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MINIMALLY INVASIVE VASCULAR HITCH TO TREAT PEDIATRIC EXTRINSIC URETEROPELVIC JUNCTION OBSTRUCTION BY CROSSING POLAR VESSELS: A SYSTEMATIC REVIEW AND META-ANALYSIS.

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Abstract:	INTRODUCTION: Vascular hitch (VH) gained an increasing success in treating ureteropelvic junction obstruction (UPJO) by crossing vessels (CV) in pediatrics. We aimed: (i) to compare laparoscopic VH versus laparoscopic dismembered pyeloplasty (DP) to treat UPJO by CV; (ii) to review possible amelioration given by a robot-assisted procedure. METHODS: Using defined search strategy, three investigators identified all studies on laparoscopic VH. Those studies comparing VH versus DP or versus robot-assisted VH were included in the meta-analysis. The meta-analysis was conducted using RevMan 5.3. Data are mean±SD. RESULTS: Systematic review - Of 2,460 titles/abstracts screened, 39 full-text articles were analyzed. Eleven studies on VH (278pts) reported 98.5% success rate, with 1.5% intra-operative complications. Meta-Analysis - Four studies compared VH versus DP (183pts). Operative time was reduced in VH (95.7±56.5min) compared to DP (142.1±53.7min; p<0.00001). Complications were similar (VH 3/99pts, 3.0% versus DP 4/84pts, 4.8%; p=ns). Hospital stay was shortened in VH (1.9±0.7dd) versus DP (5.9±4.0dd; p=0.0007). The success rate was comparable (VH 97/99pts, 97.9% versus DP 80/84pts, 95.2%; p=ns). Two prospective studies compared robot-assisted VH to laparoscopic VH (53pts). No differences were found among complications (robot-assisted VH 0/13pts, 0% versus laparoscopic VH 1/40pts, 2.5%; p=ns) and success rate (robot-assisted VH 13/13pts, 100% versus laparoscopic VH 39/40pts, 97.5%; p=ns). CONCLUSIONS: Laparoscopic VH seems to be a safe and reliable procedure to treat UPJO by CV. The procedure appeared quicker than laparoscopic DP, with shortened hospital stay. Further studies are needed to corroborate these results and to establish amelioration given by a robot-assisted procedure.
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September 23rd, 2020

Dear Editor,

Re: Submission to Journal of Pediatric Urology.

We would be grateful if you could consider our original paper entitled "Minimally Invasive Vascular Hitch to Treat Pediatric Extrinsic Ureteropelvic Junction Obstruction by Crossing Polar Vessels: a Systematic Review and Meta-Analysis" for publication in Journal of Pediatric Urology.

To the best of our knowledge, this study to analyze the evidence on vascular hitch to treat pediatric extrinsic ureteropelvic junction obstruction by crossing polar vessels. To address this topic, we have conducted a systematic review of the literature and a meta-analysis of comparative studies. We believe that our findings add new knowledge to the current literature.

All authors have made a substantial contribution in the development of this paper, and have agreed to the submission of this manuscript in its present form.

All the work in this study is original and not under consideration elsewhere.

Moreover, the current study has been accepted as conference abstract and oral communication at the IPEG (International Pediatric Endosurgery Group) 2020 Program, which was originally planned as the EUPSA-IPEG-ESPES "Among Friends" congress in Vienna in June 2020. Because of Covid issues, the study was later accepted at the 2020 Virtual IPEG Meeting.

Signature of the corresponding author

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ABSTRACT

INTRODUCTION: Vascular hitch (VH) gained an increasing success in treating ureteropelvic junction obstruction (UPJO) by crossing vessels (CV) in pediatrics. We aimed: (i) to compare laparoscopic VH *versus* laparoscopic dismembered pyeloplasty (DP) to treat UPJO by CV; (ii) to review possible amelioration given by a robot-assisted procedure.

METHODS: Using defined search strategy, three investigators identified all studies on laparoscopic VH. Those studies comparing VH *versus* DP or *versus* robot-assisted VH were included in the meta-analysis. The meta-analysis was conducted using RevMan 5.3. Data are mean±SD.

RESULTS: Systematic review - Of 2,460 titles/abstracts screened, 39 full-text articles were analyzed. Eleven studies on VH (278pts) reported 98.5% success rate, with 1.5% intra-operative complications. Meta-Analysis - Four studies compared VH *versus* DP (183pts). Operative time was reduced in VH (95.7±56.5min) compared to DP (142.1±53.7min; p<0.00001). Complications were similar (VH 3/99pts, 3.0% *versus* DP 4/84pts, 4.8%; p=ns). Hospital stay was shortened in VH (1.9±0.7dd) *versus* DP (5.9±4.0dd; p=0.0007). The success rate was comparable (VH 97/99pts, 97.9% *versus* DP 80/84pts, 95.2%; p=ns). Two prospective studies compared robot-assisted VH to laparoscopic VH (53pts). No differences were found among complications (robot-assisted VH 0/13pts, 0% *versus* laparoscopic VH 1/40pts, 2.5%; p=ns) and success rate (robot-assisted VH 13/13pts, 100% *versus* laparoscopic VH 39/40pts, 97.5%; p=ns).

CONCLUSIONS: Laparoscopic VH seems to be a safe and reliable procedure to treat UPJO by CV. The procedure appeared quicker than laparoscopic DP, with shortened hospital stay. Further studies are needed to corroborate these results and to establish amelioration given by a robot-assisted procedure.

KEYWORDS: ureteropelvic junction obstruction, lower pole crossing vessels, vascular hitch, pediatric, systematic review, meta-analysis

INTRODUCTION

Ureteropelvic Junction Obstruction (UPJO) is the condition where the urine is unable to flow from the renal pelvis to the ureter [1-3]. It may be caused by an intrinsic or an extrinsic cause. Intrinsic obstructions depend on an interruption of development of the ureteral musculature or an abnormal development of collagen fibers that separate the muscle fibers. Both these issues cause a consequent incapability of contraction. Extrinsic obstructions may depend on a lower pole crossing vessel, fibrous band adhesions, or a kinking of a normal ureteropelvic junction [1,2].

The gold standard treatment for the UPJO repair (both intrinsic and/or extrinsic) is the dismembered pyeloplasty (DP), as proposed by Anderson and Hynes in 1949 [1-7]. Nowadays, this technique is also performed throughout minimally invasive approaches (i.e. laparoscopy, retroperitoneoscopy, and robot-assisted procedure).

In 1951, Hellström firstly introduced an alternative procedure to treat the pure extrinsic UPJOs. This procedure, also known as “vascular hitch” (VH), consisted on a suspension of the crossing vessel on the renal pelvis through vascular adventitial sutures [1,2]. The procedure has been later modified by Chapman, who eliminated the adventitial sutures and introduced a pelvic wrap to suspend the polar vessel [1,4].

The “vascular hitch” procedure reached a little success until the widespread of the laparoscopy, as it eliminates the technical difficulties linked to the intracorporeal laparoscopic sutures, required for the DP. Moreover, the Hellström technique avoids the opening of the collecting system and does not require the positioning of a stent, thus reducing the risk of complications (such as leakages or urinomas) and eliminating the need for a second anesthesia to remove the stent [1-3,8].

The main challenge of the VH remains to exclude a concomitant intrinsic obstruction [3]. As a matter of fact, it has been reported that up to 33% of patients with a lower pole crossing vessel (LPCV) had also an intrinsic obstruction [6]. Therefore, few studies have been suggested to perform an intraoperative diuretic test [1,3,5-7].

To reduce the technical difficulties of the laparoscopic DP, the robot-assisted procedure has been introduced, showing comparable results with the open procedure in terms of sewing [9].

Even if the VH has gained popularity as alternative for the treatment of pure extrinsic UPJO, a few studies compared this technique to the dismembered pyeloplasty in children.

Therefore, the aims of our study were:

1. to determine whether laparoscopic VH was superior to laparoscopic dismembered pyeloplasty to treat extrinsic UPJO by crossing vessels (CV);

2. to review the published results with regards to robot-assisted laparoscopic VH *versus* pure laparoscopic VH.

METHODS

Both the systematic review and the meta-analysis were conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [10].

The present study was registered on PROSPERO - international prospective register of systematic reviews [11].

Using a defined search strategy, three investigators (MEM, AR, GLa) independently searched the main databases (PubMed/Medline, Scopus, Web of Science, and Cochrane databases) using a combination of keywords (**Table 1**). MeSH headings and terms used were “pyeloplasty”, “lower pole crossing vessels”, “hydronephrosis AND crossing vessels”, “polar vessels AND hydronephrosis” and ‘‘hellström AND crossing vessels” (**Supplementary file 1**). Studies published from 1950 until July 2020 were included.

Reference lists were searched to identify relevant cross references. Case reports, opinion articles, and case series with less than 10 patients were excluded. All grey literature publications (i.e. reports, theses, conference proceedings, bibliographies, commercial documentations, and official documents not published commercially) were also excluded. We tried to identify all the studies reporting the results of laparoscopic/robot-assisted VH and/or laparoscopic Anderson/Hynes dismembered pyeloplasty (DP) to treat extrinsic UPJO secondary to crossing vessels in pediatric patients.

The full text of potentially eligible studies was retrieved and independently assessed for eligibility by the investigators. Any disagreement between them over the eligibility of particular studies was resolved through discussion with a fourth author (GLi).

We included in the meta-analysis only those studies comparing laparoscopic VH *versus* laparoscopic DP or *versus* robot-assisted laparoscopic VH. The meta-analysis was conducted with RevMan 5.3 [12], using the random-effects model to produce risk ratio (RR) for categorical variables and mean differences (MD) for continuous variables, along with 95% confidence intervals (CI). Data are expressed as mean±SD. We produced I^2 values to assess homogeneity and quantify the dispersion of effect sizes. Publication biases were assessed using the funnel plot method. Data were compared using Fisher's Exact Test and are expressed as mean±SD and range. When median and range were reported, mean ± SD were estimated, as reported [13].

Quality Assessment

Risk of bias for individual studies was assessed in duplicate (MEM and GL) using the methodological index for nonrandomized studies (MINORS) [14]. Differences between the two reviewers (MEM and GLa) were resolved through consensus and discussion with a third author (GLi). The total score for this 12-item instrument ranges 0–24 points with a validated “gold standard” cut-off of 19.8.

Moreover, we assessed the methodological quality for each outcome by grading the quality of evidence using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology [15]. Quality of evidence was rated as high, moderate, low, and very low for each outcome. Observational studies start with a low quality of evidence. The quality of evidence was rated down in the presence of risk of bias, inconsistency, indirectness, imprecision, and publication bias. For assessment of risk of bias in observational studies, we used the MINORS instrument. Inconsistency was determined according to heterogeneity. We produced I^2 values to assess heterogeneity. As established by Cochrane guidelines, I^2 value of 0–40, 30–60, 50–90, and 75–100% were considered as low, moderate, substantial, and considerable heterogeneity, respectively [16]. In case of a score overlapping two groups (e.g. 35), we would insert in our GRADE table a mixed inconsistency (e.g. low/moderate). Imprecision was assessed using optimal information size (OIS), which was based on 25% relative risk reduction, 0.05 of α error and 0.20 of β error [17].

RESULTS

Systematic review - Of 2,460 titles or abstracts screened, 203 met the inclusion criteria and 39 full-text articles were analyzed. Eleven studies (278 children; **Figure 1**) reported an overall success rate of laparoscopic VH in 274 cases (98.5%), with 4 intra-operative complications (1.5%) [1-9,18,19].

Meta-Analysis - Four retrospective studies comparing laparoscopic VH *versus* laparoscopic DP were included (183 patients) [1,4,5,9]. Operative time was significantly reduced in VH (95.7±56.5min) compared to DP (142.1±53.7min; $p<0.00001$, MD -48.9, 95% CI -66.6 to -31.2, I^2=83%; **Figure 2**). The incidence of complications was similar between the two groups (VH 3/99pts, 3.0±1.0% *versus* DP 4/84pts, 4.8±6.8%, p=ns, RR 0.6, 95% CI 0.1 to 2.8, I^2=0%; **Figure 3**). The length of hospital stay was significantly shortened in VH (1.9±0.7 days) compared to DP (5.9±4.0 days, p=0.0007, MD -2.6, 95%

CI -4.2 to -1.1, I^2=91%; **Figure 4**). The success rate was comparable between the two procedures (VH 97/99pts, 97.9±1.6% *versus* DP 80/84pts, 95.2±1.8%, p=ns, RR 0.99, 95% CI 0.90 to 1.1, I^2=0%; **Figure 5**).

Only two studies with prospectively followed-up cohort of patients compared robot-assisted laparoscopic VH to laparoscopic VH (53 patients) [2,6]. No differences were found with regards to complications (robot-assisted VH 0/13pts, 0% *versus* laparoscopic VH 1/40pts, 2.5±1.5%, p=ns, RR 1.50, 95% CI 0.1 to 30.5; **Figure 6**) and success rate (robot-assisted VH 13/13pts, 100% *versus* laparoscopic VH 39/40pts, 97.5±1.5%, p=ns, RR 0.99, 95% CI 0.9 to 1.1, I^2=0%; **Figure 7**).

Quality assessment

All but two studies included in the meta-analysis were retrospective observational studies [1,4,5,9]. Two studies were prospectively followed-up cohort of patients [2,6]. Therefore, only one of the included studies reached the gold standard cut-off on MINORS of 19.8 out of 24 (**Table 2**) [2]. None of the papers provided sample size calculations and none of the studies reported a blinded evaluation of objective endpoints. Moreover, even if follow-up periods were usually appropriate to the aim of the studies, none of the studies have reported the loss to follow-up.

As there were a maximum of four included studies, we did not perform funnel plot analysis. According to the GRADE methodology, the quality of evidence was low with regards operative time, incidence of complications, and success rate in laparoscopic VH compared to laparoscopic DP. The quality was very low with regards the length of hospital stay in laparoscopic VH compared to laparoscopic DP. In the meta-analysis comparing robot-assisted laparoscopic VH to laparoscopic VH, both incidence of complications and success rate reached a very low quality of evidence (**Table 3**). Moreover, when independently assessed by two authors (PLC and GLi) using A Measurement Tool to Assess Systematic Reviews (AMSTAR) [20], the present systematic review and meta-analysis received a decent score (**Supplementary file 2**). The PRISMA checklist was then completed (**Supplementary file 3**).

DISCUSSION

The extrinsic UPJO is generally caused by the presence of an aberrant lower pole crossing vessel, usually arising from the descending aorta. An aberrant lower pole crossing vessel caused UPJO in 11-15% of cases and this percentage raises up to 58% in older children [5].

Extrinsic obstruction, in fact, often presents in late childhood/adolescence (around 10 years of age). Patients do not usually have a history of prenatally diagnosed hydronephrosis and they complain of an intermittent flank pain associated with a hydronephrosis, that completely regresses after the resolution of the symptoms [1,3]. Nonetheless, those children usually have a normal renal function, especially if they did not experience any episode of urinary tract infections [1,8].

However, the diagnosis and the choice of the correct management of extrinsic obstructions caused by a crossing vessel are not easy. As a matter of fact, it is not clear if the crossing vessel is responsible for the obstruction alone or if there is an additional fibrotic component. It has been postulated that the UPJ of children that experienced many episodes of infections may undergo fibrotic and ischemic changes that lead to a long-term intrinsic obstruction [5,18]. Moreover, a concomitant intrinsic obstruction has been reported in up to 33% of patients diagnosed with a polar crossing vessel and it has been suggested that patients diagnosed with a CV and a history of spontaneous resolution of a hydronephrosis are at higher risk for an associated intrinsic obstruction [3,5,6].

Since its description by Anderson and Hynes in 1949, the dismembered pyeloplasty has always been the gold standard for the management of both intrinsic and extrinsic hydronephrosis [1,9]. It can be performed in an open, pure laparoscopic or robot-assisted fashion [5].

In 1951, Hellström has been proposed an alternative to the dismembered pyeloplasty to treat the pure extrinsic UPJO: it consisted of the cranial displacement of the crossing vessel, which was anchored to the anterior pelvis through vascular adventitial sutures. Later on, Chapman has been modified the Hellström technique by eliminating the vascular sutures, hence introducing a pelvic wrap to anchor the vessel [1,2,8].

This technique has been re-proposed in children in 2006, when Godbole et al. published a series of 12 pediatric patients successfully treated through a laparoscopic vascular hitch, and has gained increasing popularity since it was easy and quick to be performed [2,21]. Moreover, it preserved the integrity of the UPJ and did not require the positioning of a stent, thus avoiding a second anesthesia to remove it [2,8].

On the other side, some Authors questioned if the traction of the crossing vessel resulting from the vascular hitch may determine the development of hypertension after puberty [3]. However, Madec et al. have been demonstrated in 2016 that none of the patients treated with the VH in their cohort showed and increased blood pressure or an impaired renal vascularization at the ColorDoppler after a long-term follow-up [2].

The main challenge of the vascular hitch is the choice of the patient: Chiarenza et al. proposed a "profile" of eligible patients for the VH according to their clinical history, the late onset of symptoms, the typical intermittent flank pain associated with a transient hydronephrosis, and a Ultrasound (US) or Magnetic Resonance (MR) evidence of a crossing vessel [1]. Moreover, Shneider et al. have been suggested an intraoperative classification of the lower pole crossing vessel, according to its relationship with the UPJ. They identified 3 types of LPCV and purely the type 3 was candidate for the VH [5].

In order to exclude an intrinsic obstruction, an intraoperative visualization of the ureteral peristalsis with a prompt emptying of the pelvis after the vessel mobilization should suffice. Otherwise, a diuretic test should be performed intraoperatively [1,3,5-7]. However, the evidence of an extrinsic hydronephrosis by CV with a concomitant intrinsic stenosis can only be proven histologically [22]. As a matter of fact, intraoperative aspect of a CV and the uretero-pelvic junction does not serve to discriminate between intrinsic and extrinsic stenosis. Therefore, a VH procedure could bear the risk that a remaining intrinsic obstruction will be disregarded [23].

Although several studies have been reported decent long-term results after the vascular hitch in children, a very few literatures exist that demonstrates the superiority of the modified Hellström technique over the dismembered pyeloplasty in the treatment of extrinsic UPJO [1].

Gundeti et al, in 2008, reviewed a series of 20 patient treated with VH, reporting a 95% of success rate, with only 1/20 patients reporting a persistent hydronephrosis requiring a DP [6]. Similarly, Villemagne et al. reported nearly 96% of success rate and Chiarenza et al. described a 100% of success rate after performing the vascular hitch, which was comparable to the results obtained after the DP [1,3]. In the present study, we found the same incidence of complications and the same risk of failed procedure when comparing laparoscopic DP *versus* laparoscopic VH. Nonetheless, the operative time and the length of hospital stay were significantly reduced when performing the VH compared to the DP.

With the widespread use of the robotic-assisted surgery in children, an increasing number of pediatric procedures are performed in a robotic-assisted fashion. The robot, in fact, allows the magnification of the image and the free movement of the instruments, thus reducing the problems and the limitations related to the pure laparoscopy [9]. This is mainly true for the DP, in which the robot-assisted procedure avoids the technical challenges of the laparoscopic sutures [9]. Several surgeons have also tried to perform the robotic-assisted vascular hitch, reporting comparable results with the laparoscopic procedure [2,3,6]. In fact, we found a similar incidence of complications and success rate in both robot-assisted and laparoscopic VH.

Limitations of the study

We are aware of the limitations of our study that, as in any other meta-analysis, are mainly related to its retrospective nature and to the quality of the studies included. Moreover, all the studies included in the meta-analysis comparing laparoscopic VH *versus* laparoscopic DP were retrospective. Only two studies were included in the meta-analysis comparing robot-assisted laparoscopic VH *versus* laparoscopic VH. Even if both these studies reported on prospectively followed-up cohort of patients, the number of cases were too small to reach any reliable conclusion.

CONCLUSIONS

The vascular hitch seems to be a valid alternative to the classic Anderson-Hynes dismembered pyeloplasty in pure extrinsic obstructions. To the best of our knowledge, the present study is the first meta-analysis that compares the two techniques. It seems that both were comparable in terms of complications and success rate. Moreover, vascular hitch requires shorter operative time and hospitalization compared to dismembered pyeloplasty.

Therefore, in our opinion, following a proper patient selection and an intraoperative visualization of the ureteropelvic junction, the vascular hitch seems to be preferable to the dismembered pyeloplasty in the presence of a ureteropelvic junction obstruction caused by an anomalous crossing vessel.

Up to date, data are scarce regarding the outcomes of the robotic-assisted vascular hitch, but it seems to show similar outcomes of the laparoscopic procedure. However, further high-quality studies are needed to corroborate our results.

DISCLOSURE STATEMENT

All authors declare that they have no conflict of interest to disclose.

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Figure 1

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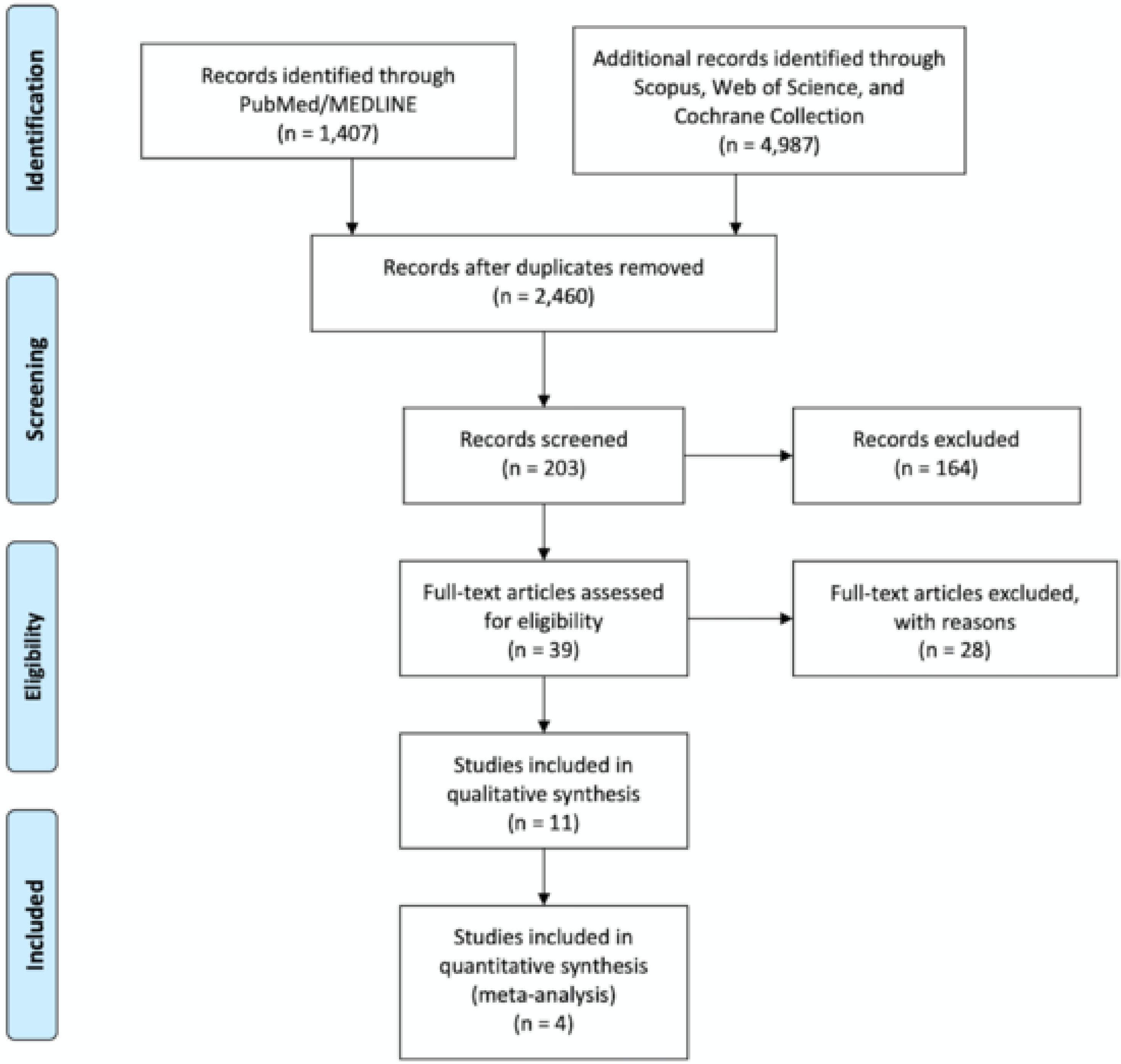

Figure 2

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Study or Subgroup	VH Mean	VH SD	VH Total	DP Mean	DP SD	DP Total	Weight	Mean Difference IV, Random, 95% CI	Year
Simforoosh 2010	112.2	1	9	153.7	1	54	35.7%	-41.50 [-42.21, -40.79]	2010
Schneider 2013	60	9	8	125	20	11	29.7%	-65.00 [-78.36, -51.64]	2013
Chiarenza 2017	108	38.7	51	195	41.2	3	9.9%	-87.00 [-134.82, -39.18]	2017
Polok 2019	80	16.2	31	105	38.7	16	24.7%	-25.00 [-44.80, -5.20]	2019
Total (95% CI)			**99**			**84**	**100.0%**	**-48.91 [-66.61, -31.21]**	

Heterogeneity: $Tau^2 = 228.12$; $Chi^2 = 18.00$, df = 3 (P = 0.0004); $I^2 = 83\%$

Test for overall effect: Z = 5.42 (P < 0.00001)

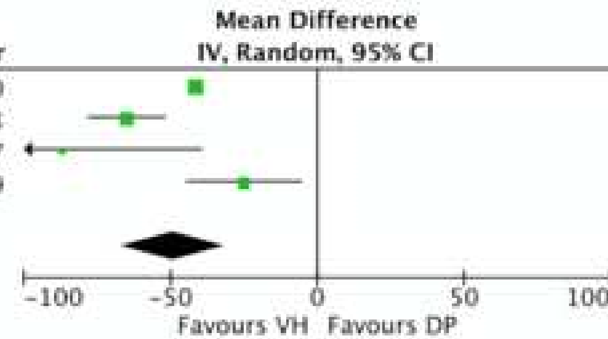

Figure 3

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Study or Subgroup	VH Events	VH Total	DP Events	DP Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Polok 2019	1	31	0	16	22.5%	1.59 [0.07, 37.05]	2019
Chiarenza 2017	2	51	0	3	27.2%	0.38 [0.02, 6.72]	2017
Schneider 2013	0	8	3	11	27.7%	0.19 [0.01, 3.24]	2013
Simforoosh 2010	0	9	1	54	22.7%	1.83 [0.08, 41.89]	2010
Total (95% CI)		**99**		**84**	**100.0%**	**0.62 [0.14, 2.76]**	
Total events	3		4				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.60$, df = 3 (P = 0.66); $I^2 = 0\%$

Test for overall effect: Z = 0.63 (P = 0.53)

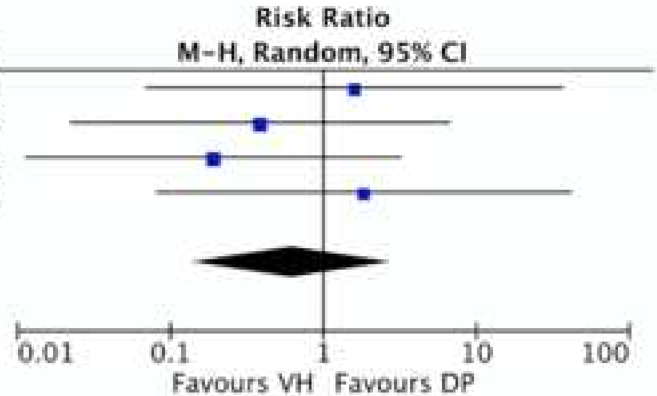

Figure 4

Study or Subgroup	VH Mean	VH SD	VH Total	DP Mean	DP SD	DP Total	Weight	Mean Difference IV, Random, 95% CI	Year
Simforoosh 2010	2.1	0.75	9	6.4	3	54	32.4%	-4.30 [-5.24, -3.36]	2010
Schneider 2013	2	0.2	8	4	1.5	11	32.7%	-2.00 [-2.90, -1.10]	2013
Chiarenza 2017	1.8	0.7	51	3.5	0.5	3	34.9%	-1.70 [-2.30, -1.10]	2017
Total (95% CI)			**68**			**68**	**100.0%**	**-2.64 [-4.17, -1.11]**	

Heterogeneity: $Tau^2 = 1.65$; $Chi^2 = 21.72$, df = 2 ($P < 0.0001$); $I^2 = 91\%$
Test for overall effect: $Z = 3.39$ ($P = 0.0007$)

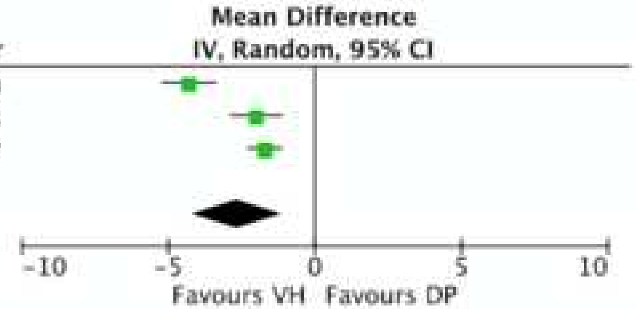

Figure 5

	VH		DP			Risk Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	Year
Simforoosh 2010	9	9	50	54	29.2%	1.03 [0.88, 1.22]	2010
Schneider 2013	8	8	11	11	19.8%	1.00 [0.82, 1.22]	2013
Chiarenza 2017	51	51	3	3	5.6%	1.00 [0.69, 1.45]	2017
Polok 2019	29	31	16	16	45.4%	0.95 [0.83, 1.08]	2019
Total (95% CI)		**99**		**84**	**100.0%**	**0.99 [0.90, 1.08]**	
Total events	97		80				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.68$, df = 3 (P = 0.88); $I^2 = 0\%$

Test for overall effect: Z = 0.30 (P = 0.76)

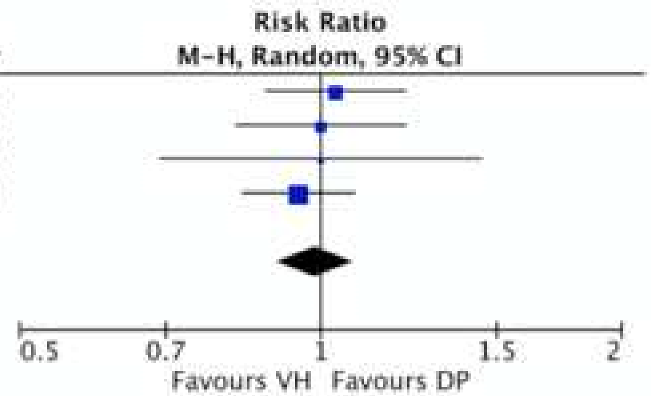

Figure 6

	Robot VH		Lap VH			Risk Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	Year
Gundeti 2008	0	3	1	17	100.0%	1.50 [0.07, 30.48]	2008
Madec 2016	0	10	0	23		Not estimable	2016
Total (95% CI)		**13**		**40**	**100.0%**	**1.50 [0.07, 30.48]**	
Total events	0		1				

Heterogeneity: Not applicable
Test for overall effect: Z = 0.26 (P = 0.79)

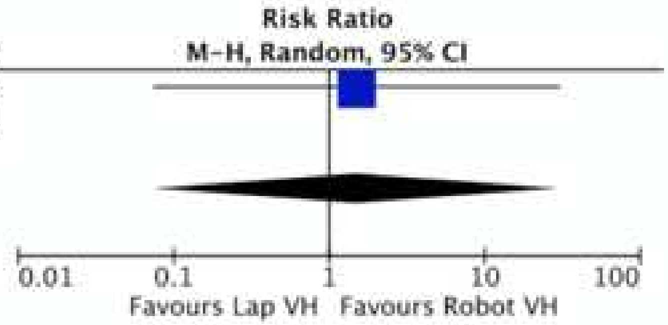

Figure 7

Study or Subgroup	Robot VH Events	Robot VH Total	Lap VH Events	Lap VH Total	Weight	Risk Ratio M-H, Random, 95% CI
Gundeti 2008	3	3	16	17	11.3%	0.95 [0.64, 1.42]
Madec 2016	10	10	23	23	88.7%	1.00 [0.87, 1.15]
Total (95% CI)		**13**		**40**	**100.0%**	**0.99 [0.87, 1.14]**
Total events	13		39			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.06$, df = 1 (P = 0.81); $I^2 = 0\%$

Test for overall effect: Z = 0.08 (P = 0.94)

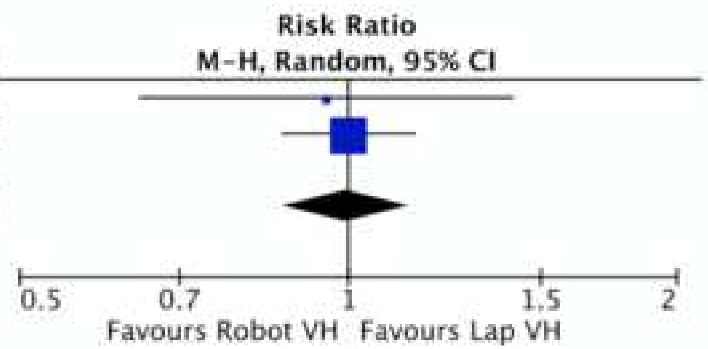

Figure captions.

Figure 1. Diagram of workflow in the systematic review and meta-analysis.

Figure 2. Forest plot comparison of the operative time between laparoscopic VH and laparoscopic DP.

Figure 3. Forest plot comparison of the incidence of complications between laparoscopic VH and laparoscopic DP.

Figure 4. Forest plot comparison of the length of hospital stay between laparoscopic VH and laparoscopic DP.

Figure 5. Forest plot comparison of the success rate between laparoscopic VH and laparoscopic DP.

Figure 6. Forest plot comparison of the incidence of complications between robot-assisted laparoscopic VH to laparoscopic VH.

Figure 7. Forest plot comparison of the success rate between robot-assisted laparoscopic VH to laparoscopic VH.

Table 1. Inclusion criteria of the Systematic Review

Publication	
Language	English
Time period	January 1950 – July 2020
Subject	Human studies
Study type	Retrospective Prospective Case-control Cohort
Excluded	Case-report Editorials Letters Grey Literature
Keywords	Pyeloplasty Lower pole crossing vessels Polar vessels Crossing vessels Hydronephrosis Hellström Children

Table 2

Table 2. Risk of bias assessment for individual studies using methodological index for nonrandomized studies (MINORS) [14].

Item	Polok [4]	Chiarenza [1]	Schneider [5]	Simforoosh [9]	Madec [2]	Gundeti [6]
1. A clearly stated aim	2	2	2	2	2	2
2. Inclusion of consecutive patients	2	2	2	2	2	2
3. Prospective collection of data	0	0	0	0	2	2
4. Endpoints appropriate to the aim of the study	2	2	2	2	2	2
5. Unbiased assessment of the study endpoint	0	0	0	0	0	0
6. Follow-up period appropriate to the aim of the study	2	2	1	2	2	2
7. Loss to follow-up less than 5%	0	0	0	0	2	2
8. Prospective calculation of the study size	0	0	0	0	0	0
9. An adequate control group	2	2	2	2	2	2
10. Contemporary groups	2	2	2	2	2	2
11. Baseline equivalence of groups	2	2	2	2	2	0
12. Adequate statistical analyses	2	2	2	2	2	0
Total score	16	16	15	16	20	16

0 = not reported; **1** = reported but inadequate; **2** = reported and adequate.
Validated “gold standard” cut-off: 19.8.

Table 3

Table 3. GRADE Evidence Profile [15] for the present Meta-Analysis.

Quality assessment							No. of patients		Effect		
No. of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considera-tions**	**Cases**	**Controls**	**Relative (95% CI)**	**Absolute (95% CI)**	**Quality**
Operative time in laparoscopic VH vs. laparoscopic DP							**VH**	**DP**			
4	OS	Moderate[a]	Substantial	Not serious	Serious[b]	None	99	84	---	MD 48.91 lower (66.61 lower to 31.21 lower)	⊗⊗OO LOW
Complications in laparoscopic VH vs. laparoscopic DP							**VH**	**DP**			
4	OS	Moderate[a]	Low	Not serious	Serious[b]	None	3/99 (3.0%)	4/84 (4.8%)	RR 0.62 (0.14, 2.76)	18 fewer per 1000 (from 41 fewer to 83 more)	⊗⊗OO LOW
LOS in laparoscopic VH vs. laparoscopic DP							**VH**	**DP**			
3	OS	Moderate[a]	Substantial	Not serious	Serious[b]	None	68	68	---	MD 2.64 lower (4.17 lower to 1.11 lower)	⊗OOO VERY LOW
Success rate in laparoscopic VH vs. laparoscopic DP							**VH**	**DP**			
4	OS	Moderate[a]	Low	Not serious	Serious[b]	None	97/99 (97.9%)	80/84 (95.2%)	RR 0.99 (0.90, 1.08)	27 more per 1000 (from 216 fewer to 270 more)	⊗⊗OO LOW
Complications in robot-assisted laparoscopic VH vs. laparoscopic VH							**Robot VH**	**Lap VH**			
2	OS	Moderate[a]	Substantial	Not serious	Serious[b]	None	0/13 (0%)	1/40 (2.5%)	RR 1.50 (0.07, 30.48)	25 fewer per 1000 (from 1,474 fewer to 46.5 more)	⊗OOO VERY LOW
Success rate in robot-assisted laparoscopic VH vs. laparoscopic VH							**Robot VH**	**Lap VH**			
2	OS	Moderate[a]	Low	Not serious	Serious[b]	None	13/13 (100%)	39/40 (97.5%)	RR 0.99 (0.87, 1.14)	25 more per 1000 (from 350 fewer to 325 more)	⊗OOO VERY LOW

VH: vascular hitch; **DP:** dismembered pyeloplasty; **LOS :** length of hospital stay ; **OS:** observational study; **CI:** confidence interval; **MD:** Mean Difference; **RR:** risk relative; **Lap:** laparoscopic.

[a] Bias due to possible confounding; [b] OIS not met

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

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Supplementary Data
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Supplementary file 2

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