

Cumulative incidence and registry validation of groin hernia repair in a 34-year nationwide cohort

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ABSTRACT

INTRODUCTION: The purpose of this study was to present a nationwide cumulative incidence and an age-specific incidence rate of groin hernia repair as well as to evaluate the validity of inguinal and femoral hernia operation codes in the Danish National Patient Registry (DNPR).

METHODS: All persons born in Denmark from 1977 to 2010 were investigated for groin hernia operations registered in the DNPR with respect to date of admission, operation, discharge and specific operation codes. To validate the predictive values of registrations, we randomly extracted data on elective and emergency groin hernia operations from the DNPR from 2005 to 2010 and examined the medical records.

RESULTS: The study population ($n = 2,109,417$) from 1977 to 2010 was followed from the primary groin hernia operation ($n = 53,262$) to 2010, yielding a total of 33.4 million person-years of follow-up. The probability of being operated for a groin hernia prior to the age of 34 years was 5.70% (95% confidence interval (CI): 5.62-5.78) for males and 1.26% (95% CI: 1.20-1.32) for females. The highest incidence rate was seen among males aged 0-1 years (10.19 (95% CI: 10.00-10.38)). The positive predictive value of patients registered with inguinal hernia operations in the DNPR who had been operated for an inguinal hernia was 100% (95% CI: 96-100%) and 91.3% (95% CI: 83-96%) for femoral hernia operations.

CONCLUSIONS: The incidence rate of groin hernia operations peaked at the 0-1 year age group in males and at the 3-4-year age group in females. Furthermore, the validation of the DNPR showed very high positive predictive values for both inguinal hernia operations and femoral hernia operations.

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Groin hernia surgery is a common surgical operation in children and adults [1]. Groin hernias are classified into inguinal and femoral hernias; and inguinal hernias are further sub-classified into indirect and direct inguinal hernia [2]. The majority of groin hernia operations are performed due to inguinal hernias and only a minor fraction due to femoral hernias. The groin hernia subtypes (inguinal hernia, femoral hernia) occur with different frequencies depending on age and gender [1].

Population-based studies in surgery can establish the burden of a disease and guide decision-makers in allocating resources appropriately. Furthermore, these studies can also be used to identify associations and fuel new research hypotheses. For this, the Danish National Patient Registry (DNPR) is useful as an administrative population-based health registry [3]. The DNPR was established in 1977 to form the basis for health economic calculations, monitor the frequency of diseases and treatments and provide a framework for population-based research [4]. Prevalence estimates have earlier been reported within the field of hernia surgery [1, 5, 6], but no nationwide longitudinal incidence studies have been reported. The DNPR provides a valuable source and base for health-related research by providing linkage to other nationwide administrative health-based registries, nationwide geographic coverage and complete systematic follow-up of all patients. However, the conclusions made on the data drawn from the DNPR largely depend on the data validity. The DNPR is generally considered a valid registry [4]; however, it has not been validated for groin hernia operations.

Thus, the purpose of this study was two-fold: First, to present the age- and gender-stratified incidence rate and cumulative incidence of groin hernia repair in a nationwide birth-cohort in order to describe the timing of groin hernia surgery and overall disease burden. Second, to evaluate the validity of inguinal hernia and femoral hernia operation codes in the DNPR through manual medical record review.

METHODS

Study population and assessment of groin hernia operations

The Danish Civil Registration System (CRS) is a nationwide administrative register that was established in 1968. The CRS registers contain data on all people who are alive and living in Denmark [6]. Among many other variables, the CRS includes the personal identification number (CPR number, in Danish), sex, date of birth and continuously updated information on vital status, registration of parents, and siblings with the same mother. The unique CPR number is used in all Danish national registers enabling linkage between the registers.

The DNPR was established in 1977 and obtained na-

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tionwide coverage regarding inpatient admissions in 1978 [3]. From 1995, the Danish National Hospital Register was expanded to also include outpatient and emergency room contacts [7], and since 2002 the DNPR also covered private hospitals as well as private specialty clinics in Denmark. The economic reimbursements for medical services are tied to the DNPR through the Diagnosis-Related Group system [8], which ensures a vested interest on the part of the providers in entering accurate and timely information. Medical diagnoses are classified by the International Classification of Diseases, eighth edition (ICD-8) from 1977-1994 and by the ICD-10 since 1995. Surgical operations are classified by three versions of the Danish Classification of Surgical Operations and Therapies from 1977 to 1995 and by the Nordic Medico-Statistical (NOMESCO) Classification of Surgical Operations since 1996 [9].

By the use of the CPR number, a register-based cohort consisting of all Danish residents who were born in Denmark in 1977 or later was established. Within this cohort, all groin hernia operations (inguinal and femoral hernias) performed in the study period (1 January 1977-31 December 2010) were identified through the Danish Classification of Surgical Operations and Therapies and the NOMESCO Classification of surgical operations. The included operation codes from 1977-2010 are presented in **Table 1**.

Study design

All persons were followed from birth until the first groin hernia operation, death, emigration or until 31 Decem-

ber 2010, whichever came first. To estimate the incidence rate and the cumulative incidence (%) of groin hernia operations, we considered all persons born in Denmark from 1 January 1977 to 31 December 2010. Each person could only appear once in this study with one groin hernia operation, no matter the number of operations performed. Date of onset was defined as the operation day for the first groin hernia operation in the study period.

Validation of operation codes

In order to validate the groin hernia operations, we extracted data on all groin hernia operations registered in the DNPR between 2005 and 2010 (Table 1). We sampled this specific five-year period since no sub-classification of groin hernia surgery (i.e. inguinal hernia and femoral hernia operations) existed prior to the introduction of the NOMESCO classification. Within this sample, we divided all patients who had received a groin hernia operation into ten-year age groups (0-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years, 61-70 years, 71-80 years, 81-90 years, 91-100 years). We then randomly extracted 200 inpatient and elective or emergency groin hernia operations (100 inguinal hernia operations and 100 femoral hernia operations).

It was ensured that the 200 randomly drawn patients were geographically distributed nationwide, had been operated in both private and public hospitals, were equally distributed regarding emergency and elective admissions, and were equally distributed regarding gen-

 **TABLE 1**

Groin hernia operation codes.

Operation code	Time period	
	1977-1994	1996-present
Inguinal hernia operation codes	40620: Inguinal hernia operation 40621: Endoscopic inguinal hernia operation 40640: Preperitoneal inguinal hernia operation 42000: Inguinal hernia operation	KJAB00: Inguinal hernia operation KJAB10: Inguinal hernia operation with plasty KJAB20: Inguinal hernia operation with fascia repair KJAB30: Inguinal hernia operation with synthetic implant KJAB40: Inguinal hernia with laparotomy and abdominal wall plasty KJAB96: Other operation for inguinal hernia KJAB97: Other laparoscopic operation for inguinal hernia
Femoral hernia operation codes	40660: Femoral hernia operation 42100: Femoral hernia operation	KJAC10: Femoral hernia operation KJAC11: Laparoscopic femoral hernia operation KJAC30: Femoral hernia operation with synthetic implant KJAC40: Femoral hernia with laparotomy and abdominal wall plasty KJAC96: Other operation for femoral hernia KJAC97: Other laparoscopic operation for femoral hernia
Subtype-unspecific groin hernia operation codes	40740: Groin hernia operation 42900: Groin hernia operation 40760: Groin hernia operation with fascia repair 40800: Groin hernia operation with synthetic material 40801: Laparoscopic groin hernia repair with synthetic material 40840: Groin hernia operation with synthetic material 42810: Groin hernia operation with biological material	—

der in the ten-year age intervals. The latter was done to reduce the risk of selecting specific high-probability or low-probability age and gender groups and to overcome the fact that a completely random sample would consist mainly of adult males with inguinal hernias [1]. Thus, in each ten-year interval there were five male patients operated for inguinal hernia, five male patients operated for femoral hernia, five female patients operated for inguinal hernia and five female patients operated for femoral hernia.

Through the DNPR, we extracted the dates of operation, admission and discharge as well as data on hospital performing the operation, admission type and specific operation codes used. The operating hospitals were contacted in order to obtain the medical records. The medical records were evaluated by two authors (JB, MSL) who were blinded to the type of groin hernia operation registered. This was subsequently compared with the registration in the DNPR.

Data analysis and ethics

The incidence rate of groin hernia operation was calculated as the number of new cases in the population at risk who were operated for a groin hernia at a given age. The cumulative incidence of groin hernia operations was calculated as the probability to have been groin hernia operated at a specified age taking into account that persons may die from other causes or emigrate [10, 11]. Persons were censored from the analysis by emigration or death.

Validation of operation codes in the medical records was evaluated for agreement with the registered codes in DNPR with positive predictive values (PPV) for registration, which were calculated for each of the groin hernia types and reported as a frequency (%) with a 95% confidence interval (CI). We defined PPV as the proportion of patient registered with a disease who truly had the disease when examining the medical records as standard reference.

Approval for this study was obtained from The Danish Data Protection Agency (no. 2011-41-6149) and the Danish Health Authority (no. 7-505-29-1765/1).

Trial registration: not relevant

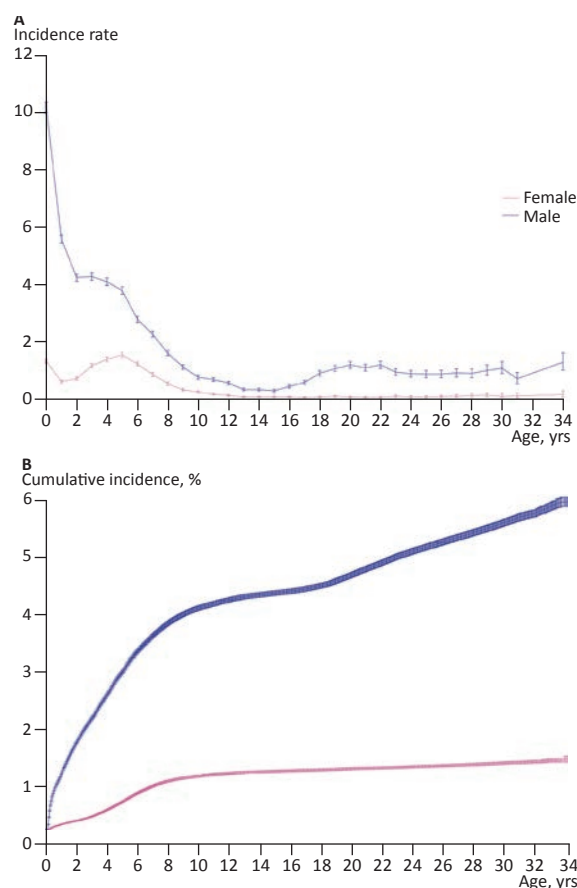
RESULTS

Incidence rate and cumulative incidence

The study population included 2,109,417 persons born in Denmark in the 1977-2010 period, who were followed until their first surgery for groin hernia from birth until 2010, yielding a total of 33.4 million person-years of follow-up. A total of 53,262 persons were operated for groin hernia during the study period, corresponding to an incidence rate of 1.59 per 1,000 person-years at risk.



FIGURE 1



Incidence rate and cumulative incidence for groin hernia operations.

A. Incidence rate stratified by age and gender. The highest incidence rate of 10.19 (95% confidence interval (CI): 10.00-10.38) was seen among males aged 0-1 years.

B. Cumulative incidence and 95% CI stratified by age and gender in the nationwide 34-year population.

Figure 1A shows the incidence rate stratified by age and sex. For males, the incidence rate was highest for children aged 0-1 years, after which it declined until the 10-14-year age group. The incidence rate for females followed a similar pattern, but the rate was lower throughout the study period (Figure 1A). The cumulative incidence of groin hernia surgery is seen in Figure 1B. For all ages, males had a higher absolute risk of hernia operation than females. The probability of being operated for a groin hernia before the age of 34 was 5.70% (95% CI: 5.62-5.78) for males and 1.26% (95% CI: 1.20-1.32) for females.

Validation of operation codes

The medical records of 200 groin hernia operations (100 inguinal hernia operations and 100 femoral hernia operations) were requested from the operating departments. A total of 13 medical records could not be retrieved despite multiple requests, resulting in data on 95 inguinal hernia operations and 92 femoral hernia operations (Table 2).

When examining the medical records, it was found

TABLE 2

Demographics and predictive values of groin hernia operations as registered in the Danish National Patient Registry.

	Hernia operations	
	inguinal (N = 100)	femoral (N = 100)
Obtained medical records, n (%)	95 (95)	92 (92)
Male/female, n (%)	47 (49)/48 (51)	45 (48)/47 (52)
Emergency operations/elective operations, n (%)	41 (43)/54 (57)	54 (58)/38 (42)
Positive predictive value, % (95% CI)		
KJAB00	100 (81.5-100)	–
KJAB10	100 (15.6-100)	–
KJAB11	100 (76.8-100)	–
KJAB30	100 (92.3-100)	–
KJAC00/10	–	96.5 (82.2-99.9)
KJAC11	–	100 (80.5-100)
KJAC30/40	–	92.3 (74.8-99)
KJAC96	–	75.1 (34.9-96.8)

CI = confidence interval.

that all (100%) of the inguinal hernia operation medical records described the correct operation, matching the operation code that was registered in the DNPR, which corresponded to a PPV of 100% (95% CI: 96-100%). We found that eight operations that were coded as femoral hernia operations was not, in fact, femoral hernia operations; instead other unrelated operations had been performed (five patients had inguinal hernias, one patient had a sphincter reconstruction, one patient had a laparoscopic cholecystectomy and one patient had an incisional hernia). This corresponded to a PPV of 91.3% (95% CI: 83-96%). Of the eight misclassified femoral hernia operations, six were classified as emergency operations. Hence, there was a trend towards emergency operations being misclassified. When examining the validity for groin hernia operations (inguinal hernias and femoral hernias combined), the overall PPV for groin hernia operations in the DNPR was 98.4% (95% CI: 95-99%). Regarding age, the PPV was generally higher than 97% for all age groups.



Male with left-sided groin hernia.

DISCUSSION

This study found that the incidence rate of groin hernia operations in a nationwide cohort peaked within the first year of life in males and around the age of four years of age in females. The cumulative incidence revealed that one in 17 males has been operated for a groin hernia by the age of 34 years, whereas one in 80 females has been operated for a groin hernia by the age of 34 years. The validity measured by PPVs of inguinal and femoral hernia operations in the Danish National Patient Registry (DNPR) were generally very high with a PPV of 100% (95% CI: 96-100%) for inguinal hernia operations and 91% (95% CI: 83-96%) for femoral hernia operations, which render data from the DNPR valid for register-based studies on groin hernia operations.

This study confirmed that primary groin hernia operations are commonly performed in children aged 0-5 years. Males have a higher operation rate than females throughout the first 34 years of life. Earlier large-scale studies have found similar results [1, 12]; however, without performing thorough incidence studies. These findings support the hypothesis that some subtypes of groin hernias are congenital [13]. This hypothesis is supported particularly by the high frequency of groin hernia operations in newborn (Figure 1A). Earlier studies have attempted to confirm that groin hernias are inherited [14]. However, it remains to be established whether groin hernias are inherited or not and how the specific inheritance patterns are.

The DNPR has been validated numerous times [4], but not previously for groin hernia operations. Earlier validation studies have shown a variety of valid data stratified by disease and operation. However, surgical operations and admissions are generally valid [15]. The present study confirms that DNPR is a reliable source for register-based studies on inguinal hernia operations and femoral hernia operations with regard to operation, age, gender and mode of admission and operation.

This study holds a number of strengths and limitations. Among the limitations are that it was not possible in the registry to divide the inguinal hernias anatomically into direct and indirect inguinal hernias, respectively. This would have required that the data should have been validated by linkage to other sources such as the Danish Hernia Database (DHDB) [16]. However, the DHDB only registers operations in adults, and since the majority of operations in this study were performed in patients < 18 years, the medical records remain the reference standard. Being an incidence study, the risk estimates found with this method will be minimum values since only the first groin hernia operation was included. Measures of completeness defined as the proportion of true cases that are correctly captured by the registry could not be estimated since the DNPR is used as a ref-

erence for other registers. However, surgical operations are likely to have a high degree of completeness compared with medical diagnoses [4]. Other limitations include that we cannot find hernia procedures that have been coded as completely different diseases in the DNPR. Furthermore, we are able to conclude only on the validity of groin hernia surgery in the investigated period (2005-2010). In that time period, the validity of groin hernia surgery in all age groups was investigated, whereas the incidence part of this study covered a 34-year time period in persons aged up to 34 years. Among the strengths is the fact that this study is a nationwide incidence study with more than 33 million person years of complete follow-up based on very valid data.

CONCLUSIONS

This study showed that the incidence rate of groin hernia operations peaked around the age of 0-1 years in males and 3-4 years in females. The validation of the DNPR showed high PPVs for both inguinal and femoral hernia operations, making the DNPR a highly accurate register for further research in groin hernia surgery.

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