premature infants that presented with a symptomatic inguinal hernia that could not be manually reduced and required emergency surgery within 24 hours, resulting in a complication rate of 27.3%, which renders early elective repair more appealing. The use of contralateral inguinal exploration in premature infants is another topic still under debate.[13] In literature, incidences of metachronous inguinal hernia vary up to 18.6%.[14,15] In our study, the incidence of contralateral hernia after initial repair was considerably higher after emergency surgery (18.2%) compared with elective repair (5.1%). Because in this study, both the elective and emergency repairs were performed with an open procedure, this difference could not be explained by a difference in techniques used, as they (emergency vs elective repair) bear the same risk of overlooking a metachronous hernia. However, meticulous clinical examination of the contralateral side and its registration are still mandatory.

The current study has several shortcomings, most of which are attributable to the retrospective design. Selection bias could have occurred, as no protocol on timing of repair is available in our hospital for premature infants. In addition, the premature infants could have been diagnosed with an inguinal hernia earlier in a different hospi-

tal, resulting in a delay between diagnosis and first presentation in our hospital. This makes it difficult to draw general conclusions on the actual timing of repair.

Keeping these limitations in mind, this retrospective cohort shows that more than half of premature infants with an inguinal hernia experience incarceration, and that VLBW have a 3-fold greater risk of requiring an emergency procedure than heavier premature infants. Because emergency repair results in higher recurrence rates and more complications, it can even be argued that this particular group of premature infants should be operated on during their birth hospitalization. A multicenter, randomised controlled trial comparing direct and delayed inguinal hernia repair in premature infants should be conducted, stratifying for weight of birth (≤1,500g or >1,500g), to provide more evidence on optimal timing in this fragile group of patients. Until then, elective hernia repair, particularly in VLBW premature infants, is recommended.

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