A comparison of operative outcomes between standard and robotic laparoscopic surgery for endometrial cancer: A systematic review and meta-analysis

Thomas Ind1,2 | Alex Laios1 | Matthew Hacking1 | Marielle Nobbenhuis1

1 Department of Gynaecological Oncology, Royal Marsden Hospital, London, UK
2 St George’s University of London, London, UK

Correspondence
Thomas E. J. Ind, Department of Gynaecological Oncology, Royal Marsden Hospital, London, SW3 6JJ, UK.
Email: thomasind@mac.com

Abstract

Background: Evidence has been systematically assessed comparing robotic with standard laparoscopy for treatment of endometrial cancer.

Methods: A search of Medline, Embase and Cochrane databases was performed until 30th October 2016.

Results: Thirty-six papers including 33 retrospective studies, two matched case–control studies and one randomized controlled study were used in a meta-analysis. Information from a further seven registry/database studies were assessed descriptively. There were no differences in the duration of surgery but days stay in hospital were shorter in the robotic arm (0.46 days, 95%CI 0.26 to 0.66). A robotic approach had less blood loss (57.74 mL, 95%CI 38.29 to 77.20), less conversions to laparotomy (RR = 0.41, 95%CI 0.29 to 0.59), and less overall complications (RR = 0.82, 95%CI 0.72 to 0.93). A robotic approach had higher costs ($1746.20, 95%CI $63.37 to $3429.03).

Conclusion: A robotic approach has favourable clinical outcomes but is more expensive.

1 | INTRODUCTION

Evidence from randomised controlled trials support the use of laparoscopic techniques over open surgery for endometrial cancer.1 Standard laparoscopy for endometrial cancer is often possible but can be difficult to perform due to co-morbidities such as obesity that can be associated with uterine malignancy.2 It has been proposed that robotic surgery is easier to learn than standard laparoscopy,3 and a number of studies have demonstrated improved ergonomics and outcomes in vitro.3,4 Furthermore, it has been suggested that the in vitro benefits for robotics might be paralleled by improved clinical outcomes for endometrial cancer patients. To date, a number of studies have demonstrated a higher proportion of women having a laparoscopic approach instead of open surgery when a robot is available.5,6 Furthermore, they have suggested that this would improve the overall rate of conversion to laparotomy, operative complications and costs.5,6 The aim of this study is to systematically assess comparative cohort studies from single institutions that compare standard laparoscopy with robot assisted laparoscopy for the treatment of endometrial cancer.

2 | METHOD

A systematic search of Medline, Embase and the Cochrane database was performed for the period 1st January 1991 until 30th October 2016. No start date was used for the search. The search criteria included a search of titles, abstracts, and Medical Subject Headings for the words ('uterine' or 'uterus' or 'endometrial' or 'endometrium') and ('carcinoma' or 'cancer' or 'neoplasmia' or 'neoplasm') and ('robot' or 'robotic' or 'DaVinci'). Studies that compared a standard laparoscopic approach to endometrial cancer with a robotic approach within a discrete cohort were included. Papers were eliminated from the analysis if there was no such comparison or if it was not possible to extract data for endometrial cancer patients from other diagnoses. If two papers were published from the same institution, only the most recent...
A manuscript was used to avoid duplication. The exception was when different outcomes were reported in separate papers. It was not possible to include papers that looked at outcomes from large registries as many patients from the other studies would have been included in national and regional databases resulting in duplication. However, registry papers were retrieved from the search and assessed descriptively in the discussion of this paper.

Data were taken from the text and tables of the published papers. The presentation of data depended on that reported in individual papers. For example, if a study reported both the pelvic and para-aortic lymph node yields, it was only possible to include this data in total lymph node counts if that data was reported. A similar situation was applied to the reporting of operative complications. To avoid a complication being counted twice and potentially prejudicing one arm, a conversion to a laparotomy in its own right was not reported in the complication fields but treated separately. The same applied to blood transfusions. Where possible, complications were reported as ‘total’ but divided into ‘major’ and ‘minor’ in nature if reported as well as ‘intra-operative’ and ‘post-operative’ if separated in a paper’s text. If the Clavien-Dindo classification was used in a paper, post-operative complications classed as III or above were defined as ‘major’. Additional information clarifying data was sought from three authors and in one case this was provided.

Costs and charges were presented in United States Dollars. If this was reported in another currency then this was converted to Dollars using the exchange rate published for the middle year of the recruitment period from the Bank of England website (www.bankofengland.co.uk). The data were recorded using Review Manager. Dichotomous data were presented as Risk Ratios using the Mantel–Haenszel method with random effects. Continuous data were presented as means with standard deviations and analysed using the Inverse Variance method using random effects. When continuous data were presented as medians with ranges, the data were converted for inclusion into the meta-analysis using the method described by Hozo et al. When only interquartile ranges were reported, the data could not be included into the meta-analysis.

### 3 RESULTS

A flowchart of how papers were selected is given in Figure 1. This revealed 35 papers that were included in the study. A further hand-search of review article references included one additional paper. Therefore, a total of 36 papers were included in the analysis and these involved 8075 patients (3830 robotic and 4245 laparoscopic). A list of papers included in the meta-analysis and the outcomes included are detailed in Table 1. This included 35 retrospective cohort studies of which two contained matched case-controls. In addition, there was one randomised controlled study (Table 1). Furthermore, seven papers reporting data from registries were carefully read and used for comparative discussion in the relevant section of this paper.

A summary of the outcomes is shown in Table 2. Across all studies, there was no statistically significant difference in the duration of surgery or operating room times (Table 2). However, the one randomized
| First author | Year | Design | Countries | Period of recruitment | N-rob | N-lap | Outcomes included in meta-analysis |
|-------------|------|--------|-----------|-----------------------|-------|-------|-----------------------------------|
| Bell        | 2008 | RCC    | USA       | May 2000 to Jun 2009  | 40    | 30    | OT, Los, RNA, TLN, BL, BT, ac, AMC, C, Tc |
| Boggess     | 2008 | RCC    | USA       | Jun 2005 to Dec 2007 - Rob Apr 2000 to Sep 2004 - lap | 103   | 81    | OT, Los, BL, BT, TLN, PLN, PALN, cl, ac, AIC, mic, APC |
| Hoekstra    | 2009 | RCC    | USA       | Jul 2007 to Jul 2008  | 24    | 7     | BT, cl, Ra, ac, AMC, AIC |
| Seamon      | 2009 | RCC    | USA       | Jan 2006 to Apr 2008  | 105   | 76    | OT, ort, Orit, Los, BT, PLN, PALN, BL, cl, ac |
| Holtz       | 2010 | RCC    | USA       | Jul 2007 to Jul 2008  | 13    | 20    | OT, LOS, PLN, PALN, BL, DHb, CL, AC, AMC, AIC, mic, APC |
| Jung        | 2010 | RCC    | Korea     | May 2006 to Jan 2009  | 28    | 25    | OT, Los, PLN, PALN, BT, cl, ac, AMC, AIC, mic, APC, MPC |
| Lim         | 2011 | mRCC   | USA       | Mar 2008 to Jul 2010  | 122   | 122   | OT, Los, TLN, PLN, PALN, BL, BT, cl, Ra, ac, AMC, AIC, mic |
| Magrina     | 2011 | RCC    | USA       | Mar 2004 to Dec 2007 - rob; Nov 1999 to Aug 2006 - lap | 37    | 67    | OT, LOS, PLN, BALN, BT, CL, RA, AC, AIC, APC, rec |
| Martino     | 2011 | RCC    | USA       | Sep 2005 to Jun 2010  | 101   | 114   | PPS |
| Shah        | 2011 | RCC    | USA       | Jan 2009 to Dec 2009  | 43    | 118   | OT, Los, BL, cl, ac, AIC, mic, APC |
| Coronado    | 2012 | RCC    | Spain     | 2003 to Jun 2011      | 71    | 84    | OT, Los, PLN, BL, BT, DHb, CL, AC, AIC, mic, APC, TC |
| Escobar     | 2012 | mRCC   | USA       | Apr 2009 to Sep 2010  | 30    | 60    | OT, Los, PLN, PALN, BL, BT, cl, ac, AMC, AIC, mic |
| Estape      | 2012 | RCC    | USA       | 2002 to 2009: robot from 2006 | 102   | 104   | OT, Los, TLN, BL, BT, cl, Ri, Ra, ac, AMC, AIC, mic |
| Fagotti     | 2012 | RCC    | Italy     | Feb 2009 to Jun 2011  | 75    | 75    | OT, Los, TLN, BL, cl, ac, AMC, AIC, APC, MPC |
| Fleming     | 2012 | RCC    | USA       | Jun 2008 to Sep 2010  | 23    | 43    | OT, Los, ort, PLN, PALN, BL, cl, ac, AMC, AIC, mic, MPC, PPS, INU, PNU |
| Leitao MM Jr| 2012 | RCC    | USA       | May 2007 to Dec 2010  | 347   | 302   | OT, ort, Los, BT, TLN, PLN, PALN, BL, cl, ac, AMC, AIC |
| Nevadunsky  | 2012 | RCC    | USA       | Aug 2006 to Jan 2009  | 102   | 115   | OT, Los, BL, cl, ac, APC |
| Venkat      | 2012 | RCC    | USA       | 2008–2010             | 27    | 27    | OT, ort, Los, TLN, BL |
| Cardenas-Goicoechea | 2013 | RCC    | USA       | Dec 2007 to Apr 2010 - Rob Jan 2003 to Dec 2007 - lap | 187   | 245   | OT, Los, TLN, PLN, PALN, BL, BT, cl, RI, Ra, ac, AIC, mic, APC |
| Desille-Gbaguidi | 2013 | RCC    | France    | 2008 to Dec 2011      | 20    | 15    | OT, Los, TLN, BL, Ra, Tc |
| Leitao MM Jr| 2013 | RCC    | USA       | May 2007 to Jun 2010  | 239   | 236   | PPS, D1PS |
| Turnunen    | 2013 | RCC    | Finland   | May 2009 to Feb 2013  | 67    | 150   | OT, PLN, BL, cl |
| Leitao MM Jr| 2014 | RCC    | USA       | Jan 2009 to Dec 2010  | 262   | 132   | TC |
| Mendivil    | 2014 | RCC    | USA       | Sep 2008 to Dec 2011  | 13    | 16    | OT, Los, TLN, BL, BT, cl, Ra, ac, AIC, mic, APC |
| Pakish      | 2014 | RCC    | USA & Brazil | Jan 2007 to Nov 2012 | 52    | 142   | OT, PLN, PALN, BL, BT, cl, Ra, AIC, mic |
| Seror       | 2014 | RCC    | France    | Jan 2002 to Dec 2011, (robotics started in 2008) | 40    | 106   | BT, cl, ac, AMC, AIC, mic, APC, MPC |
| Chiou       | 2015 | RCC    | Taiwan    | 2011 to 2013 - rob; 2005–2013 - lap | 86    | 150   | OT, Los, DFD, TLN, PLN, BL, ac, AMC, PPS, D1PS |
| Corrado     | 2015 | RCC    | Italy     | Jan 2001 to Dec 2013  | 72    | 277   | OT, LOS, PLN, BL, BT, CL, RI, AC, AMC, AIC, mic, APC, MPC, rec |
| Frey        | 2015 | RCC    | UA        | May 2006 to Oct 2010  | 77    | 45    | OT, Los, TLN, PLN, PALN, BL, cl |
| Ind         | 2015 | RCC    | UK        | Jan 2010 to Dec 2013, (robot from 2012) | 24    | 77    | OT, LOS, BL, BT, DHb, CL, AL, AC, AMC, AIC, mic, APC, MPC, TC |
| Manchana    | 2015 | RCC    | Thailand  | Jan 2011 to Dec 2004  | 28    | 47    | BT, cl, AIC, mic, APC |
| Turner      | 2015 | RCC    | USA       | Jan 2008 to may 2012  | 122   | 213   | Ort, BL, cl, INU, PNU |

(Continues)
### TABLE 1 (Continued)

| First author | Year | Design | Countries | Period of recruitment | N-rob | N-lap | Outcomes included in meta-analysis |
|--------------|------|--------|-----------|-----------------------|-------|-------|-----------------------------------|
| Barrie       | 2016 | RCC    | USA       | Jan 2009 to Jan 2014  | 745   | 688   | Ac, AMC, AIC, mic, APC, MPC, d, BT |
| Johnson      | 2016 | RCC    | USA       | Oct 2008 to Sep 2012 | 353   | 187   | OT, ort, los, PLN, PALN, BL, d, Ra, ac, AIC, APC |
| Maenpaa      | 2016 | RCT    | Finland   | Dec 2010 to Oct 2013 | 50    | 49    | OT, ORT, LOS, TLN, PLN, BL, BT, PHb, HBb, CL, AC, AMC, AIC, MIC, APC, MPC, D1PS, D2PS |
| Pilka        | 2016 | RCC    | Czech Republic | Oct 2012 to Jun 2015 | 64    | 13    | TLN, BL, DHb, PPS |

**Abbreviations**

- RCC – Matched Retrospective Cohort Comparison
- mRCC – Matched Retrospective Cohort Comparison
- RCT – Randomised Controlled Trial
- OT – Operative Time
- ORT – Operating Room Time
- LOS – Length Of Stay
- ORIT – Operating Room to Incision Time
- DFD – Days to Full Diet
- RNA – Days Return to Normal Activity
- TLN – Total Lymph Node count
- PLN – Pelvic Lymph Node count
- PALN – Para-aortic Lymph Node count
- BL – Blood transfusion
- PHb – Post-operative Haemoglobin
- DHb – Drop in Haemoglobin
- CL – Conversion to Laparotomy
- RI – Re-Intervention
- RA – Re-Admission
- AC – All Complications
- AMC – All Major Complications
- AIC – All Intra-operative complications
- MIC – Major Intra-operative complications
- APC – All Post-operative complications
- MPC – Major Post-operative complications
- PPS – Post-operative Pain Score
- D1PS – Day 1 Pain Score
- D2PS – Day 2 Pain Score
- INU – Intra-operative Narcotic Usage
- PNU – Post-operative Narcotic Usage
- C – Charges
- TC – Total Costs
- Rec – Recurrences
obesity in particular is associated with worse outcomes.53 Therefore the data in favour of robotic laparoscopy is in spite of adverse confounders.

Other recent reviews and meta-analyses of the subject exist.54,55 They do not include all the citations that are in this study nor the randomized controlled study. Some of these meta-analyses include registry studies even though some analyse the same databases and include patients reported in the institutional cohorts. However, the findings of less operative conversions, lower blood loss, and a shorter hospital stay are consistent findings within meta-analyses but this study also demonstrates less overall complications in the robotic arm as well as higher costs.54,55

This study found significantly longer operating times for robotic surgery in the retrospective cohort studies. However, the one randomized controlled study showed shorter operating times for robotic surgery.32 This may be due to the ‘early series’ effect described when a teams first few operations took longer than the later procedures in their series but in one study where the surgeon and team was already experienced in robotic surgery, longer operating times were still demonstrated.5 It is possible that this is a power effect and a larger study

| Outcome or subgroup                               | Studies | Participants | Statistical method       | Effect estimate          |
|---------------------------------------------------|---------|--------------|--------------------------|--------------------------|
| Operation time (m)                                | 27      | 4665         | Mean difference (IV, random, 95% CI) | 16.42 (−0.04, 32.88)     |
| Operating room time (m)                           | 7       | 1647         | Mean difference (IV, random, 95% CI) | 17.76 (−15.09, 50.61)    |
| In OR to incision time (m)                        | 1       | 181          | Mean difference (IV, random, 95% CI) | 6.00 (2.80, 9.20)        |
| Hospital stay (days)                              | 25      | 4367         | Mean difference (IV, random, 95% CI) | −0.46 (−0.66, −0.26)*    |
| Receiving full diet (days)                        | 1       | 236          | Mean difference (IV, random, 95% CI) | −0.20 (−0.35, −0.05)*    |
| Days return to normal activity (days)             | 1       | 70           | Mean difference (IV, random, 95% CI) | −7.50 (−12.04, −2.96)*   |
| **Lymph nodes**                                   |         |              |                          |                          |
| Total lymph node count (n)                        | 14      | 2086         | Mean difference (IV, random, 95% CI) | −0.14 (−5.73, 5.46)      |
| Pelvic lymph node count (n)                       | 18      | 2852         | Mean difference (IV, random, 95% CI) | 1.24 (−0.75, 3.22)       |
| Para-aortic lymph node count (n)                  | 13      | 1908         | Mean difference (IV, random, 95% CI) | 0.83 (1.04, 2.71)        |
| **Bleeding**                                      |         |              |                          |                          |
| Blood loss (ml)                                    | 28      | 5115         | Mean difference (IV, random, 95% CI) | −57.74 (−77.20, −38.27)* |
| Blood transfusions                                 | 21      | 4911         | Risk ratio (M-H, random, 95% CI) | 0.77 (0.5, 1.07)         |
| Postoperative Haemoglobin (g/L)                    | 1       | 99           | Mean difference (IV, random, 95% CI) | −5.00 (−10.77, 0.77)     |
| Drop in Haemoglobin (g/L)                          | 5       | 457          | Mean difference (IV, random, 95% CI) | −3.93 (−8.72, 0.87)      |
| **Adverse events**                                |         |              |                          |                          |
| Conversion to laparotomy                           | 28      | 6558         | Risk ratio (M-H, random, 95% CI) | 0.41 (0.29, 0.59)*       |
| Re-operation/re-intervention                       | 3       | 594          | Risk ratio (M-H, random, 95% CI) | 0.78 (0.02, 30.03)       |
| Re-admission                                       | 9       | 1823         | Risk ratio (M-H, random, 95% CI) | 1.55 (0.82, 2.92)        |
| All complications                                  | 25      | 5823         | Risk ratio (M-H, random, 95% CI) | 0.82 (0.72, 0.93)*       |
| All major complications                            | 16      | 3787         | Risk ratio (M-H, random, 95% CI) | 1.06 (0.61, 1.90)        |
| Intra-operative complications                      | 22      | 4853         | Risk ratio (M-H, random, 95% CI) | 0.81 (0.61, 1.06)        |
| Major intra-operative complication                 | 18      | 3957         | Risk ratio (M-H, random, 95% CI) | 0.85 (0.58, 1.23)        |
| Post-operative complications                       | 18      | 4327         | Risk ratio (M-H, random, 95% CI) | 0.85 (0.72, 1.02)        |
| Major post-operative complications                 | 9       | 2430         | Risk ratio (M-H, random, 95% CI) | 1.18 (0.79, 1.76)        |
| **Pain and analgesia**                            |         |              |                          |                          |
| Postoperative visual analogue pain score (0–10)    | 5       | 1070         | Mean difference (IV, random, 95% CI) | −0.08 (−0.36, 0.20)      |
| Day 1 visual analogue pain score (0–10)           | 3       | 788          | Mean difference (IV, random, 95% CI) | −0.48 (−1.07, 0.10)      |
| Day 2 visual analogue pain score (0–10)           | 1       | 27           | Mean difference (IV, random, 95% CI) | 0.00 (−1.31, 1.31)       |
| Intra-operative narcotic usage (mg m-e)            | 2       | 179          | Mean difference (IV, random, 95% CI) | −40.00 (−52.13, −27.87)  |
| Post-operative narcotic usage (mg m-e)             | 2       | 180          | Mean difference (IV, random, 95% CI) | −1.50 (−8.83, 5.82)      |
| **Finances**                                      |         |              |                          |                          |
| Charges ($)                                        | 1       | 70           | Mean difference (IV, random, 95% CI) | 1746.20 (63.37, 3429.03)* |
| Total costs ($)                                    | 6       | 788          | Mean difference (IV, random, 95% CI) | 1869.42 (267.89, 3470.94)* |
| **Oncological Outcomes**                          |         |              |                          |                          |
| Recurrences                                        | 2       | 453          | Risk ratio (M-H, random, 95% CI) | 0.66 (0.33, 1.34)        |

* = Statistically Significant
IV = Inverse Variance
M-H = Mantel-Haenzel
with even more numbers would have demonstrated a longer duration of surgery. From studies reporting outcomes from registries and databases, one study reported a non-significant shorter operative time in

\[ \text{Robotic} = 0.2 \text{ vs. Laparoscopic} \]

The mean difference of 18 minutes has to be put in perspective as most people accept the benefits of laparoscopic compared to open surgery for endometrial cancer. A meta-analysis has shown that a standard laparoscopic approach has an additional operative duration of 33 minutes over laparotomy.

In this analysis we demonstrated less blood loss in the robotic arm. However, this could be perceived as a surrogate outcome as 50 mL

with even more numbers would have demonstrated a longer duration of surgery. From studies reporting outcomes from registries and databases, one study reported a non-significant shorter operative time in the robotic arm and no studies report longer operative times. The mean difference of 18 minutes has to be put in perspective as most people accept the benefits of laparoscopic compared to open surgery for endometrial cancer.

FIGURE 2
Duration of operations for endometrial cancer (mins)

FIGURE 3
Days in hospital following surgery for endometrial cancer

This study demonstrates a shorter hospital stay for robotic cases. This is supported by one registry study that showed a significantly lower proportion of women staying three nights or more in hospital. One other registry study reports a non-significant shorter stay in the robotic group. Return to normal activity is shorter for robotics in the one study that reports this outcome in the meta-analysis. The reduction in conversion to laparotomies and less complications might explain these findings as one would expect a patient who had a laparotomy or one who suffered complications to spend longer in hospital and take longer to return to normal activity.

This study demonstrates a shorter hospital stay for robotic cases. This is supported by one registry study that showed a significantly lower proportion of women staying three nights or more in hospital. One other registry study reports a non-significant shorter stay in the robotic group. Return to normal activity is shorter for robotics in the one study that reports this outcome in the meta-analysis. One registry study reports on this. That study reports on a 6.7 days quicker return to normal activity for the robotic arm but reports this as being non-significant. However, using the Inverse Variance method this would have 95% confidence intervals of 2.05 to 11.35 days shorter return to normal activity which supports the data we report.
less blood loss might not be reflected in a drop in haemoglobin concentration or the use of blood transfusions. Although blood transfusion usage was much lower in the robotic arm (RR = 0.76, 95%CI 0.57 to 1.01) this failed to reach statistical significance. Furthermore, no difference in the drop in haemoglobin could be demonstrated either. Blood loss was reported in one registry study and was not significantly different.\textsuperscript{46} Blood transfusion usage was not shown to be different in any of the registry studies but was lower in all four papers that reported this outcome.\textsuperscript{46,49-51} Therefore, the importance or not in the finding of 50 mL less blood loss remains to be defined.

The finding of less conversions to laparotomy is an important one as the relative risk is 0.42 with tight confidence intervals (0.30 to 0.59). This is likely to be related to the increased ergonomics of robotic surgery over standard laparoscopy.\textsuperscript{57} However, the outcome is not supported in a registry study.\textsuperscript{51} Re-operation and re-admission rates are also reported in registry studies without any demonstrable significant difference.

The findings of less overall complications may also be related to ergonomic reasons although it will be interesting to see with time how further studies not influenced by the 'early series' effect will alter the analysis of intra-operative, post-operative, and major complications. The registry studies have conflicting results for this outcome.

Total complication rates are very heterogeneous as they are dependent on the definition of a complication and the systematic way in which the outcomes are measured.

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|c|c|c|}
\hline
\textbf{Study or Subgroup} & \textbf{Robotic (SD [ME]}} & \textbf{Laparoscopic (SD [ME]}} & \textbf{Total (SD [ME]}} & \textbf{Mean Difference} & \textbf{Year} & \textbf{Subtotal (95% CI)}} \\
\hline
Bell et al 2008 & 40 & 2 & 30 & 40 & 0.0% & 0.00 (0.95, 2.85) \\
Birnbaum et al 2008 & 3 & 2 & 2 & 3 & 0.0% & 0.00 (0.95, 2.85) \\
Seamon et al 2009 & 2 & 1 & 2 & 1 & 0.0% & 0.00 (0.95, 2.85) \\
Nijsten et al 2010 & 1 & 1 & 2 & 1 & 0.0% & 0.00 (0.95, 2.85) \\
Morgan et al 2010 & 2 & 1 & 3 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Amir et al 2011 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Kim et al 2011 & 2 & 1 & 3 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Wang et al 2011 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Leppanen et al 2012 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Nevadwsky et al 2012 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Cardenas-Cascales et al 2012 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Barrit et al 2013 & 3 & 2 & 5 & 2 & 0.0% & 0.00 (0.95, 2.85) \\
Subtotal (95% CI)}} & 2344 & 2672 & 1.2% & 1.2% & 1.2% & 1.2% \\
\hline
\end{tabular}
\caption{Mean estimated blood loss (mL) following surgery for endometrial cancer}
\end{table}

\begin{figure}
\centering
\includegraphics{fig4}
\caption{Mean estimated blood loss (mL) following surgery for endometrial cancer}
\end{figure}
which complications are collected. One registry study reported ‘similar morbidity’ yet the analysis in a table showed significantly less medical complications, significantly less bladder injuries, and significantly less re-operations for robotic surgery compared with standard laparoscopy. Another study by the same group showed a 4% increase in all complications and medical complications in the robotic arm.

FIGURE 6 All complications related to surgery for endometrial cancer

FIGURE 7 Conversions to laparotomy following surgery for endometrial cancer

| Study or Subgroup | Robotic Events | Laparoscopic Events | Total Weight | Risk Ratio | M-H, Random, 95% CI | Year | Risk Ratio | M-H, Random, 95% CI |
|-------------------|---------------|---------------------|--------------|-----------|---------------------|------|-----------|---------------------|
| 1.1.6.1 Retrospective Cohort Comparisons | | | | | | | | |
| Boogjes et al 2008 | 6 | 102 | 11 | 81 | 1.9% | 0.43 (0.17, 1.11) | 2008 | 0.43 (0.17, 1.11) | 2008 |
| Bell et al 2008 | 5 | 40 | 9 | 80 | 1.1% | 0.28 (0.08, 0.87) | 2009 | 0.28 (0.08, 0.87) | 2009 |
| Seaman et al 2009 | 11 | 85 | 8 | 58 | 2.2% | 0.94 (0.40, 2.19) | 2009 | 0.94 (0.40, 2.19) | 2009 |
| Hoekstra et al 2009 | 5 | 31 | 7 | 20 | 2.0% | 2.67 (0.16, 42.41) | 2009 | 2.67 (0.16, 42.41) | 2009 |
| Jung et al 2010 | 2 | 28 | 2 | 25 | 0.5% | 0.89 (0.14, 5.88) | 2010 | 0.89 (0.14, 5.88) | 2010 |
| Horta et al 2010 | 0 | 12 | 3 | 20 | 0.6% | 1.03 (0.20, 5.33) | 2010 | 1.03 (0.20, 5.33) | 2010 |
| Lim et al 2011 | 12 | 122 | 17 | 122 | 3.4% | 0.71 (0.35, 1.41) | 2011 | 0.71 (0.35, 1.41) | 2011 |
| Shah et al 2011 | 3 | 43 | 9 | 118 | 1.1% | 0.91 (0.26, 3.22) | 2011 | 0.91 (0.26, 3.22) | 2011 |
| Magnani et al 2011 | 9 | 67 | 8 | 71 | 2.3% | 0.62 (0.26, 1.47) | 2011 | 0.62 (0.26, 1.47) | 2011 |
| Corrado et al 2012 | 15 | 71 | 24 | 84 | 5.1% | 0.74 (0.42, 1.30) | 2012 | 0.74 (0.42, 1.30) | 2012 |
| Faggioni et al 2012 | 8 | 75 | 6 | 75 | 1.7% | 1.31 (0.49, 3.66) | 2012 | 1.31 (0.49, 3.66) | 2012 |
| Nenckowski et al 2012 | 7 | 102 | 3 | 115 | 1.0% | 2.95 (0.70, 9.49) | 2012 | 2.95 (0.70, 9.49) | 2012 |
| Estape et al 2012 | 5 | 102 | 3 | 104 | 0.9% | 1.70 (0.42, 6.33) | 2012 | 1.70 (0.42, 6.33) | 2012 |
| Escobar et al 2012 | 1 | 30 | 2 | 30 | 0.3% | 0.50 (0.05, 5.22) | 2012 | 0.50 (0.05, 5.22) | 2012 |
| Lettao et al 2012 | 11 | 310 | 38 | 263 | 7.9% | 0.69 (0.44, 1.08) | 2012 | 0.69 (0.44, 1.08) | 2012 |
| Fleming et al 2012 | 4 | 23 | 8 | 43 | 1.4% | 0.93 (0.31, 2.78) | 2012 | 0.93 (0.31, 2.78) | 2012 |
| Carneiro-da-Cunha et al 2013 | 19 | 187 | 68 | 245 | 12.3% | 0.77 (0.55, 1.08) | 2013 | 0.77 (0.55, 1.08) | 2013 |
| Mendivil et al 2014 | 2 | 13 | 1 | 16 | 0.3% | 2.46 (0.25, 24.21) | 2014 | 2.46 (0.25, 24.21) | 2014 |
| Serss et al 2014 | 14 | 105 | 10 | 40 | 4.5% | 1.28 (0.70, 2.35) | 2014 | 1.28 (0.70, 2.35) | 2014 |
| Ind et al 2015 | 1 | 24 | 23 | 77 | 5.5% | 0.14 (0.02, 0.98) | 2015 | 0.14 (0.02, 0.98) | 2015 |
| Chiou et al 2015 | 2 | 86 | 2 | 50 | 0.5% | 1.74 (0.25, 12.16) | 2015 | 1.74 (0.25, 12.16) | 2015 |
| Corrado et al 2015 | 4 | 72 | 28 | 77 | 3.6% | 0.55 (0.29, 1.52) | 2015 | 0.55 (0.29, 1.52) | 2015 |
| Johnson et al 2016 | 11 | 353 | 3 | 187 | 1.1% | 1.94 (0.55, 6.88) | 2016 | 0.55 (0.29, 1.52) | 2016 |
| Barre et al 2016 | 235 | 247 | 680 | 42% | 0.79 (0.47, 0.99) | 2016 | 0.79 (0.47, 0.99) | 2016 |

Total (95% CI): 2882 300 95.7% 0.79 [0.71, 0.88]

Test for overall effect: \(I^2 = 4.15 \% (P < 0.00001)\)

1.1.6.2 Randomised Controlled Studies

Maenioa et al 2016 | 18 | 59 | 12 | 49 | 4.3% | 1.47 [0.79, 2.72] | 2016 | 1.47 [0.79, 2.72] | 2016 |

Subtotal (95% CI): 2882 300 100% 0.82 [0.72, 0.93]

Test for overall effect: \(I^2 = 1.23 \% (P = 0.22)\)

1.1.7 Subgroup Comparisons

Maenioa et al 2016 | 0 | 59 | 5 | 49 | 1.3% | 0.09 [0.01, 1.57] | 2016 | 0.09 [0.01, 1.57] | 2016 |

Subtotal (95% CI): 3106 3452 100% 0.41 [0.28, 0.59]

Test for overall effect: \(I^2 = 2.85 \% (P = 0.0000001)\)

Maenioa et al 2016 | 0 | 59 | 5 | 49 | 1.3% | 0.09 [0.01, 1.57] | 2016 | 0.09 [0.01, 1.57] | 2016 |

Subtotal (95% CI): 3106 3452 100% 0.41 [0.28, 0.59]

Test for overall effect: \(I^2 = 2.85 \% (P = 0.0000001)\)

Maenioa et al 2016 | 0 | 59 | 5 | 49 | 1.3% | 0.09 [0.01, 1.57] | 2016 | 0.09 [0.01, 1.57] | 2016 |

Subtotal (95% CI): 3106 3452 100% 0.41 [0.28, 0.59]
The cost analysis is in favour of the standard laparoscopy arm of the study being $1869.42 less expensive. This is consistent with outcomes from a large registry study where standard laparoscopy was $1291.00 cheaper than a robotic approach to endometrial cancer.\textsuperscript{50} This figure reduces to $688.00 for individual surgeons who perform more than 50 cases a year\textsuperscript{48} and that caseload could be considered as an absolute minimum for endometrial cancer surgeons. Other studies that report on hospital charges rather than costs show greater differences.\textsuperscript{51,58} However, some might argue that such an increased cost compares favourably compared with other interventions in the field of gynecological oncology such as some chemotherapy agents. What a straight comparison between robotic and standard approaches does not reveal is the additional cost from those patients who have open surgery in institutions not using robotics. To date, two studies have demonstrated greater utilisation of laparoscopic approaches with the use of the robot with less laparotomies, less complications and less overall costs when including the expense of open surgery into the cohorts.\textsuperscript{5,6} One problem with analysing cost data in such a way is that different countries have variable healthcare reimbursement systems and wage costs. For example in some countries where there is social healthcare, surgeons are salaried by institutions and in other countries they charge separately. Therefore, a cost–benefit may exist in one healthcare system and not in another and it is difficult to interpret how this data would apply to a single institution although it is clearly of interest.

One matter to consider when assessing these outcomes is the innovation in new platforms over time. In early series, the Da Vinci Standard® system will have been used, whereas in latter series the fourth generation of platform (Da Vinci Xi®) may have been available. To date there is no published data on the value of the updated systems on outcomes and it would be interesting to analyse this. Furthermore, different institutions have different protocols for para-aortic and pelvic lymph node dissections resulting in a heterogeneity of operations performed across institutions. If a consensus ever occurs on the role of lymphadenectomy in endometrial cancer then it would be wise to assess separate subgroups but this is not possible currently.

In summary, this study demonstrates that the current evidence is in favour of robotic assisted laparoscopy for endometrial cancer over standard laparoscopy for clinic outcomes but costs are probably greater. To date there are only 99 patients recruited to randomized controlled trials\textsuperscript{32} and an increase in this number will undoubtedly provide stronger evidence.

CONFLICT OF INTERESTS

Marielle Nobbenhuis and Thomas Ind have proctored for Intuitive Surgical.

ETHICS

As this is a review no ethics was required.

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