Feasibility of Robotic Surgery in Comparison to the conventional Laparoscopic and Open Procedures in Urology: A Systematic Review

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Abstract

PURPOSE

To establish the feasibility of robotic surgical procedures in urology in terms of the applications, pros and cons as well as the postoperative and oncological outcomes while comparing it with the conventional approaches.

METHODS

A systematic search of electronic databases was performed to identify Randomized Controlled Trials and Cohort studies on Robot Assisted urological surgical procedures in comparison with the conventional methods. The quality assessment of included studies was performed using the Newcastle-Ottawa Scale and the revised Cochrane “Risk of Bias” tool. A qualitative narrative synthesis of the data extracted from the studies was performed and presented in tabulated form.

RESULTS

After screening, 34 studies were included in our review (3 Randomized Controlled Trials and 31 Cohort studies). Robot Assisted Prostatectomy appears to be associated with lower estimated blood loss and shorter length of hospital stay. For Robot Assisted Cystectomy, the results suggest longer operative time and fewer complications. Robot Assisted Radical Nephrectomy was found to be associated with fewer perioperative complications and longer mean operative time while Robot Assisted Partial Nephrectomy was associated with less positive surgical margins, no recurrence and reduced need of postoperative analgesia. The mean operative time was longer while length of stay was shorter for the robotic approach in inguinal lymphadenectomy and ureteral re-implantation.

CONCLUSION

The feasibility of Robot Assisted surgery varied for different outcome measures as well as for different procedures. Some common advantages were shorter length of stay, lesser blood loss and fewer complications while the drawbacks included longer operative time.

Introduction

The use of Artificial Intelligence (AI) in the field of surgery has been increasing over the past few decades. The first robot ever used for surgery was the Unimation PUMA 200 to assist a neurosurgical intervention performed by Kwoh et al. in 1985[1] while the first urological procedure for which a robot was used was transurethral prostate resection, performed by the assistance of PROBOT in 1989[2, 3]. AESOP (Automated Endoscopic System for Optimal Positioning) was the first surgical robotic system that became FDA approved in 1993 and commercially available for use in surgical procedures, including those in the field of

urology[4]. The ZEUS system was developed by Computer Motion Corporation (Goleta, CA) and introduced in the market in 1998. It was initially designed for use in procedures of cardiology but later on its use was extended to other fields too. However, it was discontinued in 2003[5]. The da Vinci surgical system was developed by Intuitive Surgical, Sunnyvale, CA, USA, and approved by the FDA for human use in 2000, and for prostate surgery in 2001[6].

Since then, the da Vinci system has been used in cardiothoracic, gastrointestinal, gynecologic, otolaryngologic and urologic procedures. In the field of urology, the first radical prostatectomy was performed in Germany and reported in literature by Abbou et al. in France[7] while the first nephrectomy was reported by Guillonnet et al[8]. The robot assisted laparoscopic procedures in the field of urology being performed nowadays include prostatectomy, cystectomy, nephrectomy, pyeloplasty, nephroureterectomy, ureteric reimplantation, inguinal lymphadenectomy and adrenalectomy.

The use of robots in surgical procedures has been increasing due to the advantages over the conventional surgical techniques including lower death rate, fewer complications, fewer transfusions, shorter length of stay, three-dimensional view of the operative field, and ergonomic benefits for the surgeon[9]

Previous systematic reviews on the subject target specific robot assisted procedures in urology including cystectomy[10, 11], nephrectomy[11, 12], nephroureterectomy[13] and prostatectomy[14]. Our systematic review aims at comprehensively compiling the information on all the commonly performed robot assisted procedures in the field of urology.

Our objective is to establish the feasibility of robot assisted procedures in terms of the applications, pros and cons, postoperative and oncological outcomes as well as cost effectiveness while comparing it with the more conventional open and laparoscopic approaches.

Material And Methods

This systematic review was conducted according to the methods recommended by the Cochrane Handbook for Systematic Reviews of Interventions[15] and written according to the PRISMA statement[16]. Ethical approval was not required for the study. This review was registered in The International Prospective Register of Systematic Reviews (PROSPERO) (Registration Number: CRD42021256623).

ELIGIBILITY CRITERIA

The studies included were in accordance to the following criteria: 1) The study designs included were Randomized Controlled Trials (RCTs) and Cohort Studies. 2) The studies published in English language during the years 2000 to 2021. 3) The articles including one or more of the following interventions regardless of the cause of the intervention: Robot Assisted Prostatectomy, Robot Assisted Cystectomy, Robot Assisted Radical Nephrectomy, Robot Assisted Partial Nephrectomy, Robot Assisted Laparoscopic Nephroureterectomy, Robot Assisted Laparoscopic Ureteral Reimplantation, Robot Assisted Adrenalectomy and Robot Assisted Inguinal Lymphadenectomy. 4) The studies that compared the robotic method to the conventional open and laparoscopic methods. 5) The studies conducted on human populations irrespective

of the age. 6) The articles including patients belonging to any age group who underwent surgical interventions for urological conditions. 7) The articles on the feasibility of robotic surgery in the field of urology in terms of the outcome measures (primary, secondary and additional).

The studies were excluded according to the following criteria: 1) Systematic reviews, meta-analysis and other study designs except Randomized Controlled Trials (RCTs) and Cohort Studies. 2) Unpublished articles and those published in languages other than English. 3) Studies conducted on non-human populations. 4) The studies not dealing with robotic interventions. 5) The articles that did not deal with urological procedures. 6) The articles that did not deal with the feasibility of robotic surgery in terms of the outcome measures (primary, secondary and additional). 7) The studies that did not compare the robotic method to the conventional open and laparoscopic methods.

INFORMATION SOURCES

Studies were selected by searching electronic databases and scrutinizing the reference list of articles (citation tracking). Electronic searches of the following online resources were run:

- Electronic databases: Cochrane Central Register of Controlled Trials (CENTRAL, via The Cochrane Library), MEDLINE (via PubMed) and ScienceDirect.
- Grey literature sources: Open Access Theses and Dissertations (OATD), OpenGrey and Google Scholar.

The search was run on 5 August 2021. No publication restrictions were applied to the search. The studies published in English language between 2000 and present were sought. The database search was updated on 20 August 2021 just before the final analyses and further studies retrieved for inclusion.

SEARCH STRATEGY

The database search was done using the terms “Robotic surgical procedures”, “Robotic surgery”, “Urology” “Robot Assisted Prostatectomy”, “Robot Assisted Cystectomy” etc. and their combinations.

The detailed search strategy is presented in Table 1.

Table 1
Search strategy for MEDLINE (PubMed format)

NUMBER	SEARCH TERMS
#1	Feasibility [All fields]
#2	Advantages [All Fields]
#3	Disadvantages [All Fields]
#4	Cost* [All Fields]
#5	"Costs and Cost Analysis" [mh]
#6	"Robotic Surgical Procedures/adverse effects" [mh]
#7	"Robotic Surgical Procedures/mortality" [mh]
#8	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7
#9	Robotic Surgery [All fields]
#10	Robot Assisted Prostatectomy [All Fields]
#11	Robot Assisted Cystectomy [All Fields]
#12	Robot Assisted Radical Nephrectomy [All Fields]
#13	Robot Assisted Partial Nephrectomy [All Fields]
#14	Robot Assisted Laparoscopic Nephroureterectomy [All Fields]
#15	Robot Assisted Laparoscopic Ureteral Reimplantation [All Fields]
#16	Robot Assisted Adrenalectomy [All Fields]
#17	Robot Assisted Inguinal Lymphadenectomy [All Fields]
#18	#9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17
#19	Urology [All Fields]
#20	"Urology/surgery" [mh]
#21	#19 OR #20
#22	#8 AND #18 AND #21

STUDY SELECTION

After the database search, the articles were imported to EndNote X9 Software and de-duplication was done. Two independent reviewers screened the articles, initially according to the title and abstract and later based on the full text. The articles were selected based on the inclusion criteria. Any conflict during the screening process was resolved by discussion. In case of unresolved disagreements, it was planned that the third author would make the decision.

DATA COLLECTION PROCESS AND DATA ITEMS

Data extraction was performed by the two reviewers independently. The data was extracted into a structured Microsoft Excel sheet and it consisted of two categories: study variables and outcome variables. Study variables included Author ID, year of publishing, study design, type of intervention, years of intervention and number of patients. The outcome variables included primary, secondary and additional outcomes.

PRIMARY OUTCOMES

The primary outcomes were: (i) oncological outcomes (For example: positive surgical margins, recurrence rate and mean lymph node yield); (ii) functional outcomes (For example: time to flatus, renal function (reduction of GFR), urinary and sexual function); and (iii) complications.

SECONDARY OUTCOMES

The secondary outcome measures comprised of: (i) mortality; (ii) length of hospital stay; (iii) blood loss; (iv) mean operative time; (v) warm ischemia time; and (vi) need for postoperative analgesia.

The additional outcome was cost effectiveness.

RISK OF BIAS (QUALITY) ASSESSMENT

For Cohort Studies

The Newcastle-Ottawa Scale (NOS) checklist[17] was used. It consists of three categories, namely Selection, Comparability and Representativeness, on the basis of which the cohort studies were divided into three levels of scoring: poor quality (1 to 4 stars), fair quality (5 to 7 stars) and good quality (8 to 9 stars).

For Randomized Controlled Trials (RCTs)

The quality assessment of the Randomized Controlled Trials was performed using the revised Cochrane "Risk of Bias" tool for randomized trials (RoB 2.0)[18]. RoB 2.0 consists of five specific domains: (1) bias arising from the randomization process; (2) bias due to deviations from the intended interventions; (3) bias due to missing outcome data; (4) bias in measurement of the outcome; and (5) bias in the selection of the reported result.

Using RoB 2.0, each specific outcome was assessed and its overall Risk of Bias was found (low; some concerns; high). The overall Risk of Bias was derived using the highest RoB levels in any of the domains that were tested.

The quality assessment of each study was performed by two review authors independently. Any disagreements were resolved by discussion. In case of unresolved disagreements, a third review author was consulted to make the decision.

DATA SYNTHESIS

A qualitative synthesis of the data extracted from the included studies was performed. The data was presented in a tabulated form and included study variables, outcome variables, quality assessment and the conclusions of each individual study. Meta-analyses could not be conducted because of the heterogeneity of interventions, participants and outcome measures.

Results

STUDY SELECTION

A total of 12,088 records were found through databases searching. After de-duplication, 10,631 records were screened on the basis of title and abstract, from which we reviewed 151 full-text documents, and finally included 30 articles. Later, 25 studies were identified through citation searching, out of which 18 were assessed for eligibility, and 4 were finally included in the review. Hence, a total of 34 studies were included in our review. [Figure 1]

STUDY CHARACTERISTICS

34 studies, published between the years 2002 to 2020, were included in our systematic review, of which 31 (91.1%) were cohort studies while 3 (8.9%) were Randomized Controlled Trials (RCTs). Out of the included studies, 6 (17.6%) dealt with Robot Assisted Radical Prostatectomy[19–24], 6 (17.6%) dealt with Robot Assisted Cystectomy[25–30], 4 (11.7%) dealt with Robot Assisted Radical Nephrectomy[31–34], 7 (20.5%) dealt with Robot Assisted Partial Nephrectomy[35–41], 2 (5.8%) dealt with Robot Assisted Laparoscopic Nephroureterectomy[42, 43], 4 (11.7%) dealt with Robot Assisted Laparoscopic Ureteral Reimplantation[44–47], 3 (8.9%) dealt with Robot Assisted Adrenalectomy[48–50] and 2 (5.8%) dealt with Robot Assisted Inguinal Lymphadenectomy[51, 52]. The study characteristics are summarized in Table 2.

Table 2
Study Characteristics

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Robot-Assisted Prostatectomy					
Mani Menon et al.	2002	Cohort Study	Conventional radical retropubic prostatectomy (RRP) and Robot- assisted anatomic prostatectomy (RAP)	March 2001 to August 2001	RRP = 30 RAP = 30
Christian Bolenz et al.	2009	Cohort Study	Robotic-Assisted Laparoscopic Radical Prostatectomy (RALP), Laparoscopic Radical Prostatectomy (LRP), and open Retropubic Radical Prostatectomy (RRP).	2003 to 2008	RALP = 262 LRP = 220 RRP = 161
Jim C. Hu et al.	2009	Cohort Study	Minimally Invasive Radical Prostatectomy (MIRP) and open Retropubic Radical Prostatectomy (RRP)	2003 to 2007	MIRP = 1938 RRP = 6899
Jong Wook Park et al.	2011	Cohort Study	Laparoscopic Radical Prostatectomy (LRP) and Robot- Assisted Laparoscopic Prostatectomy (RALP)	2007 to 2009	LRP = 62 RALP = 44
Guillaume Ploussard et al.	2012	Cohort Study	Robot-Assisted Radical Prostatectomy (RALP) and Laparoscopic Radical Prostatectomy (LRP)	2001 to 2011	LRP = 1377 RALP = 1009

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Francesco Porpiglia et al.	2016	Randomized Controlled Trial	Robot-assisted radical prostatectomy (RARP) and Laparoscopic radical prostatectomy (LRP)	2010 to 2011	120
Robot-Assisted Cystectomy					
Casey K Ng et al.	2010	Cohort Study	Open Radical Cystectomy (ORC) and Robot-Assisted Radical Cystectomy (RARC)	2002 to 2008	ORC = 104 RARC = 83
Bernard H. Bochner et al.	2015	Randomized Controlled Trial	Open Radical Cystectomy (ORC) and Robot-Assisted Radical Cystectomy (RARC)	2010 to 2013	ORC = 58 RARC = 60
Muhammad Shamim Khan et al.	2016	Randomized Controlled Trial	Open Radical Cystectomy (ORC), Laparoscopic Radical Cystectomy (LRC), and Robot-Assisted Radical Cystectomy (RARC).	2009 to 2012	ORC = 20 RARC = 20 LRC = 20
Agata Gastecka et al.	2018	Cohort Study	Laparoscopic Radical Cystectomy (LRC) and Robot-Assisted Radical Cystectomy (RARC)	2016 to 2018	LRC = 37 RARC = 52
Shiwei Zhang et al.	2019	Cohort Study	Laparoscopic Radical Cystectomy (LRC) and Robot-Assisted Radical Cystectomy (RARC)	2010 to 2019	LRC = 126 RARC = 172
Janet Baack Kukreja et al.	2020	Cohort Study	Open Radical Cystectomy (ORC) and Robot-Assisted Radical Cystectomy (RARC)	2007 to 2015	RARC = 100 ORC = 96
Robot-Assisted Radical Nephrectomy					

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Tanya Nazemi et al.	2006	Cohort Study	Robotic Radical Nephrectomy (RRN), Laparoscopic Radical Nephrectomy (LRN), and Open Radical Nephrectomy (ORN)	2000 to 2004	ORN = 18 RRN = 6 LRN = 33
Ashok K. Hemal et al.	2008	Cohort Study	Robotic Radical Nephrectomy (RRN) and Laparoscopic Radical Nephrectomy (LRN).	2006 to 2007	RRN = 15 LRN = 15
In Gab Jeong et al.	2017	Cohort Study	Robotic Radical Nephrectomy (RRN) and Laparoscopic Radical Nephrectomy (LRN)	2003 to 2015	RRN = 5180 LRN = 18573
Boris Gershman et al.	2018	Cohort Study	Robot-Assisted Laparoscopic Radical Nephrectomy (RALRN) and Laparoscopic Radical Nephrectomy (LRN)	2010 to 2013	RALRN = 4926 LRN = 3390
Robot-Assisted Partial Nephrectomy					
Leslie A Deane et al.	2008	Cohort Study	Robot-assisted Laparoscopic Partial Nephrectomy (RLPN) and Laparoscopic Partial Nephrectomy (LPN)	2003 to 2007	LPN = 12 RLPN = 10
Ali Riza Kural et al.	2009	Cohort Study	Laparoscopic Partial Nephrectomy (LPN) and Robot-Assisted Partial Nephrectomy (RAPN)	2003 to 2009	LPN = 20 RAPN = 11
Brian M Benway et al.	2009	Cohort Study	Laparoscopic Partial Nephrectomy (LPN) and Robot-Assisted Partial Nephrectomy (RAPN)	2004 to 2008	LPN=118 RAPN = 129

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Agnes J Wang et al.	2009	Cohort Study	Laparoscopic Partial Nephrectomy (LPN) and Robotic- assisted Partial Nephrectomy (RPN)	Not mentioned	LPN = 62 RPN = 40
Sangchul Lee et al.	2011	Cohort Study	Robot-assisted Partial Nephrectomy (RPN) and Open Partial Nephrectomy (OPN)	2003 to 2010	OPN = 234 RPN = 69
Phillip M. Pierorazio et al.	2011	Cohort Study	Robot-Assisted Laparoscopic Partial Nephrectomy (RALPN) and Laparoscopic Partial Nephrectomy (LPN)	2006 to 2011	LPN = 102 RALPN = 48
Ali Khalifeh et al.	2012	Cohort Study	Laparoscopic Partial Nephrectomy (LPN) and Robotic- assisted Partial Nephrectomy (RPN)	2002 to 2012	RPN = 261 LPN = 231
Robot-Assisted Laparoscopic Nephroureterectomy					
Vincent Trudeau et al.	2014	Cohort Study	Robotic-Assisted Nephroureterectomy (RANU) and Laparoscopic radical Nephroureterectomy (LNU)	2008 to 2010	LNU = 1199 RANU = 715
Hakmin Lee et al.	2019	Cohort Study	Open Nephroureterectomy (ONU), Laparoscopic Nephroureterectomy (LNU), and Robotic- Assisted Laparoscopic Nephroureterectomy (RALNU)	2004 to 2017	ONU = 161 LNU = 137 RALNU = 124
Robot Assisted Laparoscopic Ureteral Reimplantation					

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Ryan P. Smith et al.	2011	Cohort Study	Robotic Extravesical Ureteral Reimplantation (RALUR) and Open Ureteral Reimplantation	2006 to 2009	RALUR = 25 Open ureteral reimplantation = 25
John L. Schomburg et al.	2014	Cohort Study	Robot-assisted laparoscopic Extravesical Ureteral Reimplantation (RALUR) and Open Extravesical Ureteral Reimplantation	2008 to 2010	RALUR = 20 Open ureteral reimplantation = 20
Michael P. Kurtz et al.	2016	Cohort Study	Robot-assisted laparoscopic Extravesical Ureteral Reimplantation (RALUR) and Open Extravesical Ureteral Reimplantation	2003 to 2013	Open ureteral reimplantation = 1494 RALUR = 108
Rodolfo A. Elizondo et al.	2020	Cohort Study	Robot-assisted laparoscopic Extravesical Ureteral Reimplantation (RALUR) and Open Extravesical Ureteral Reimplantation	2013 to 2015	Open ureteral reimplantation = 38 RALUR = 38
Robot-Assisted Adrenalectomy					
Luis Felipe Brandao et al.	2014	Cohort Study	Robotic Adrenalectomy (RA) and Laparoscopic Adrenalectomy (LA)	2004 to 2013	RA = 30 LA = 46
Arman Arghami et al.	2015	Cohort Study	Single Port Robotic Adrenalectomy (SPRA) and Laparoscopic Adrenalectomy (LA)	2006 to 2013	SPRA = 16 LA = 16
Kai Alexander Probst et al.	2016	Cohort Study	Robot-Assisted Laparoscopic Adrenalectomy (RALA) and Open Adrenalectomy (OA)	2001 to 2005	RALA = 56 OA = 33
Robot-Assisted Inguinal Lymphadenectomy					

Author ID [Reference]	Year of Publishing	Study Design	Type of Intervention	Years of Intervention	Number of patients
Amitabh Singh et al.	2018	Cohort Study	Robot-Assisted Inguinal Lymphadenectomy (RAIL) and Open Inguinal Lymphadenectomy	2012 to 2016	RAIL = 51 Open Inguinal Lymphadenectomy = 100
Hualiang Yu et al.	2019	Cohort Study	Robot-Assisted Inguinal Lymphadenectomy (RAIL) and Open Inguinal Lymphadenectomy	2013 to 2017	RAIL = 9 Open Inguinal Lymphadenectomy = 10

RISK OF BIAS

Newcastle-Ottawa Scale (NOS) was used in order to perform the quality assessment of the 31 cohort studies included in the review. 29 (93.5%)^{19–23,25,28–30,32–40,42–52} of the included cohort studies were assessed to have a good quality (low risk of bias) while 2 (6.5%)[31, 41] were assessed to have a fair quality (medium risk of bias). The most common methodological flaws were inadequate representativeness of the exposed cohort, non-adjustment for the confounders and inadequate duration of the follow-up. The findings are summarized in Table 3.

The quality assessment of the 3 Randomized Controlled Trials (RCTs) was performed using the revised Cochrane “Risk of Bias” tool for randomized trials (RoB 2.0). The overall risk of bias was assessed to be “low” for 1 (33.3%) study[27] and “some concerns” for the other 2 (66.6%)[24, 26]. The most common methodological flaws were lack of blinding of participants and outcome assessors, improper allocation concealment, deviations from the intended interventions and lack of information regarding pre-specified analysis plan. The RoB plot was created using the Robvis tool[53]. [Figure 2]

RESULTS OF INDIVIDUAL STUDIES

The results of each individual study included in the review are presented in Table 4.

Table 4
Summary of findings of included studies

Author ID, Year	Summary of Findings
Robot-Assisted Prostatectomy	
Mani Menon et al, 2002	Robot-assisted prostatectomy was found to take a longer time (2.3 hours for conventional radical retropubic prostatectomy versus 4.8 hours for robot-assisted prostatectomy ($p < 0.001$)) but associated with less blood loss (970 mL for RRP versus 329 mL for RAP ($p < 0.001$)), early discharge from the hospital and less postoperative pain (mean pain score on postoperative day 1 was 7 in the RRP group and 4 in the RAP group ($p = 0.05$)). The complications and oncological outcomes were found to be similar to those of radical retropubic prostatectomy.
Christian Bolenz et al, 2009	The robot-assisted surgery was found to be more expensive than open and laparoscopic approaches (RALP: \$6752, LRP: \$5687, RRP: \$4437, $p < 0.001$).
Jim C. Hu et al, 2009	Robot-assisted surgery was found to be associated with less need of transfusions (2.7% versus 20.8%; $p < 0.001$), less risk of respiratory (4.3% versus 6.6%; $p = 0.004$), and other complications (4.3% versus 5.6%; $p = 0.03$) but higher risk of genitourinary complications (4.7% versus 2.1%; $p = 0.001$) like incontinence and erectile dysfunction as compared to the open approach.
Jong Wook Park et al, 2011	Both robot-assisted and laparoscopic prostatectomy had similar safety and efficacy but the robotic approach was associated with faster recovery of continence, although the continence rate at 12 months became similar (95% for LRP versus 94.4% for RALP, $p = 1.00$).
Guillaume Ploussard et al, 2012	The robot-assisted approach was found to be associated with shorter operative time (129 versus 175 min; $p < 0.001$), less blood loss (515 versus 800 ml; $p < 0.001$), and shorter hospital stays (4.0 versus 5.7 days; $p < 0.001$) as compared to the pure laparoscopic approach. Continence was unaffected by the type of procedure performed while there was an early recovery of potency by the robot-assisted approach (After 6 months, 20% patients were potent after LRP and 42% after RALP. After 12 months, 31.6% of patients were potent after LRP and 57.7% after RALP)
Francesco Porpiglia et al, 2016	Robot-assisted prostatectomy was associated with better functional outcomes in terms of recovery of continence ($p < 0.021$) and potency ($p < 0.028$) but was found to be similar to the laparoscopic approach in terms of the oncological outcomes and major complications.
Robot-Assisted Cystectomy	
Casey K. Ng et al, 2010	Robot-assisted surgery was found to be associated with a lesser risk of complications (59% for the open group versus 41% for the robot-assisted group; $p = 0.04$), both major and minor as compared to the open approach but the types of complications were similar in both groups.
Bernard H. Bochner et al, 2015	Robot-assisted radical cystectomy (RARC) was found to be associated with no significant advantage over standard open radical cystectomy with respect to 90-d complications, length of stay, 3-month and 6-month quality of life, or costs.

Author ID, Year	Summary of Findings
Muhammad Shamim Khan et al, 2016	There was no significant difference in the 30-day or 90-day complications between the different approaches. However, the robot-assisted approach was found to be associated with greater mean operating time ($p < 0.001$), positive surgical margins as well as the greatest risk of recurrence as compared to the open and laparoscopic approaches (ORC: 2 of 19, RARC: 5 of 19, LRC: 3 of 18; $p = 0.5$)
Agata Gastecka et al, 2018	Robot-assisted cystectomy was found to be less cost-effective as compared to the laparoscopic approach (LRC: €3336; RARC: €4052; $p < 0.001$). The higher cost was attributed to the robotic instruments (LRC: €130; RARC: €1166; per case)
Shiwei Zhang et al, 2019	The robotic approach was associated with some perioperative benefits as compared to the laparoscopic approach. RARC group had lesser operative time ($p < 0.001$), lesser blood loss ($p < 0.001$), lower intraoperative transfusion rate ($p < 0.05$), shorter hospital stays ($p < 0.001$), and a lower 90-day complication rate compared with the LRC group, but there was no difference in the rate of readmissions between the two approaches.
Janet Baack Kukreja et al, 2020	The robot-assisted approach was more expensive as compared to the open approach but was associated with lesser costs per quality-adjusted life years (RARC was \$17 000 more expensive, but associated with an increase of 0.32 QALYs)
Robot-Assisted Radical Nephrectomy	
Tanya Nazemi et al, 2006	The robot-assisted approach was said to be associated with lower blood loss ($p = 0.01$) and analgesia use (open nephrectomy compared to robotic and hand-assisted laparoscopic methods at 75% versus 0% and 14%, for the robotic and hand-assisted laparoscopic methods respectively ($p = 0.0035$)) and shorter hospital stay (3 vs. 5 days for the open method ($p < 0.01$)) but greater operative time (345 (246–548) minutes compared to the open method, 202 (116–382) minutes ($p = 0.02$)). The oncological outcomes were similar in all the approaches.
Ashok K. Hemal et al, 2008	The robot-assisted approach was similar to the laparoscopic approach in terms of the oncological and perioperative complications but was associated with a slightly longer operative time (221 versus 175.3 minutes in robot-assisted and laparoscopic methods, respectively, $p = 0.001$).
In Gab Jeong et al, 2017	The robot-assisted approach was associated with higher costs as compared to the other approaches for nephrectomy (\$19,530 versus \$16,851; difference, \$2678; 95% CI, \$838 to \$4519)
Boris Gershman et al, 2018	Robot assisted nephrectomy was found to be associated with lower intraoperative (0.9% versus 1.8%; $p < 0.001$) and postoperative (20.4% versus 27.2%; $p < 0.001$) complications but higher costs (median \$16,207 versus \$15,037; $p < 0.001$)
Robot Assisted Partial Nephrectomy	
Leslie A Deane et al, 2008	Robot-assisted partial nephrectomy was not associated with any significant difference from the laparoscopic approach in terms of blood loss (115 mL versus 198 mL; $p = 0.169$), total operative time (228.7 minutes versus 289.5 minutes; $p = 0.102$), and warm ischemia time (32.1 minutes versus 35.3 minutes; $p = 0.501$). There was no reported case of recurrence or any major complications.

Author ID, Year	Summary of Findings
Ali Riza Kural et al, 2009	Robot-assisted partial nephrectomy was associated with the advantages of three-dimensional vision and easier suturing over the traditional laparoscopic approach. The mean warm ischemia time was found to be significantly shorter in the RAPN group (27.3 minutes for the RAPN group and 35.8 for the LPN group) ($p = 0.02$). Some demerits included higher costs and the need for surgeons with experience in the field.
Brian M Benway et al, 2009	Robot-assisted partial nephrectomy provided comparable pathological outcomes and morbidity as compared to traditional laparoscopy. However, it was associated with reduced blood loss (155 for RAPN versus 196 ml for LPN, $p = 0.03$), warm ischemia time (19.7 versus 28.4 minutes, $p < 0.0001$), and length of hospital stay (2.4 versus 2.7 days, $p < 0.0001$). It was also found to be supposedly superior to the laparoscopic approach while dealing with more complex tumors.
Agnes J Wang et al, 2009	The robot-assisted procedure was comparable to the laparoscopic partial nephrectomy in terms of postoperative outcomes but was associated with shortened warm ischemia time (19 versus 25 minutes, $p = 0.03$). Some disadvantages included higher cost, use of extra trocars (4.6 versus 3.2, $p = 0.01$), and the more invasive nature of the robotic approach.
Sangchul Lee et al, 2011	Both the robotic and open approaches were associated with similar changes in GFR (83.3 for RPN versus 79.6 mL/min/1.73 m ² for OPN, $p = 0.146$) but the robotic surgery was preferred due to shorter length of hospital stay (6.2 versus 8.9 days, $p < 0.001$) and lesser analgesic use (0.3 versus 0.9 ampules, $p < 0.001$) while the open approach was favorable in terms of duration of operation (192 versus 143 minutes, $p < 0.001$) and ischemia time (22.99 versus 18.14 minutes, $p < 0.001$).
Phillip M. Pierorazio et al, 2011	Robot-assisted partial nephrectomy was found to be associated with the advantages of having shorter operative (152 versus 193 minutes, $p < 0.001$) and ischemia times (14.0 versus 18.0 minutes, $p < 0.001$) as well as reduced blood loss (122 versus 245 mL, $p = 0.001$) as compared to the traditional laparoscopic approach.
Ali Khalifeh et al, 2012	The robot-assisted approach was found to have the advantages of having lower intraoperative complications (2.6% for the robotic approach versus 5.6% for the laparoscopic approach, each $p < 0.001$), lower postoperative complications (24.53% for the robotic approach versus 32.03% for the laparoscopic approach, $p = 0.004$) and lower risk of positive surgical margins (2.9% for the robotic procedure versus 5.6% for the laparoscopic procedure, $p < 0.001$) as compared to the conventional laparoscopic method of surgery.
Robot-Assisted Laparoscopic Nephroureterectomy	
Vincent Trudeau et al, 2014	The robot-assisted approach was found to be more costly (\$23,235 for the robotic approach versus \$17,637 for the laparoscopic approach; $p < 0.001$) but associated with lesser complications (11.9% in the robotic approach versus 18.2% in the laparoscopic approach; $p < 0.001$) as compared to the traditional laparoscopic approach.
Hakmin Lee et al, 2019	The laparoscopic and robotic showed some better perioperative outcomes (all p -values > 0.05) after radical nephroureterectomy as compared to the open approach in patients with non-metastatic UTUC. The recurrence rate was comparable in all the groups ($p = 0.279$).
Robot Assisted Laparoscopic Ureteral Reimplantation	

Author ID, Year	Summary of Findings
Ryan P. Smith et al, 2011	Mean operative time was longer by 12% in the robotic group as compared to the controls ($p < 0.05$). The mean length of stay (33 versus 53 hours) and the use of postoperative analgesia were significantly less in the robotic group ($p < 0.001$). Robot-assisted surgery for ureteral reimplantation had similar success rates as compared to the open approach (97% for robot-assisted laparoscopy versus 100% for open reimplantation).
John L. Schomburg et al, 2014	The clinical outcomes for the robotic approach were almost the same as those for the open approach while the postoperative analgesic requirement was significantly reduced for the robotic approach (RALUR: 0.14 mg/kg, open: 0.25 mg/kg, $p = 0.021$).
Michael P. Kurtz et al, 2016	RALUR was associated with a significantly higher rate of complications (13.0% of RALUR versus 4.5% of OUR; $p = 0.0037$) as well as higher direct costs (\$9,128 for RALUR versus \$7,273 for OUR; $p = 0.0043$) as compared to the open approach.
Rodolfo A. Elizondo et al, 2020	<p>The clinical outcomes (open 94.8% versus robotic 94.8%) for both the open and robotic approaches were found to be comparable.</p> <p>The overall total charges including the costs of hospitalization were similar between the OUR (\$21,461) and RALUR groups with (\$22,860) and without cystoscopy (\$21,437) ($p = 0.34$ and $p = 0.53$ respectively)</p>
Robot Assisted Adrenalectomy	
Luis Felipe Brandao et al, 2014	A significantly lower median estimated blood loss was recorded for the robotic group (50 ml [IQR: 50] in the robotic group versus 100 ml [IQR: 288] in the laparoscopic group; $p = 0.02$). The distribution of pheochromocytomas in the Laparoscopic group was significantly higher than in the Robotic group (43.5% in Laparoscopic Adrenalectomy versus 16.7% in Robotic Adrenalectomy; $p = 0.02$)
Arman Arghami et al, 2015	Robot-assisted adrenalectomy was found to be a feasible approach since it was associated with lesser use of analgesics (43 mg in Robotic Adrenalectomy versus 84 mg in Laparoscopic Adrenalectomy group, $p < 0.001$) but comparable costs ($84\% \pm 14\%$ in Robotic Adrenalectomy versus $100\% \pm 16\%$ in Laparoscopic Adrenalectomy)
Kai Alexander Probst et al, 2016	The robot-assisted approach was found to be feasible for the dissection of adrenal tumors. Although it was associated with longer operative time (128.5 ± 46.5 min for RALA versus 102.2 ± 44.5 min for OA), the overall hospital stay was found to be shorter for the robotic approach (6.8 ± 1.2 days for RALA versus 11.1 ± 4.8 days for OA).
Robot-Assisted Inguinal Lymphadenectomy	
Amitabh Singh et al, 2018	The robot-assisted approach was found to be associated with lower morbidity and comparable lymph node yield (13 in Robot-assisted procedure versus 12.5 in open inguinal lymph node dissection) as compared to the open approach.
Hualiang Yu et al, 2019	The robot-assisted approach was found to be associated with fewer intraoperative and postoperative complications while achieving the desired outcomes.

RESULTS OF SYNTHESSES

A qualitative narrative synthesis of the data extracted from the included studies was performed and presented in the form of tables. There was not a scope for a meta-analysis, given the likely range of

interventions, participants and outcomes. The results for the feasibility of each surgical intervention according to the outcomes have been presented in Table 5.

Table 5
Findings of studies according to outcome measures

Robot-Assisted Prostatectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSIONS
Positive Surgical Margins	266 (Three Studies)	No significant difference was found between the robotic and other approaches
Recovery of continence	9063 (Three Studies)	Two studies reported faster recovery of continence in the robotic approach as compared to the other approaches while one reported greater urinary incontinence for the robotic procedure.
Recovery of sexual function	9063 (Three Studies)	Two studies reported faster recovery of potency in the robotic approach while one reported greater erectile dysfunction for the robotic approach.
Complications	11389 (Four Studies)	Two studies reported lesser complications for the robotic approach while one reported no difference. According to one study, the rate of genitourinary complications was higher in the robotic approach.
Postoperative analgesia	8837 (One Study)	Reduced need for postoperative analgesia as compared to the other approaches.
Estimated blood loss	11283 (Three Studies)	Less as compared to other approaches
Mean operative time	2552 (Three Studies)	Two studies reported greater mean operative time while one reported shorter operative time.
Length of stay	11223 (Two Studies)	Shorter as compared to the other approaches.
Robot-Assisted Cystectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSION
Positive Surgical Margins	247 (Two Studies)	One study reported a higher rate of positive surgical margins while one reported comparable rates to the other approaches.
Mean Lymph node Yield	247 (Two Studies)	According to one study, the lymph node yield was comparable in the robotic and other approaches while one study reported greater lymph node yield as compared to the laparoscopic approach but lesser as compared to the open approach.
Recurrence Rate	60 (One Study)	Greater as compared to the other approaches.
Mortality	60 (One Study)	According to one study, the mortality for the robotic-assisted procedure was found to be higher than the open approach but lower than the laparoscopic approach.

Robot-Assisted Prostatectomy		
Complications	247 (Two Studies)	Fewer as compared to the open approach while one study reported thromboembolic complications.
Estimated Blood Loss	187 (One Study)	Less as compared to the other methods.
Mean Operative Time	247 (Two Studies)	Greater as compared to the other approaches.
Length of Stay	187 (One Study)	Shorter median length of stay.
Robot-Assisted Radical Nephrectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSIONS
Oncological Outcomes	102 (One Study)	Comparable to the other approaches.
Complications	8316 (One Study)	Fewer perioperative complications for the robotic approach.
Postoperative analgesia	132 (Two Studies)	According to one study, the need for postoperative analgesia was less as compared to the conventional methods while one study reported comparable postoperative analgesia use.
Estimated Blood Loss	132 (Two Studies)	According to one study, the estimated blood loss was less as compared to the conventional methods while one study reported comparable blood loss.
Mean Operative Time	132 (Two Studies)	Greater as compared to the conventional methods.
Length of Stay	132 (Two Studies)	According to one study, the length of stay was shorter as compared to the conventional methods while one study reported a comparable length of stay.
Robot-Assisted Partial Nephrectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSIONS
Positive Surgical Margins	1175 (Five Studies)	No or less positive surgical margins as compared to the other approaches.
Recurrence Rate	53 (Two Studies)	No recurrence after the robotic surgery.
Renal Function (GFR)	463 (Two Studies)	According to one study, the decrease in GFR was less as compared to the conventional methods while one study reported comparable changes in GFR.

Robot-Assisted Prostatectomy		
Complications	998 (Five Studies)	Two studies reported decreased complications as compared to the other methods while two reported one complication each for the robotic approach. According to one study, the robotic approach was associated with increased complications, the most common being urinary leakage while one reported comparable intraoperative complications.
Postoperative Analgesia	303 (One Study)	Reduced need for postoperative analgesia.
Estimated Blood Loss	855 (Six Studies)	Three studies reported reduced blood loss for the robotic approach while according to three studies, the blood loss was similar for all approaches.
Mean Operative Time	1347 (Seven Studies)	According to four studies, the operative time was shorter for the robotic approach while the others reported comparable, or even increased operative time.
Length of Stay	380 (Three Studies)	The length of stay was found to be shorter for the robotic method by two studies but one reported similar results for the different approaches.
Warm Ischemia Time	1347 (Seven Studies)	According to five studies, the warm ischemia time was shorter for the robotic approach while the others reported comparable, or even increased warm ischemia time.
Robot-Assisted Laparoscopic Nephroureterectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSIONS
Mortality	1914 (One Study)	Less for the robotic approach.
Complications	1957 (Two Studies)	Fewer for the robotic approach as compared to the other methods.
Estimated Blood Loss	43 (One Study)	No significant difference in the blood loss for the different approaches.
Length of Stay	1957 (Two Studies)	According to one study, the length of stay was less as compared to the conventional methods while one study reported comparable outcomes.
Robot Assisted Laparoscopic Ureteral Reimplantation		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSION
Complications	204 (Two Studies)	Less for the robotic approach while one study reported increased risk of vesicoureteral reflux.
Postoperative analgesia	101 (Two Studies)	Reduced need for postoperative analgesia for the robotic approach.

Robot-Assisted Prostatectomy		
Mean Operative Time	101 (Two Studies)	Increased for the robotic approach.
Length of Stay	193 (Two Studies)	Shorter as compared to the conventional methods.
Robot-Assisted Adrenalectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSION
Complications	165 (Two Studies)	Fewer complications in the robot-assisted method.
Postoperative analgesia	108 (Two Studies)	Reduced or comparable need of postoperative analgesia as compared to the other methods.
Estimated Blood Loss	76 (One Study)	Less for the robotic approach.
Mean Operative Time	194 (Three Studies)	Different studies reported variable results of the mean operative time for the robotic approach as compared to the other methods.
Length of Stay	194 (Three Studies)	Reduced length of stay for the robotic approach while one study reported a similar length of stay.
Robot-Assisted Inguinal Lymphadenectomy		
OUTCOME	NO. OF PARTICIPANTS (STUDIES)	CONCLUSION
Complications	167 (Three Studies)	Fewer complications as compared to the conventional methods.
Estimated Blood Loss	151 (One Study)	Similar for all the approaches.
Mean Operative Time	164 (Two Studies)	Longer for the robotic approach.
Length of Stay	154 (Two Studies)	Shorter as compared to the conventional methods.

Discussion

The use of robots for surgical procedures has been gaining popularity, especially in certain fields including urology. This has become an important topic for researchers, and many studies have reported their superiority as compared to the conventional open and laparoscopic methods. Our study explains the

differences between the robotic and other approaches in terms of outcome measures comprehensively, covering all the urological procedures.

The results of our systematic review suggest that Robot Assisted Prostatectomy is associated with reduced need of postoperative analgesia, lower estimated blood loss and shorter length of hospital stay as compared to the conventional methods. No significant difference in positive surgical margins (PSM) was found between the robotic and other approaches. Tang et al.[54] and Cao et al.[55] reported similar outcomes regarding estimated blood loss and length of hospital stay but Tang et al.[54] reported lower PSM rates for Robotic approach while Cao et al.[55] reported no significant difference in the PSM rates for the different approaches.

For Robot Assisted Cystectomy, the findings of our study suggest lesser blood loss, shorter median length of hospital stay, greater recurrence rate and longer operative time for the robotic procedure as compared to the conventional approaches. Our results were in accordance with other meta-analyses[56, 57] while Iwata et al. [58] reported no significant difference in the recurrence rate between robotic and other approaches.

Robot Assisted Radical Nephrectomy was found to be associated with fewer perioperative complications and longer mean operative time. This was in contrast to the findings of two meta-analyses[59, 60], which reported comparable complications rates for the robotic and other approaches. The results of our review suggested no or less positive surgical margins, no recurrence and reduced need of postoperative analgesia for Robot Assisted Partial Nephrectomy as compared to the other approaches. The results of two previous meta-analyses[61, 62] suggested that the robotic method had no significant difference from the other methods regarding positive surgical margins (PSM) and recurrence rates.

The mean operative time was longer while length of stay was found to be shorter for the robotic approach in the procedures of inguinal lymphadenectomy and ureteral reimplantation as compared to their respective conventional approaches. According to the results of a study conducted in 2020[63], the robot assisted ureteral reimplantation was found to have longer operative time as well as longer time to discharge. The overall complications were less for the robotic approach in the procedures of inguinal lymphadenectomy, adrenalectomy and nephroureterectomy according to our study. Veccia et al.[64] reported similar outcome of lower complications for robot assisted nephroureterectomy while Tang et al.[65] reported comparable complications for adrenalectomy.

Our results are consistent with the fact that robot assisted surgeries, being minimally invasive, have the advantage of being associated with fewer complications, lesser blood loss, lesser need of postoperative analgesia and shorter length of hospital stay. The mean operative time was found to be longer for robot assisted surgeries due to extra time required for robot specific tasks, such as set-up of equipment and longer trocar entry time[66]. For some of the outcome measures, our results differed from those of other systematic reviews and meta-analyses because of the differences in the study settings and the surgeon skill set of the studies included. The differences can also be attributed to a bias in the selection of the studies that were included in the reviews.

Most of the studies included in our review were limited by short periods of follow up and lack of randomization. Other limitations included small sample size and the retrospective nature of some studies, which introduced an inherent selection bias. Some of the included cohort studies were not controlled for confounders.

Our review was registered in the International Prospective Register of Systematic Reviews (PROSPERO). A highly sensitive search strategy was applied for the selection of articles and all the robotic surgical procedures in the field of urology have been included. There were certain limitations of the review process. A meta-analysis could not be conducted owing to the significant heterogeneity between the study results. Only the articles that were published in English language were included. The number of RCTs included was less, and so was the number of articles of each surgical procedure. The assessment and reporting of outcomes was not well standardized. However, we are confident that these limitations would not have an effect on the conclusions of the review.

According to our review, the robotic approach can be a good alternative to the conventional procedures due to the advantage of being associated with shorter length of hospital stay, lesser estimated blood loss, reduced need of postoperative analgesia and fewer perioperative and postoperative complications.

Our review can be used by patients, urologists and policy makers to make decisions regarding robotic surgical procedures by weighing the pros and cons and establishing its feasibility. There is an existing research gap when it comes to robotic surgery, especially in procedures like Inguinal Lymphadenectomy, Ureteral Reimplantation, Nephroureterectomy and Adrenalectomy.

More Randomized Controlled Trials (RCTs), especially those dealing with outcome measures like oncological and postoperative measures, and those with longer follow up duration are required to better ascertain the feasibility of robotic surgical procedures.

Conclusion

The feasibility of Robot Assisted surgery varied for different outcome measures as well as for different procedures. Some of the common advantages included shorter length of hospital stay, lesser estimated blood loss, reduced need of postoperative analgesia and fewer perioperative and postoperative complications while the disadvantages included longer operative time. The feasibility of Robot Assisted procedures can be better determined by more and larger clinical trials.

Declarations

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COMPETING INTERESTS

We do not have any relevant financial or non-financial interests.

AUTHOR CONTRIBUTIONS

Afra Zahid, Muhammad Ayyan, Huzaifa Ahmad Cheema and Minaam Farooq contributed to the conception and design of the review and screening of the articles to be included. Abia Shahid, Faiza Naeem, Abdullah Ilyas and Shehreen Sohail performed the analysis and interpretation of the included studies. All the authors contributed to the drafting, reviewing, and final approval of the manuscript.

ETHICS APPROVAL

No ethical approval was required for this study.

Abbreviations And Acronyms

AI- Artificial Intelligence

PUMA- Programmable Universal Manipulation Arm

AESOP- Automated Endoscopic System for Optimal Positioning

FDA- Food and Drug Administration

PRISMA- Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROSPERO- The International Prospective Register of Systematic Reviews

RCT- Randomized Controlled Trial

CENTRAL- Cochrane Central Register of Controlled Trials

MEDLINE-

OATD- Open Access Theses and Dissertations

GFR- Glomerular Filtration Rate

NOS- Newcastle-Ottawa Scale

RoB 2.0- Cochrane “Risk of Bias” tool for randomized trials

RRP- Radical Retropubic Prostatectomy

RAP- Robot-Assisted anatomic Prostatectomy

RALP- Robotic-Assisted Laparoscopic radical Prostatectomy

LRP- Laparoscopic Radical Prostatectomy

RRP- Retropubic Radical Prostatectomy

MIRP- Minimally Invasive Radical Prostatectomy

ORC- Open Radical Cystectomy

RARC- Robot Assisted Radical Cystectomy

LRC- Laparoscopic Radical Cystectomy

RRN- Robotic Radical Nephrectomy

LRN- Laparoscopic Radical Nephrectomy

ORN- Open Radical Nephrectomy

RALRN- Robot-Assisted Laparoscopic Radical Nephrectomy

RLPN- Robot-assisted Laparoscopic Partial Nephrectomy

LPN- Laparoscopic Partial Nephrectomy

RPN- Robotic-assisted Partial Nephrectomy

OPN- Open Partial Nephrectomy

RALPN- Robot-Assisted Laparoscopic Partial Nephrectomy

RANU- Robotic-Assisted Nephroureterectomy

LNU- Laparoscopic radical Nephroureterectomy

ONU- Open Nephroureterectomy

RALNU- Robotic-Assisted Laparoscopic Nephroureterectomy

RALUR- Robotic Extravesical Ureteral Reimplantation

RA- Robotic Adrenalectomy

LA- Laparoscopic Adrenalectomy

SPRA- Single Port Robotic Adrenalectomy

RALA- Robot-Assisted Laparoscopic Adrenalectomy

OA- Open Adrenalectomy

RAIL- Robot-Assisted Inguinal Lymphadenectomy

QALY- Quality-Adjusted Life Year

UTUC- Upper Tract Urothelial Cancer

IQR- Inpatient Quality Reporting

PSM- Positive Surgical Margins

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Table 3

Table 3 is available in the Supplemental Files section

Figures

Figure 1: PRISMA flow diagram of included studies

Figure 1

See image above for figure legend.

		Risk of bias domains					
		D1	D2	D3	D4	D5	Overall
Study	Bernard H. Bochner et al. (2015)						
	Muhammad Shamim Khan et al. (2016)						
	Fransesco Porpiglia et al. (2016)						

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

Judgement
 Some concerns
 Low

Figure 2: Risk of Bias (RoB) plot of RCTs

Figure 2

See image above for figure legend.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table3.docx](#)