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Title:

Does pre-operative urodynamics lead to better outcomes in management of urinary incontinence in women? A linked systematic review and meta-analysis

Authors:

Dr Kar Yee Lor MBChB[1] and Maria Soupashi, BSc (Honours)[1]

Prof Mohamed Abdel-Fattah, FRCOG, M.D.[2]

Dr Alyaa Mostafa ♠, MB B Ch, MD, DipMEd, FHEA[3]

[1]Medical Student - University of Aberdeen, Aberdeen, UK
[2]Clinical Chair in Gynaecology / Consultant Gynaecologist & Sub-specialist Urogynaecologist - University of Aberdeen, Aberdeen, UK
[3]Clinical lecturer - University of Aberdeen, Aberdeen, UK

♠ **Corresponding Author**: Dr Alyaa Mostafa
Clinical Lecturer
School of Medicine, Medical Sciences and Nutrition, University of Aberdeen
Address: Second Floor, Aberdeen Maternity Hospital, Foresterhill, Aberdeen, AB25 2ZD, UK
Tel: 01224 438422
E-mail: a.mostafa@abdn.ac.uk

Conflict of interests:

M.A.F is the chief investigator and A.M. is a co-investigator on the ongoing National Institute for Health Research (NIHR)-funded FUTURE Study evaluating the clinical and cost effectiveness of urodynamics in women with refractory overactive bladder symptoms (https://w3.abdn.ac.uk/hsru/FUTURE/Public/Public/index). They are also part of the team applying for further relevant NIHR funding. Professor Abdel-Fattah and Dr. Mostafa have no potential conflicts of interest for this study. For the full declaration by Professor Abdel-Fattah please see this weblink https://www.abdn.ac.uk/iahs/research/obsgynae/profiles/m.abdelfattah. K.Y.L and M.S. report no conflict of interest.

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Does pre-operative urodynamics lead to better outcomes in management of urinary incontinence in women? A linked systematic review and meta-analysis

Lor KY, Soupashi M, Abdel-Fattah M, Mostafa A

ABSTRACT

The use of preoperative urodynamics as a standard investigation for urinary incontinence (UI) has long been a subject of debate, with a lack of robust evidence to demonstrate improved patients' outcomes. We aim to compare the clinical and cost effectiveness of urodynamics versus office clinical evaluation only, prior to the treatment of UI. We conducted three linked systematic reviews and meta-analyses of randomised controlled trials (RCTs) comparing urodynamics assessment versus clinical evaluation only in women prior to 1) non-surgical treatment of UI, 2a) surgical treatment of stress urinary incontinence (SUI) and 2b) invasive treatment for overactive bladder (OAB). Women with severe pelvic organ prolapse, previous continence surgery and neuropathic bladder were excluded. Primary outcomes were patient-reported and objective success post-treatment. Secondary outcomes were adverse events, quality of life, sexual function and health economic measures. We searched MEDLINE, Embase and Cochrane Central Register of Controlled Trials databases for each category, which was last updated on January 2019. Study selection, risk of bias assessment and data extraction were performed independently by two reviewers. The random effects model was used to assess risk ratio and mean difference with 95% confidence interval. Statistical heterogeneity was assessed by I^2 statistics and the quality of evidence by the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach.

Four RCTs compared urodynamics versus clinical evaluation only prior to non-surgical management of UI. Treatment consisted of pelvic floor muscle training, with or without pharmacological therapy. Meta-analysis of 150 women showed no evidence of significant difference in the patient-reported and objective success rates between groups (P=0.520, RR: 0.91, 95% Cl 0.69-1.21, I^2 = 0% and P=0.470, RR:0.87, 95% Cl 0.59-1.28, I^2 = n/a, respectively). Seven RCTs were identified for surgical management of SUI. The majority of women underwent mid-urethral tape procedures (retropubic or transobturator approach). Meta-analysis of 1,149 women showed no evidence of significant difference in patient-reported (P=0.850, RR:1.01, 95% CI 0.88-1.16, I^2 = 53%) and objective success between groups (P=0.630, RR:1.02, 95% CI 0.95-1.08, I^2 = 28%). There was no significant difference in incidence of voiding dysfunction, *de novo* urgency, and urinary tract infection between groups. No RCTs were identified for invasive management of OAB.

In conclusion, limited evidence shows that routine urodynamics prior to non-surgical management of UI or surgical management of SUI is not associated with improved treatment outcomes, when compared to clinical evaluation only. Well-designed clinical trials are needed to evaluate the clinical and cost-effectiveness of routine urodynamics prior to surgical management of SUI and OAB.

Key words:

Urodynamics; clinical evaluation; stress urinary incontinence; overactive bladder; surgical outcome

1. Introduction

Urinary incontinence (UI) is a common problem affecting women of all ages, and can have a profound impact on their physical and psychosocial wellbeing as well as their quality of life (QoL) [1,2].

A longitudinal study [3] of 2025 women aged ≥ 65 years reported the baseline prevalence of urgency urinary incontinence (UUI) and stress urinary incontinence (SUI) to be 36.3% and 40.3% respectively. Data from the European Prospective Investigation into Cancer and Nutrition (EPIC) study estimated that 1.3 billion females ≥20 years worldwide suffer from lower urinary tract symptoms (LUTS), with a projected increase to 1.6 billion in 2018 [4].

The current standard for clinical assessment of women with UI includes detailed history to determine the type of UI; risk factors and possible associating symptoms such as voiding difficulties, recurrent urinary tract infection (UTI), prolapse, sexual or bowel symptoms. The assessment also includes examination (for pelvic masses or pelvic organ prolapse (POP)), the use of specific tools such as bladder diaries, validated symptom severity questionnaires as well as non-invasive tests such as stress test and bladder scan to assess post-voiding residual volume (PVR).

The bladder has traditionally been labelled as an "unreliable witness" [5], hence the vast majority of clinicians recommend further investigation of UI with urodynamics to confirm the diagnosis and establish any concomitant pathology prior to any invasive treatment. Urodynamics aims to evaluate the neuromuscular function of the bladder and urethra as well as demonstrate an underlying abnormality of storage or voiding. Urodynamics includes non-invasive tests such as uroflowmetry, and invasive tests such as multichannel filling

cystometry with or without Valsalva leak-point pressures (VLPP), urethral pressure studies and pressure flow studies (PFS) [6]. Results from urodynamics assessments are also used to counsel women regarding their suitability for surgery and their expected outcomes and/or adverse events.

For patients, urodynamics can be perceived to be invasive, uncomfortable, associated with an element of emotional distress and carries the risk of developing UTI (3–5%) [4,7-9]. However, most women find urodynamics to be acceptable provided it will improve their outcomes post-treatment [9-12].

A large survey of urologists and urogynecologists in the United Kingdom (UK) showed that 90% would routinely perform urodynamics prior to surgery in women with SUI or stress-predominant mixed urinary incontinence (MUI) [13]. A systematic review and meta-analysis in 2014 suggested that routinely performing urodynamics had no impact on patient-reported outcomes for those undergoing surgical treatment for "pure SUI" symptoms compared to standard clinical assessment [14]. The study included three randomised controlled trials (RCTs) with a small number of women (n=775). A Cochrane review also reached similar results [15], with authors reporting a small number of included studies and an increased risk of bias.

We performed a linked systematic review and meta-analyses to provide the most up-to-date evidence on clinical and cost-effectiveness of routine invasive urodynamics investigation compared to clinical evaluation only, prior to non-surgical treatments of UI and surgical treatments for women with SUI and overactive bladder (OAB).

2. Methods

Three linked systematic reviews and meta-analyses of RCTs were performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement guidance [16]. The eligibility criteria for included studies were all RCTs comparing the use of urodynamics investigation as part of assessment versus clinical evaluation only in three categories of women with UI prior to 1) non-surgical treatment of UI, 2a) surgical treatment of SUI and 2b) invasive treatment for OAB. The inclusion criteria for the non-surgical treatment of UI review included all women with UI symptoms including SUI, OAB or MUI. For the surgical treatment of SUI review, the inclusion criteria were women with SUI or MUI with predominant SUI symptoms, while for the invasive treatment for OAB review, women were included if they had OAB or urgency predominant MUI symptoms. Exclusion criteria for all groups were: neuropathic bladder, concomitant severe POP and previous continence surgery.

Primary outcomes were: i) patient-reported success (cure or improvement) of UI and ii) objective success (cure or improvement). Secondary outcomes were i) adverse events (i.e. voiding dysfunction, *de novo* urgency, UTI), ii) impact on QoL, iii) sexual function and iv) health economic measures such as cost-effectiveness of the interventions and cost/resource implications to health services.

The literature searches were last updated on January 2019 using MEDLINE, Embase, and CENTRAL (Cochrane Central Register of Controlled Trials) databases. A manual search of

relevant conferences and bibliographies of relevant reviews was carried out. Search criteria were limited to human and females, while no language restrictions were applied.

The search was performed independently by two authors (KYL and MS) and included Medical Subject Heading subheadings, word variations, and free text such as urodynamics, clinical evaluation, urinary incontinence, stress urinary incontinence, urgency incontinence, overactive bladder, conservative management, pharmacological management, and surgical outcome.

Full-text articles were independently screened and assessed for eligibility by two authors (KYL and MS). A third author (AM) resolved any discrepancies. Two authors (KYL and MS) independently performed data extraction and assessed risk of bias of included RCTs in accordance with the Cochrane Handbook for Systematic Reviews of Intervention [17]. Primary authors for all selected RCTs were contacted to request for supplementary data. Table 1 shows a list of the included RCTs for each review. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology was used to assess the quality of evidence and interpret findings for primary outcomes and any secondary outcomes able to be pooled into a meta-analysis [18].

Data were analysed using RevMan v.5.2.20 (Cochrane Collaboration, Oxford, UK) [19]. Meta-analysis results were expressed as risk ratios (RR) with 95% confidence intervals (CI) for dichotomous variables using the Mantel-Haenszel method [20]. Statistical heterogeneity was measured using the chi-square test and I^2 scores, and methodological heterogeneity was assessed during selection. To control for the effect of unobserved heterogeneity, the random effects model was used throughout [21]. Sensitivity analysis was performed for primary

outcomes by excluding conference abstracts for which results were not published in full-text publications.

3. Results

3.1 Non-surgical management of UI review:

The literature search (Fig.1) generated 1647 studies with an additional six studies identified manually. Full-text articles were reviewed for nine studies and four RCTs were selected to be included in this review.

Three RCTs [22-24] were conducted in the UK and one [25] in Norway. One study was a conference abstract [23]. The mean follow-up was 14.3 months (SD:14.97 months; range:3-36 months). Three RCTs [23-25] reported pharmacological therapy in addition to pelvic floor exercises within their non-surgical management plan.

Two RCTs [22,25] (n= 150 women) included suitable data available to be pooled and included in the meta-analysis (n=73 women in urodynamics group, n=77 women in clinical evaluation group). There was no statistically significant difference in patient-reported success rates after non-surgical treatment for UI between the urodynamics group and the clinical evaluation only group (P=0.520, RR:0.91, 95% Cl, 0.69-1.2, GRADE quality of evidence: low) (Fig.2a). Only one RCT [22] provided outcomes on objective success, defined as being dry on pad testing. This RCT showed no evidence of significant difference between both groups (P=0.470, RR:0.87, 95% Cl, 0.59-1.28, GRADE quality of evidence: very low) (Fig.2b). None of the RCTs reported any adverse events post-treatment.

Similarly, there were no statistically significant differences between groups in QoL improvement assessed by the King's Health Questionnaire (KHQ) (P>0.05), reported in only one RCT [24]. No RCTs reported data regarding the impact on sexual function or health economic measures.

For patient-reported cure/improvement, the statistical heterogeneity was estimated to be low (I^2 <25%). Risk of bias was assessed using the Cochrane Collaboration Risk of Bias Assessment graph (Fig.3a,b). Most RCTs demonstrated good random sequence generation, with 50% demonstrating adequate allocation concealment, blinding of outcome assessor and rates of incomplete outcome data.

3.2 Surgical management of SUI review

The literature search (Fig.4) generated 331 studies, with 12 additional studies identified manually. Full articles were reviewed for 26 studies. Seven RCTs were included [23,26-31], with six having suitable data to be included in the meta-analysis [26-31]. One of the studies [27] was a feasibility study, which included a multi-centre randomised pilot trial with relevant outcomes being reported. Another study, Agarwal et al, [31] made a post-randomisation exclusion of 12 women (28.6%) in the urodynamics arm in accordance with their pre-specified RCT protocol for women with unfavourable urodynamics parameters. Four RCTs [23,27,29,30] were conducted in European countries, two in the United States of America [26,28] and one in India [31]. Three of the RCTs were abstracts [23,26,29].

The mean follow-up was 23.1 months (SD: 15.1 months; range: 6 – 47.5 months). There was variation in urodynamics parameters studied in each RCT, with VLPP and PFS being the

most commonly assessed. Mid-urethral tapes (retropubic or transobturator approach) were the predominant surgical interventions used in all RCTs, while a very small number underwent colposuspension, urethropexy or urethral bulking.

Patient-reported success was evaluated using standardised questionnaires such as Urogenital Distress Inventory Scale and Patient Global Impression of Improvement (PGI-I) scale [28,30]. Five RCTs (n =1069; women n=542 in the urodynamics group, n =527 in the clinical assessment only group) included relevant patient-reported outcomes with 234 women, (21.9%) lost to follow-up. Meta-analysis showed no evidence of significant difference in patient-reported success rates between the urodynamics and clinical evaluation only groups (P=0.850, RR:1.01, 95% CI 0.88-1.16, GRADE quality of evidence: low) (Fig.5a). The results were consistent after conducting a sensitivity analysis [31] excluding abstracts and Agarwal et al. (P=0.340, RR:0.90, 95% CI, 0.74-1.11). Objective success was defined as a negative stress test in five RCTs (n=927 women; n= 470 in the urodynamics group, n=457 in the clinical evaluation only group) with 104 women (11.2%) lost to follow-up. Meta-analysis showed no evidence of a significant difference (P=0.630, RR:1.02, 95% CI 0.95-1.08, GRADE quality of evidence: moderate) between the two groups (Fig.5b). The results pertained on sensitivity analysis (P=0.190, RR:0.95, 95% CI, 0.89-1.02). Meta-analysis for adverse events showed no evidence of significant differences between both groups for *de novo* urgency/ urgency incontinence (P=0.640, RR:1.16, 95% CI, 0.62-2.17) and UTI (P=0.970, RR:0.99, 95% CI, 0.51-1.90). Data from two RCTs showed a non-significant trend favouring urodynamics for voiding dysfunction (P=0.360, RR:0.65, 95% CI, 0.26-1.64) (Fig.6).

QoL was assessed using the incontinence quality of life (I-QoL) questionnaire [29], International Consultation on Incontinence Modular Questionnaire Lower Urinary Tract Symptoms Quality of Life (ICIQ-LUTSqol) [27] and Incontinence Impact Questionnaire (IIQ) [28]. Data from these RCTs individually showed no significant differences between groups with regards to the impact on QoL, but due to the different tools used, it was not possible to conduct a meta-analysis.

Impact on sexual function was not reported in any of the studies. Health economic evaluation was reported in one study [27], which demonstrated a mean difference in total average cost of £138 (p=0.071) per woman favouring urodynamics.

In this review, no studies were excluded due to methodological heterogeneity. For patient-reported and objective cure/improvement, the statistical heterogeneity was estimated to be moderate (I^2:25%-75%). Voiding dysfunction, *de novo* urgency as well as UTI incidence rates demonstrated low heterogeneity (I^2<25%). Risk of bias was assessed using a Cochrane Collaboration Risk of Bias Assessment graph (Fig.7a,b). Random sequence generation was appropriately described in three studies, while only a few described adequate methods of allocation concealment and blinding of outcomes assessor.

3.3 Invasive management of UUI/OAB review

The literature search generated n=211 studies with an additional study identified manually. Full-text articles were reviewed for four studies. No RCTs were available to assess the clinical and cost effectiveness of urodynamics versus clinical evaluation only, in women with OAB prior to invasive or surgical treatment (Fig.8).

4. Discussion

The paucity of robust evidence on the clinical and cost-effectiveness of routine urodynamics assessment, especially prior to surgical or invasive management of female UI (both SUI and OAB), represents a dilemma to patients and clinicians as well as policymakers.

This review found no evidence of significant differences in patient-reported and objective success (cure/improvement) rates between women assessed by urodynamics versus clinical evaluation only prior to non-surgical management of UI (SUI and OAB). The fact that urodynamics assessment is not required prior to commencing non-surgical treatment of any type of UI is now considered standard clinical practice and is in agreement with the NICE (UK) and European Association of Urology guidelines [32]. Similarly, no statistically significant differences in treatment outcomes were observed between women assessed by urodynamics versus clinical evaluation only prior to surgical management for SUI. However, the GRADE quality of evidence for these outcomes were moderate and low respectively. No RCTs were available to assess the role of urodynamics prior to the invasive management of OAB.

Urodynamics has been traditionally used to help clinicians establish the correct diagnosis for the type of UI and also to plan the appropriate surgical treatment for individual patients. A systematic review [33] in 2011 which included 23 studies involving 6,282 women, showed that a "clinical diagnosis" of SUI was re-diagnosed into MUI and detrusor overactivity (DO) in only 9% and 7% of cases respectively following urodynamics. Findings differed for clinical diagnosis of MUI, which was re-classified to pure SUI in 46% of women and to DO in 21%. The authors concluded that the importance of urodynamics for diagnosing different

types of UI was unclear and recommended the need for further research to evaluate their effect on treatment outcomes.

Two retrospective studies assessing outcomes of tension-free vaginal tape (TVT) in 264 women, showed an association between pre-operative VLPP <60 cm H2O and a lower success rate [34-35]. Houwert et al. collected data from 387 patients who underwent mid-urethral tape procedures and showed that specific parameters could also lead to a more individualised selection for the type of mid-urethral tape to be used: DO was associated with a higher failure rate following retropubic TVT while low maximum urethral closure pressure (MUCP) was associated with lower success rates for transobturator tape (TOT) [36].

Interestingly, a Dutch survey in 2011 completed by gynaecologists (n=103) and urologists (n=60) representing 80 hospitals, has shown that only 37% performed urodynamics as part of routine investigation prior to SUI surgery, while 88% stated that a positive stress test during clinical examination would be sufficient for them to proceed with surgery. In this review, the commonest indications for urodynamics prior to surgery were symptoms indicating possible DO such as urgency [37]. Another survey in 2012 of gynaecologists (n=400) and urogynaecologists (n=200) conducted in the UK showed that the majority of surgeons agreed that urinary diary (95.8%), free uroflowmetry (94.2%), multichannel subtraction filling cystometry (99.5%), and voiding cystometry (98%) should be amongst the tools for UI assessment when contemplating secondary surgery [38].

A secondary analysis of the VALUE trial reported that clinicians are reluctant to omit urodynamics prior to UI management especially pre-operatively as the diagnosis could be revised following findings, possibly modifying the treatment plan. However, despite

urodynamics' propensity to significantly change the clinical diagnosis, the clinician/surgeon rarely made cancellations or modifications to the surgery or revised any conservative treatment plan [39].

Urodynamics can be seen as a useful tool for clinicians to predict the likelihood of postoperative adverse events [33], however, the current evidence to support this hypothesis is scarce. A retrospective study investigating postoperative voiding dysfunction in women (n=159) who underwent TOT surgery for SUI reported that maximum flow rate (Q-Max) <15ml/s was associated with the likelihood of developing postoperative voiding dysfunction [40]. However, a secondary analysis of an RCT (n=341) of two different types of TOT has shown that none of the pre-operative urodynamics parameters have affected the likelihood of postoperative voiding dysfunction [41]. Similarly, the secondary analysis of the VALUE trial reported that women who had their treatment plan changed based on voiding phase measurements did not have decreased odds of voiding dysfunction [39]. Our meta-analysis demonstrates that urodynamics prior to surgery of SUI did not improve the incidence of postoperative *de novo* urgency and UTI, however, a non-significant trend was observed favouring urodynamics for voiding dysfunction.

A secondary analysis of the INVESTIGATE-I trial assessed the cost-effectiveness of urodynamics and demonstrated a mean difference in total average cost of £138 (p=0.071) per woman favouring routine urodynamics prior to surgery for SUI. This difference is partly due to fewer women undergoing surgical management in the urodynamics group, and the fact that costs of non-invasive investigations were excluded in the cost-utility analysis. The study was not powered to provide statistically significant results as it was a mixed-methods study to assess the feasibility of a future definitive RCT [42]. Conversely, the secondary analysis of

the VALUE trial estimated that omitting urodynamics from the pre-operative clinical assessment in women with uncomplicated SUI could potentially save 13 to 33 million US dollars every year [43].

The paucity of evidence is even more pronounced for the clinical and cost-effectiveness of routine urodynamics prior to invasive treatments for OAB. A large retrospective study (n=4500) showed that only 54.2% of women with OAB symptoms had proven DO diagnosed upon urodynamics. Interestingly, 72.4% of women with DO demonstrated on urodynamics had no prior OAB symptoms [44]. Despite the above, the results from a recent observational study (n=666) embedded within the Bladder Ultrasound Study (BUS) RCT, suggested that clinicians and patients were partly guided by the urodynamics diagnosis while selecting treatment options [9].

An RCT by Rovner et al. of onabotulinumtoxin-A (BoNT-A) versus placebo suggested that successful treatment outcomes of patients with OAB did not appear to be related to the preoperative urodynamics diagnosis of DO [45]. Similarly, a placebo-controlled RCT showed that approximately 60% of the women who received BoNT-A had a positive clinical response based on the PGI-I [46]. Urodynamics is also considered a standard practice prior to Sacral Neuromodulation (SNM) treatment of OAB. A recent observational study concluded that preoperative diagnosis of DO should not be a prerequisite for SNM, given that clinical improvement for those with confirmed DO have comparable clinical improvement to those without [47]. However, there is not much evidence on whether the best indicator for a successful SNM is the presence of DO on urodynamics compared to a positive SNM lead test.

Our review showed that there are currently no RCT data to assess the role of urodynamics prior to invasive management of OAB. Results are awaited from a large multi-centre RCT (FUTURE Study) currently underway in the UK, assessing the clinical and cost-effectiveness of routine urodynamics in women with refractory OAB [48].

This comprehensive linked systematic review presents the most up-to-date evidence from RCTs comparing the impact of routine urodynamics assessment versus clinical evaluation only, on the most relevant outcomes for women after non-surgical and surgical management of UI. Such evidence is required in order to support patients', clinicians' as well as policymakers' decisions regarding the use of urodynamics. The quality of any systematic review depends on the quality of the RCTs and the completeness of the datasets. The overall quality of evidence of the included RCTs was assessed using the GRADE methodology, and sensitivity analyses were performed for a more robust interpretation of our findings. All authors have been contacted for missing data. This systematic review and meta-analyses would be of interest to countries or healthcare systems with limited resources so that better-informed decisions can be made regarding funding allocation without compromising patient safety.

We acknowledge a number of limitations such as the small number of included studies; however, this is a reflection of the surprisingly limited number of RCTs in this field despite the widespread use of urodynamics in clinical practice and the high prevalence of UI. There is a high level of heterogeneity between the RCTs included, especially with regards to patient population and outcome assessment methods (Table 1), and hence the random effect model was used. The wide range of patients' presenting symptoms and baseline characteristics as well as the intra and inter-study variation of urodynamics measurements performed may have

had an effect on the results. As studies in this review did not provide separate outcomes for different subtypes of presenting symptoms (i.e. pure SUI and stress-predominant MUI separately), subgroup analyses were not possible.

This systematic review does not address the value of urodynamics for women with previous continence surgery, UI resulting from neurological disease and/or significant associated POP.

The RCTs included were all evaluating the effectiveness of urodynamics as a diagnostic test, for which blinding of both patients and assessors was not possible. Hence, study types such as prospective and retrospective analyses of large databases might provide additional valuable information for evaluating the role of urodynamics in the treatment of incontinence.

5. Conclusions

There is no robust evidence to show significantly better outcomes in patient-reported and objective success with the routine use of urodynamics versus clinical evaluation only, prior to non-surgical treatments of UI and surgical treatments of SUI in women. No evidence was found on the role of urodynamics prior to the invasive management of OAB. The results need to be interpreted with caution due to the small sample size, the quality of RCTs as well as the vast heterogeneity between studies. This review highlights the need for well-designed RCTs to address the clinical and cost-effectiveness of routine urodynamics prior to surgical managements of SUI and OAB.

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Table

Table 1: Included studies and their characteristics for the three systematic reviews.

Study reference	Design	Participant characteristics	Clinical evaluation and urodynamics (I)	Clinical evaluation only (C)	Follow-up (FU)	Patient-reported success	Objective success
Non – surgical treatment (SUI and OAB)							
Majumdar et al., 2010 [24]	Single-centre patient preference trial with embedded RCT, UK	Inclusion criteria: >18 years old with UI and other LUTS Exclusion criteria: Patients referred for POP surgery (≥stage 2), previous consultation and referral for incontinence surgery, neurological disorders, previous incontinence treatment at tertiary level, recurrent dysuria or positive urine culture. Lost to FU: (I) 10 and (C) 14	UDS n=52	History, urine dipstick, 3-day bladder diary n=47	5-6 months	N/A	Incontinence episode frequency based on 3-day bladder diary
Holtedahl et al., 2000 [25]	Multi-centre population-based RCT, Norway	Inclusion criteria: Women with ≥2 leakage episodes per month. Leakage was demonstrated either by a positive stress test, positive 48hr pad test or "wet" recording in a 48hr frequency/volume chart. Exclusion criteria: Cardiac pacemaker, dementia and psychological or medical problems that might affect treatment. Lost to FU: (I) 2 and (C) 3	PVR, UPP, stress test, pad weighing before and after split jumps, cystometry, cystoflowmetry, cystoscopy and gynaecological examination. Women received treatment 6 months after initial consultation n=46	Examination by general practitioner. Women received treatment immediately after diagnosis n=44	6, 12 months	Total number of women 'cured' (no reported leakage + 0 wet episodes) and 'improved' (improvement in at least 2/4 of: frequency, amount, impact, wet episodes consistent with pad test results and health workers feedback)	N/A
Ramsay et al., 1995 [22]	Single-centre RCT, UK	Inclusion criteria: Women with frequency, urgency, nocturia, UUI and SUI. Exclusion criteria:	UDS n=27	Clinical evaluation n=33	3 months	Cure/ improvement rate based on the questions: "Are you cured?" or "Are you improved to the extent that you do	Dry on pad test

		Previous incontinence treatment, haematuria, recurrent dysuria/voiding difficulty and positive urine culture. Lost to FU: (I) 7 and (C) 5				not require any further treatment?"	
Khullar et al., 2000 [23]	Single-centre RCT, UK	<u>Inclusion criteria:</u> Women with urinary symptoms without a UDS diagnosis. Total number of patients randomised: 105 Total lost to FU: n=41	4-hour ambulatory UDS	Clinical evaluation	3 years	Urinary symptoms using questionnaire	N/A
Surgical treatment – SUI							
Choe, 2001[26]	RCT, USA (conference abstract)	<u>Inclusion criteria:</u> Women with type II/III SUI Lost to FU: 0	Multichannel UDS n=40	Urethroscopy, Q-tip test and supine cough stress test n=40	36 months (mean)	N/A	No urine loss with physical activity
Hilton et al., 2015 [27]	Multi-centre pilot RCT, UK [INVESTIGATE – I]	<u>Inclusion criteria:</u> SUI or stress predominant MUI, family complete and had previous conservative treatment (single PFMT ± other) with inadequate symptom resolution. <u>Exclusion criteria:</u> Symptomatic uterovaginal prolapse requiring treatment, previous surgery for UI/POP, UDS ≤ 3 year ago and neurological cause of UI. Lost to FU: (I) 75 and (C) 55	Dual-channel subtracted cystometry with simultaneous PFS, VUDS and ambulatory urodynamics at clinician's discretion n=112	Clinical assessment and non-invasive tests at clinician's discretion (i.e. frequency/volume charts or bladder diary, MSSU, urine flow rate, PVR) n=110	6 months	Number without any incontinence within the first year	N/A
Nager et al., 2012 [28]	Multi-centre, noninferiority RCT, USA [VALUE]	<u>Inclusion criteria:</u> Uncomplicated, stress predominant UI >21 years old, duration ≥3 months, MESA questionnaire: SUI score > UUI score, PVR <150ml, negative urinalysis/urine culture, assessment of urethral mobility, positive	Non-instrumented uroflowmetry, filling cystometry with VLPP & PFS and optional UPP & VUDS	SUI symptoms, stress test, PVR, urine dipstick, standing and straining	After discharge, 3 and 12 months	Reduction in UDI score by ≥ 70% at 12 months and a PGI-I response of "very much better" or "much better"	Negative stress test on examination

		stress test <u>Exclusion criteria</u>: Previous UI surgery, pelvic surgery ≤3 months, pelvic irradiation, anterior/apical prolapse ≥1cm distal to the hymen Lost to FU: (I) 43 and (C) 49	n = 315	prolapse exam, assessment of urethral mobility (Q-Tip test, visual inspection, palpation, point Aa on POP-Q exam or lateral cystogram) n = 315			
Romero et al., 2010 [29]	RCT, Spain (conference abstract)	<u>Inclusion criteria:</u> Women with SUI/MUI <u>Exclusion criteria:</u> <18 years, previous radiotherapy or UI procedure Lost to FU: 0	Measurements of MCC, voiding pressure, Qmax, VLPP and DOA n=42	History, physical evaluation with full bladder, flowmetry, and PVR n=44	(I) 46 months (C) 49 months	ICIQ-SF: "How often do you leak urine?" (either never, once/week, 2-3 times/week or once/day)	Dry on cough test
van Leijsen et al., 2012 [30]	Multicentre noninferiority RCT, Netherlands [VUSIS]	<u>Inclusion criteria:</u> SUI or stress predominant MUI demonstrated on physical examination and/or micturition diary, failed conservative therapy <u>Exclusion criteria</u>: Previous UI surgery, ≥POP-Q stage 3 and/or PVR >150ml on US or catheterisation Lost to FU: 0	Free flow and PVR measurement, filling cystometry with ALPP and PFS ± UPP n=31	History and physical examination, 48hr bladder diary, 48hr pad test, urinalysis and PVR n=28	6 weeks 6, 12 and 24 months	UDI-6: "urine leakage related to physical activity, coughing or sneezing" (negative answer)	Negative stress test
Agarwal et al. 2014 [31]	RCT, India	<u>Inclusion criteria:</u> Uncomplicated SUI (≥ 3 months), failed non-surgical treatment, PVR <150ml, negative urine culture, assessment of urethral mobility, positive stress test <u>Exclusion criteria:</u>	Non-invasive uroflowmetry, filling cystometry with VLPP & PFS, stress test and UPP	History, PVR measurement, urine culture, stress test, urethral mobility	6, 12 months	Reduction in UDI-6 score by ≥ 70%	Negative stress test

		Previous UI surgery, pelvic surgery ≤3 months, pelvic irradiation, anterior/apical prolapse ≥1cm distal to the hymen		assessment			
Invasive treatment – OAB							
No studies found							

Abbreviations: SUI (stress urinary incontinence), OAB (overactive bladder), UI (urinary incontinence), LUTS (lower urinary tract symptoms), POP (pelvic organ prolapse), UDS (urodynamics), PVR (post void residual), UPP (urethra pressure profile), UUI (urgency urinary incontinence), MUI (mixed urinary incontinence), PFMT (pelvic floor muscle training), PFS (pressure flow studies), VUDS (video-urodynamics), MSSU (mid-stream specimen urine), MESA (Medical, Epidemiological and Social Aspects of Ageing Questionnaire), UDI (Urogenital Distress Inventory), PGI-I (patient global impression of improvement), MCC (maximum cystometric capacity), Qmax (maximum flow rate), VLPP (Valsalva leak-point pressure), (DOA (detrusor overactivity), ICIQ - SF (International Consultation on Incontinence Questionnaire - short form), US (ultrasound scan), ALPP (abdominal leak-point pressure)

Figure

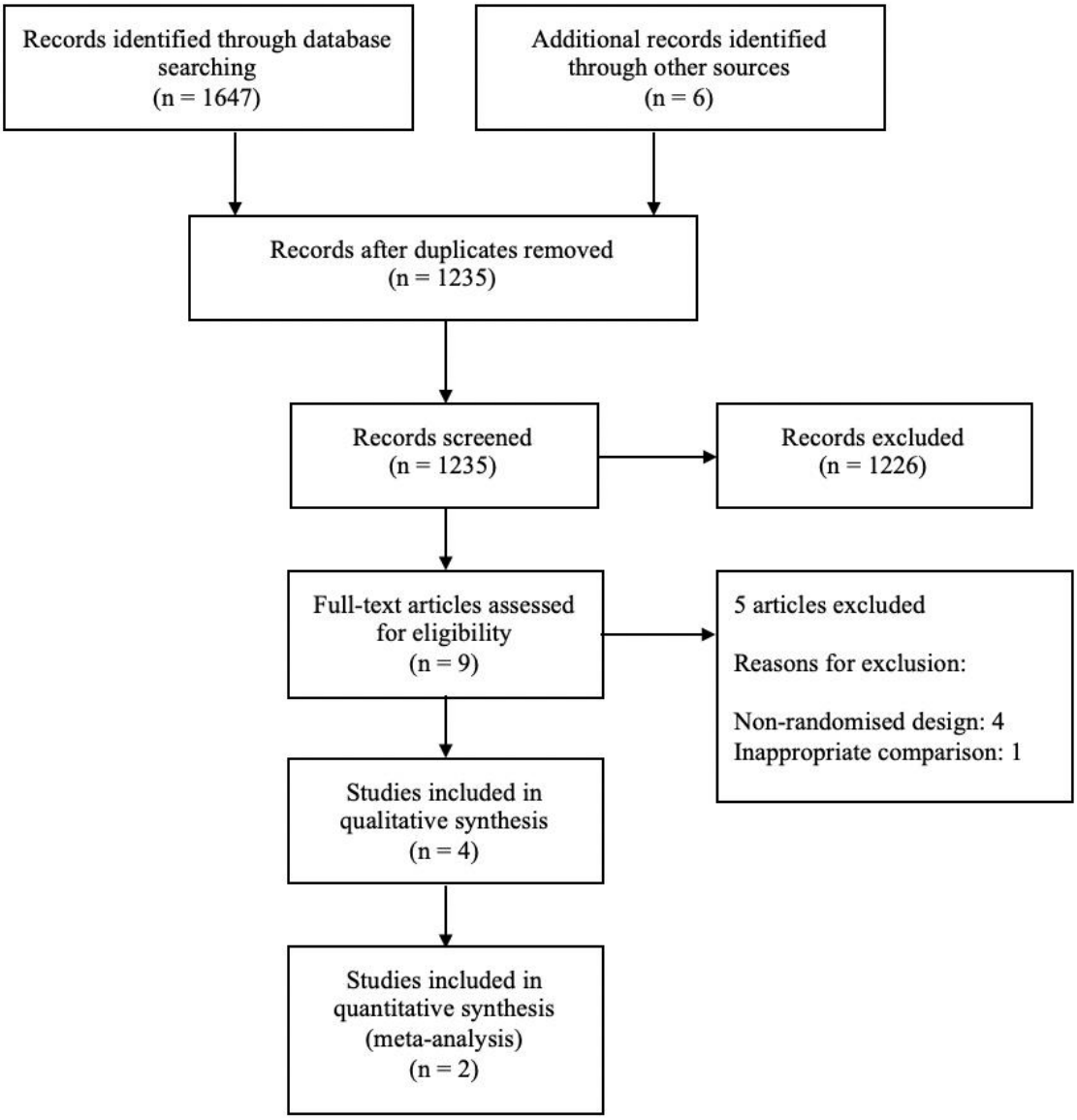


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart showing the literature search results and the selection process for the review of urodynamic versus clinical evaluation only prior to non-surgical management of women with urinary incontinence (stress urinary incontinence and overactive bladder).

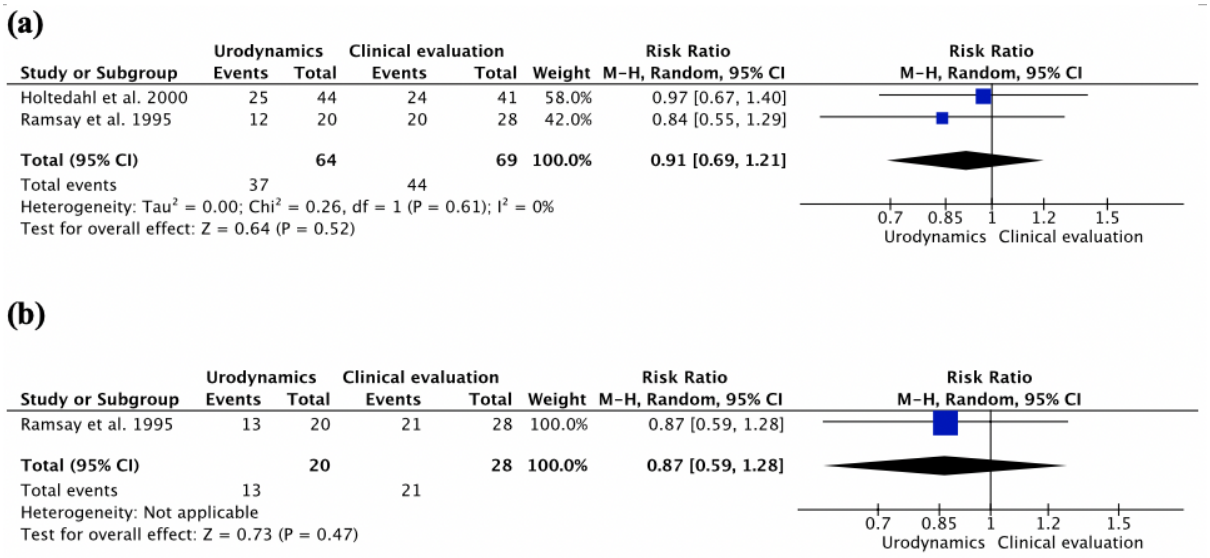
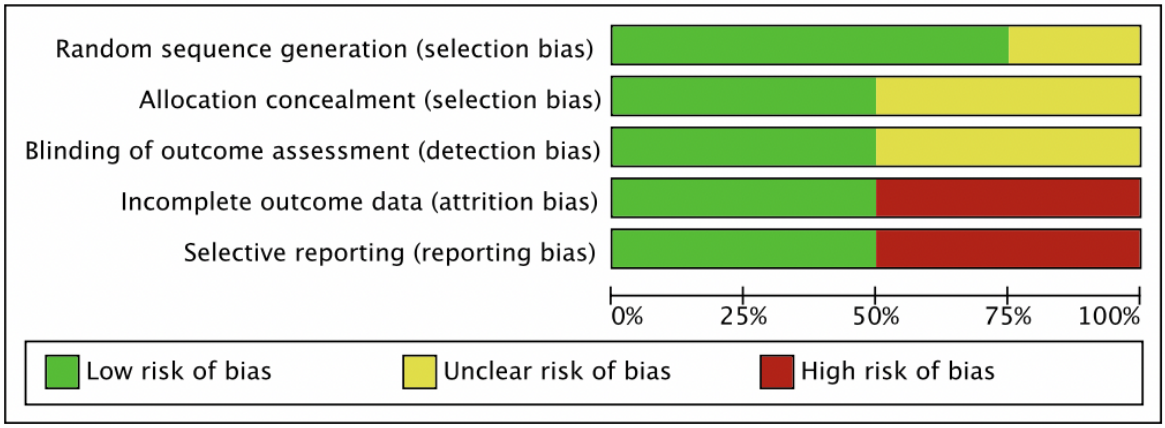


Figure 2. Success after non-surgical management: (a) patient-reported success; (b) objective success

(a)



(b)

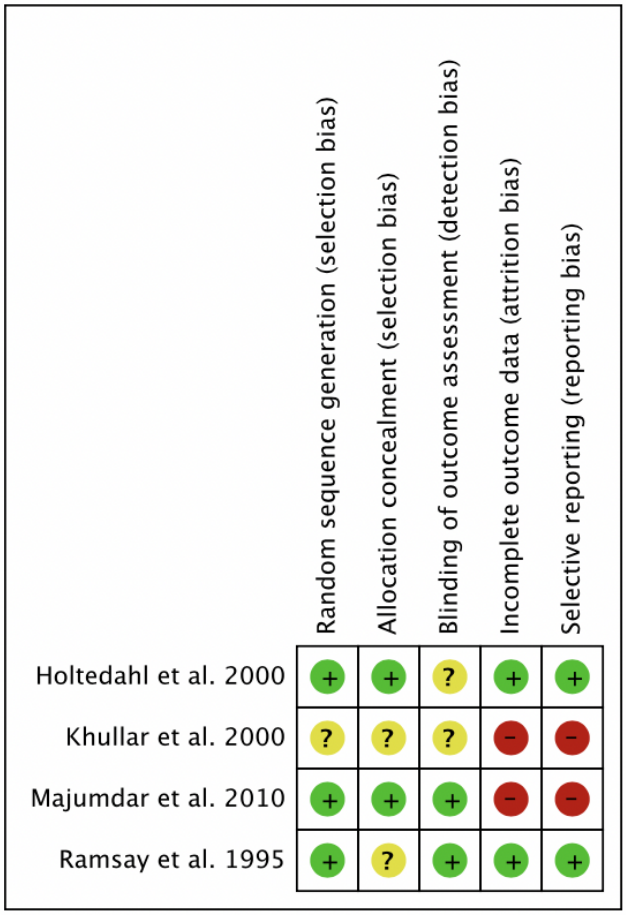


Figure 3. Risk of bias (a) graph (b) summary for non-surgical management of urinary incontinence

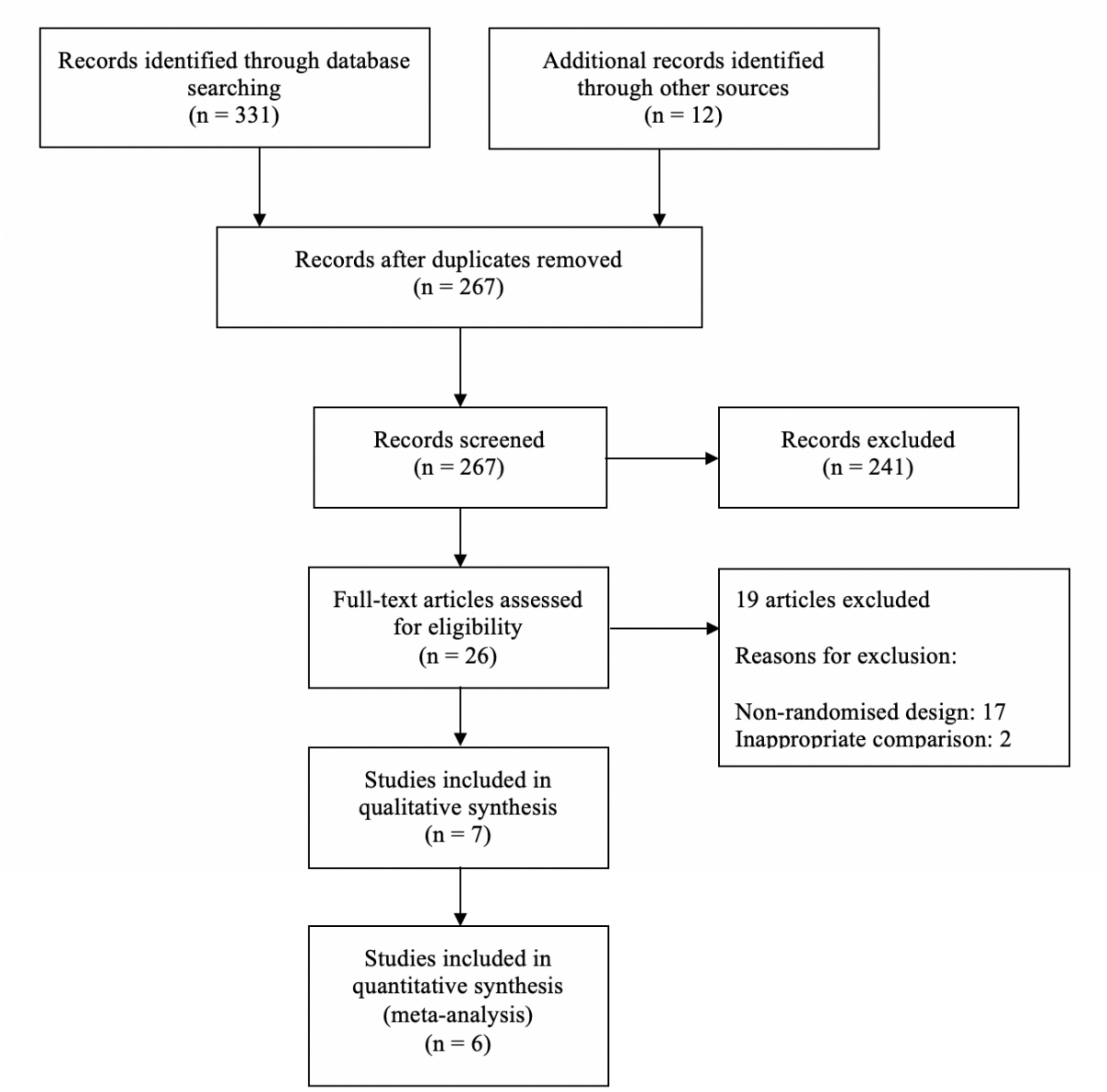
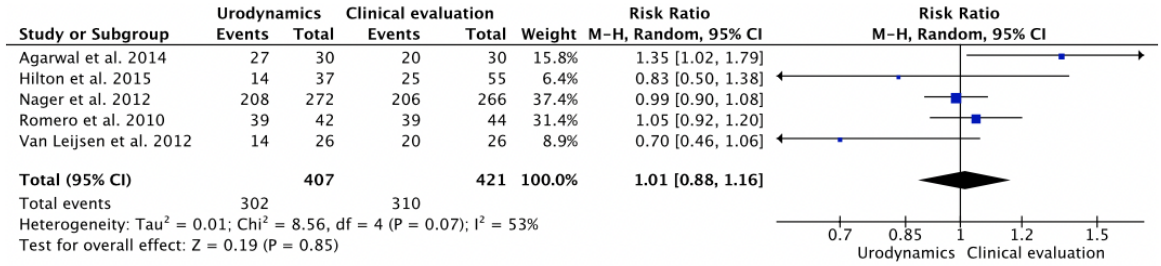


Figure 4. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart showing the literature search results and the selection process for the review of urodynamic versus clinical evaluation only prior to surgical management of women with stress urinary incontinence.

(a)



(b)

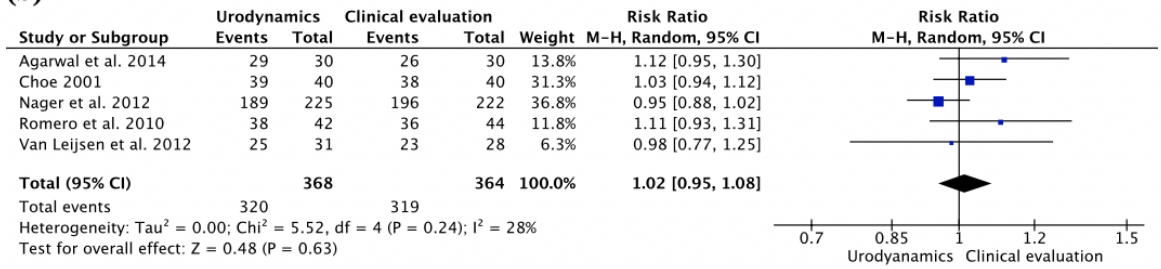


Figure 5. Success after surgical management of stress urinary incontinence: (a) patient-reported success; (b) objective success

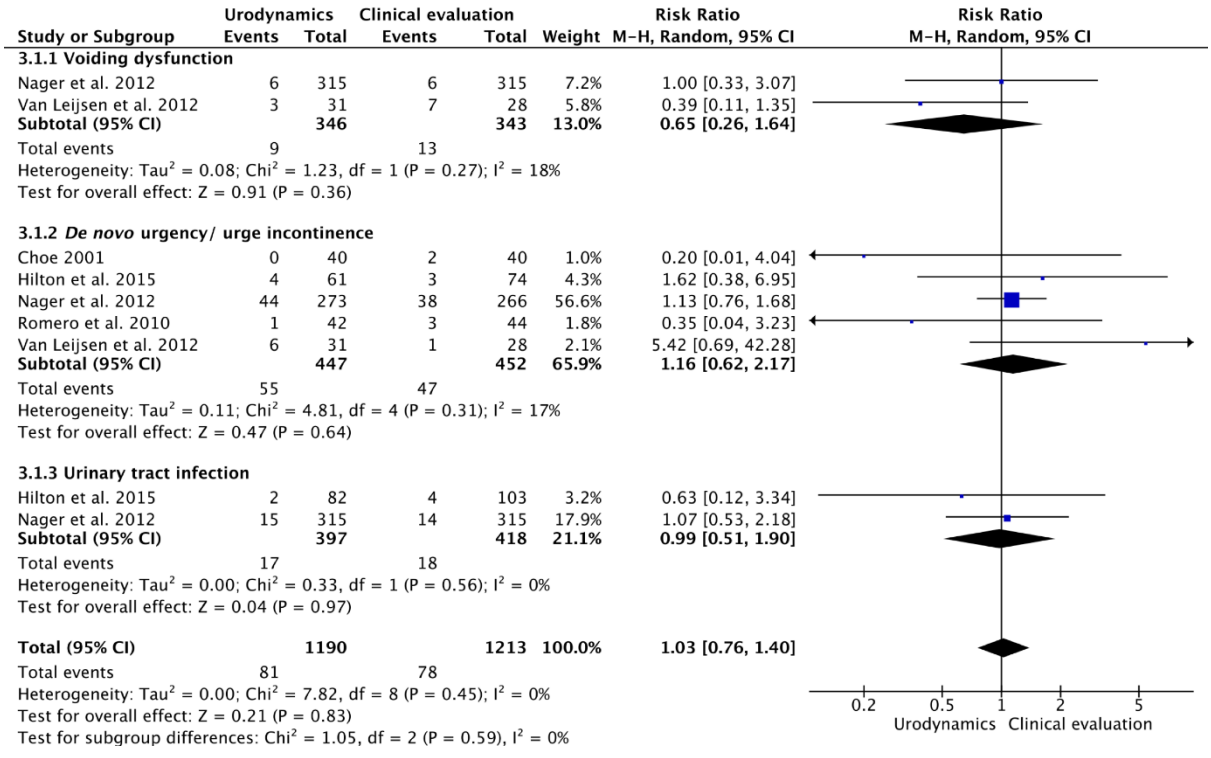


Figure 6. Adverse events after surgical management of stress urinary incontinence

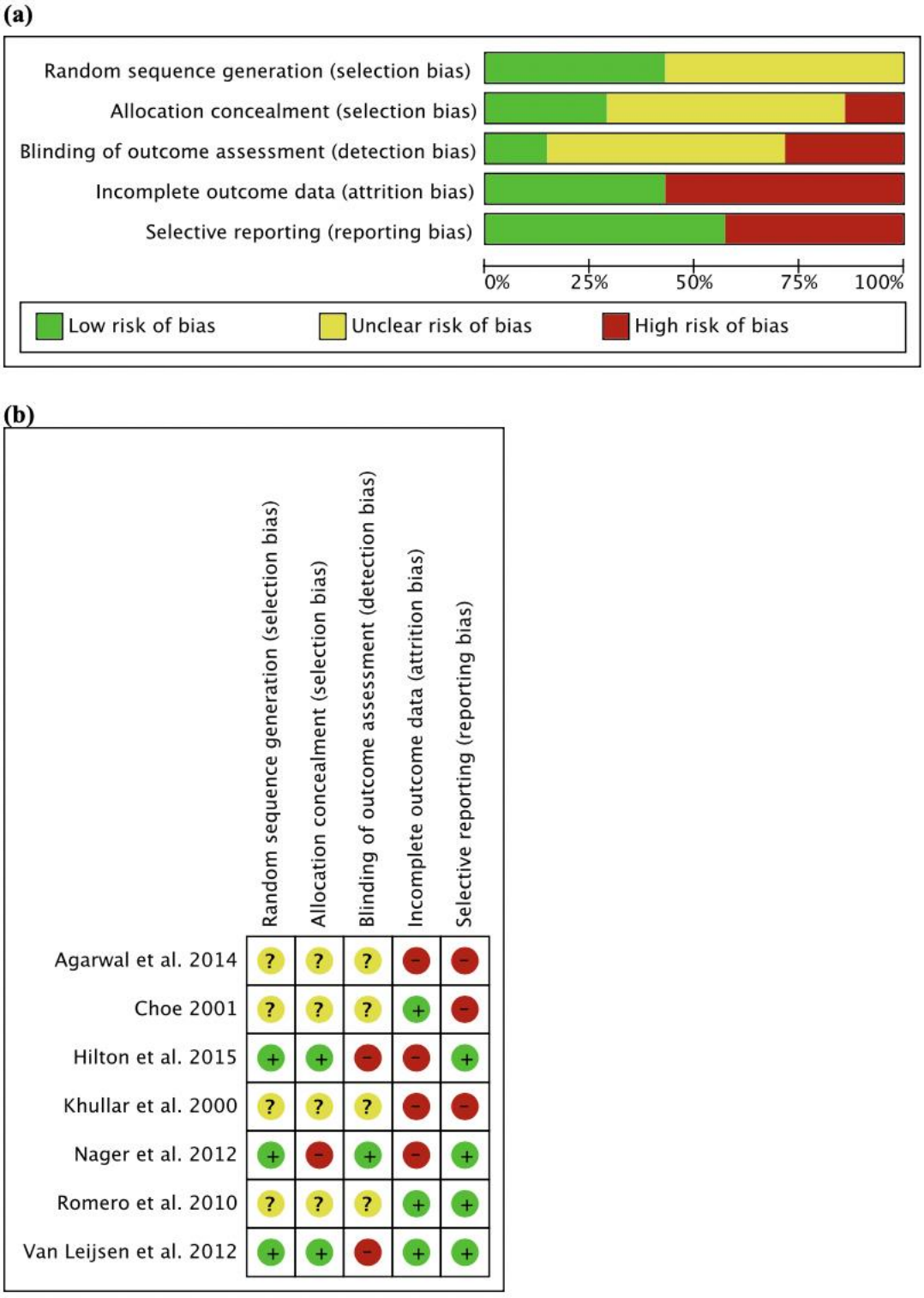


Figure 7 Risk of bias (a) graph (b) summary for surgical management of stress urinary incontinence

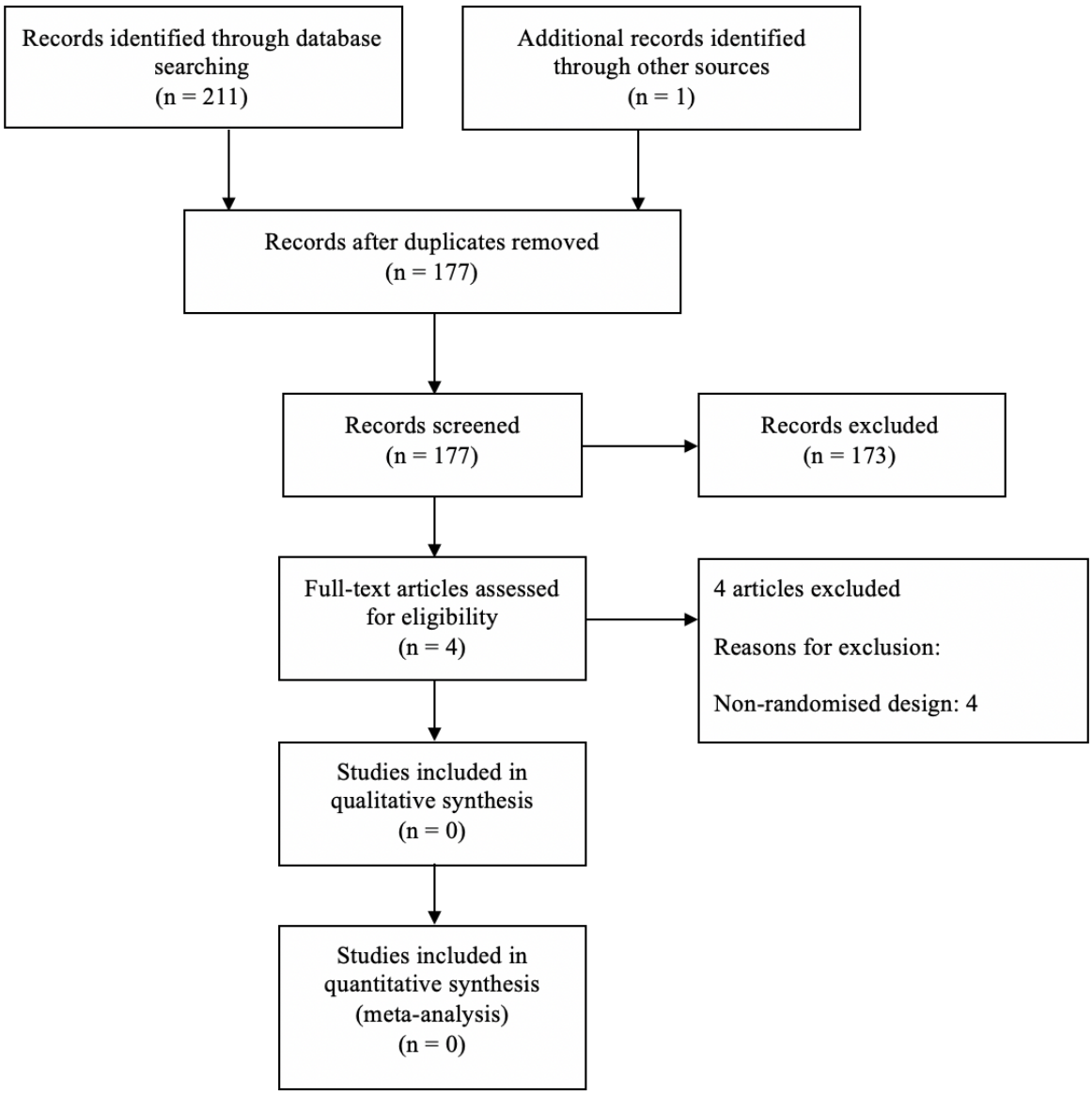


Figure 8. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart showing the literature search results and the selection process for the review of urodynamic versus clinical evaluation only prior to invasive management of women with overactive bladder/urgency urinary incontinence.

***Conflict of Interest**

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

M.A.F is the chief investigator and A.M. is a co-investigator on the ongoing National Institute for Health Research (NIHR)-funded FUTURE Study evaluating the clinical and cost effectiveness of urodynamics in women with refractory overactive bladder symptoms (https://w3.abdn.ac.uk/hsru/FUTURE/Public/Public/index). They are also part of the team applying for further relevant NIHR funding. Professor Abdel-Fattah and Dr. Mostafa have no potential conflicts of interest for this study. For the full declaration by Professor Abdel-Fattah please see this weblink https://www.abdn.ac.uk/iahs/research/obsgynae/profiles/m.abdelfattah. K.Y.L and M.S. report no conflict of interest.

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