FEMALE UROLOGY
Systematic Review

Determining the risk factors and characteristics of de novo stress urinary incontinence in women undergoing pelvic organ prolapse surgery: A systematic review

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ABSTRACT

Objective: Stress urinary incontinence (SUI) is a common problem in women that affects their quality of life. According to the current evidence, 15%–50% of severe pelvic organ prolapse (POP) surgeries lead to *de novo* urinary incontinence (UI). This study aimed at determining the risk factors and characteristics of *de novo* SUI after POP surgeries in a systematic review.

Material and methods: We conducted a systematic search of articles in English related to the risk of UI after POP surgery published until December 2019 in the selected bibliographic databases, including PubMed, EMBASE, Scopus, Cochrane Library, and ProQuest.

Results: The initial search resulted in 2,363 studies, and after reviewing the titles and abstracts, 146 studies were identified. Moreover, 2 independent reviewers, using the Joanna Briggs Institute checklists, evaluated the risk of biases in the selected studies. Finally, 40 studies met the inclusion criteria. The most important predictors of UI after POP surgery were positive pessary testing, age >50 years, and maximum urethral closure pressure (MUCP) <60 cmH_2O.

Conclusion: Positive pessary testing, older age, and low MUCP were the most important risk factors for *de novo* incontinence after POP surgeries.

Keywords: Pelvic organ prolapse; risk factors; operative surgical procedures; stress urinary incontinence

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Introduction

Pelvic floor disorders (PFDs) are common urological disorders in women that can result in sexual and social problems and affect the overall quality of life (QoL).[1-3] Various risk factors trigger pelvic organ prolapse (POP) and cause stress urinary incontinence (SUI). Accurate recognition of the relevant risk factors could be effective in preventing PFDs and improving patients' QoL.[4]

The risk of surgery for prolapse in a woman's lifetime is 7%–11%.[5] Several factors such as aging, obesity, childbirth, previous hysterectomy, constipation, estrogen deficiency, and smoking increase the risk of POP.[6] POP surgery can result in *de novo* urinary incontinence (UI),[7] but some factors may increase the risk of SUI in general, such as race, obesity, vaginal delivery, age, parity, genetics, and chronic obstructive pulmonary disease.[2,4,8-11] It is obvious that for patients with severe POP, surgery can be the best therapeutic approach.[12] In a study by van der Ploeg et al. [9] the incidence of postoperative UI was reported to be 11%–44%. According to recent studies, 36%–80% of women with severe prolapse may develop UI after surgery,[13] and 29% of women need surgery for UI.[14] In addition to the high costs of reconstructive or recurrent surgeries, *de novo* incontinence can impair daily functioning and can cause sexual and mental health problems.[2] Many diagnostic tests such as urodynamic tests, stress tests, and pessary tests can help to detect post-POP disorders, but none of these

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tests can assure the accuracy of diagnosis because the sensitivity of these tests in predicting UI is very low (17%–39%).[15] On the other hand, although ultrasound has high sensitivity for diagnose of stress urinary incontinence, it is not sensitive for diagnosis of prolapse.[16] Adding a preoperative urodynamic test can partially help predict the risk of UI.[9] Although any of the factors mentioned earlier may individually increase the risk of *de novo* incontinence, we need to quantify the number of multiple risks for presenting this condition. Preoperative risk prediction is also known as one of the best strategies to manage and reduce the risk factors for SUI after POP surgeries.[4] This study aimed at identifying the risk factors for *de novo* SUI after surgery for moderate to severe POP.

Material and methods

Review question

The Patient Intervention Comparison Outcome (PICO) schema includes: Patients: female candidate for POP surgeries; Intervention/Exposure: POP surgery; Comparison: no treatment or exposure; Outcome: *de novo* SUI.

This systematic review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[17] According the PICO schema, the question of the review was: What are the risk factors that cause *de nov*o SUI in patients after POP surgeries?

Search strategy

A systematic search was conducted in databases, including PubMed, EMBASE, Scopus, Cochrane Library, and ProQuest (thesis & dissertation), for articles published until December 2019. Google Scholar was also used to search for more relevant studies. Reference lists and citations of the included articles were correspondingly tracked. Hand searching was further performed for relevant studies. Both free-text and controlled vocabularies were searched accordingly using the keywords extracted from the PICO schema, including "*de novo* stress urinary incontinence," "post-operative stress urinary incontinence," "postsurgical stress urinary incontinence," and "pelvic organ prolapse." The full search strategy in EMBASE is shown in Appendix 1.

Main Points:

- According to our study, a positive pessary test had the highest risk or predictor compared with other diagnostic tests.
- In this study, low maximum urethral closure pressure (MUCP), functional urethral length, and lower urinary tract obstruction were the most important urodynamic variables in the incidence of urinary incontinence, and MUCP was the most common among them.
- In total, 3 studies suggested that the most important predictors of urinary incontinence after pelvic organ prolapse surgery were positive pessary testing, age >50 years, and MUCP <60 cmH_2O.

Eligibility criteria

The studies with women of any age who underwent POP surgery and had no early symptoms of SUI but had moderate to severe POP were included in the review. We included randomized controlled trials, quasi-experimental trials, and cohort, case-control, and case series studies. All women with preoperative SUI, urinary tract infection, and bladder disorders were excluded. Letters, commentaries, editorial notes, conference proceedings, and review articles were excluded.

Study selection and data extraction

Two independent reviewers screened and selected the retrieved articles. In the first phase, the articles were screened by titles and abstracts according to the inclusion and exclusion criteria. The articles were then screened on the basis of full texts, and finally, the selected studies were included in the quality assessment. In case of disagreements, a third reviewer rechecked the studies. If the full text of the article was not available, the relevant authors were contacted to send the full text. All the eligible risk factors and their odds ratio (OR) were extracted from the selected papers. If the OR was not reported, it was calculated. We defined the eligibility as statistical significance ($p<0.05$) of the risk factor. It should be noted that in this study, we considered only OR with positive confidence interval (CI), except[18] that the pessary test was considered with a negative CI (Table 1).

Methodological quality assessment

The quality of the selected studies was evaluated using the Joanna Briggs Institute critical appraisal tools (appropriate tool was used, based on the study design, for every article).[19] Two authors independently assessed the quality of the studies, and in case of disagreement, a third reviewer assessed the study for confirmation. The qualitative evaluation of the results is summarized in Table 2-6.

Results

Of the 2,363 studies retrieved from the bibliographic databases and other relevant resources, duplicated studies were eliminated, and 146 articles were screened on the basis of title and abstract. Furthermore, 40 studies were potentially eligible for inclusion in the review. After the assessment of full texts and considering the inclusion and exclusion criteria, 24 studies were excluded from the review (Appendix 2), and 40 studies were selected for quality assessment. Figure 1 illustrates the flow diagram of study selection. The list of excluded studies and the reasons for exclusion are listed in Appendix 2.

The final list of selected articles (n=40) included 31 cohort studies, 6 randomized control trials, 1 case-control study, 1 case series, and 1 quasi-experimental study.[1,3,5,6,9,10,13,18,20-51]

The studies were categorized according to quality as low, moderate, and high groups (Table 2-6). We considered 3 levels of risk for the assessment of each article, 0%–35% (low risk), 35%–70% (moderate risk), and 70%–100% (high risk). Of the 40 studies that were included, 22 studies (55%) had low and 18 had moderate risk of bias (45%), but all 40 studies were included. No low-quality (high risk) studies were obtained. The study was approved by the Ethics Committee of Tabriz University of Medical Sciences and Iranian Registry of Clinical Trials.

Study characteristics

We retrieved any significant OR from the selected articles. If OR was not reported in a study, we calculated the OR using available data if possible. Appendix 3 describes the characteristics of selected studies. In 28 studies, the measurable risk factors were not reported (Appendix 3). In the included studies, the follow-up period was 3–12 months or more than 1 year, neither could be categorized as a long-term follow-up period. The major diagnostic tests used in the studies that reported measurable risk factors were urodynamic test (40%), pessary test (25%), and stress test (27.5%). In most of these studies, urodynamic variables were used for risk identification (5 of 12). In 15% (6 of 40) of the studies, the type of previously performed surgery was vaginal hysterectomy, and in 17.5% (7 of 40) of them, it was abdominal surgery. Owing to the high levels of heterogeneity, meta-analysis was not possible.

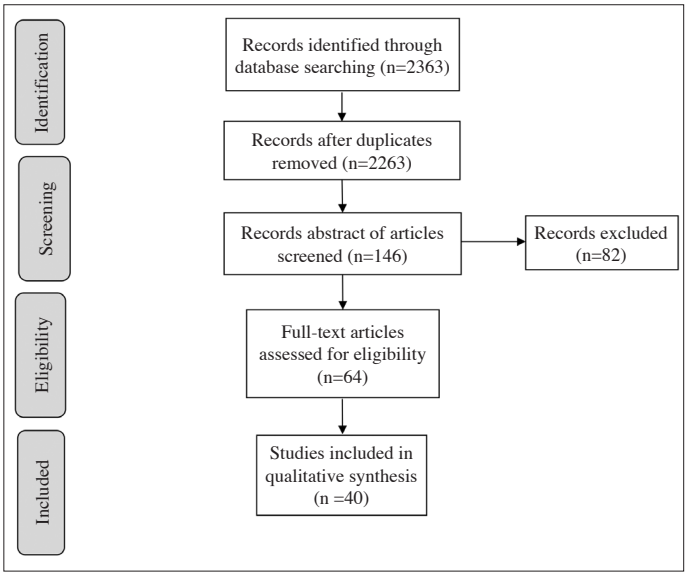

Figure 1. The PRISMA flow diagram of study selection

Risk factors for SUI

The results showed that 3 studies suggested age >60, ≥50, and ≥66 years (OR, 0.024 [95% CI, 0.001–0.416], OR, 2.07 [95% CI, 0.41–10.41], and OR, 2.86 [95% CI, 1.01–2.53], respectively) as the most prevalent risk or predictive factor for *de novo* SUI occurrence. In contrast, 2 studies suggested positive pessary testing (300 mL) (OR, 6.5 [95% CI, 1.6–25.4] and RR, 0.35 [95% CI, 0.25–0.51], respectively) as the most prevalent risk or predictive factor. Table 1 shows the extracted risk factors and their characteristics, and Table 7 shows the definitions of risk factors and characteristics of *de novo* SUI. For urodynamic characteristics, only 1 study mentioned abdominal leak point pressures (ALPPs) as a risk without any objective measurement or statistical analysis. They demonstrated the ALPP reduction range after correction and reposition of prolapse as a risk for *de novo* incontinence; however, the study had a small sample size and low-quality method. Low maximum urethral closure pressure (MUCP) (OR, 4.65 [95% CI, 2.87–8.64]) was the most prevalent variable (Table 1).

Discussion

This systematic review was an overview of the risk factors for *de novo* SUI in women undergoing POP surgery. Moreover, 50%–80% of patients with POP have UI simultaneously,[20] and women with severe prolapse complain of SUI 10%–30% more than those with mild to moderate prolapse.[21] According to the results of this review, the main risk factors for *de novo* UI after prolapse surgery in women were older age (>50 years), positive pessary testing, previous pelvic surgery, obesity, menopause, moderate or severe urethral obstruction/compression, and diabetes. Low MUCP, ALPPs, functional urethral length (FUL), and lower urinary tract obstruction were the most important urodynamic variables in the incidence of UI. Genetic factors could also play an important role in UI and POP, but the effects of environmental factors cannot be underestimated.[9] Although risk factors such as smoking, age, diabetes, obesity, pregnancy, and childbirth are presumed to increase the risk of *de novo* UI after POP surgery, we did not find strong evidence regarding the effect of smoking and parity on SUI. In our study, positive pessary testing was a strong predictive factor. This was in line with several studies that reported pessary testing as a strong predictor of *de novo* UI.[13,22,23]

ALPPs can be considered a risk factor for *de novo* SUI. ALPPs are defined as the amount of abdominal pressure needed to produce a urine leak from the urethra. In fact, if there is a leak of urine during an abdominal pressure-boosting maneuver, such as a cough or a Valsalva maneuver, nonhypertensive blood pressure causes weight gain. If ALPP is measured as standard, it has the ability to validate duct sphincter resistance. ALPP is also use-

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ful in determining the type of cause of incontinence as well as the type of surgery for stress incontinence. Occasionally, in patients with stress urinary incontinence, an ALPP of less than 60 cmH_2O is observed.

Table 1. Extracted risk factors and attributes

#	Study	Risk factor & attributes	N/n	Adjusted OR (95% CI)	p
1	Lo et al.[6]	TVM type			
		Prolift T	71/20	3.50 (1.88–5.91)	<0.001
		Elevate A	71/18	3.48 (1.90–6.10)	<0.001
		Diabetes	71/28	2.18 (1.631–4.21)	<0.002
		Age			
		≥66 years	71/45	2.86 (1.01–2.53)	<0.014
		FUL	71/33	3.48 (2.13–5.83)	<0.001
		MUCP	71/33	4.65 (2.87–8.64)	<0.001
2	Haverkorn et al.[10]	BMI	297/na**		<0.001
		BMI>30			
3	Reena et al.[13]	Menopause	47/38	2.60 (0.54–12.50)	<0.003
		Age	40/33	2.07 (0.41–10.41)	<0.005
		≥50 years			
		Pessary test (300 mL)	34/53	RR 0.35 (0.25–0.51)	<0.001
4	Engh et al.[18]	Speculum	100/74	42.9 (12.0–76.9)	***
		Pessary tests		33.3 (–4.4 to +71.5)	***
5	Weil et al.[20]	MUCP	6/na**		*
		PTR	6/na**		*
		Previous pelvic surgery	6/na**	15.56 (0.82–28.73)	<0.06
6	Borstad an Rud[21]	Age	15/16	0.024 (0.001–0.416)	0.01
		>60 years			
		Uterine prolapse	16/3	0.13 (0.0–0.3)	<0.05
		Previous pelvic surgery	16/73	0.12 (0.025–0.588)	<0.001
		CP	73/17	0.22 (0.083–0.616)	<0.05
7	Svenningsen et al.[22]	Pessary			
		Test 3 Pessary (300 mL)	107/10	6.5 (1.6–25.4)	<0.012
		Test 4 Pessary continuous use	79/15	6.5 (1.6–25.4)	<0.004
8	Liang et al.[24]	Patients with a positive stress test (Pessary test)	79/49	0.056 (0.012–0.266)	<0.001
9	Davenport et al.[27]	SUI with prolapse reduction	164	2.39 (1.10–5.21)	0.03
		Point Ba (per cm)		1.16 (1.01–1.34)	0.04
		Cystocele severity		1.17	0.02
10	Ugianskiene et al.[29]	Parity	299/678		0.03
11	Wang et al.[30]	LUTO	75/300	2.3 (1.2–4.6)	0.013
12	Kuribayashi et al.[31]	Urethral obstruction moderate or more	24/65	12.616 (1.580–268.731)	0.033

*High risk according to the study (the significant P-value was not mentioned). n: number of patients with postoperative SUI and significant risk factor. **NA /na: not available; N: the number of patients with postoperative SUI; BMI: body mass index; FUL: functional urethral length; MUCP: maximum urethral closure pressure; PTR: pressure transmission ratio; LUTO: lower urinary tract obstruction; SUI: stress urinary incontinence; TVM: transvaginal mesh
***This study reported PPV and NPV without range of statistical significance.

Table 2. Evaluation of included quasi-experimental studies

#	Study	Year of publication	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Quality of study
1	Weil et al.[20]	1993	Y	Y	Y	Y	U	Y	Y	Y	Y	low risk

Table 3. Evaluation of included case-series studies

#	Study	Year of publication	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Quality of study
1	Borstad and Rud[21]	1989	U	Y	Y	Y	Y	U	Y	Y	U	Y	low risk

Table 4. Evaluation of included case-control studies

#	Study	Year of publication	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Quality of study
1	Wang et al.[30]	2017	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	low risk

Table 5. Evaluation of included cohort studies

#	Study	Year of publication	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Quality of study
1	Liang et al.[1]	2015	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	U	low risk
2	Lo et al.[6]	2019	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	low risk
3	van der Ploeg et al.[9]	2018	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
4	Haverkorn et al.[10]	2011	Y	Y	Y	Y	U	Y	Y	Y	Y	U	U	low risk
5	Reena et al.[13]	2007	Y	Y	U	Y	Y	Y	U	N	U	U	N	moderate risk
6	Engh et al.[18]	2011	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
7	Svenningsen et al.[22]	2012	Y	Y	Y	Y	U	Y	Y	U	N	N	Y	moderate risk
8	Song et al.[23]	2016	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
9	Liang et al.[24]	2004	Y	Y	Y	Y	U	Y	U	Y	Y	U	U	moderate risk
10	Duecy et al.[25]	2010	Y	Y	U	Y	U	Y	U	Y	Y	U	U	moderate risk
11	Sierra et al.[26]	2019	Y	Y	Y	Y	Y	U	Y	N	Y	U	U	moderate risk
12	Jelovsek[28]	2013	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
13	Ugianskiene et al.[29]	2017	Y	Y	Y	Y	U	Y	Y	N	Y	U	Y	low risk
14	Kuribayashi et al.[31]	2013	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
15	Klutke and Ramos[32]	2000	Y	Y	U	Y	Y	Y	U	Y	N	U	N	moderate risk
16	Groutz et al.[33]	2004	Y	Y	U	Y	U	Y	Y	Y	Y	U	U	moderate risk
17	Ek et al.[34]	2010	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	U	low risk
18	Liapis et al.[35]	2011	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
19	Ennemoser et al.[36]	2012	Y	Y	Y	U	U	Y	Y	Y	Y	U	U	moderate risk
20	Lensen et al.[37]	2013	Y	Y	Y	Y	U	Y	Y	Y	Y	U	Y	low risk
21	Hafidh, et al.[38]	2013	Y	Y	U	Y	U	Y	Y	Y	N	Y	N	moderate risk
22	LeClaire et al.[39]	2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	low risk
23	Lo et al.[40]	2015	Y	Y	Y	Y	Y	Y	Y	N	Y	U	Y	low risk
24	El Hamamsy and Fayyad[41]	2015	Y	Y	Y	Y	U	U	Y	Y	Y	U	U	moderate risk
25	Inan et al.[42]	2016	Y	Y	Y	Y	U	Y	Y	Y	U	N	Y	low risk
26	Manodoro et al.[43]	2016	Y	Y	Y	Y	Y	Y	Y	Y	U	U	Y	low risk
27	Huang and Yang[44]	2017	Y	Y	Y	U	U	Y	U	Y	Y	U	Y	moderate risk
28	Requena et al.[45]	2018	Y	Y	Y	Y	U	Y	Y	Y	U	U	U	moderate risk
29	Sabadell et al.[46]	2018	Y	Y	Y	Y	U	Y	Y	Y	N	U	Y	low risk
30	Goessens et al.[47]	2019	Y	Y	U	N	U	Y	Y	N	Y	U	N	moderate risk
31	Kurdoglu et al.[48]	2019	Y	Y	Y	Y	U	Y	Y	N	Y	U	Y	moderate risk

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Table 6. Evaluation of included randomized control trial studies

#	Study	Year of publication	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Quality of study
1	Schierlitz et al.[3]	2014	Y	N	U	N	N	U	Y	Y	Y	Y	Y	Y	Y	moderate risk
2	Costantin et al.[5]	2011	Y	Y	U	U	N	Y	Y	U	Y	Y	Y	Y	Y	moderate risk
3	Davenport et al.[27]	2018	Y	U	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y	moderate risk
4	Brubaker et al.[49]	2006	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	low risk
5	Wei et al.[50]	2009	Y	U	Y	U	N	N	Y	Y	Y	Y	Y	Y	Y	moderate risk
6	Wei et al.[51]	2012	Y	Y	Y	N	U	Y	Y	U	Y	Y	Y	Y	Y	low risk

Table 7. Definition of risks and characteristics of de novo SUI

#	Risks and characteristics	Definition	Frequency of statistical significance
1	Age	60–70 years=high risk	3
2	Pessary test (300 mL)	"A positive pessary test could predict postsurgical stress urinary incontinence in women with severe pelvic organ prolapse. Pessaries are widely considered to be a safe and effective management option for women with pelvic organ prolapse." Positive test=high risk	3
3	History of pelvic surgery	Previous pelvic=high risk	2
4	MUCP	"MUCP is the maximum difference between the urethral pressure and the intravesical pressure." MUCP <60 cmH_2O=high risk	2
5	FUL, mm	"FUL is the length of the urethra along which the urethral pressure exceeds intravesical pressure in women." FUL <2 mm (high risk)	1
6	PTR	PTR is the increment in urethral pressure on stress as a percentage §of the simultaneously recorded increment in intravesical pressure. PTR <100% (high risk)	1
7	TVM	TVM, type (Prolift T, Elevate A)=high risk	1
8	LUTO	LUTO detected by UDS (Q max ≤12 mL/s and PdetQ max ≥25 cmH_2O or residual urine ≥100 mL)=high risk	1
9	Parity	Parity >4=high risk	1
10	Diabetes	Diabetes positive=high risk	1
11	Menopause	Menopause positive=high risk	1
12	Urethral obstruction moderate or more	Urethral obstruction moderate or more=high risk	1
13	BMI	BMI ≥30=high risk	1

MUCP: maximum urethral closure pressure; FUL: functional urethral length; PTR: pressure transmission ratio; TVM: transvaginal mesh surgery; LUTO: lower urinary tract obstruction; BMI: body mass index; UDS: Urodynamic study; PdetQ: detrusor pressure at maximal flow

The ALPP measurement method is not standardized yet, we do not yet have any specific factors for standard ALPP factors, and no specific standards have been used in the studies.

Positive pessary testing results usually occur in women with severe POP before surgery. There are individuals who do not have SUI and suffer from severe POP with a positive pessary testing result. This can be considered as a potential postsurgical risk for SUI.[24] Urodynamic testing also plays a major role in predicting *de novo* SUI after surgery.[25,26] In this study, we evaluated the urodynamic variables and showed that these variables are important in predicting *de novo* SUI. However, these tests are costly for the patients.[52] If after POP surgery, urodynamic tests show certain values (i.e., CP [cmH_2O] and pressure transmission ratio <100), there is a chance that one can predict the occurrence of SUI. Urodynamic test alone cannot predict the severity of incontinence,[20] but adding a urodynamic test may predict the risk of UI after surgery[9]. Age can also play an important role in

increasing the risk of UI because that has been shown in several studies.[19,20] Combined POP surgery and prophylactic surgeries for SUI may prevent occult incontinence that occurs after POP surgery in such cases.[22] Although the tests can be used to predict the risk of UI before the surgery, studies indicated that it could help the surgeons in only 17%–39% of the cases. In the predictive model provided by Jelovsek et al.,[28] risk factors, such as age, diabetes, smoking, parity, and body mass index, were similarly identified as candidates for *de novo* UI risk assessment. It seems that age and obesity have a greater impact on the incidence of UI.

To the best of our knowledge, most of the previous studies reported the risks of UI after surgery individually. In contrast, this is the first study to simultaneously study several risk factors, which can provide a clearer vision on the impact of risk factors in developing SUI after POP surgery. As a work in progress, this team is designing and developing a predictor system for the risk of using the extracted risk factors in this review. One of the limitations of this study was the lack of access to the raw data of all selected studies; thus, we obtained the risk on the basis of the data reported in the articles. In one of the studies, parity was considered a risk for developing *de novo* UI by including SUI as a subtype of incontinence; however, parity was not specifically identified as a risk for SUI.[29] Moreover, OR was not calculated for this risk factor because of inssufficient raw data. Furthermore, we did not consider abdominal sacrocolpopexy as a risk because of the low number of cases.[53]

In summary, several factors are recognized as risk factors for UI. However, there are no strong evidences to categorize the risk factors based on importance. This can be achieved in a well-designed original study.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of IR.TBZMED.REC (1398200).

Informed Consent: N/A.

Peer-review: Externally peer-reviewed.

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Appendix 1. Search Strategy
Embase Database Results (Updated in September 2019)

No.	Query
#1.	pelvic AND organ AND prolapse:ab,ti
#2.	'pelvic organ prolapse'/exp
#3	#1 OR #2
#4.	post*operat* AND stress AND urinary AND incontinence:ab,ti
#5.	'de novo' AND stress AND urinary AND incontinence:ab,ti
#6.	post*surg* AND stress AND urinary AND incontinence:ab,ti
#7.	#4 OR #5 OR #6
#8.	#3 AND #7

Appendix 2. List of excluded articles and exclusion reasons

	Author names	Publish	Study type	N*	Inclusion criteria	Exclusion criteria
1	C. Graham & V. Mallett[1]	2001	Cohort	324	The women with SUI ,pop	Inclusion criteria did not match the main criterion of the study.
2	D. Altman & et al [2]	2008	Cohort	3376	Women who underwent POP surgery	Only the genetic effect on urinary incontinence was considered and these patients did not undergo surgery and did not meet the inclusion criteria.
3	R. E. Gutman & et al[3]	2008	Cross- sectional	296	Women who underwent POP surgery	There was no associated risk factor and Inclusion criteria
4	P. Dällenbach & et al[4]	2012	Case- control	1811	Women who underwent POP surgery	In this paper, condition SUI Inclusion criteria is not considered
5	J. Leruth & et al[5]	2013	Cohort	106	The women with SUI	Inclusion criteria did not match the main criterion of the study
6	J. Marinus van der Ploeg & et al [6]	2018	RCT	173	The women who had SUI	Inclusion criteria did not match the main criterion of the study.
7	A G. Visco & et al[7]	2008	RCT	322	The women with SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
8	E. Borstad, et al[8]	2010	RCT	194	The women who had symptoms of SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
9	M. L. Gallentine & R. D. Cespedes[9]	2001	Cohort	24	The women with or without symptoms of SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
10	K. J. van Rensburg& J. A. van Rensburg[6]	2014	Cohort	131	The women with SUI underwent POP surgery	Inclusion criteria did not match the main criterion of the study.

Appendix 2. List of excluded articles and exclusion reasons (Continued)

	Author names	Publish	Study type	N*	Inclusion criteria	Exclusion criteria
11	J. E. Jelovsek[10]	2019	Original	239	The women with SUI	In this paper, condition SUI Inclusion criteria is not considered.
12	J. E. Jelovsek, et al[11]	2018	RCT	374	The women with SUI underwent POP surgery	The inclusion criteria and the history of people with urinary incontinence
13	A. Ugianskiene, et al[12]	2019	Cohort	678	The women with SUI underwent POP surgery	The inclusion criteria and the history of people with urinary incontinence.
14	V. leanza, et al[13]	2001	Cohort	85	The women with symptoms of SUI	The inclusion criteria and the history of people with urinary incontinence.
15	S. C. R. Panicker & S. Srinivas14	2009	Cohort	50	The women who underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
16	J. M. van derPloeg , et al[15]	2019	RCT	255	The women who underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
17	E.Borstad , et al [16]	1991	Cohort	73	The women with SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study.
18	Y. Khayyami, et al[17]	2019	Cohort	1198	The women with SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study
19	J. Marinus van der Ploeg, et al[18]	2016	RCT	231	The women with SUI, underwent POP surgery	Inclusion criteria did not match the main criterion of the study
20	M. M. E. Lakeman, et al[19]	2011	RCT	234	The women who underwent POP surgery	Inclusion criteria did not match the main criterion of the study
21	E. Costantin, et al[20]	2007	RCT	66	The women who underwent POP surgery	Inclusion criteria did not match the main criterion of the study
22	M. Frigerio, et al[21]	2018	Cohort	417	The women who underwent POP surgery	Inclusion criteria did not match the main criterion of the study
23	John E. Jelovsek[22]	2016	Model		The women who underwent POP surgery	Review
24	J. Eric Jelovsek[23]	2018	Combined cohort: 3 randomized trials and 2 prospective cohort	1,301	The women who underwent POP surgery	The output criteria was not corresponded

1.Graham CA, Mallett VT. Race as a predictor of urinary incontinence and pelvic organ prolapse. American journal of obstetrics and gynecology. 2001;185:116-20.
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Appendix 2. List of excluded articles and exclusion reasons (Continued)

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6.van der Ploeg JM, Zwolsman SE, Posthuma S, Wiarda HS, van der Vaart CH, Roovers JPW. The predictive value of demonstrable stress incontinence during basic office evaluation and urodynamics in women without symptomatic urinary incontinence undergoing vaginal prolapse surgery. Neurourology and urodynamics. 2018;37:1011-8.
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12.Ugianskiene A, Kjærgaard N, Larsen T, Glavind K. What happens to urinary incontinence after pelvic organ prolapse surgery? International urogynecology journal. 2019;30:1147-52.
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16.Borstad E, Skrede M, Rud T. Failure to predict and attempts to explain urinary stress incontinence following vaginal repair in continent women by using a modified lateral urethrocystography. Acta obstetricia et gynecologica Scandinavica. 1991;70:501-6.
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Appendix 3. List of included articles and characteristics of selected articles

#	Authors	Publication Year	Study type	Population	Inclusion criteria	Risk factors	Type of examination	Following	Type of surgery
1	E. Borstad & T.Rud[1]	1989	Case- series	102	Women with POP surgeries without SUI	Urodynamic variables	The urodynamic examinations	3 months	Manchester operation
2	A.Weil, et al[2]	1993	Cohort	40	Women with POP surgeries without SUI	Urodynamic variables	Pessary test, Urodynamic test	3-6 months	Vaginal surgery for genital prolapse
3	J. J. Klutke& S. Ramos[3]	2000	Cohort	125	Women with POP surgeries without SUI	No risk factor	Pessary test, urodynamic evaluation	3.5 year	Vaginal hysterectomy
4	C-C Liang, et al[4]	2004	Cohort	79	Women with POP surgeries without SUI	Urodynamic variables	Pessary test	1 month, 3– 6 months, 1 year	Vaginal hysterectomy
5	A. Groutz, et al[5]	2004	Cohort	100	Women with POP surgeries without SUI	No risk factor	Stress test, pad test	27 month	Transvaginal prolapse repair and prophylactic TVT procedure
6	L. Brubaker, et al[6]	2006	RCT	322	Women with POP surgeries without SUI	No risk factor	Stress test	10 year	Abdominal Sacrocolpopexy with Burch Colposuspension
7	C. Reena, et al[7]	2007	Cohort	78	Women with POP surgeries without SUI	Pessary test/ Age, Menopausal	Pessary test	6 weeks	Vaginal hysterectomy and pelvic floor repair
8	G . Wei, et al[8]	2009	RCT	337	Women with POP surgeries without SUI	No risk factor	Cough test, stress test	12 months	Vaginal prolapse surgery
9	M. Ek, et al[9]	2010	Cohort	121	Women with POP surgeries without SUI	No risk factor	No test	12 months	Trans vaginal mesh Surgery (TVM)
10	E. E. Duecy, et al[10]	2010	Cohort	41	Women with POP surgeries without SUI	No risk factor	Cough stress test, urodynamic	6 months	Vaginal surgery
11	R.M. Haverkorn, et al[11]	2011	Cohort	412	Women with POP surgeries without SUI	BMI>30	Cough stress test	Minimum of 12 months	Rectus fascia, porcine dermis and polypropylene sling procedures
12	A. M. E.Engh, et al[12]	2011	Cohort	100	Women with POP surgeries without SUI	Pessary test, Speculum	Cough test, speculum test standardized quantification test and a 48-hour pad test, pessary test	12 months	Vaginal surgery
13	E. Costantin, et al[13]	2011	RCT	66	Women with POP surgeries without SUI	No risk factor	Urodynamic test, UDI-6 and IIQ-7	97 months	Abdominal pelvic organ prolapse repair
14	A. Liapis, et al[14]	2011	Cohort	82	Women with POP surgeries without SUI	No risk factor	Pessary test, cough test	24 month	TVT-O surgery

Appendix 3. List of included articles and characteristics of selected articles (Continued)

#	Authors	Publication Year	Study type	Population	Inclusion criteria	Risk factors	Type of examination	Following	Type of surgery
15	R.Svenningsen, et al[15]	2012	Cohort	204	Women with POP surgeries without SUI	Pessary Test	Manual (100 ml), Pessary (100 ml), Pessary (300 ml), Pessary	Minimum of 3 months	POP repair (Manchester, vaginal hysterectomy Bio mesh, one or two compartments)
16	S. Ennemoser, et al[16]	2012	Cohort	491	The women without SUI, underwent POP surgery	No risk factor	A stress test, a pad test and urodynamics test	2–8 years	Vaginal prolapse surgery
17	J. T. Wei, et al[17]	2012	RCT	337	Women with POP surgeries without SUI	No risk factor	Cough test, stress test	12 month	Vaginal prolapse surgery
18	J. E.Jelovsek[18]	2013	Cohort	465	Women with POP surgeries without SUI	No risk factor	Stress test, cough stress test	12 month	Vaginal Prolapse, Midurethral Sling
19	B. A. Hafidh, et al[19]	2013	Cohort	64	Women with POP surgeries without SUI	No risk factor	Urodynamics test, cough stress test	12 month	Vaginal surgery
20	M. Kuribayashi, et al[20]	2013	Cohort	65	Women with POP surgeries without SUI	Urethral obstruction moderate or more	Stress test	6 month	Tension-free vaginal mesh procedure (TVM)
21	E. J.M. Lensen, et al[21]	2013	Cohort	907	Women with POP surgeries without SUI	No risk factor	Preoperative tests	12 months	POP surgery without concomitant UI surgery
22	L. Schierlitz, et al[22]	2014	RCT	845	Women with POP surgeries without SUI	No risk factor	Urodynamic test, cough test	6 month	Tension-free vaginal tape (TVT)
23	E. L. LeClaire, et al[23]	2014	Cohort	795	Women with POP surgeries without SUI	No risk factor	Cough stress test	15 weeks	Sacrocolpopexy (SCP)
24	D. El. Hamamsy& A. M. Fayyad 24	2015	Cohort	220	Women with POP surgeries without SUI	No risk factor	Cough stress test, urodynamic test, POP-Q system	12 months	Laparoscopic sacrocolpopexy
25	C-C Liang, et al[25]	2015	Cohort	183	Women with POP surgeries without SUI	No risk factor	Urogynecological questionnaire, POP-quantitation system, urodynamic	6 months and 12 months	Trans vaginal mesh (TVM)
26	T. Lo, et al[26]	2015	Cohort	637	Women with POP surgeries without SUI	Urodynamic variables	Cough stress test, urodynamic test	1 week, 6 months, annually	Pelvic reconstructive surgery (PRS)

Appendix 3. List of included articles and characteristics of selected articles (Continued)

#	Authors	Publication Year	Study type	Population	Inclusion criteria	Risk factors	Type of examination	Following	Type of surgery
27	S. Manodoro, et al[27]	2016	Cohort	150	Women with POP surgeries without SUI	No risk factor	Urodynamic test, pessary test	18.4 ± 9.0 month	Vaginal hysterectomy
28	X. Song, et al[28]	2016	Cohort	224	Women with POP surgeries without SUI	No risk factor	Stress test, POP-Q system, 1-h pad test	31 month	Vaginal prolapse surgery
29	A. H. Inan, et al[29]	2016	Cohort	145	Women with POP surgeries without SUI	No risk factor	Cough test, validated Urinary Distress	24 months	Abdominal sacrocolpopexy (ASC)
30	W. C. Huang& J. M. Yang[30]	2017	Cohort	102	Women with POP surgeries without SUI	Mesh location (Straining)	Son graphic	12 month	Pelvic floor reconstructive surgery
31	A. Ugianskiene, et al[31]	2017	Cohort	768	Women with POP surgery, without SUI	Parity	Pessary test, stress test, incontinence-Vaginal Symptoms (ICIQ-VS)	3 month	Cervix amputation/ vaginal hysterectomy/ vaginal vault suspension
32	S. Y. Wang, et al[32]	2017	Case - control	533	The women who had no symptoms of SUI, underwent POP surgery	LUTO (lower urinary tract obstruction)	Cough leakage postoperatively, had positive 1-h pad test, urodynamics	24 months	Pelvic floor reconstruction surgery.
33	J. F. C. Requena, et al[33]	2018	Cohort	39	Women with symptomatic grade ≥2 POP and had no symptoms of SUI	No risk factor	Cough stress test, Ultrasound measurement of bladder volume, Urodynamic	12 months	Vaginal surgery
34	J. M. van der Ploeg, et al[34]	2018	Cohort	362	Women undergoing prolapse without a SUI	No risk factor	Stress tests	12 months	Vaginal prolapse surgery
35	M.T. Davenport, et al[35]	2018	RCT	164	Women undergoing prolapse repair without a SUI	Method of prolapse repair	Cough and Valsalva test, urodynamic test	3 months	Prolapse surgery, (abdominal sacrocolpopexy)
36	J. Sabadell, et al[36]	2019	Cohort	169	Women who underwent POP surgical correction, without a SUI	No risk factor	Cough stress test, diagnostic test	10 month	Vaginal mesh repair
37	E. Goessens, et al[37]	2019	Cohort	220	Women with symptomatic POP, but without bothersome SUI	No risk factor	Pessary test	2 month	Vaginal prolapse repair

Appendix 3. List of included articles and characteristics of selected articles (Continued)

#	Authors	Publication Year	Study type	Population	Inclusion criteria	Risk factors	Type of examination	Following	Type of surgery
38	T. Lo, et al	2019	Cohort	40	Patients underwent mesh surgery and had no symptoms of SUI	No risk factor	Cough stress test, urodynamic test, 2D introital ultrasonography	1 week, 6 months, and annually	Midurethral sling (MUS), vaginal pelvic reconstructive surgery (PRS)
39	T. Sierra, et al[39]	2019	Cohort	223	Women without symptoms of SUI.	No risk factor	Stress test	6 month	POP repair UDS and subsequent prolapse surgery.
40	M. Kurdoglu, et al[40]	2019	Cohort	48	Patients underwent RALUSLS and RALSC, and had no symptoms of SUI	No risk factor	POP Quantification system (POP-Q), urodynamic	3 month	RALUSLS and RALSC procedures

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Appendix 3. List of included articles and characteristics of selected articles (Continued)

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