Hernia (2016) 20:559–563
DOI 10.1007/s10029-015-1450-x

ORIGINAL ARTICLE

The incidence of inguinal hernia and associated risk factors of incarceration in pediatric inguinal hernia: a nation-wide longitudinal population-based study

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Received: 1 April 2015 / Accepted: 22 November 2015 / Published online: 30 November 2015

Abstract
Purpose This study uses a national database to evaluate the incidence of inguinal hernia and associated risk factors of incarcerated hernia in children from birth to 15 years of age.
Methods The study selected children born from 1997 to 2005 from a randomly selected cohort of 1,000,000 from an insured population of 23 million. We regarded children that were classified with code 550 and hernia surgery in accordance to the International Classification of Diseases, 9th Revision, as having inguinal hernia. We used the 2 chi-square test and logistic regression modeling for statistical analyses.
Results In total, 79,794 children (41,767 male and 38,027 female) were enrolled in the study. The cumulative incidence of inguinal hernia in males and females from birth to 15 years old were 6.62 and 0.74 %, respectively ($p < 0.01$). The peak incidence of inguinal hernia was at 0 years of age for males and 5 years of age for females. The ratio of unilateral vs. bilateral repair was 5.54:1. Females tend to have more bilateral inguinal hernia than males (25.4 vs. 12.9 %, $p < 0.01$). Incarcerated hernia occurred in 4.19 % children with inguinal hernia without significant gender discrepancy. Approximately 40 % of incarcerated hernia underwent hernia repair immediately after visiting the emergent department. In patients who presented with reducible hernia, we did not find significant correlation between waiting time to hernia repair and occurrence of incarceration.
Conclusions The cumulative incidence of inguinal hernia from birth to 15 years of age was 6.62 and 0.74 % in males and females, respectively. Incarceration was not related to prematurity or the waiting time for surgery.

Keywords Children · Epidemiology · Inguinal hernia · Incarceration · Incidence

Introduction

Pediatric inguinal hernia is one of the most common surgical diseases in children [1]. It is estimated that over 20 million hernia repairs are performed each year worldwide. The estimated incidence of pediatric inguinal hernia ranges from 0.8 to 4 % in children [2] and is highest in infants, especially in premature children, and decreases as children age. If left untreated, one of the major complications of inguinal hernia is incarcerated hernia. Incarcerated hernia is a pediatric emergency that can lead to intestinal gangrene and gonadal atrophy [2, 3]. The risk of incarceration in children with inguinal hernia ranges from 3 to 16 % [4], with highest incidence estimated to be 30 % in premature children [5]. In clinical practice, inguinal hernia repair is performed on an elective basis, except in patients who have experienced with incarceration. Some studies advocate early intervention to prevent incarcerated hernia because prematurity and prolonged waiting after diagnosis were

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reported be significant risk factors [6]. However, early intervention may lead to a higher risk of anesthesia related complications including apnea or respiratory distress in infants and preterm babies [7]. Therefore, we used a longitudinal follow-up database, the Taiwan National Health Insurance Research Database, to evaluate the relationship between waiting time and incarcerated hernia in children with up to 15 years of follow-up.

Materials and methods

Data

National health insurance

Taiwan National Health Insurance covers more than 98 % of the total population of Taiwan with a total of 22.60 million patients. Our data set enrolled subjects who were randomly selected from the database and covered by insurance in 2005. We included children born from 1997 to 2005 for analysis. They were followed-up from their birth until July 2012.

The variables retrieved from the database

We retrieved data of beneficiaries born between 1997 and 2005 for analysis. The recorded patient characteristics included age and gender. We enrolled children and infants with a diagnosis of inguinal hernia [9th version of international classification of disease, (ICD-9)] with code 550 and surgical repair of inguinal hernia (75606B, 75607C, 75613C and 88029C for children above and under 1 year of age, respectively). Children with a procedure code of 75606B (repair of inguinal hernia with bowel resection) and 75613C (repair of inguinal hernia incarceration without bowel resection) were classified as having incarcerated hernia. Children underwent repair of recurrent inguinal hernia or metachronous contralateral inguinal hernia were not included for analysis. Premature children were defined as a gestation age of less than 37 weeks with ICD-9 codes of 765.11, 765.12, 765.13, 765.14, 765.15, 765.16, 765.17, 765.18, and 765.19.

Definition of waiting time

The time interval between the first diagnosis code of inguinal hernia at the outpatient clinic and at the time of surgery was regarded as the waiting time. Children with a diagnosis of incarcerated hernia at the emergency department and underwent hernia repair immediately after an ER visit were excluded from the waiting time analysis.

Statistics

Data were expressed as mean ± standard deviation. The proportion was calculated with a 95 % confidence interval (95 % CI). All statistical analyses were made by commercial statistical software (SAS, version 9.3, SAS institute, Inc., Cary, NC). The correlation of age and incidence of inguinal hernia were evaluated with trends tests. Chi-square test was used to compare the incidence between genders and age groups. Logistic regression was used to analyze the risk factors for incarcerated hernia with regard to age and gender. A p value of <0.05 was considered statistically significant.

Results

Incidence of inguinal hernia

A total of 79,800 subjects were born in the period between 1997 and 2005. We identified 3339 subjects with a diagnosis of inguinal hernia and undergoing hernia repair during the period. Figure 1 depicts the incidence of inguinal hernia in males and females across variable age groups from birth to 15 years of age. The incidence of inguinal hernia was highest in children under 1 year of age and then decreased with age. The cumulative incidence of inguinal hernia in males and females from birth to 15 years old were 6.62 and 0.74 %, respectively. The incidence of inguinal hernia in males peaked at under 1 year of age and then decreased with age. As for females, the incidence was highest at 5 years of age and then decreased with age.

The ratio of unilateral vs. bilateral repair was 5.56:1 (numbers of operation = 2830:509). Females tend to have more bilateral inguinal hernia than males (25.4 vs. 12.9 %,

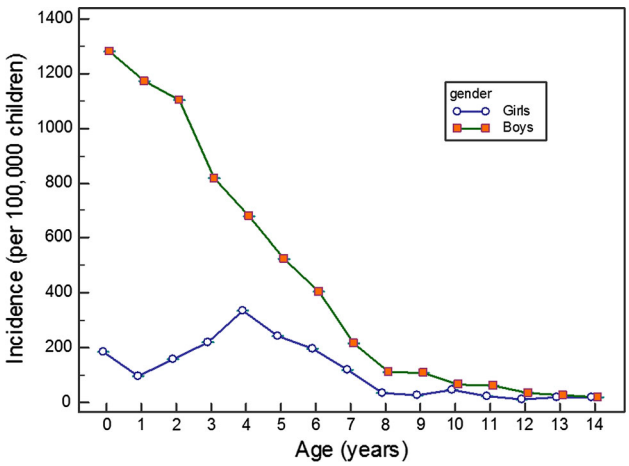

Fig. 1 Incidence of inguinal hernia in males and females across variable age groups from birth to 15 years of age

Table 1 Incidence of unilateral and bilateral inguinal hernia in boys and girls

	Boys		Girls	
	Unilateral	Bilateral	Unilateral	Bilateral
Number (%)	2358 (87.14 %)	348 (12.86 %)	472 (74.57 %)	161 (25.43 %)
Age at first op				
≥7 years old	191 (95.02 %)	10 (4.98 %)	68 (82.93 %)	14 (17.07 %)
6–7 years old	158 (92.94 %)	12 (7.06 %)	62 (80.52 %)	15 (19.48 %)
5–6 years old	197 (92.49 %)	16 (7.51 %)	58 (67.44 %)	28 (32.56 %)
4–5 years old	258 (92.14 %)	22 (7.86 %)	96 (76.80 %)	29 (23.20 %)
3–4 years old	308 (94.19 %)	19 (5.81 %)	65 (73.03 %)	24 (26.97 %)
2–3 years old	414 (90.79 %)	42 (9.21 %)	48 (78.69 %)	13 (21.31 %)
1–2 years old	460 (89.49 %)	54 (10.51 %)	26 (68.42 %)	12 (31.58 %)
0–1 years old	372 (15.78 %)	173 (31.74 %)	49 (65.33 %)	26 (34.67 %)

$p < 0.0001$). In males, the proportion of bilateral hernia repair was most commonly performed on patients under 1 year of age and then decreased as age increased while a high proportion of bilateral inguinal hernia was observed in females across all age groups (Table 1).

Out of 2015 premature children, 191 (9.5 %) had inguinal hernia and underwent hernia repair. The risk of inguinal hernia was significantly higher in premature children (OR = 2.48, 95 CI: 2.13–2.89).

The proportion of incarcerated hernia

Incarcerated hernia accounted for 4.19 % (140/3339) of all hernia repairs (Table 2). The proportion of incarcerated hernia among all inguinal hernia repairs across each age group was highest in infants, with a rate of 8.39 %. The proportion of incarcerated inguinal hernia decreased with age ($p < 0.01$). The risk factors, including gender, laterality, and prematurity, associated with incarcerated hernia were evaluated and no significant affects were observed (Table 2). Although the incidence of inguinal hernia was higher in males, there was no significant gender difference in the proportion of incarcerated hernia (OR = 0.75, 95 CI: 0.47–1.20). Among 140 children with incarcerated hernia, 55 children (39.3 %) had a first diagnosis of inguinal hernia in a visit to the emergency room and underwent operation immediately after the visit. The mean age of the 55 children (51 males and 4 females) was 1.6 ± 1.8 years, and 5 (9.1 %) of the children underwent bilateral inguinal hernia repair. After excluding these children, there were no significant difference in the waiting time from diagnosis to surgery of herniorrhaphy between children with and without incarcerated hernia (59.4 ± 245.9 vs. 59.5 ± 261.0 days, $p = 0.99$). Children with incarcerated hernia had a higher number of emergency room visits before operation than those without incarceration (0.9 ± 1.0 vs. 0.5 ± 0.9, $p < 0.001$). Among 191 premature children with inguinal hernia, 10 (5.24 %) had incarcerated hernia. Premature children were not at a significantly higher risk of developing incarcerated inguinal hernia (OR = 1.28 95 CU: 0.663–2.483). The rate of intestinal gangrene was 0.53 % (18/3339) in all children with hernia, or 12.8 % (18/140) children presenting with incarceration.

Discussion

Through this national and longitudinal study, the cumulative incidences of inguinal hernia from birth to 15 years of age were 6.62 and 0.74 % in males and females, respectively. The current cumulative incidence of inguinal hernia was aligned with the study of Pan et al. [8], which used the same database to evaluate the incidence of inguinal hernia until 7 years of age. As shown in Fig. 1, the incidence of inguinal hernia was below 0.1 % after 8 years of age. Therefore, the difference in cumulative incidence of inguinal hernia between Lin's and the current study was minimal.

In both genders, the incidence of bilateral inguinal hernia repair was highest in infants (Table 1). The percentage of bilateral inguinal herniorrhaphy remained high in the first 7 years of age in females and decreased with age in males. Similar to the results of Pan et al. [8], bilateral inguinal hernia was observed more commonly in females. The fact that females are at higher risk of having bilateral inguinal hernia and metachronous contralateral hernia [1] may explain the reasons for the higher rate of bilateral inguinal herniorrhaphy in females. In addition, some surgeons believe routine contralateral exploration in females presented with unilateral inguinal hernia may contribute to a higher rate of bilateral inguinal hernia repairs [9], despite a meta-analysis that revealed an overall recurrence of metachronous contralateral inguinal hernia was a low as 7 % [10].

Table 2 The incidence of incarcerated in children and its associated risk factors

	Non-incarceration	Incarceration	cOR (95 % C.I)
Number (%)	3199 (95.81 %)	140 (4.19 %)	
Age at first op			
≥7 years old	277 (97.88 %)	6 (2.12 %)	1
6–7 years old	244 (98.79 %)	3 (1.21 %)	0.568 (0.104–2.294)
5–6 years old	293 (97.99 %)	6 (2.01 %)	0.945 (0.301–2.966)
4–5 years old	390 (96.30 %)	15 (3.70 %)	1.776 (0.680–4.634)
3–4 years old	407 (97.84 %)	9 (2.16 %)	1.021 (0.359–2.900)
2–3 years old	499 (97.84 %)	18 (3.48 %)	1.665 (0.653–4.244)
1–2 years old	521 (94.38 %)	31 (5.62 %)	2.747 (1.132–6.664)*
0–1 years old	568 (91.61 %)	52 (8.39 %)	4.227 (1.794–9.960)*
			Trend test < 0.0001*
Gender			
Boys	2587 (95.60 %)	119 (4.40 %)	1
Girls	612 (96.68 %)	21 (3.32 %)	0.746 (0.465–1.196)
Laterality			
Unilateral	2709 (95.72 %)	121 (4.28 %)	1
Bilateral	490 (96.27 %)	19 (3.73 %)	0.851 (0.520–1.393)
Prematurity			
No	3018 (95.87 %)	130 (4.13 %)	1
Yes	181 (94.76 %)	10 (5.24 %)	1.283 (0.663–2.483)

The rate of incarcerated hernia in Taiwan (8.39 % for patient under 1 year and 5.62 % for patients between 1 and 2 years of age) was relatively lower than the rate of previous reports [1, 2, 4, 5]. Misra et al. reported an incidence of 11.9 % in children aged under 2 years of age [6]. The risk of incarcerated hernia decreased with age, and there was no significant difference between genders (Table 2). Waiting time for hernia repair was also not a significant risk factor of incarceration. Zamakhshary et al. [6] stated that a waiting time of >14 days was associated with a doubled risk of incarcerated hernia in children with hernia. The Canadian Paediatric Surgeons Guideline [10] suggests that the hernia repair should be performed 1 week after diagnosis of inguinal hernia. However, Gholoum et al. [11] did not find any difference in the incarceration rate between groups with different waiting times. In the current study, patients with a first diagnosis of inguinal hernia that received an operation immediately after entrance to the emergency room due to incarceration were excluded from the waiting time analysis. The results showed that there were no significantly longer waiting times for children with incarcerated hernia (59.4 ± 245.9 vs. 59.5 ± 261.0 days, $p = 0.99$). The results were in accordance with the study by Timmers et al., finding that early operation (<7 days after diagnosis) of non-incarcerated hernia may be unnecessary [12]. As for children who presented with incarcerated hernia, early surgical intervention is indicated due to high re-incarceration rates [13]. Such a lower rate of incarceration may be attributed to (1) a significant proportion (around 40 %) of children with a first diagnosis of incarcerated hernia in ER and underwent emergent herniorrhaphy thereafter; (2) better accessibility of the Taiwanese National Insurance system: good distribution of hospitals, good public transportation and very low self-pay for emergency visits and surgery. As a result, children with possible incarceration can be treated promptly, and the rate of untreated incarcerated hernia should be negligible in Taiwan.

Aligned with previous study, premature children had significantly higher rates of inguinal hernia (OR = 2.48, 95 CI: 2.13–2.89), which was reported to be as high as 30 % [1]. Contradictory reports exist with regard to the association between prematurity and incarcerated inguinal hernia. Our results did not find a significantly higher rate of incarcerated hernia in premature children (Table 2). Early reports showed a high rate (30 %) of incarceration in preterm infants with inguinal hernia [5]. Recently, Erdogan et al. [14] reported that premature children had an incident rate of 9.6 % for incarcerated hernia compared to 5.9 % in full-term children. This national database study also found no statistical difference.

There were several limitations to this study. First, data from the National Health Insurance were from a retrospective database that was not designed for medical study. Therefore, the database lacks clinical presentation, detailed patients characteristics, image studies, and laboratory data. Second, diagnosis and surgery were based on the claim of herniorrhaphy medical fees without the correction of

diagnostic errors. Children without herniorrhaphy were not included for incidence analysis. As the insurance covered the fee for admission and surgery, the rates of uncorrected hernia in children should be low.

Conclusion

Our large population-based study revealed that the cumulative incidence of inguinal hernia from birth to 15 years of age were 6.6 and 1.7 % in males and females. The incidence and proportion of incarcerated hernia decreased with age. Prematurity, gender, and waiting time for surgery in children undergoing elective hernia repair were not risk factors of incarceration.

Acknowledgments The study is funded by Taipei Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, TCRD-TPE-103-RT-6

Compliance with ethical standards

Conflict of interest All the authors declare that they have no conflict of interest.

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