Risk factors for inguinal hernia in middle-aged and elderly men: Results from the Rotterdam Study

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ABSTRACT

Background: Prospective data on risk factors and the incidence of inguinal hernia are sparse, especially in an elderly population. The aim of this study was to determine the incidence of and risk factors for inguinal hernia.

Methods: We analyzed data from the Rotterdam Study, a prospective cohort study that observed the general population aged ≥45 years of Ommoord, a district in Rotterdam, from baseline (1990) over a period of >20 years. Diagnoses of inguinal hernia were obtained from hospital discharge records and records from general practitioners. Multivariate regression analysis was performed to determine risk factors for inguinal hernia development.

Results: Among 5,780 men, with a total of 50,802 person-years, who did not have a hernia at baseline, 416 cases of inguinal hernia occurred (7.2%). The 20-year cumulative incidence was 14%. Age-adjusted hazard ratio (HR) for inguinal hernia for men relative to women was 12.4 (95% CI, 9.5 – 16.3; P < .001). On multivariate analysis, the risk of inguinal hernia increased with advancing age (HR per 1-year increase in age, 1.03; 95% CI, 1.02 – 1.04; P < .001). Participants with a body mass index (BMI) of 25 – 30 kg/m^2 had an HR of 0.72 (95% CI, 0.58 – 0.89; P = .003) compared with a BMI <25; a BMI >30 had an associated HR of 0.63 (95% CI, 0.42 – 0.94; P = .025).

Conclusion: Inguinal hernia is common in the middle-aged and elderly male population and its incidence increases with advancing age. Overweight or obese patients have a lower risk of developing an inguinal hernia.

INTRODUCTION

Inguinal hernia repair is the most frequently performed operation in general surgery. In 2003, approximately 770,000 inguinal hernia repairs were performed in the United States.[1-4] The lifetime risk of undergoing inguinal hernia repair is as great as 42.5% for men and 5.8% for women.[5-8]

Etiological factors for the development of a primary inguinal hernia include not only the presence of a patent processus vaginalis and altered metabolism of collagen connective tissue and the extracellular matrix, but seems also to result from increased intra-abdominal pressure.[9,10] Patient-related factors that are thought to be associated with the development of inguinal hernia are aging, male sex, smoking, diabetes, physical activities, and family history.[7,9-16]

The incidence of inguinal hernia appears to increase with age, especially in men through the fifth to seventh decade of life.[12,15] Excess body weight has also been considered to be a risk factor for the development of inguinal hernia, because it is believed, among other factors, to affect the intra-abdominal pressure.[9] However, the association of obesity with inguinal hernia is still not well established. Several studies provided conflicting data, and some even suggest a protective effect for the development of inguinal hernia.[7,9,12,15-17]

In the United States, the prevalence of obesity increased from 27.5% in 1999 to 37.2% in 2010 among men between the age of 40 and 59.[18,19] It is likely that both the incidence and prevalence of inguinal hernia will increase globally as a result of our aging population, but possibly also because of increasing prevalence of obesity. Therefore, inguinal hernia constitutes a very relevant public health issue. Despite this public health issue, data from large, prospective cohort studies that evaluate the relationship between the incidence of inguinal hernia and risk factors are sparse, and few studies have focussed on the more elderly male population.[12,15]

The aim of our study was to analyse data within the Rotterdam Study, a prospective cohort study ongoing since 1990 in the city of Rotterdam in The Netherlands, to determine the incidence of inguinal hernia among middle-aged and elderly men and to create insight into the association of inguinal hernia with potential risk factors.

MATERIALS AND METHODS

The Rotterdam Study is a prospective cohort study that included individuals from the district of Ommoord in Rotterdam, The Netherlands, from January 1990 onwards. Initially, 7,983 participants out of 10,215 invitees (78%) of the Ommoord district were recruited (RS-I). In 2000, 3,011 participants of 4,472 invitees who had become 55 years of age or moved into the study district since the start of the study were added to the cohort (RS-II). In 2006, a further extension of the cohort was initiated in which 3,932 subjects of 6,057 invitees between the ages of 45 to 54 were included (RS-III). By the end of 2008, the Rotterdam Study, therefore, comprised 14,926 subjects aged ≥45 years with an overall response at baseline of 72.0% (14,926/20,744) for all 3 cycles (RS-I, RS-II, and RS-III).

The participants were all examined in detail at baseline. They were interviewed at home (2 hours) followed by an extensive set of examinations (a total of 5 hours) in a research facility in the center of their district. These examinations focused on possible causes of invalidating diseases in participants aged ≥45 years and were repeated every 3–4 years in the participant characteristics that could change over time. The study design, objectives, and major findings of the Rotterdam Study have been described extensively elsewhere.[20] The medical ethics committee at Erasmus University of Rotterdam approved the study, and written informed consent was obtained from all participants.

Participants in the Rotterdam Study are followed for a variety of diseases, including the presence of an inguinal hernia. The participants of the first cohort (RS-I) were interviewed at baseline and asked if they were ever diagnosed or admitted to the hospital owing to the presence of an inguinal hernia. In the second (RS-II) and third (RS-III) cohorts, questions with regard to inguinal hernia were not incorporated in the baseline interview. To identify all incident events of inguinal hernia since the start of the Rotterdam Study, International Classification of Primary Care (ICPC) codes for diagnosis of inguinal hernia (D89) or other hernia (incisional- and/or umbilical hernia, D91) were retrieved from general practitioners in the Ommoord district. In addition, hospital discharge records of the participants of cohort RS-I, RS-II, and RS-III with regard to the diagnosis of inguinal hernia were obtained using the Landelijke Medische Registratie (LMR) codes, the national medical register used in The Netherlands. For all participants, these records were checked for cases of inguinal hernia including the period (far) before the point of entrance into the Rotterdam study to avoid potential bias in prevalent cases of inguinal hernia. Being added after the original design of the Rotterdam Study, the current analysis is thus classified as post-hoc. Data on body

mass index (BMI, kg/m^2), age, sex, diagnosis of diabetes mellitus, smoking, and use of corticosteroid medication were collected at baseline and extracted from the cohort database, because they were considered relevant determinants in relation to incidence of inguinal hernia. The presence of type 2 diabetes mellitus was defined by the use of antidiabetic medication or by a non-fasting or post-load plasma glucose level >11.1 mmol/L (200 mg/dL). The use of medication was determined by questionnaire at baseline. Drug exposure (classified by ATC code [http://www.whocc.no/atc_ddd_index/]) is monitored continuously since the initiation of the Rotterdam Study in 1991 by using computerized pharmacy records of the pharmacies in the Ommoord district. Both the ICPC and the LMR codes are standardized, and validity was checked by the data management team of the Rotterdam Study.

Statistical analysis

Prospective analyses were performed using the Cox proportional hazards (CPH) regression model to identify risk factors related to the proportion of incident cases of primary inguinal hernia in men. Participants with a prevalent (pre-existing) inguinal hernia at baseline or participants who developed a recurrent/contralateral hernia during the study period were excluded from the analysis. Time at risk was calculated from the date a participant entered the Rotterdam Study to the first date a primary inguinal hernia was diagnosed, date of last contact, or the date of death. We used 5-, 10-, 15-, and 20-year Kaplan-Meier estimates to infer the cumulative incidences of inguinal hernia over time.

Univariate regression analyses were performed to determine the relationship of incident cases of primary inguinal hernia with risk factors by analyzing each potential risk factor adjusted for age as a continuous variable. BMI was entered as an ordinal variable and was modelled using 3 categories for BMI: < 25.0, 25.0 – 30.0, and >30 kg/m^2. Age was modelled using 3 categories: <65, 65 – 75, and >75 years. Other baseline factors that were adjusted for age and entered in the model were: diabetes mellitus (yes/no), steroid use (yes/no), smoking (never/former/current), and presence of other hernia (yes/no).

Multivariate regression analysis was performed using a CPH model to control for effects of multiple potential risk factors. Potential risk factors that were related to incident cases of primary inguinal hernia after univariate regression analyses (P <0.10) were included in the CPH model. All factors met the proportional hazards assumption of a relatively constant risk ratio through examination of -log (-log) survival curves. All analyses were performed using the Statistical Package for the Social Sciences version 17.0 (SPSS Inc, Chicago, IL). Continuous data are presented as mean ± standard deviation.

RESULTS

In the Rotterdam Study, after exclusion of participants with an inguinal hernia at baseline (348/14,926), the overall proportion of incident cases of primary inguinal hernia was 3.2% (477 cases among 14,568 participants). There were 5,870 men and 8,788 women without a prevalent (pre-existing) inguinal hernia at baseline. The proportion of incident cases among male participants was 7.2% (416 cases among 5,780 participants) compared with 0.7% of primary inguinal hernia (61 cases among 8,788) among female participants. In the 5,870 men, the 5-year cumulative incidence of developing inguinal hernia was 4.3% compared with 0.3% in women. The mean age in men was 64.7 ± 9.5 and 68.1 ± 8.6 years in women. The 10-year cumulative incidence was 7.9% compared with 0.7%, and for 15 years it was 11.6% compared with 1.0%, and for 20 years it was 14.0% versus 1.8%. Adjusted for age, the hazard ratio (HR) for inguinal hernia for men relative to women was 12.4 (95% CI, 9.5 – 16.3; P < .001). Therefore, further analyses were conducted only on the 5,870 men of the Rotterdam Study. Baseline characteristics of the 5,870 male participants are shown in Table 1.

Table 1. *Baseline characteristics for inguinal hernia among men in the Rotterdam Study, The Netherlands (n = 5,780), 1990 – 2008.*

Characteristic	*Diagnosis of inguinal hernia (n = 416)*	*No inguinal hernia (n = 5,364)*	*P - value*
Follow-up (y)	13.0 (5.2)	9.0 (5.8)	<.001
Age (y)	66.6 (8.2)	64.5 (9.5)	<.001
Height (cm)	175.1 (6.6)	175.9 (7.1)	.025
Weight (kg)	78.5 (11.1)	82.6 (13.0)	<.001
Body mass index*	25.6 (3.1)	26.7 (3.6)	<.001
Cigarette smoking, n (%)			.199
Never	56 (13.5)	848 (15.8)	
Former	243 (58.4)	2941 (54.8)	
Current	89 (21.4)	1280 (23.9)	
Corticosteroid use, n (%)	2 (0.5)	85 (1.6)	.091
Diabetes Mellitus, n (%)	27 (6.5)	438 (8.2)	.004
Other hernia, n (%)	1 (0.2)	38 (0.7)	.525

**BMI was calculated as weight (kg)/length (m^2).*
Data are mean (SD) values unless otherwise specified.

The 5-, 10-, 15-, and 20-year cumulative incidence of developing an inguinal hernia and its association with increasing age was unadjusted; all other potential risk factors

and the cumulative incidence of the development of an inguinal hernia over 20 years were adjusted for age (Fig. 1; Table 2). The HRs for development of an inguinal hernia were greater for participants between the age of 65 and 75 years (HR, 1.4; 95% CI, 1.11 – 1.70; P < .001) and for participants >75 years of age (HR, 1.9; 95% CI, 1.46 – 2.51; P < .001) in comparison with the reference group of participants <65 years of age.

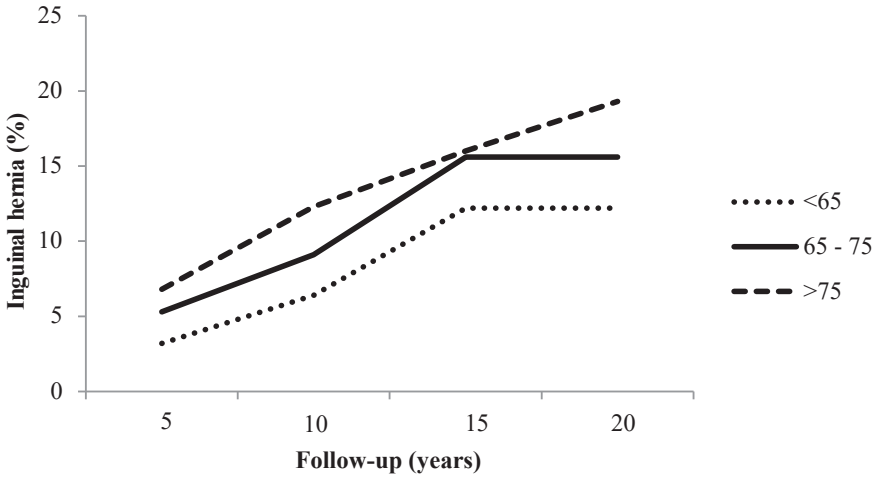

Figure 1. *Risk of inguinal hernia by age among men in the Rotterdam Study, The Netherlands, 1990 – 2008.*

The cumulative incidence the development of an inguinal hernia among men decreased with baseline BMI. The 20-year cumulative incidence was 17.2% in participants with a BMI of <25 kg/m^2 and 12.3% in participants with both BMI of 25 – 30 kg/m^2, and participants with a BMI >30 kg/m^2. The HRs for the development of an inguinal hernia were less for participants with a BMI of 25 – 30 kg/m^2 (HR, 0.71; 95% CI, 0.58 – 0.87; P < .001) and for participants with a BMI >30 kg/m^2 (HR, 0.53: 95% CI, 0.36 – 0.79; P < .001) in comparison with the reference group of participants with a BMI <25 kg/m^2.

The presence of diabetes mellitus at baseline showed a cumulative incidence of 15.3% over 20 years for the development of inguinal hernia among men. The HR for the development of an inguinal hernia showed a protective effect in the presence of diabetes mellitus, which was of borderline significance (HR, 0.68; 95% CI, 0.46 – 1.00; P = .05). Cigarette smoking, corticosteroid use, or the presence of another hernia at baseline were not associated with the development of inguinal hernia in the middle-aged and elderly male population of the Rotterdam Study.

Table 2. *Risk of inguinal hernia (unadjusted) over 20 years and age-adjusted hazard ratio for inguinal hernia among men in the Rotterdam Study, The Netherlands (n = 5,780), 1990 – 2008.*

Risk factor	*No. of participants*	*No. with inguinal hernia*	*Risk of inguinal hernia (%)*	*Age-adjusted hazard ratio**	*95% CI*	*P - value*
Age (y)						<.001
<65	3,377	204	12.2	1.0		
65 – 75	1,485	141	15.6	1.4	1.1 – 1.70	
>75	918	71	19.3	1.9	1.46 – 2.51	
Body mass index						<.001
<25	1,793	176	17.2	1.0		
25 – 30	2,727	187	12.3	0.71	0.58 – 0.87	
>30	747	30	12.3	0.53	0.36 – 0.79	
Cigarette smoking						.609
Never	904	56	17.4	1.0		
Former	3,184	243	14.3	0.86	0.65 – 1.16	
Current	1,369	89	12.7	0.87	0.62 – 1.21	
Corticosteroid use						.156
No	5,665	412	14.1	1.0		
Yes	87	2	3.9	0.37	0.09 – 1.47	
Diabetes Mellitus						.050
No	3,581	353	14.8	1.0		
Yes	465	27	15.3	0.68	0.46 – 1.00	
Other hernia						.593
No	5,741	415	14.0	1.0		
Yes	39	1	2.6	0.59	0.08 – 4.17	

**Estimated using Cox Proportional Hazards regression analysis, adjusted for age a continuous factor; the factor age was unadjusted.*

The final CPH model for multivariate regression analysis included age, BMI and diabetes mellitus (Table 3). Increased baseline age remained associated with a greater risk of inguinal hernia development (HR, 1.3; 95% CI, 1.02 – 1.04; P < .001). Increased baseline BMI had still a protective effect for inguinal hernia among middle-aged and elderly men; participants with a BMI of 25 – 30 kg/m^2 had a HR of 0.72 (95% CI, 0.58 – 0.89; P = .003), and participants with a BMI >30 kg/m^2 had a HR of 0.63 (95% CI, 0.42 – 0.94; P = .025) in comparison with the reference group of participants with a BMI <25 kg/m^2. Increased baseline BMI remained protective when included in the model as a continuous variable (HR, 0.93; 95% CI, 0.90 – 0.97; P < .001). Although diabetes mellitus seemed to show a protective effect in univariate analysis, this result did not remain significant after adjustment for age and BMI in the final CPH model (HR, 0.70; 95% CI, 0.47 – 1.05; P = .086).

Table 3. *Multivariate-adjusted hazard ratio for inguinal hernia among men in the Rotterdam Study, The Netherlands (n = 5,780), 1990 – 2008.*

Risk factor	*Multi - adjusted hazard ratio*[*]	*95% CI*	*P value*
Age (y)	1.03	1.02, 1.04	<0.001
Body mass index			
<25	1.0	(Referent)	-
25 – 30	0.72	0.58, 0.89	.003
>30	0.63	0.42, 0.94	.025
Diabetes Mellitus			
No	1.0	(Referent)	-
Yes	0.7	0.47, 1.05	.086

DISCUSSION

This study showed a 20-year cumulative incidence of inguinal hernia in 5,870 middle-aged and elderly men of the Rotterdam Study of 14.0%. The age-adjusted HR for the development of inguinal hernia was 12 times greater among men. This study also demonstrated that being overweight or obese was associated with decreased incidence of inguinal hernia. Advancing age was a significant risk factor for development of an inguinal hernia in middle-aged and elderly men, but no relationship could be determined between diabetes mellitus and inguinal hernia development.

These are relevant findings, because inguinal hernia repair is the most performed procedure in general surgery. In 2003, approximately 777,000 inguinal hernia repairs were performed in the United States.[1-4] Others have reported that the lifetime risk of undergoing inguinal hernia repair is greatest for the adult male population, especially in the final decades of life.[5-8,12,15] Obesity is also considered to be a risk factor for inguinal hernia.[9] In the United States, the prevalence of obesity increased from 27.5% in 1999 to 37.2% in 2010 among men between the age of 40 and 59.[18,19] Surprisingly, the relationship between obesity and inguinal hernia is still not well established; even a protective effect has been suggested.[7,9,12,15-17] Therefore, it can be argued that owing to ageing of the population and increasing prevalence of obesity, inguinal hernia constitutes a relevant public health issue.

The theory that collagen quality of collagen and collagen metabolism are important in the development of (direct) inguinal hernia is widely accepted.[21] In the elderly population, the balance between the formation and degradation of collagen seems to be shifted, favouring a decrease in connective tissues, resulting in less collagen

cross-linking and, therefore, less strength and stability of the collagen fibres.[22,23] In addition, data on skin biopsies of elderly patients have demonstrated an increase in matrix metalloproteases 2 and 9 (MMP) and a decrease in the tissue inhibitors of metalloproteinases 1 and 2 (TIMP), which play a role in this collagen degeneration.[24,25] These changes may increase the risk of developing an inguinal hernia with advancing age.[26] The current study provides data on the 5-, 10-, 15-, and 20-year cumulative incidence of development of an inguinal hernia in middle-aged and elderly men and the association of inguinal hernia with increasing baseline age. The HR in male participants aged >75 years almost doubled in comparison with participants <65 years, supporting the theory described herein.

The hypothesis that individuals who are overweight or obese are more likely to develop inguinal hernia has been questioned by several studies.[7,9,12,15-17] Our study contributes to these previous findings and provides data on the 20-year cumulative incidence of development of an inguinal hernia among middle-aged and elderly and an association with decreasing baseline BMI; the HR of the development of an inguinal hernia was decreased by almost half in men with a BMI >30 kg/m^2 compared with men with a BMI <25 kg/m^2.

To date, only two prospective cohort studies have been performed that evaluate the relationship between inguinal hernia and potential risk factors.[12,15] Both studies demonstrated an "unexpected" relationship between overweight or obese male participants and a decreased risk of inguinal hernia. It was hypothesized in these studies that the lesser incidence of inguinal hernia in participants with increased body weight could be explained by a decreased chance of diagnosis of inguinal hernia in these participants on physical examination.

In 2007, Ruhl et al[15] examined risk factors for inguinal hernia among US adults aged 25 – 74 years who participated in the National Health and Nutrition Examination Survey I Epidemiologic Follow-up Study (1971 -1975) and were followed through 1992 – 1993. They demonstrated in multivariate analysis that a greater incidence of inguinal hernia among men was associated with increasing baseline age and the presence of concomitant hiatal hernia, whereas black race, being overweight and obesity were associated with a lesser incidence. Although the conclusions drawn from that study support our data with respect to age and BMI, the National Health and Nutrition Examination Survey I study focused only on the adult US population aged 25 – 74 years, whereas the present study focused more on the elderly male population. Furthermore, as mentioned by the authors, the follow-up occurred only 10 and 20 years after the baseline examination. Two recently published papers based on a retrospective review

of all inguinal hernia performed on adult US residents of Olmsted County, Minnesota, supported these findings.[8,17]

In 2008, Rosemar et al examined risk factors for inguinal hernia in a community-based sample of middle-aged Swedish men who were followed-up from baseline (1970 – 1973) until 2004. The conclusion drawn from that study was that middle-aged Swedish men who are overweight or obese also had a lesser incidence of inguinal hernia. A decreased risk was noted with advancing age and among heavy smokers. Although this study supports the results of both the study by Ruhl et al and the current study, this Swedish study only analyzed middle-aged men and only allowed identification of participants who were hospitalized for inguinal hernia, whereas the current study included middle-aged and elderly men and diagnoses of inguinal hernia not only from hospital discharge records, but also from the medical files of general practitioners.

Although our study confirms the previous findings of the 2 earlier mentioned cohort studies, our study provides insight into the association of inguinal hernia with potential risk factors of a middle-aged and elderly male population in Western Europe. Our study has limitations. The Rotterdam Study contains data of 3 cohorts (RS I, RS II, and RS III); in the first cohort it was asked explicitly if participants had a known inguinal hernia, which was not the case for the other 2 cohorts, which may have led to potential differences in prevalent cases of inguinal hernia between the cohorts. In an attempt to compensate for this potentially huge bias, all 3 cohorts were checked for a diagnosis of inguinal hernia through records of hospitals and general practitioners, including the period (far) before entrance into the Rotterdam Study. Therefore, this possibility should have biased the results only minimally. Because case definition was based on records of hospitals and general practitioners, and a questionnaire was only used for the first cohort, participants with asymptomatic inguinal hernia could have been missed and case ascertainment may have been incomplete; confirmation of hernia diagnoses by physical examination or ultrasonography within the Rotterdam Study was not possible. These limitations also played a role in the other 2 mentioned cohort studies. Another limitation is that the protective effect of BMI in relation to inguinal hernia development could also be attributable to the fact that diagnosing an inguinal hernia can be more difficult in overweight or obese patients owing to their obesity.[12,15] Therefore, imaging should be incorporated in future studies.

In conclusion, this large prospective cohort study that provides evidence for risk factors of inguinal hernia in middle-aged and elderly West-European males by confirming previous findings of an increased risk of developing an inguinal hernia with advancing age and lesser risk of inguinal hernia in overweight and obese male participants.

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