



Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and Reproductive Biology

journal homepage: www.elsevier.com/locate/ejogrb

Full length article

Pelvic organ prolapse surgery after native tissue vault suspension at hysterectomy—A prospective cohort study

Lisbeth Bonde^{a,b,*}, Lauge Østergaard^c, Emil L. Fosbøl^d, Lars A. Møller^e, Bent Ottesen^f, Gunnar H. Gislason^{b,g}, Helga Gimbel^{b,e}

^a Department of Obstetrics and Gynecology, Nykøbing Falster Hospital, Nykøbing Falster, Denmark^b University of Southern Denmark, Odense, Denmark^c Department of Cardiology, Copenhagen University Hospital, Rigshospitalet, Denmark^d Department of Cardiology, Copenhagen University Hospital Herlev and Gentofte, Denmark^e Department of Obstetrics and Gynecology, Zealand University Hospital, Roskilde, Denmark^f Department of Gynecology, Juliane Marie Centre, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark^g Department of Cardiology, Herlev and Gentofte University Hospital, Herlev/Hellerup, The Danish Heart Foundation, Copenhagen, Denmark

ARTICLE INFO

Article history:

Received 15 November 2018

Received in revised form 18 June 2019

Accepted 21 June 2019

Keywords:

Benign indication

Hysterectomy

Pelvic organ prolapse

Suspension

Vaginal vault

ABSTRACT

Objective: The effect of prophylactic vaginal vault suspension during hysterectomy in prevention of subsequent development of pelvic organ prolapse (POP) is unknown. We aimed to investigate incidences and risk of POP surgery in women who had undergone hysterectomy on benign indication with and without prophylactic suspension.

Study design: We linked the national clinical Danish Hysterectomy and Hysteroscopy Database (DHHD) to administrative registries to assess data on all total hysterectomies (1 May 2012 to 31 December 2014), suspension methods, age, POP surgery, births, obstetric complications, prescriptions, socioeconomic- and vital status. Women undergoing total hysterectomy on non-prolapse and benign indication with no prior POP surgery were included and followed from hysterectomy to POP surgery, death/emigration or end of study period (maximum 2 years). Descriptive statistics, cumulative incidence curves and multivariable Cox proportional hazard models were fitted to assess the associated risk of POP in relation to prophylactic suspension.

Results: We included 7625 patients undergoing total hysterectomy; of these, 6538 (85.7%) were registered with prophylactic suspension during hysterectomy and 1087 (14.3%) women were specifically registered with *no suspension* in the DHHD. At baseline, women undergoing hysterectomy with suspension were on average 47.1 years of age (standard error SE 0.1) compared to 48.4 years (SE 0.3) in women with *no suspension* (p-value <0.0001). Moreover, women with suspension differed from their counterparts with *no suspension* with respect to geographical site of hysterectomy, hysterectomy method, parity and income. The cumulative risk of POP surgery after two years follow-up was 0.9% and 0.5% in the suspension group and the *no suspension* group, respectively. In the adjusted analysis, we found no association of prophylactic suspension and risk of POP surgery, hazard ratio (HR) = 2.1 (95% confidence interval (CI) 0.8–5.3, p-value 0.13).

Conclusion: Of all women undergoing hysterectomy for benign indication, 0.84% (N = 64) were surgically treated for POP. At two-year follow-up, there was no association between prophylactic vaginal vault suspension at time of hysterectomy and subsequent POP surgery.

© 2019 Elsevier B.V. All rights reserved.

Introduction

Women undergoing hysterectomy on benign indication tend to experience increased risk of undergoing surgery for pelvic organ

prolapse (POP) with increased rates of surgery within the first five years [1]. In Denmark the cumulative incidence of post hysterectomy POP is 12% at 32 years of follow-up, however, after only two years the hazard of POP surgery reaches the same level as after 20 years [2]. Well established risk factors of POP count age, body mass index (BMI), vaginal and instrumental delivery, parity, infant weight, ethnicity, history of POP and connective tissue diseases [3–5]. However, the pathophysiology of hysterectomy as a risk factor is not fully elucidated.

* Corresponding author at: Fjordvej 15, 4800, Nykøbing Falster, Denmark.
E-mail address: lisbeth.bonde@dadlnet.dk (L. Bonde).

Vaginal vault suspension is used in surgical treatment of POP [6]. Moreover, suspension is recommended by the British Society of Urogynecology, The American Association of

Gynecologic Laparoscopists and the Danish Health Authority as a prophylactic procedure during hysterectomy in order to try to prevent post hysterectomy POP. These recommendations are however made on sparse evidence [7–10]. The possible prophylactic effect is supported by Summers et al., who described that loss of apical support results in apical descent with POP beyond the hymen and contributes to 50% of anterior prolapse [11]. Therefore, in theory, suspending and thereby supporting the apex during hysterectomy should prevent subsequent POP.

When this study was initiated, data on prophylactic suspension during hysterectomy had not previously been registered in the Danish national databases. Therefore, in order to investigate our hypothesis that prophylactic vaginal vault suspension during hysterectomy prevents POP surgery, registration of prophylactic suspension during hysterectomy on benign indications was added to the national clinical Danish Hysterectomy and Hysteroscopy Database (DHHD) in 2012. This enabled us to conduct this observational follow-up study to investigate incidences and risk of POP surgery in women undergoing hysterectomy with and without prophylactic suspension two years after hysterectomy.

Material and methods

Design

A prospective exploratory cohort study of prophylactic suspension methods during hysterectomy on benign indication in Denmark and its possible association to subsequent prolapse surgery.

Population

Between 1 May 2012 and 31 December 2014, all women undergoing total hysterectomy in Denmark on non-prolapse and benign indication with no prior POP surgery were included in the study (N = 8806). Of these, 7625 (86.4%) had information on suspension registered and were divided into 6538 (85.7%) women with a suspension method and 1087 (14.3%) women registered specifically with *no suspension* (Fig. 1).

Data sources

The DHHD holds prospectively registered data on all hysterectomies on benign indication performed in Denmark since 2003 [12].

To enable this study, the DHHD trial group discussed preferences and used suspension methods on their affiliated departments and added five suspension methods and one related procedure to the DHHD registration chart in 2012. The suspension methods were 1) *suspension ad modem (a.m.) McCall* (also known as “low uterosacral ligament suspension”), 2) *suspension a.m. Bob Shull* (also known as “high uterosacral ligament suspension”), 3) *suspension to the cardinal ligament*, 4) *suspension to the uterosacral ligament* and 5) *suspension a.m. modified TAIL* (total atraumatic intrafascial hysterectomy by laparoscopic route and during hysterectomy by abdominal route, clamping and ligating the cardinal- and the uterosacral ligaments in one take before vaginal vault attachment). The related method was *inclusion of the anterior and posterior fasciae* during closure of the vaginal vault. Also, gynecologists had the opportunity to select *other suspension* technique or *no suspension* [13]. Please refer to Table 1 for details on the registered suspension methods.

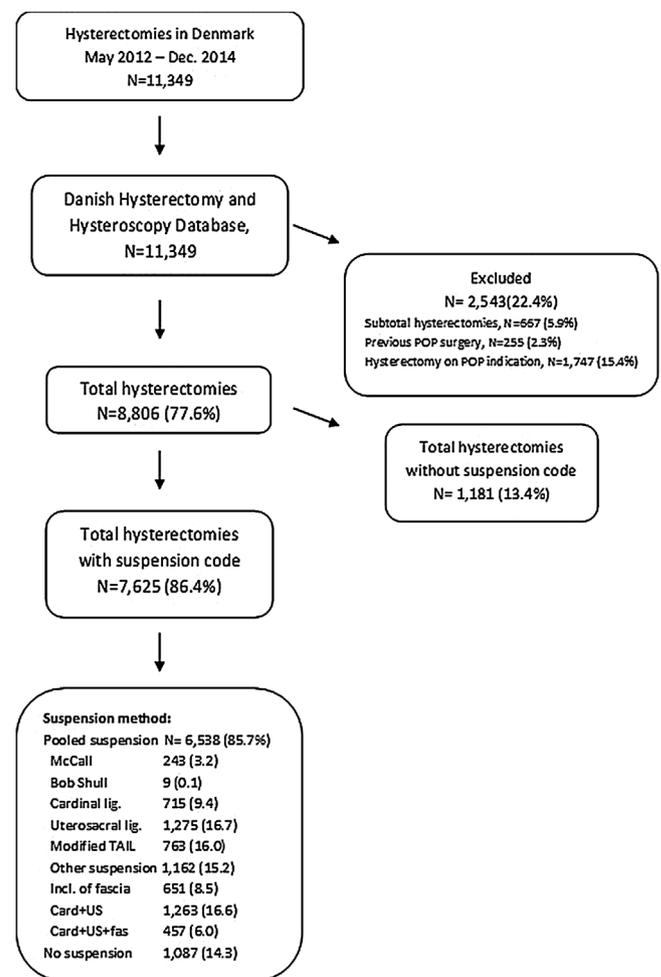


Fig. 1. Study population of hysterectomies in Denmark, 1 May 2012 to 31 Dec 2014. Fig. 1. POP = Pelvic organ prolapse. TAIL = Total atraumatic intrafascial laparoscopic hysterectomy. Card + US = Concomitant vault suspension to the cardinal- and uterosacral ligament. Card + US + fas = Concomitant vault suspension to the cardinal- and uterosacral ligament with inclusion of fasciae.

We linked data from the DHHD on a personal level with six Danish administrative registries. Linkage of registries is possible because all Danish citizens upon birth are assigned a unique personal social security number [14]. From these registries, we collected data on hospitalizations (diagnoses and procedures), births and obstetric complications, outpatient contacts, prescriptions, socioeconomic- and vital status. Details on registries and specific variables are listed in Table 2.

Outcome measures

As mentioned above, apical support has been shown to contribute to development of POP in the anterior compartment [11]. We therefore included POP in all compartments and defined our outcome ‘POP surgery’ as *surgery for POP in all compartments performed in public and private hospitals (NCSP code KLEF)* as described by Lykke et al [2].

Exposure

Prophylactic vaginal vault suspension was included as two different exposure variables, one for each multivariable Cox proportional hazard analysis. **Analysis 1** was performed as to whether any suspension was registered (*pooled suspension*) or not

Table 1
Detailed description of suspension methods.

Method of suspension	Operation codes	Description
McCall	KZLA01	Internal McCall: One to three non-absorbable sutures are placed through the left uterosacral ligament, thereafter plication of the peritoneum in the cul-de-sac ending in the right uterosacral ligament. External McCall: Before tying the internal sutures, one to three additional absorbable sutures are placed. Each suture is applied through the posterior vaginal wall, through both uterosacral ligaments and then back through the vaginal wall.
Bob Shull	KZLA02	Attachment of one to three non-absorbable sutures in the right- and the left uterosacral ligament. The anterior- and the posterior arm of each suture is fastened to the pubocervical- and the rectovaginal fascia, respectively.
Cardinal ligament	KZLA03	The cardinal ligament is held independently with a pean, cut and ligated. Thereafter the ligament is fastened to the vagina.
Uterosacral ligament	KZLA04	The uterosacral ligament is held independently with a pean, cut and ligated. Thereafter the ligament is sutured to the vagina.
Modified TAIL	KZLA05	The cardinal- and the uterosacral ligaments are held together with a pean, cut and ligated. Thereafter the ligaments are sutured to the vagina.
Other suspension	KZLA06	A procedure with suspension to anatomical structures not described in this table.
No suspension	KZLA07	No suspension performed.
Inclusion of fascia	KZLA08	The pubocervical and rectovaginal fasciae are visualized and included during closure of the vagina.

Table 2
Data sources.

Name and year of establishment of database / registry	Variable	Classification system (if any)	Code (if any)
Danish Hysterectomy and Hysteroscopy Database (DHHD), 2003	Age		
	Date of hysterectomy		
	Body mass index	ICD-10	DVRA01 (weight), DVRA10 (height)
	Geographical site of hysterectomy		
	Suspension method	NCSP	KLZA01-08
	Hysterectomy method	NCSP	KLCC, KLCD
Danish civil registration system (CRS), 1968	POP as indication of hysterectomy	ICD-10	DN815
	Vital status		
	Date of emigration		
National Patient Registry (NPR), 1977	Date of POP surgery		
	POP surgery method	NCSP	KLEF
	Complications to hysterectomy	ICD-10	DT810E-H, DT814F + I, DK565, DT813D, DN998a
	Constipation	ICD-10	DK590
The Danish National Prescription Registry (DNPR), 1994	Date of dispensed prescription		
	Type of hormone replacement therapy	ATC	G03CA03 + 04 + 53 + 57, G03CB01, G03DC02 + 03 + 05, G03DA02 + 04, G03FA01 + 12, G03FB01 + 05 + 06 + 09, G03HB01, G03XC01, G02BA03
	Type of pharmaceutical treatment of cough		R03 (excluding R03AC02 + 03, R03CC02 + 03), R05FA02
The Danish Medical Birth Registry (DMBR), 1968	Date of birth(s) (parity)		
	Instrumental delivery		
	Birth weight		
The Income Statistics Register (ISR), 1970	Annual household adjusted income		
The Danish Education Register (DER), 1910	Highest achieved education	ISCED	

POP = Pelvic organ prolapse.

NCSP = The Nordic Medico-Statistical Committee's classification of surgical procedures (1996-present.).

ICD-10 = The 10th revision of the International Classification of Diseases.

ATC = Anatomic Therapeutical Chemical.

ISCED = The International Standard Classification of Education 2011 scale.

(no suspension) [13]. In analysis 2, the exposure variable included the following individually registered suspension methods and the two most common combinations of suspension methods: *suspension to the cardinal ligament + suspension to the uterosacral ligament* as well as *suspension to the cardinal ligament, suspension to the uterosacral ligament + inclusion of fasciae*. We categorized all other registered combinations as 'other suspension technique' (Fig. 1).

Covariables for adjustment

Baseline data and the known or suspected predictors of POP are listed in Table 3. All listed variables apart from body mass index were included in the multivariable analyses [3–5,15,16]. Body mass

index was excluded because of missing data. Covariables with baseline differences were therefore also included in the analyses. We used filled prescriptions to account for concomitant use of hormone replacement therapy (HRT) and chronic cough. With respect to HRT, we used the ATC codes described by Løkkegård [17] and grouped women into never-, past- and current users. If a woman had filled a prescription for HRT within 6 months before hysterectomy, she was categorized as current user of HRT. Regarding chronic cough, we used filled prescriptions of pharmaceuticals used in treatment of cough as a proxy. In order to exclude cases who suffered from light or transient cough, we deducted short acting beta-agonists (Anatomic Therapeutical Code R03AC02 + 03 and R03CC02 + 03) (Table 3).

Table 3
Patient characteristics.

	Total N	%	Pooled suspension N	%	No suspension N	%	p-value
Covariables	7,625	100.0	6,538	85.7	1,087	14.3	
Age (years, mean (SE), N = 7,625)	47.3	0.1	47.1	0.1	48.4	0.3	<.0001
Body mass index (kg/m ² , mean (SE), N = 7,077)	26.5	0.1	26.5	0.1	26.4	0.2	0.32
Geographical site of hysterectomy							
Capital Region of Denmark	1,956	25.7	1,467	22.4	489	45.0	<.0001
Region Zealand	1,233	16.2	1,163	17.8	70	6.4	<.0001
Region of Southern Denmark	1,479	19.4	1,244	19.0	235	21.6	0.05
Central Denmark Region	2,197	28.8	1,987	30.4	210	19.3	<.0001
North Denmark Region	760	10.0	677	10.4	83	7.7	<0.01
Hysterectomy method							
Abdominal route	2,432	31.9	2,074	31.7	358	32.9	0.43
Laparoscopic route	3,937	51.6	3,307	50.6	630	58.0	<0.001
Vaginal route	1,256	16.5	1,157	17.7	99	9.1	<0.001
Major complications after hysterectomy ^a	381	5.0	327	5.0	54	6.3	0.96
Education ^b							
Lower secondary education, ISCED 0-2	1,654	21.7	1,406	21.5	248	22.8	0.33
Upper secondary education, ISCED 3	358	4.7	309	4.7	49	4.5	0.75
Post secondary non-tertiary education, ISCED 4	3,141	41.2	2,718	41.6	423	38.9	0.10
Short cycle tertiary education or Bachelor's degree, ISCED 5-6	1,889	24.8	1,620	24.8	269	24.7	0.98
Master's or Doctoral degree, ISCED 7-8	402	5.3	331	5.1	71	6.5	0.05
Unknown	181	2.4	154	2.4	27	2.5	0.80
Household adjusted income							
< 299,999 Dkr ^c	1,525	20.0	1,257	19.2	268	24.7	<0.001
300,000 - 499,999 Dkr	3,541	46.4	3,063	46.8	478	44.0	0.08
> 500,000 Dkr	2,559	33.6	2,218	33.9	341	31.4	0.10
Obstetric factors							
Birth weight ^d	1,742	22.8	1,516	23.2	226	20.8	0.08
Parity (Mean (SE))	1.8	0.01	1.8	0.01	1.6	0.03	<0.001
Instrumental delivery ^e	689	9.0	596	9.1	93	8.6	0.55
Hormone replacement therapy							
Never user	5,647	74.1	4,838	74.0	809	74.4	0.77
Past user	1,697	22.3	1,461	22.3	236	21.7	0.64
Current user	281	3.7	239	3.7	42	3.9	0.74
Chronic cough	<50	<1.0	<40	<1.0	<10	<1.0	0.41
Constipation	325	4.3	274	4.2	51	4.7	0.45

Frequencies are n (%) or mean (SE).

p-value of difference between women with and without vaginal vault suspension.

^a Major complications included hospitalization because of hemorrhage, intraabdominal infections, obstructive intestinal adherence, wound or vaginal vault rupture within 30 days after hysterectomy.

^b Highest completed educational level, ISCED = International standard classification of education.

^c Mean income in Denmark before taxes, Dkr = Danish kroner.

^d Largest birth weight > 4000 g.

^e Vacuum or forceps delivery.

Statistical analyses

For descriptive statistics, continuous variables are presented as mean values with standard error (SE) and categorical variables as frequencies. For comparisons, we used unpaired t-tests for continuous variables and Pearson's χ^2 tests for dichotomous variables. We performed a cumulative incidence plot of first POP surgery stratified into *pooled suspension* and *no suspension*, accounting for death as a competing risk.

Cox proportional hazard analyses were fitted to assess risk of POP surgery a maximum of 24 months after hysterectomy in women with vaginal vault suspension and in women with *no suspension*, respectively. Analysis 1 included *pooled suspension* as exposure variable with *no suspension* as reference. Analysis 2 included the individually registered suspension methods and the two most frequent combinations of suspension methods as described above. Again, the group of reference was *no suspension*. We performed crude- and multivariable analyses with covariates mentioned above. Index date was set to 30 days after hysterectomy in order to include complications that women might have experienced after surgery in baseline. Women were therefore followed from 30 days after hysterectomy until 1) end of study period (31 Dec. 2016), 2) emigration, 3) death, 4) POP surgery, 5) 24 months after the hysterectomy, whichever came first. The

proportional hazard assumption was assessed through formal testing. Continuous variables were tested for linearity. We tested for effect modification between the exposure variable *pooled suspension* and age, HRT, chronic cough, age, method of hysterectomy and income, respectively. We present results with hazard ratios and 95% confidence limits. Level of statistical significance was set to 0.05. Statistical analyses were performed using SAS statistical software (version 9.4, Cary, NC, USA).

Ethics

The study was approved by the steering group of DHHD and by the Danish Data Protection Agency (9 July 2013, no. REG-30-2013). No ethical approval is required for register studies in Denmark. The study is registered in clinicaltrials.gov (no. NCT02859272).

Results

Women undergoing hysterectomy with *pooled suspension* were older (p-value <0.01) and had higher parity (p-value <0.0001) than their counterparts with *no suspension*. For differences of less clinical relevance please refer to baseline [Table 3](#).

At maximum of two years follow up, women who had undergone hysterectomy with *pooled suspension* had a cumulative

risk of 0.9% (95% confidence interval (CI) 0.7–1.2) of POP surgery compared with 0.5% (95% CI 0.2–1.0) among women with *no suspension* (p-value 0.14) (Fig. 2). Women with *pooled suspension* were operated for POP after a median of 338 days (25 and 75 percentiles: 246–490) and women with *no suspension* had surgery after a median of 364 days (25 and 75 percentiles: 274–581) after baseline.

Cox proportional hazards analyses were performed as complete case analysis and thereby 7625 women were included in the two analyses. Analysis 1 showed no association of *pooled suspension* and POP surgery in both the crude and adjusted model (crude hazard ratio (HR) 2.0 (95% CI 0.8–4.9, p-value 0.15) and adjusted HR 2.1 (95% CI 0.8–5.3, p-value 0.13); Fig. 3). In analysis 2, the individual *suspension a.m. McCall* was associated with a significantly increased crude and adjusted risk of POP (crude HR 4.5 (95% CI 1.3–15.5, p-value 0.02) and adjusted HR 4.8 (95% CI 1.2–19.2, p-value 0.03); Fig. 3). We found no effect modification among relevant variables.

Comment

Main findings

In this study, we investigated risk of POP surgery in women undergoing hysterectomy with and without prophylactic vaginal vault suspension. In both the crude and adjusted model, we report no association between prophylactic suspension during hysterectomy and risk of POP surgery in the short term.

Strengths and limitations

One strength of this study is the large study population. This reduces the chance of a type two error and increases the external validity of the results. Further, Danish legislation require all hospitals, both public and private, to register 1) primary diagnosis (in this study indication of hysterectomy) and 2) procedure (in this study POP surgery) to the NPR. In return this registration leads to the departments' reimbursement from the Danish health system which increases completeness of data in the registries. Consequently, we can account for all women undergoing hysterectomy on benign indication and all POP surgeries in Denmark during the study period. We hereby avoid selection bias. In Denmark, everyone has access to health care regardless of social status, participation in the labor market or private health insurance programs. This also reduces selection bias. Moreover, our outcome

variable (POP surgery) and the exposure variable (pooled suspension) have been validated previously [13,18]. Last, personal level linkage of the many administrative registries enables us to account for a large number of known and suspected risk factors.

Certain limitations also exist. It is possible that comparisons between groups in this study is underpowered considering that the group of reference (*no suspension*) consists of only 14.3% (N = 1087) of the total study cohort. This might bias our estimates. Also, validity of some individual suspension methods have been shown to be low [13] and conclusions therefore have to be interpreted cautiously. In addition, data regarding earlier POP surgery dates back to 1996 and data on births back to 1978. This might introduce an underestimation of frequencies in these variables. One study investigating age specific incidences of POP surgery in Denmark found that most women underwent surgery at the age of 60–80 years [19]. As 90% of women in this study were younger than 66.8 years of age, it is unlikely that a substantial part of our cohort had POP surgery 20 years earlier before 1997. Regarding parity, 90% of the cohort were 28.8 years of age or less in 1978. Therefore, missing data from births before the start of the Danish medical birth registry in 1978 is again unlikely to introduce significant bias. Last, given the observational design we cannot rule out that our results are confounded by uneven distribution of unknown factors among groups.

Comparison with existing literature

To our knowledge, the literature on POP in women after prophylactic suspension compared to *no suspension* is very sparse. One recent study which is in line with our results of no associated risk of *pooled suspension* and POP surgery is a pilot RCT by Till et al. They showed no effect on anatomical position of the vaginal apex during Valsalva after *suspension a.m. McCall* compared with uterosacral ligament plication in women who underwent hysterectomy by vaginal- and laparoscopic route, respectively [20]. Nonetheless, we need to keep the small population size (N = 50) in mind and Till et al.'s study might be underpowered to show a significant association. One other study mimic a comparison of prophylactic apical suspension to *no suspension*. Cruikshank et al.'s [21] randomized controlled trial (RCT) from 1999 evaluated POP at pelvic examination three years after three different types of surgical treatment of POP during hysterectomies by vaginal route: *technique am Moschcowitz*, *suspension am McCall* and simple closure of the cul-de-sac. As only *suspension am McCall* include apical suspension, the remaining two procedures can be perceived

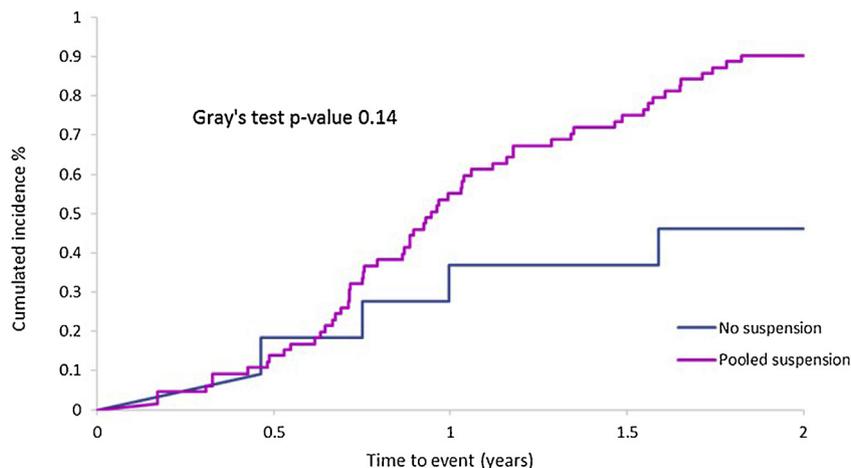


Fig. 2. Cumulative incidence of pelvic organ prolapse surgery after hysterectomy.

Fig. 2: Cumulative incidence of prolapse surgery in women with and without vaginal vault suspension.

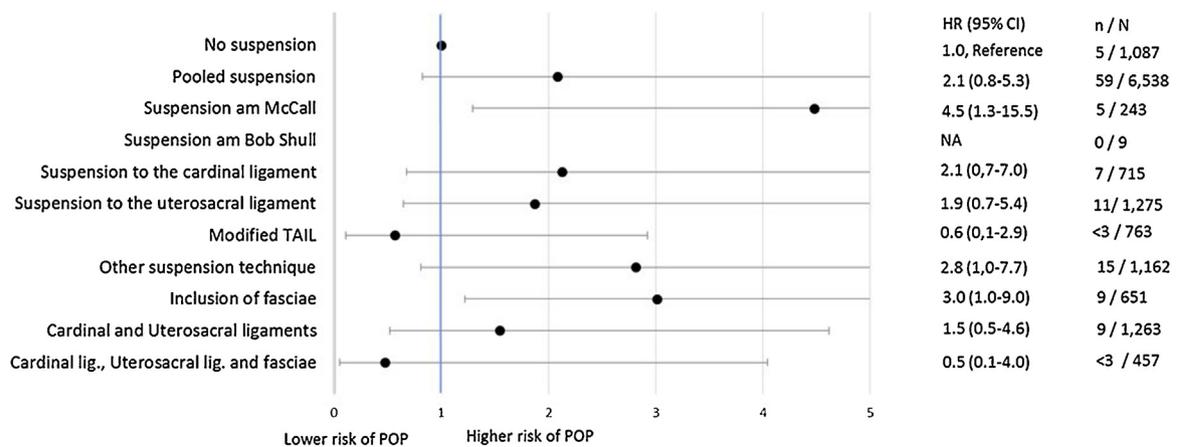


Fig. 3. Hazard ratios of pelvic organ prolapse surgery after hysterectomy.

Fig. 3. Hazard ratios of pelvic organ prolapse (POP) surgery after hysterectomy on benign indication adjusted for age, geographical site of hysterectomy, hysterectomy method, household adjusted income, educational level major complications to hysterectomy, hormone replacement therapy, chronic cough, constipation, parity, instrumental delivery and birth weight.

Analysis 1: Pooled suspension with *no suspension* as reference. Analysis 2: The individually registered suspension methods and the two most common combinations of suspension methods including: *suspension to the cardinal ligament + suspension to the uterosacral ligament* and *suspension to the cardinal ligament, suspension to the uterosacral ligament + inclusion of fasciae* with *no suspension* as reference.

as *no suspension* for purpose of comparison. Cruikshank found *suspension am. McCall* to be most effective. We did not show this beneficial effect of apical suspension. As well as Cruikshank et al., we included women who underwent hysterectomy on different benign indications. Cruikshank et al., however, evaluated prolapse at pelvic examination and included prolapse of all stages. This might be the reason that they found a risk reduction after apical *suspension am. McCall*. Our main outcome was POP surgery two years after hysterectomy which might not be enough time as surgery is the choice of treatment in more advanced stages of prolapse. It speaks to the benefit of Cruikshank that they performed an RCT. We studied a large national cohort and the demonstrated risk factors of prolapse were in line with literature [4,15] which speaks to the benefit of our results. Nevertheless, even though we included most of the known risk factors related to POP, our conclusions might be confounded by factors that we cannot account for given our observational design. One factor to suspect is women's state of apical support before hysterectomy. The decision-making process for deciding whether to perform prophylactic suspension during hysterectomy or not relied completely on the surgeon. If a woman lacked apical support, it is likely that the gynecologist was more prone to perform suspension. Consequently, our results might be confounded by indication. Finally, even though we did validate the term *pooled suspension* in an earlier study [13], we cannot be certain that all registered suspension procedures were performed properly with sufficient supportive result. An ongoing RCT (PULS) which compares *suspension to the uterosacral ligament* and *no suspension* during open or laparoscopic hysterectomy will hopefully shed more light on these above mentioned factors [22].

Conclusions

We found no risk association between POP surgery and vaginal vault suspension during hysterectomy on benign indication at two years of follow up. This explorative study could therefore not confirm our hypothesis of vaginal vault suspension's prevention of POP surgery in the short term. We suspect anatomical factors (for example preoperative apical descent) among unknown factors to influence the results and emphasize the need for an RCT to uncover the effect of prophylactic suspension during hysterectomy on women's risk of developing POP.

Acknowledgements

This study was funded by The Research Foundation of Region Zealand, The University of Southern Denmark, Nykøbing Falster Hospital and Edith and Henrik Henriksen's Memorial Scholarship. The funders did not play a role in conducting the study or writing the paper.

References

- [1] Altman D, Falconer C, Cnattingius S, Granath F. Pelvic organ prolapse surgery following hysterectomy on benign indications. *Am J Obstet Gynecol* 2008;198:572.e1–6.
- [2] Lykke R, Blaakær J, Ottesen B, Gimbel H. Pelvic organ prolapse (POP) surgery among Danish women hysterectomized for benign conditions: age at hysterectomy, age at subsequent POP operation, and risk of POP after hysterectomy. *Int Urogynecol J Pelvic Floor Dysfunct* 2015;26:527–32.
- [3] Gyhagen M, Bullarbo M, Nielsen T, Milsom I. Prevalence and risk factors for pelvic organ prolapse 20 years after childbirth: a national cohort study in singleton primiparae after vaginal or caesarean delivery. *BJOG Int J Obstet Gynaecol* 2013;120:152–60.
- [4] Mant J, Painter R, Vessey M. Epidemiology of genital prolapse: observations from the Oxford Family Planning Association study. *BJOG Int J Obstet Gynaecol* 1997;104:579–85.
- [5] Hendrix SL, Clark A, Nygaard I, Aragaki A, Barnabei V, McTiernan A. Pelvic organ prolapse in the women's health initiative: gravity and gravidity. *Am J Obstet Gynecol* 2002;186:1160–6.
- [6] Giarenis I, Robinson D. Prevention and management of pelvic organ prolapse. *F1000Prime Rep* 2014, doi:http://dx.doi.org/10.12703/P6-77.
- [7] RCOG / BSUG. Post-hysterectomy vaginal vault prolapse (Green-top guideline No. 46). *R. Coll. Obstet. Amp Gynaecol*; 2015. Accessed 27 June 2017 <https://www.rcog.org.uk/en/guidelines-research-services/guidelines/gtg46/>.
- [8] National clinical guideline on hysterectomy (surgical removal of the uterus) for benign gynaecological conditions. 2017. Accessed 27 Jun <https://www.sst.dk/en/publications/2015/hysterectomy-surgical-removal-of-the-uterus>.
- [9] AAGL practice report: practice guidelines on the prevention of apical prolapse at the time of benign hysterectomy. *J Minim Invasive Gynecol* 2014;21:715–22.
- [10] Sloth SB, Schroll JB, Settnes A, Gimbel H, Rudnicki M, Topsoe MF, et al. Systematic review of the limited evidence for different surgical techniques at benign hysterectomy: a clinical guideline initiated by the Danish Health Authority. *Eur J Obstet Gynecol Reprod Biol* 2017;216:169–77.
- [11] Summers A, Winkel LA, Hussain HK, DeLancey JOL. The relationship between anterior and apical compartment support. *Am J Obstet Gynecol* 2006;194:1438–43.
- [12] Hansen CT, Møller C, Daugbjerg S, Utzon J, Kehlet H, Ottesen B, et al. Establishment of a national Danish hysterectomy database: preliminary report on the first 13,425 hysterectomies. *Acta Obstet Gynecol Scand* 2008;87:546–57.
- [13] Bonde L, Noer MC, Møller LA, Ottesen B, Gimbel H. Vaginal vault suspension during hysterectomy for benign indications: a prospective register study of agreement on terminology and surgical procedure. *Int Urogynecol J Pelvic Floor Dysfunct* 2016;1–9.
- [14] Pedersen CB. The Danish Civil Registration System. *Scand J Public Health* 2011;39:22–5.

- [15] Forsgren C, Zetterström J, López A, Altman D. Risk factors for vaginal vault prolapse surgery in postmenopausal hysterectomized women. *Menopause NY N* 2008;15:1115–9.
- [16] Spence-Jones C, Kamm MA, Henry MM, Hudson CN. Bowel dysfunction: a pathogenic factor in uterovaginal prolapse and urinary stress incontinence. *Br J Obstet Gynaecol* 1994;101:147–52.
- [17] Løkkegaard E. Hormone replacement therapy in Denmark, 1995–2004. *Acta Obstet Gynecol Scand* 2007;86:1342–51.
- [18] Ottesen M. [Validity of the registration and reporting of vaginal prolapse surgery]. *Ugeskr Laeger* 2009;171:404–8.
- [19] Løwenstein E, Ottesen B, Gimbel H. Incidence and lifetime risk of pelvic organ prolapse surgery in Denmark from 1977 to 2009. *Int Urogynecol J Pelvic Floor Dysfunct* 2015;26:49–55.
- [20] Till SR, Hobbs KA, Moulder JK, Steege JF, Siedhoff MT. McCall Culdoplasty during total laparoscopic hysterectomy: a pilot randomized controlled trial. *J Minim Invasive Gynecol* 2017. doi:<http://dx.doi.org/10.1016/j.jmig.2017.10.036>.
- [21] Cruikshank SH, Kovac SR. Randomized comparison of three surgical methods used at the time of vaginal hysterectomy to prevent posterior enterocele. *Am J Obstet Gynecol* 1999;180:859–65.
- [22] Alperin M, Weinstein M, Kivnick S, Duong TH, Menefee S. A randomized trial of prophylactic uterosacral ligament suspension at the time of hysterectomy for Prevention of Vaginal Vault Prolapse (PULS): design and methods. *Contemp Clin Trials* 2013;35:8–12.