Robotic versus laparoscopic hysterectomy: a review of recent comparative studies
Dimitri Sarlos and LaVonne A. Kots

Introduction
Laparoscopic procedures in gynaecologic surgery have been performed successfully for more than 20 years now. The first total laparoscopic hysterectomy was carried out by Reich et al. [1] in 1988.

Since then, substantial improvements in optic systems and instrumentation have made laparoscopic surgery much more accurate, safer and probably easier to learn. Owing to these technical advances during the past 20 years, complicated procedures such as gynaecologic cancer surgery, surgery of deep infiltrating endometriosis or prolapse surgery today can be performed safely by laparoscopy and have become standard procedures in numerous centres worldwide.

Many studies in the past have demonstrated that laparoscopic hysterectomy leads to lower perioperative morbidity, shorter hospital stay and speedier return to work than abdominal hysterectomy [2–5]. These studies also showed that complication rates are not higher if the operation is performed in experienced centres [6,7].

For all these reasons, laparoscopic hysterectomy should be considered the gold standard procedure for benign indications if vaginal hysterectomy is not possible in cases with large uteri, nulliparity or because of additional pathologies such as adnexal masses or endometriosis, in which abdominal access is needed.

Despite these promising results, the percentage of laparoscopic hysterectomies is disappointingly low compared with laparotomy; as a result, abdominal hysterectomy remains the most common approach in nearly all countries worldwide [8,9]. An unfavourable learning curve and extensive training of surgeons and the whole surgical team are cited as reasons for this [10,11]. Another reason is probably the limited exposure to laparoscopic surgery in many hospitals in which gynaecologic surgeons are educated and trained.

To overcome all these drawbacks and allow more patients to benefit from a less invasive procedure, robotic surgery is frequently brought up as a possible solution. It is often stated that one of the suggested advantages of robotic surgery is a favourable learning curve [11].
After the introduction of robotic surgery in the field of urology, cardiac and general surgery [12–15], it gained more and more interest in gynaecologic surgery [16–18].

Meanwhile, the da Vinci surgical system (Intuitive Surgical Inc., Sunnyvale, California, USA), which until now is the only Food and Drug Administration (FDA) approved robotic device, has been used in gynaecological surgery for nearly all gynaecologic procedures such as hysterectomy, myomectomy, radical hysterectomy with pelvic and paraaortic lymphadenectomy, prolapse surgery, tubal anastomosis and endometriosis surgery [19–23].

Recently, most comparative studies on robotics in gynaecology have been published about oncological procedures such as staging for endometrial cancer or cervical cancer [24–28]. There are only few studies about robotic hysterectomy for benign indications and most of them are retrospective. Even fewer studies exist comparing robotic with laparoscopic hysterectomy (Table 1) [19,29–31,32,33]. All these studies have sufficiently demonstrated the feasibility and safety of robotic hysterectomy during the past years [17,18,33–35]. However, to date, no randomized controlled trial has been published about this topic.

Now that the first excitement over this innovative and sophisticated technology has settled, the real place for robotic hysterectomy in benign cases is not clear [34,35]. The most important questions that should be answered are as follows:

1. Is there an improvement in surgical outcome in comparison to laparoscopic hysterectomy?
2. Is the learning curve for the inexperienced laparoscopic surgeon shorter with robotics?
3. Is there an advantage for the experienced laparoscopic surgeon?
4. What are the differences in costs?

With this review article, we have tried to answer these questions with recent data.
Review

One of the first publications reporting about the outcome of total robotic hysterectomy for benign conditions after the FDA approval for the da Vinci surgical system (Intuitive Surgical Inc.) in 2005 was published by Reynolds and Advincula [36] in 2006. In this study, 16 patients with no major complications were reported with no conversions to laparotomy and operative times of 242 min for a median uterine weight of 131 g. Several case series about robotic hysterectomy were published in the following years [37,38], the most recent of which is by Boggess et al. [39] reporting on 152 cases of total robotic hysterectomy with benign indications with no conversions to laparotomy and a median operating time of 122.9 min. In this series big uteri with a median weight of 347 g were also included.

There are few more recent studies comparing robotic with conventional laparoscopic hysterectomy for benign indications [19,30,31,32,33]. Table 1 lists all PubMed cited comparative studies on this topic. The number of patients is low in most series except for the study by Pasic et al. [29*] and the only prospective comparative study was published by our group [31*]. The study by Pasic et al. analyses data from the Premier hospital database of 358 hospitals in the USA, all the other cited studies are conducted at one or two hospitals and involve not more than two surgeons performing the robotic procedure. The only two studies reporting on the comparison of costs are the studies by Pasic et al. [29*] and by our group [31*].

Surgeon’s experience in robotic and conventional laparoscopic surgery is not cited in most studies [29*,32] and comparison between the different studies is difficult, as some studies only included total laparoscopic or robotic hysterectomies [31,32,33] and others also included laparoscopic assisted vaginal hysterectomies or laparoscopic supracervical hysterectomies [29*,30*].

Clinical outcome
In order to compare these two minimally invasive procedures, we have focused this review on the clinical outcome of both robotic and conventional laparoscopic hysterectomy according to the following points.

Operative time
In five of the six reviewed comparative studies that are listed in Table 1, operating times were significantly longer in the robotic group compared with the conventional laparoscopic group [19,29*,31,32,33]. Only the study by Giep et al. [30*] showed no significant difference in operating times. It has to be mentioned that in this study 87 supracervical hysterectomies with a low median uterus weight of 140 g were analysed in the conventional laparoscopic group and these operations were performed by nine different surgeons in a period of 18 months. This translates into a mean frequency of one laparoscopic supracervical hysterectomy per surgeon every 2 months in the conventional group. These results were compared with 237 total robotic hysterectomies performed by only two surgeons in a period of 22 months.

The most important variables that can influence operative times are experience of the surgeon, uterine weight and incidence of difficult patient-related conditions such as adhesions or obesity. Uterine weights showed no significant statistical differences in most studies except for the one by Giep et al. [30*].

Surgeon’s experience unfortunately is not mentioned in most studies [29*,32,33]. Of course, surgeon’s experience is difficult to compare because most surgeons or institutions do not have the same experience in robotic and conventional laparoscopic surgery.

Operative times for robotic and conventional laparoscopic hysterectomy reported by Payne and Dauterive [19] are comparable to our study [31*]. Surgeon’s experience in both studies also seems to be comparable, as both institutions were experienced laparoscopic centres prior to initiation of their robotic program.

In our study [31*], we compared the first consecutive 40 robotic hysterectomies performed by two experienced laparoscopic surgeons with a matched control group of conventional laparoscopic hysterectomies by the same surgeons which is a standard procedure in our institution. The operating time in our study was significantly longer in the robotic group (109 versus 83 min), reflecting the beginning of our learning curve in robotic surgery. However, the overall operative time for robotic hysterectomy was quite less when comparing it with the large series by Boggess et al. [39] or Lenihan et al. [11,40] reporting operative times of 122.9 min and 148 min, respectively.

This fact seems to confirm that there is a learning curve for robotic hysterectomy even for experienced laparoscopic surgeons of at least 50 cases which was also reported by other authors [40] and that experience in conventional laparoscopic surgery probably facilitates the approach to robotic surgery.

With the comparative data that are available today, operating times seem to be longer for robotic hysterectomy when comparing it with conventional laparoscopic hysterectomy. It has to be taken into account that until now there is no randomized controlled trial comparing both procedures and that the bias of surgeons’ experience is an unsolved problem.
Complications, conversions, blood loss and hospital stay

In most comparative studies [29–31,32,33], there was no difference in intraoperative conversion rates between the two groups. The only study that reported a higher rate of conversions for the conventional laparoscopic group was the study by Payne and Dauterive [19] who reported a conversion rate of 4 and 9%, respectively. It has to be mentioned that a conversion rate of 9% for a conventional laparoscopic hysterectomy seems to be quite high when comparing it with other series [41,42] that reported conversion rates of 1.4–4% and our own experience [31].

The complication rate was equal for both procedures in all studies, but the caseload of all series was too small to demonstrate any statistical differences. No significant differences in blood loss were noted in most studies. Hospital stay was longer in the conventional laparoscopic group in the study by Payne and Dauterive [19] who reported 1 versus 1.6 days and in the study by Shashoua et al. [32] it was 1 versus 1.4 days. These findings have to be carefully interpreted as to their clinical relevance. We could not see any significant differences in our study [31] which was the only prospective comparative study. Hospital stay was 3.9 days in the conventional laparoscopic group and 3.3 days in the robotic group. To explain the large difference of 3 days mean hospital stay in our study versus 1 day in the other studies, one has to look at the different hospitalization practices in various countries. Our study was the only one conducted in an European centre. The only robotic device that has been approved by the FDA for gynecological laparoscopic procedures is the da Vinci surgical system (Intuitive Surgical Inc.). The investment costs for the whole robotic system depend on the technical equipment and range from 2–2.3 million USD (quote from Intuitive Surgical Inc. in February 2011). As healthcare system reimbursement varies from country to country, it is difficult to compare the total cost of robotic procedures, including the amortization of the device.

Costs

The only robotic device that has been approved by the FDA for gynecological laparoscopic procedures is the da Vinci Surgical System (Intuitive Surgical Inc.). The investment costs for the whole robotic system depend on the technical equipment and range from 2–2.3 million USD (quote from Intuitive Surgical Inc. in February 2011). As healthcare system reimbursement varies from country to country, it is difficult to compare the total cost of robotic procedures, including the amortization of the device.

Table 2 Surgical outcome of studies reviewed

<table>
<thead>
<tr>
<th>Reference</th>
<th>Operating time (min)</th>
<th>Blood loss (ml)</th>
<th>Conversion rate (%)</th>
<th>Hospital stay (days)</th>
<th>Uterus weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>vs.</td>
<td>Robotic</td>
<td>Conventional</td>
<td>Robotic</td>
<td>Conventional</td>
<td>Robotic</td>
</tr>
<tr>
<td>Pasic et al. [29*]</td>
<td>193 versus 180a</td>
<td>169 versus 147a</td>
<td>Yes</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Giep et al. [30*]</td>
<td>89.9</td>
<td>89.6</td>
<td>No</td>
<td>59.0</td>
<td>65.7</td>
</tr>
<tr>
<td>Sarlos et al. [31*]</td>
<td>109</td>
<td>83</td>
<td>Yes</td>
<td>81</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Shashoua et al. [32]</td>
<td>142.2</td>
<td>122.1</td>
<td>Yes</td>
<td>113.5</td>
<td>98.8</td>
</tr>
<tr>
<td>Nazhat et al. [21]</td>
<td>276</td>
<td>206</td>
<td>Yes</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>Payne and Dauterive</td>
<td>119.4</td>
<td>92.4</td>
<td>Yes</td>
<td>61</td>
<td>113</td>
</tr>
</tbody>
</table>

LAVH, laparoscopic assisted vaginal hysterectomy; LSH, laparoscopic supracervical hysterectomy; NS, not stated.

a Mean skin-to-skin time.

b Outpatient versus inpatient hospital setting, respectively.
been shown for a long time that endoscopic procedures are less invasive and offer better postoperative results for the patient than open procedures [43,44].

The currently available data show that the clinical outcome seems to be the same for robotic and conventional laparoscopic hysterectomy, a fact that is not astonishing as both are minimally invasive endoscopic procedures with the only difference being the use of the robot. Costs are significantly higher for robotic hysterectomy and the difference per case adds up to approximately 2500 USD not including the cost for investment and amortization. Robotic hysterectomy is easy to learn for the experienced laparoscopic surgeon, but to reach operating times of conventional laparoscopic hysterectomy, a learning curve of at least 50 cases seems to be needed.

The rate of abdominal hysterectomy in the United States in 2003 and 2005 was still over 60% [8,9] and only 12–14% were performed laparoscopically – a proportion that is probably comparable to most countries worldwide and has probably not changed significantly in the past years. This means that 23 years after the first laparoscopic hysterectomy has been performed, the abdominal approach is still the most frequent route of access for hysterectomy. Robotic hysterectomy may not offer a benefit for expert laparoscopic surgeons and the clinical outcome is probably not better, but it could be a tool that offers the possibility to perform a minimally invasive hysterectomy to more surgeons and to give more patients the advantages of minimally invasive surgery.

As robotic surgery does not actually seem to give an advantage in surgical and clinical outcome for simple benign hysterectomy, it could be of higher interest for more complicated procedures such as prolapse surgery, myomectomy or cancer surgery.

This point has to be confirmed in controlled randomized trials.

For the future, we urgently need randomized controlled trials including cost–effectiveness analysis and quality-of-life assessment to define the value of robotic surgery. As technical evolution has always influenced surgery in the past, we think that with the input of experienced endoscopic surgeons, robotic surgery with its enormous technical potential could play an important role over the next years and decades.

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References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

** of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 304).


