

LAPAROSCOPIC HYSTERECTOMY

OUTCOME AND COMPLICATIONS IN FINLAND

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ACADEMIC DISSERTATION

To be presented for public examination by permission
of the Medical Faculty of the University of Helsinki,
in the Auditorium of the Department of Obstetrics and Gynecology,
Helsinki University Central Hospital, Haartmaninkatu 2, Helsinki,
on November 5th, 1999, at 12 o'clock noon

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ISBN 951-45-8721-9 (PDF version)
Helsingin yliopiston verkkojulkaisut, Helsinki 1999
<http://ethesis.helsinki.fi/>

***To my family
and friends***

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text by their Roman numerals. In addition, some unpublished material is presented.

- I Härkki-Sirén P, Sjöberg J. Evaluation and the learning curve of the first one hundred laparoscopic hysterectomies. *Acta Obstet Gynecol Scand* 1995;74:638-641.
- II Härkki-Sirén P, Sjöberg J, Mäkinen J, Heinonen PK, Kauko M, Tomás E, Laatikainen T. Finnish national register of laparoscopic hysterectomies: A review and complications of 1165 operations. *Am J Obstet Gynecol* 1997;176:118-122.
- III Härkki-Sirén P, Sjöberg J, Toivonen J, Tiitinen A. Clinical outcome and tissue trauma after laparoscopic and abdominal hysterectomy: a randomized controlled study. Submitted for publication.
- IV Härkki-Sirén P, Sjöberg J, Tiitinen A. Urinary tract injuries after hysterectomy. *Obstet Gynecol* 1998;92:113-118.
- V Härkki-Sirén P, Kurki T. A nationwide analysis of laparoscopic complications. *Obstet Gynecol* 1997;89:108-112.
- VI Härkki-Sirén P, Sjöberg J, Kurki T. Major complications of laparoscopy: a follow-up Finnish Study. *Obstet Gynecol* 1999,94:94-98.

ABBREVIATIONS

AAGL	American Association of Gynecologic Laparoscopists
AH	Abdominal hysterectomy
CA 125	Tumor-associated antigen CA 125
CRP	C-reactive protein
ICD-9	International Classification of Diseases, 9th Revision
ICD-10	International Classification of Diseases, 10th Revision
IL-6	Interleukin-6
SAH	Subtotal abdominal hysterectomy
TAH	Total abdominal hysterectomy
TATI	Tumor-associated trypsin inhibitor
VH	Vaginal hysterectomy

"Laparoscopic hysterectomy" is used in the text to describe any type of surgery where laparoscopy and hysterectomy are linked together. When different techniques of laparoscopic hysterectomy are discussed the following abbreviations are used:

CISH	Classical intrafascial supracervical hysterectomy
LADH	Laparoscopically assisted Döderlein hysterectomy
LAVH	Laparoscopically assisted vaginal hysterectomy
LH	Laparoscopic hysterectomy
LSH	Laparoscopic subtotal hysterectomy
TLH	Total laparoscopic hysterectomy
VALH	Vaginally assisted laparoscopic hysterectomy

INTRODUCTION

Hysterectomy is one of the most frequently performed of all surgical operations. Approximately 10,000 hysterectomies are performed annually in Finland and one fifth of women over 45 years of age have their uterus removed. The annual incidence of hysterectomy in Finland has been lower than in the United States, the same as in the United Kingdom but the highest among Nordic countries (Easterday et al. 1983; Luoto et al. 1994; Davies et al. 1998). However, the incidence has increased from 340/100,000 in 1987 to 414/100,000 in 1992 in Finland (Vuorma et al. 1998).

Traditionally the uterus has been removed by an abdominal or vaginal route. In spite of the lower complication rate in vaginal hysterectomies (Dicker et al. 1982), abdominal hysterectomy has been the main method of hysterectomy in the United States, the United Kingdom and Finland (Easterday et al. 1983; Luoto et al. 1994; Davies et al. 1998). Ten years ago 92% of hysterectomies were performed abdominally in Finland (Luoto et al. 1994). The optimum approach to hysterectomy would retain the advantages of the abdominal route, which include clear visualization and ease of manipulation of the adnexal structures, and to combine these features with the principal advantage of vaginal hysterectomy, namely avoidance of a large abdominal incision. Laparoscopic hysterectomy tries to combine these techniques and it has already influenced approaches to hysterectomy, offering a short recovery for the patient (Garry 1998).

This study evaluates the advantages and disadvantages of laparoscopic hysterectomy and its influence on other methods of hysterectomy in Finland.

REVIEW OF THE LITERATURE

HISTORY OF HYSTERECTOMY

Vaginal hysterectomy

Vaginal hysterectomy dates back to ancient times. The procedure was performed by Soranus in Greece 120 years after the birth of Christ. The first authenticated vaginal hysterectomy was performed by Berengario da Capri of Bologna in 1507. These hysterectomies were carried out sporadically and only because of uterine prolapse or uterine inversion. Usually the bladder and the ureters were torn and the patients rarely survived. However, there are some reports of patients surviving after vaginal hysterectomy in the middle ages. Baudelocque of France introduced the technique of artificially prolapsing and cutting away the uterus. He performed 23 vaginal hysterectomies over 16 years from 1800. Most of these procedures were emergency operations on puerperal uteri. At the end of the 19th century and the beginning of the 20th century, the development of instrumentation, anesthesia and antisepsis decreased the mortality rate from 15% in 1886 to 2.5% in 1910. These figures were at that time much lower than for abdominal hysterectomy (Sutton 1997) .

Abdominal hysterectomy

The human abdomen was deliberately surgically opened for the first time in 1809 by the pioneering surgeon McDowell in Kentucky, USA. The first abdominal hysterectomy in the world was performed by Charles Clay in 1843 in Manchester, England. He performed a subtotal hysterectomy as a result of a huge uterine fibroid and the patient died from a massive hemorrhage within a few hours. The first successful abdominal hysterectomy with a patient surviving was performed by Ellis Burnham in 1853 in Massachusetts, USA. Early procedures were performed without anesthesia and the mortality rate was 70-90%, even as late as 1880. In the late 19th century Thomas Keith from Scotland reported a mortality rate of 8% after cauterizing the cervical stump and allowing it to fall internally. Hysterectomy also became safer with the introduction of anesthesia, antibiotics, antisepsis, blood infusions and intravenous therapy. Up until the 1950s, the main approach to hysterectomy was the subtotal procedure. In 1929 Richardson in the USA performed the first total abdominal hysterectomy to avoid discharge from the cervical remnant

and to avoid cervical stump carcinoma (Sutton 1997).

Laparoscopic hysterectomy

The origin of endoscopy can be traced to the Greek school of Kos led by Hippocrates (460-375 BC), who described the use of rectal and primitive vaginal speculae. Bozzini of Italy in 1805 looked inside the urethra by using a tube and a candle. The forerunner of the optical system of modern endoscopes is a cystoscope developed by Nitze of Germany in 1877. The first human laparoscopy was performed by Jacobaeus of Sweden in 1910 by using pneumoperitoneum and a Nitze cystoscope. It was Raoul Palmer of France who popularized gynecological laparoscopy in the 1940s and he is considered to be the father of modern gynecological laparoscopy. He also performed the first human laparoscopic tubal fulguration in 1962. The development of rod lens systems, external cold light sources and fiberoptics in the 1950s improved the visibility, but because of the uncomfortable working position, laparoscopy was used only by a limited group of gynecologists in the 1970s (Semm in Germany, Bruhat in France, Gomel in Canada and Hulka and Phillips in the USA). In the 1980s, the introduction of videolaparoscopy and monitors was revolutionary and it became clear that laparoscopy could be used for therapy as well as diagnosis. Thus, more difficult procedures were carried out laparoscopically (Gomel 1989; Nezhat et al. 1992a; Garry 1993; Sutton 1997).

Kurt Semm in Germany first described a technique for laparoscopic assistance in vaginal hysterectomy in 1984. The adnexa were separated laparoscopically in order to simplify vaginal hysterectomy (Munro and Deprest 1995; Mettler et al. 1996). This was later called laparoscopically assisted vaginal hysterectomy (LAVH) (Kovac et al. 1990). Harry Reich performed the first laparoscopic hysterectomy (LH) in January, 1988. The ligaments and uterine vessels were coagulated with bipolar forceps and cut with scissors. The anterior vagina was opened using a unipolar cutting current and the posterior vaginal fornix using laser. The uterosacral ligaments were clamped and divided vaginally and the uterus was removed. The vagina was closed vaginally. The total operating time was 180 minutes, the uterus weighed 230 g and the patient was discharged on the fourth postoperative day (Reich et al. 1989).

ALTERNATIVE TECHNIQUES OF HYSTERECTOMY

Abdominal hysterectomy (AH)

Total abdominal hysterectomy (TAH)

This technique has undergone few modifications in modern times since it was described originally by Dr. Edward Richardson in 1929 and it is still the main technique used in many countries. Women are operated on through a lower midline or Pfannestiel incision. The upper pedicles are clamped, cut and ligated. The leaves of the broad ligament are incised, the bladder is gently pulled down, the uterine vessels are skeletonized, cut and ligated and the cardinal and uterosacral ligaments are also clamped, cut and ligated. The uterus is removed by incising the vagina below the cervix (Thompson and Warshaw 1996).

Subtotal abdominal hysterectomy (SAH)

The technique of a subtotal hysterectomy is identical to that for total abdominal hysterectomy until ligation of the uterine vessels has been performed. The uterine corpus is amputated by cutting across the cervix at the level of the internal cervical os. The cervical stump is closed and suspended with ligaments (Thompson and Warshaw 1996).

Vaginal hysterectomy (VH)

A circumferential incision is made around the cervix, the bladder is dissected away from the cervix and the peritoneal cavity is reached from the anterior and posterior vaginal fornix. The cardinal and uterosacral ligaments are ligated to allow the uterus to descend before cutting the uterine vessels. The upper pedicles are ligated after the uterus has been delivered vaginally. If the ovaries are to be removed, clamps are first placed across the mesosalpinx and then across the infundibulopelvic ligament (Thompson and Warshaw 1996). There are also several techniques to reduce uterine size during the procedure. The uterus may be bisected with a knife in an antero-posterior direction towards the fundus. Wedge morcellation may be performed by amputating the cervix and removing V-shaped pieces of tissue, combined with myomectomy if necessary. In addition, intramyometrial coring decreases the size of the uterus. It is carried out by incising the myometrium parallel to the long axis of the uterine cavity (Kovac 1986 and 1997; Magos et al. 1996).

A technique without ligation of the paracervical ligaments is used in Japan. The lower ligaments are cut only with scissors, and the uterine arteries, the upper ligaments and tubes are ligated and divided. At this stage the uterine arteries and cardinal ligaments are sutured together (Kudo et al. 1990). Another modification of vaginal hysterectomy is Döderlein vaginal hysterectomy. After first delivering the fundus of the uterus through the anterior or posterior vaginal wall, the pedicles can then be secured vaginally in the same order as they would be in regular abdominal hysterectomy (Garry 1994a). Subtotal hysterectomy may be also performed in this manner (Pelosi and Pelosi 1997).

Laparoscopic hysterectomy

Laparoscopy can be used to completely remove the uterus or to facilitate vaginal hysterectomy. After the first laparoscopic hysterectomy was performed in January 1988 (Reich et al. 1989), many different techniques have been reported. The procedure usually begins with insufflation of the abdomen with a Veress needle and insertion of the primary trocar through the umbilicus. A videolaparoscope is introduced into the abdominal cavity through the umbilical trocar. One to four secondary trocars are inserted under direct vision, avoiding abdominal wall vessels. Reusable (Chapron et al. 1994) or disposable instruments (Ou et al. 1994), electrocoagulation (Reich et al. 1989), a laser (Liu 1992a), clips (Canis et al. 1993), staplers (Reich et al. 1993), endoloops (Canis et al. 1993), sutures (Reich et al. 1993) and an ultrasonic scalpel (Kauko 1998) have been used to ligate ligaments and for hemostasis in these procedures. The metabolic and hemodynamic changes caused by pneumoperitoneum can be avoided by gasless laparoscopy (Koivusalo 1997). The operating space is created with an abdominal wall elevator which makes it possible to use conventional surgical instruments through lateral ports under the vision of the laparoscope (Maher et al. 1994; Wood and Maher 1997).

Laparoscopic hysterectomy is a spectrum of procedures and the phrase "laparoscopic hysterectomy" has been used to describe any type of surgery where laparoscopy and hysterectomy are linked together. The most commonly used classification system is presented here (Garry and Reich 1993).

Diagnostic laparoscopy with vaginal hysterectomy

The laparoscope is used for diagnostic purposes to determine if vaginal hysterectomy is possible. It can be used at the beginning of hysterectomy recommended to be performed abdominally because of

possible contraindications to the vaginal route. If no pelvic pathology is found the procedure can be continued vaginally (Kovac et al. 1990; Garry and Reich 1993; Reich et al. 1994).

Laparoscopically assisted vaginal hysterectomy (LAVH)

The fallopian tubes, round and utero-ovarian or infundibulopelvic ligaments are ligated laparoscopically. The broad ligament is opened and the bladder is pulled down. The uterine vessels, cardinal and uterosacral ligaments are ligated vaginally and the uterus is also removed through the vagina (Garry and Reich 1993; Reich et al. 1994)

Laparoscopic hysterectomy (LH)

This procedure denotes laparoscopic ligation of the upper pedicles and the uterine arteries. Cardinal and uterosacral ligaments can be divided either laparoscopically or vaginally. The uterus is removed and the vaginal incision is sutured vaginally (Garry and Reich 1993; Reich et al. 1994).

Total laparoscopic hysterectomy (TLH)

This procedure involves complete laparoscopic dissection until the uterus lies free of all attachments in the peritoneal cavity. The ureters may be dissected retroperitoneally. The uterus is morcellated in the abdominal cavity or removed through the vagina. The vaginal incision is closed with laparoscopically placed sutures (Garry and Reich 1993; Reich et al. 1994).

Laparoscopic supracervical hysterectomy (LSH)

The upper pedicles are ligated, the leaves of the broad ligament are opened and the bladder pulled down. After ligating the uterine vessels the cervix is amputated below the level of the endocervical os. The anterior pubocervical fascia and posterior cervix are sutured together and the corpus uteri is morcellated or removed through the posterior wall of the vagina (Garry and Reich 1993; Lyons 1997).

Laparoscopic classical intrafascial supracervical hysterectomy (CISH)

This procedure was described by Kurt Semm in Germany, first by the abdominal route and later by the laparoscopic route. The perforation rod is introduced transcervically up through the fundus uteri under laparoscopic control. To core out the transcervical-transuterine cylinder, a calibrated uterine resection tool (CURT) is used and the remaining cervix is electrocoagulated. The uterine body is separated from the cervix, and the cervical stump is suspended by attaching to the round ligaments. The uterus is morcellated and extracted using a

serrated-edged macro morcellator (SEMM) (Mettler et al. 1996).

Laparoscopically assisted Döderlein hysterectomy (LADH)

The upper pedicles are divided and the bladder is pulled down laparoscopically. The pneumoperitoneum is then released. An incision is made vaginally on the anterior vaginal wall. A tenaculum is applied to the fundus of the uterus and downward traction is applied to deliver the fundus vaginally. The uterine vessels and ligaments are clamped with standard hysterectomy forceps vaginally (Garry 1994a; Wood and Maher 1997).

Vaginally assisted laparoscopic hysterectomy (VALH)

The procedure is started with a vaginal part. A circular incision is made around the cervix, the bladder is pushed upwards and the anterior and posterior vaginal walls are opened. After ligating the lower ligaments and the uterine vessels, the cervix is pushed up to the abdominal cavity and the vaginal vault is closed with a continuous suture. A pneumoperitoneum is created and the remaining ligaments are cut laparoscopically. When the whole uterus lies free in the abdomen it is morcellated with a macromorcellator (Roushdy 1997).

CHARACTERISTICS OF LAPAROSCOPIC HYSTERECTOMY

Indications

Traditionally, abdominal hysterectomy has been indicated in cases of fibroids, bleeding, suspected adnexal pathology, severe endometriosis and pelvic inflammatory disease and chronic pelvic pain, and vaginal hysterectomy has been indicated mainly in cases of uterovaginal prolapse. In a CREST study in 1982 the indications for abdominal hysterectomy included fibroids (40%), and pelvic pain and endometriosis (22%), but those for vaginal hysterectomy included pelvic relaxation (30%), bleeding (28%), cervical dysplasia (21%) and fibroids (7%) (Dicker et al. 1982). Laparoscopic hysterectomy is considered as an alternative to abdominal hysterectomy when vaginal hysterectomy is contraindicated, with the advantages of avoiding a major abdominal scar and reducing recovery time. Those who are familiar with a vaginal approach to hysterectomy will not greatly benefit from the laparoscopic technique (Garry 1998).

However, not all gynecologists are prepared to perform difficult vaginal procedures and laparoscopic hysterectomy may be the way to

become familiar with a vaginal approach. Laparoscopic hysterectomy may be used in association of those indications which traditionally have been contraindicated as regards vaginal hysterectomy, thus avoiding abdominal incision (Garry 1998). Although expert vaginal surgeons report a 94% success rate in vaginal oophorectomy (Sheth 1991), most gynecologists would rather perform oophorectomy laparoscopically (Garry 1998). The great majority of hysterectomies in nulliparous women have been carried out abdominally because vaginal access may be difficult due to limited uterine mobility (Dorsey et al. 1995). In a French study, 80% of hysterectomies in nulliparous women were performed laparoscopically by experienced laparoscopists when uterine weight ranged from 40 to 840 g (Chapron et al. 1996). Laparoscopic surgery with small incisions, may also reduce the risk of wound infection in obese women (Kadar and Pelosi 1994). With large uteri, ligation of the uterine vessels is often difficult laparoscopically and may force the surgeon to convert the procedure to an abdominal operation. An extraperitoneal technique in laparoscopic hysterectomy offers systematic dissection of the retroperitoneum to identify the ureters and uterine arteries, where they can be ligated safely without the danger of ureteral damage (Kadar 1996).

Learning curve

In Belgium, a group of eight gynecological laparoscopic surgeons from six centers started a register on laparoscopic hysterectomy in June 1991 to study first experiences of laparoscopic hysterectomy (the Belcohyst register). Every surgeon had great experience in endoscopic surgery before performing the first procedures. Altogether, 413 hysterectomies were carried out; about two-thirds were LAVH, one-third LH and only a few were TLH. The mean operating time among all the cases was 118 min and during the first year of registration the operating time decreased with increasing experience. In the first 30 cases, operating time decreased sharply in one center from 200 min to 100 min and leveled after 40 cases to 80 min. The operating time did not drop further because at the same time uterine weight went up slightly. Major complications and conversions to abdominal hysterectomy continued to occur at the same rates throughout the study (Deprest et al. 1996).

Another study was carried out in Australia to determine learning curves for laparoscopic hysterectomy for a trainee and for an experienced gynecologist. The investigators wanted to see how many procedures are needed to achieve an acceptable level of

performance. Over a 12-month period 21 women were operated on by the trainee and 33 women by the experienced surgeon. The average operating time for the trainee was 145 min, decreasing from 180 min to 105 min by the end of the period. After 16 completed procedures, the operating time was 105 min and it was considered by supervising staff that the trainee had achieved sufficient competence. As expected, the average operating time for the experienced surgeon was shorter (99 min), decreasing from 145 min to 80 min within the first year. A plateau was reached after ten cases. No correlation was found in either group between operating time and uterine weight, patient weight or previous abdominal surgery and no difference in complications was seen between the trainee's patients and those of the experienced surgeon (Rosen et al. 1998).

Clinical outcome

After the report of the first LH (Reich et al. 1989) many observational reports of personal experience or results from specialized centers were published. Later on some comparative studies on clinical outcome between different hysterectomy techniques were reported and there have been eleven randomized controlled studies in which laparoscopic and abdominal or vaginal hysterectomy have been compared (Nezhat et al. 1992b; Summitt et al. 1992; Phipps and Nayak 1993; Raju and Auld 1994; Richardson et al. 1995; Langebrenne et al. 1996; Olsson et al. 1996; Summitt et al. 1998; Yuen et al. 1998; Falcone et al. 1999; Marana et al. 1999). Two large review articles have been published concerning data on clinical outcome from small personal and comparative series, and including different techniques. Munro and Deprest analyzed all reported studies from 1989 to 1994. A total of 2975 laparoscopic hysterectomies were recorded, with 314 reported in the context of a comparative study (Munro and Deprest 1995). Meikle et al. reviewed published literature on laparoscopic hysterectomy from 1989 to September 1995. Cases identified included 3112 laparoscopic, 1618 abdominal and 690 vaginal hysterectomies. The studies were from eight countries, but more than half of them were from the United States (Meikle et al. 1997). Two other reviews were concentrated only on complications: 29 studies and 3189 procedures (Garry and Phillips 1995), and 34 studies and 2412 procedures (Harris and Daniell 1996).

Operating time

Operating times have ranged on average from two to four hours in personal reports by experts in laparoscopy (Kovac et al. 1990;

Langebrekke et al. 1992; Liu 1992b; Nezhat et al. 1992b; Padial et al. 1992; Canis et al. 1993; Hasson et al. 1993; Phipps et al. 1993; Chapron et al. 1994). In the two reviews, the average operating times were 115 and 117 minutes (Munro and Deprest 1995; Meikle et al. 1997). These authors stated that most of these reports were the surgeon's or institution's initial experiences and operating times would decrease with the learning curve. The group with a 4-hour average operating time had 29 surgeons, but 13 performed the procedure only once and only four surgeons performed more than five operations (Boike et al. 1993). The shortest reported operating times were those of a single surgeon or small groups of surgeons who reported more than 100 laparoscopic hysterectomies (range 65-180 min). In all comparative studies the shortest operating time was in vaginal hysterectomy and the longest in laparoscopic hysterectomy (Munro and Deprest 1995; Meikle et al. 1997).

In a large retrospective hysterectomy study from one hospital, 2563 hysterectomies were performed from 1991 to 1993 (1184 abdominal, 530 vaginal and 839 laparoscopic hysterectomies) and average operating times were 82, 63 and 102 minutes, respectively (Johns et al. 1995). In the Belcohyst study the mean operating time among all 413 cases was 118 min, but this differed according to the extent of the laparoscopic part of the operation (104 min for LAVH, 123 min for LH and 120 min for TLH). The operating time was negatively correlated with the experience of the surgeon and positively correlated with uterine weight (Deprest et al. 1996). Some surgeons have reported that the operating time is decreased when using stapling devices (Phipps et al. 1993; Molloy and Doodly 1997) and a mean operating time of 60 min has been reported when vessels were ligated vaginally (Bolger et al. 1997). Short operating times have also been reported in LSH; a mean operating time of 62 min in a series of 500 operations (Donnez et al. 1997).

Nine of the eleven randomized controlled trials compared laparoscopic hysterectomy with abdominal operation and two of them with vaginal hysterectomy. In eight studies it was concluded that laparoscopic procedures took significantly longer to perform than traditional hysterectomies (Table 1). In one study there was a positive correlation between uterine weight and operating time in vaginal hysterectomy but not in laparoscopic hysterectomy (Richardon et al. 1995). The results of two randomized studies showed for the first time that the mean operating times were similar in laparoscopic and abdominal hysterectomy (Yuen et al. 1998; Marana et al. 1999).

Table 1. Randomized studies comparing laparoscopic hysterectomy with abdominal or vaginal hysterectomy

Authors	Study	Operating time (minutes)	Blood loss (milliliters)	Pain	Hospital stay (days)	Convalescence (days)	Complications
Nezhat et al. 1992	10 LH vs 10 TAH	160 vs 102*	210 vs 330*	NR	2.4 vs 4.4*	21 vs 35*	10% vs 20%
Phipps et al. 1993	24 LH vs 29 TAH	65 vs 30*	NR	more in TAH*	2.0 vs 6.0*	14 vs 42*	0% vs 0%
Raju et al. 1994	40 LAVH vs 40 TAH	100 vs 57*	260 vs 220	more in TAH*	3.5 vs 6.0*	21 vs 42*	5% vs 2.5%
Langebrekkeet al. 1996	46 LH vs 54 TAH	100 vs 61*	Hb drop same	more in TAH*	2.0 vs 5.0*	20 vs 37*	22% vs 26%
Olsson et al. 1996	71 LH vs 72 TAH	148 vs 85*	Hb drop in TAH*	more in TAH*	2.0 vs 4.0*	16 vs 35*	27% vs 33%
Summit et al. 1998	34 LAVH vs 31 TAH	180 vs 146	568 vs 661	more in TAH*	2.1 vs 4.1*	28 vs 38*	21% vs 32%
Yuen et al. 1998	20 LH vs 24 TAH	95 vs 105	200 vs 450*	NR	4.0 vs 6.0*	NR	50% vs 63%
Falcone et al. 1999	23 LH vs 23 TAH	180 vs 130*	450 vs 250*	more in TAH*	1.5 vs 2.5*	33 vs 42	43% vs 24%
Marana et al. 1999	58 LAVH vs 58 TAH	91 vs 92	265 vs 354*	more in TAH*	4.0 vs 5.9*	NR	5% vs 12%
Summitt et al. 1992	29 LH vs 27 VH	120 vs 65*	204 vs 376*	more in LH*	0.5 vs 0.5	NR	11% vs 7%
Richardson et al. 1995	22 LH vs 23 VH	131 vs 77*	272 vs 181	same	3.2 vs 3.3	23 vs 22	36% vs 30%

LH = laparoscopic hysterectomy

LAVH = laparoscopically assisted vaginal hysterectomy

TAH = total abdominal hysterectomy

VH = total vaginal hysterectomy

NR = not reported, *statistically significant $P < 0.05$

Figures are means

Operative blood loss

Blood loss is often calculated as the difference between the amount of irrigation fluid introduced into the pelvic cavity and the amount of fluid aspirated during surgery. Some authors have estimated blood loss by the drop in hemoglobin concentration or hematocrit from the preoperative value. In the Belcohyst study the hematocrit drop was 6.2% from the preoperative value and the blood transfusion rate was 5.4% (Deprest et al. 1996). In one observational retrospective study the hematocrit drop was 5.4% in abdominal, 5.5% in vaginal and 6% in laparoscopic hysterectomy, but there was no statistical difference in these parameters (Johns et al.1995). There was significantly less blood loss in laparoscopic compared with traditional hysterectomies in six out of ten randomized studies (Table 1).

Postoperative pain

In Meikle's review, postoperative analgesia was reported by six authors. Analgesia requirements were measured either by the duration of use of any analgesic or the amount of both oral and injectable pain medication. Abdominally operated women needed more pain medication than laparoscopically operated women and a slight increase of pain medication use or no difference was seen between laparoscopic and vaginal hysterectomy (Meikle et al. 1997). In one prospective study, the least postoperative pain was experienced in laparoscopic and laparoscopic subtotal hysterectomy, followed by vaginal and abdominal hysterectomy (Roushdy et al. 1997). Finally, in nine randomized trials, pain was measured as need of analgesia or by means of a visual analog scale. In seven studies there was less pain after laparoscopic than abdominal hysterectomy, one study showed less pain after vaginal than laparoscopic hysterectomy and in one study there was no difference in analgesia between vaginal and laparoscopic hysterectomy (Table 1).

Hospital stay

In a report of Texas, the mean hospital stay was 44 hours for laparoscopic, 68 hours for abdominal and 43 hours for vaginal hysterectomy. During the three study years, the length of stay for vaginal and laparoscopic hysterectomy steadily converged and was identical at the end of the study period (Johns et al. 1995). In the Belcohyst study the mean duration of hospital stay was 4.0 days, but a patient having an abdominal hysterectomy usually stayed in hospital for 7 to 9 postoperative days (Deprest et al. 1996). In the review by Munro and Deprest (1995) the average hospital stay was 1.6 days for laparoscopic, 4.2 days for abdominal and 4.0 days for vaginal hysterectomy and in the review by Meikle et al. (1997) the average

hospital stay was 2.0 days for laparoscopic and 3.3 days for abdominal hysterectomy. In all randomized trials the hospital stay was significantly shorter after laparoscopic compared with abdominal hysterectomy and similar to that after vaginal hysterectomy (Table 1).

Convalescence time

A retrospective telephone survey of 100 women who had undergone laparoscopic hysterectomy revealed the mean time to return to work to be 3.3 weeks in Australia. The women reported that they could have returned to work at 2.3 weeks on average (Rosen et al. 1997). In one comparative study the patients returned to work in two weeks after laparoscopic hysterectomy compared with five to six weeks after abdominal and vaginal hysterectomy (Bronitsky et al. 1993). In the review by Meikle et al. (1997) of observational and comparative studies, the time to return to work was always less for laparoscopic compared with abdominal hysterectomy (2 to 6 weeks for LH and 5 to 9 weeks for TAH). In all but one randomized trial comparing laparoscopic with abdominal hysterectomy, the average convalescence time was shorter after laparoscopic hysterectomy, but no difference was seen between laparoscopic and vaginal hysterectomy (Table 1).

Tissue trauma

Surgical tissue trauma can be measured by means of biochemical markers. Surgical trauma is followed by a release of cytokines from lymphocytes, macrophages, fibroblasts and endothelial cells of damaged tissues. A major cytokine is interleukin-6 (IL-6), which stimulates acute phase protein synthesis such as C-reactive protein (CRP) in the liver, and elevated levels of IL-6 and CRP have been detected postoperatively (Ohzato et al. 1992; Wortel et al. 1993; Moore et al. 1994; Gabay and Kushner 1999). Tumor-associated trypsin inhibitor (TATI) is synthesized, for example, in the pancreas and liver. TATI has also been suggested to be an acute phase reactant which is induced by inflammatory cytokines such as interleukins IL-1 and IL-6. The mechanisms causing elevation of TATI and CRP concentrations are not identical and a very strong acute phase stimulus is required before TATI levels become increased. Elevated TATI levels after major surgery could be related to the repair of injured tissues (Matsuda et al. 1985; Stenman et al. 1989). The tumor-associated antigen CA 125 (CA 125) is a glycoprotein and its circulating concentrations were initially reported to be elevated in ovarian cancer, but later it was also found to be a normal product of the endometrium. Elevated serum concentrations of CA 125 have

been detected during menstruation, pregnancy, in endometriosis and after surgery (Jacobs and Bast 1989; Van Der Zee et al. 1990; Talbot et al. 1989).

Metabolic changes and intraperitoneal trauma have been found to be more marked after gynecological laparotomy than after laparoscopy (Volz et al. 1997). Tissue damage has been assessed and compared during laparoscopic, abdominal and vaginal hysterectomy by measuring the activity of creatine kinase. Statistically, the highest values were associated with abdominal hysterectomy, followed by laparoscopic and vaginal hysterectomy, suggesting the greatest tissue damage after abdominal hysterectomy (Holub et al. 1998). Two randomized studies have been published in which tissue trauma after laparoscopic and abdominal hysterectomy has been investigated. In one study, postoperative concentrations of IL-6, cortisol, CRP, polymorphonuclear elastase, and terminal C5b-9 complement complex were assessed. Elevated levels were seen in all but the last marker after the procedures, but no difference was seen between laparoscopic and abdominal hysterectomy (Ellström et al. 1996). In the other study, the laparoscopic hysterectomy group demonstrated a less intense stress response in terms of lower concentrations of serum IL-6, CRP and cortisol, white blood cell count and urinary excretion of cortisol and norepinephrine, compared with the abdominal hysterectomy group (Yuen et al. 1998).

Long-term follow-up

Since only ten years have passed since the first LH, no long-term results are available. There are no data to suggest or refute claims that the laparoscopic approach to hysterectomy reduces or increases the risk of later vaginal prolapse or incontinence.

Postoperative changes in the vaginal axis have been noticed after abdominal, vaginal and laparoscopic hysterectomy. At postoperative examination at seven weeks, the angulated shape of the vagina remained almost unchanged after VH, whereas after TAH, the vagina had become very straight. Vaginal angulation after LH was similar to that after VH and it may be important in speculation about the risk of vaginal vault prolapse after hysterectomy (Virtanen et al. 1996).

Hysterectomy and sexuality have been a subject of debate for decades. Reasons to retain the cervix have been avoidance of injury to the pelvic floor and limitation of surgical risk (Thompson et al. 1996; Scott et al. 1997). Both improvement and deterioration of sacral

nervous function and pelvic muscular strength have been found following subtotal abdominal hysterectomy, but the changes were of no value in predicting or evaluating postoperative sexual function (Helström et al. 1994; Brown and Erian 1995). Women at risk of developing problems with sexuality have been those with no or low sexual activity, negative attitudes to sex, poor social support, complicating psychiatric or somatic problems and a history of sexual dysfunction in the couple (Helström et al. 1993). In early reports, hysterectomy alone did not have any effect on libido (Richards et al. 1974). Kilkku et al. reported in 1983 that total abdominal hysterectomy more adversely affected female orgasm and dyspareunia compared with subtotal abdominal hysterectomy (Kilkku 1983; Kilkku et al. 1983), but ten years later the results of another study showed that total abdominal hysterectomy did not provoke harmful urinary or sexual symptoms (Virtanen et al. 1993). According to one study of laparoscopic hysterectomy, sex life was improved in 40%, unchanged in 53% and worse in 7% of women after the operation (Ewert et al. 1995).

Cost-effectiveness

In early studies of laparoscopic hysterectomy, the costs of laparoscopic procedures were greater than those of abdominal and vaginal hysterectomy because more expensive disposable instruments were used. Although the hospital stay was shorter in laparoscopic hysterectomy groups, the hospital expenses were increased (Munro and Deprest 1995; Dorsey et al. 1996; Weber and Lee 1996; Meikle et al. 1997). In two large comparative studies, hospitalization costs were highest for abdominal hysterectomy, followed by laparoscopic and vaginal hysterectomy, when using reusable instruments. In addition, after abdominal hysterectomy women came for more postoperative visits, which also increased total costs for abdominal hysterectomy (Johns et al. 1995; Van Der Eeden et al. 1998). Laparoscopic hysterectomy was found to be the cheapest method of hysterectomy when using reusable instruments, in a Belgian study (Nisolle and Donnez 1997).

In five randomized studies the total costs of these three different types of hysterectomy were compared. Laparoscopic hysterectomy was more expensive than abdominal and vaginal hysterectomy when disposable instruments were used (Summitt et al. 1992; Phipps and Nayak 1993; Summitt et al. 1998), but in one study the total costs were less for laparoscopic hysterectomy because of the shorter hospital stay (Raju and Auld 1994). In a Swedish study comparing

laparoscopic and abdominal hysterectomy the economic analysis covered a period of 12 weeks, starting on the day the patients entered the hospital. The direct and indirect costs were lower in laparoscopic hysterectomy and by changing from laparotomy to laparoscopic surgery the indirect costs following hysterectomy could be halved (Ellström et al. 1998). None of these studies, however, included the costs of the possible complications.

COMPLICATIONS

Complications of laparoscopy

Complications in the early years of laparoscopy

Surveys of laparoscopic complications were started in Germany as early as 1949 (Table 2) (Lehmann-Willenbrock et al. 1992), in France in the 1950s (Mintz 1977) and in the United States in 1972 (Table 3) (Phillips et al. 1977, 1978, 1981, 1984; Hulka 1980; Hulka et al. 1987, 1990; Peterson et al. 1990). In the United Kingdom, a prospective national survey of laparoscopic complications was performed for one year from 1976 (Chamberlain 1980; Hulka 1990). According to these studies, major complications requiring laparotomy decreased and at the end of the 1980s the incidence of major complications varied between 1.0/1000 and 3.1/1000 in diagnostic laparoscopies, between 0.4/1000 and 2.1/1000 in sterilization laparoscopies and between 1.4-4.7/1000 in operative laparoscopies.

Table 2. Major complications of laparoscopy in Germany

Survey	Major complications	Deaths
1949-1977	3.6 /1000	9.0 /100,000
1978-1982	1.9 /1000	5.1 /100,000
1983-1985	2.0 /1000	2.4 /100,000
1986-1988	2.4 /1000	0.8 /100,000
Total	2.5 /1000	4.4 /100,000

Table 3. Surveys of the American Association of Gynecologic Laparoscopists

Year	Major complications (n/1000)			Deaths (n/100,000)		
	Diagnostic	Sterilization	Operative	Diagnostic	Sterilization	Operative
1972	6.0	6.0	-	30.0	30.0	-
1973	5.0	5.0	-	13.0	13.0	-
1974	8.5	4.2	-	-	-	-
1975	3.1	2.8	-	11.0	0.0	-
1976	5.4	2.7	-	0.0	4.0	-
1979	2.6	1.8	-	0.0	2.0	-
1982	-	1.5	-	-	-	-
1985	3.1	1.6	-	0.0	0.0	-
1988	3.1	2.1	4.7	4.8	0.0	5.4
1991	4.9	1.4	12.2	2.4	3.3	1.8
1993	5.0	1.0	15.3	0.0	4.4	6.7

Complications of laparoscopy in the 1990s

The American Association of Gynecologic Laparoscopists (AAGL) was founded in 1972 and since then it has evaluated complications of laparoscopy among its members. The response rate, however, has decreased from 78% in 1972 to as low as 12% in 1993. Major complications, which include injuries requiring laparotomy, decreased in sterilization laparoscopies but increased in diagnostic and operative laparoscopies including laparoscopic hysterectomies (Table 3). In addition, bowel and urinary tract injuries increased from 1.6/1000 in 1988 to 4.1/1000 in 1993 (Hulka et al. 1993, 1995a, 1995b; Peterson et al. 1993; Levy et al. 1994).

Table 4. Major complications of laparoscopy in France

Years	Diagnostic	Minor	Major	Advanced	Major+Advanced	All
1987-1989	1.6	0.4	4.5	12.5	4.6	2.8
1990-1991	1.8	0.7	5.2	8.6	5.8	4.0
1992-1995	2.2	1.8	3.6	22.0	8.9	6.9
Total	1.8	0.8	4.3	17.5	6.8	4.6

Numbers are given as n/1000

In France, seven highly specialized laparoscopic centers

retrospectively studied major complications from 1987 to 1989 and prospectively studied them from 1990 through 1995 (Table 4). Minor laparoscopies included minimal adhesiolysis, destruction of minimal endometriosis, ovarian puncture and biopsy and tubal sterilization; major laparoscopies included extended adhesiolysis, tuboplasties, procedures associated with ectopic pregnancy, ovarian cysts and moderate and severe endometriosis, and advanced laparoscopies included procedures such as hysterectomy, adnexectomy, myomectomy, bladder neck suspension and lymphadenectomy. A total of 29,966 procedures has been carried out, the overall major complication rate has been 4.6/1000 laparoscopies and the mortality rate has been 3.3/100,000 laparoscopies. The incidences of major complications in diagnostic and minor laparoscopies were significantly lower than in major and advanced laparoscopies. Complications in advanced laparoscopies increased significantly from the first to the last survey and the proportion of major and advanced laparoscopies increased from 49% to 71%. Bowel injuries decreased and urological injuries increased during the nine study years and the incidence of major complications in laparoscopic hysterectomy was 13.3/1000 (Querleu et al. 1993; Chapron et al. 1998).

A nationwide prospective study was performed in The Netherlands in 1994. Questionnaires were sent to all gynecological units and 55% responded. Major complications requiring further surgery, either laparoscopy or laparotomy, and deaths were investigated. The total complication rate was 5.7/1000 laparoscopies; 2.7/1000 in diagnostic laparoscopies, 4.5/1000 in sterilization laparoscopies and 17.9/1000 in operative laparoscopies. The highest incidence was registered for complications occurring in laparoscopic hysterectomies (90.2/1000). The overall laparotomy rate was 3.3/1000 and the death rate was 7.8/100,000. The most frequently observed complications were hemorrhage of the epigastric vein and intestinal injury. Previous laparotomy and surgical experience were associated with complications requiring laparotomy (Jansen et al. 1997).

Retrospective analyses of single centers have revealed major complication rates of 1.2-2.2/1000 laparoscopic procedures not including laparoscopic hysterectomies (Bateman et al. 1996; Tsaltas et al. 1996). In one French center the major complication rate was 0/1000 in diagnostic laparoscopies but 10.6/1000 in operative laparoscopies, even without laparoscopic hysterectomies (Lécuru et al. 1996). On the other hand, in some personal surveys of operative laparoscopies carried out by experienced surgeons, the reported total complication rate has been 10.4% and the unplanned surgery rate for

management of complications has been 3.8% (Saidi et al. 1994, 1996).

Complications associated with laparoscopic entry

Laparoscopic surgery has both risks associated with the specific operation undertaken and with laparoscopic access. Complications specifically associated with laparoscopic entry include: 1. failure to gain access to the abdominal cavity, 2. damage to major retro-peritoneal blood vessels, 3. damage to the gastrointestinal tract, 4. damage to the vessels of the abdominal wall and 5. post-laparoscopic bowel herniation through the entry scars (Garry 1997).

In the French anonymous register of laparoscopic complications, regardless of the operator, the indication for laparoscopy or the type of trocar used, some patients appeared to be particularly at risk as regards entry-related laparoscopic injuries. Seventy-two percent of the women had undergone previous abdominal surgery and 54% were overweight. In 30% of cases, safety rules for trocar insertion were not followed. Laparotomy was needed in 64% of all cases, and 90% of cases if vascular injuries to the abdominal wall were not included (Marret et al. 1998).

In the Netherlands' study, 57% of all complications were a result of the surgical approach. In diagnostic laparoscopies, as many as 94% of the complications were caused by the laparoscopic approach. The overall major complication rate was 5.7/1000 and the rate of entry-related complications was 3.2/1000 laparoscopies. Fifty-two percent of entry-related injuries were treated by way of laparotomy (Jansen et al. 1997).

The incidence of incisional hernias has been between 0.1/1000 (Jansen et al. 1997) and 10/1000 laparoscopies (Li et al. 1997). In gynecological laparoscopy the most often used trocar sizes are 5, 10 and 12 mm. An incidence of 2.3/1000 has been reported with 10 mm trocars and 31.0/1000 with 12mm trocars (Kadar et al. 1993). Ninety-six percent of incisional hernias have been caused by trocars of at least 10 mm in size and fascial closure is recommended whenever a 10 mm or larger trocar is used. One-fourth of hernias have been umbilical. Most hernias have occurred without peritoneal lining and have contained small or large bowel or omentum (Lajer et al. 1997; Li et al. 1997). In addition, abdominal wall vessel injuries are related to laparoscopic entry at an incidence rate of 0.2-1.5/1000 laparoscopies (Mintz 1977; Lehmann-Willenbrock et al. 1992; Jansen et al. 1997; Chapron et al. 1998).

Gastrointestinal injuries

Bowel injuries are one of the most important complications of laparoscopic surgery because they are potentially life threatening, especially if the injury is not recognized at the time of operation. The overall incidence of bowel injury has been 0.4-1.6/1000 laparoscopies (Mintz 1977; Lehmann-Willenbrock et al. 1992; Jansen et al. 1997; Chapron et al. 1998). The risk is higher in operative laparoscopy (2.4/1000) than in diagnostic laparoscopy (0.5/1000) (Chapron et al. 1998). Damage to the small bowel is frequently missed and commonly leads to severe complications (Garry 1994b). The injury caused by a Veress needle may be managed expectantly. Trocar perforation or sharp laceration with another instrument may be sutured by way of laparoscopy, minilaparotomy or laparotomy. Thermal injury may be sutured or may necessitate segmental resection depending on the size of the injury (Nezhat et al. 1993; Li et al. 1997; Hill et al. 1998a).

Fifty-six patients with 62 gastrointestinal injuries were reported to the register of the French Society of Gynecological Endoscopy anonymously. One-third of the complications occurred during the laparoscopic approach and 79% of cases occurred during operative laparoscopies. Diagnosis of these injuries was made during primary surgery in only 36% of cases. The small bowel was injured in 34% of cases and the large bowel in 48%. Treatment of bowel injuries was most often performed by way of laparotomy. However, almost half of the injuries diagnosed peroperatively were treated by way of laparoscopy, but only 3% of injuries diagnosed postoperatively (Chapron et al. 1999).

Urinary tract injuries

Injury to the bladder may result from a secondary trocar or from dissection of the bladder, and the incidence rate is 0.2-1.1/1000 laparoscopies (Jansen et al. 1997; Chapron et al. 1998). Bladder injuries have even occurred at a rate of 8.4/1000 in major operative laparoscopies (Saidi et al. 1996a). Bladder injury recognized during laparoscopy may be sutured by way of laparoscopy (Reich et al. 1990) or laparotomy followed by bladder drainage. Small bladder injuries not recognized during laparoscopy may be managed conservatively with a Foley catheter, whereas a larger defect would require sutures (Li et al. 1997).

Bladder perforation may result in vesicovaginal fistula and incidence rates of 0.03/1000 in all laparoscopies (Chapron et al. 1998) and 0.3-3.1/1000 in advanced laparoscopies have been reported (Saidi et al. 1996; Chapron et al. 1998). The fistula may be repaired

laparoscopically (Nezhat et al. 1994), vaginally (Labasky and Leach 1990) or abdominally (Saidi et al. 1996b).

Ureteral injuries occur in 0.08-0.2/1000 laparoscopies (Jansen et al. 1997; Chapron et al. 1998) but the incidence increases with more advanced operative laparoscopies, up to 1.2-4.2/1000 (Saidi et al. 1996b; Tamussino et al. 1998; Chapron et al. 1998). Ureteral injury rates as high as 42.9/1000 in laparoscopic hysterectomies (Tamussino et al. 1998) and 29.4/1000 in laparoscopic adnexectomy (Saidi et al. 1996b) have been reported. A small laceration of the ureter may be managed by insertion of a ureteric stent or it can be sutured even laparoscopically (Nezhat and Nezhat 1992). In most cases, laparotomy is required with one of the following procedures: reimplantation of the ureter into the bladder, end-to-end anastomosis of the damaged ureter, or transureteral ureterostomy (Li et al. 1997; Grainger et al. 1990).

In a review of thirteen ureteral injuries in the 1980s, none were diagnosed intraoperatively. Endometriosis was the indication for the laparoscopic procedure in 39% of cases and adhesions in 31% of cases. Thirty-three percent of patients underwent transverse ureteroureterostomy, 25% end-to-end anastomosis, 25% ureteral stenting, 8% ureteroneocystostomy and 8% ileal interposition (interposition of a loop of ileum between the ureter and the bladder). In the follow-up period, 58% of the patients had an uncomplicated recovery, 17% underwent nephrectomy (2 patients), 8% (1 patient) ureteral dilatation, 8% (1 patient) had hydronephrosis with chronic infection and 8% (1 patient) had a loss of renal function but did not undergo nephrectomy (Grainger et al. 1990).

Major vascular injuries

The most dangerous complications of laparoscopy are injuries of the aorta, vena cava, iliac vessels and mesenteric vessels. The incidence of major vascular injury has been reported to be 0.2-1.0/1000 laparoscopies (Mintz 1977; Lehmann-Willenbrock et al. 1992; Jansen et al. 1997; Chapron et al. 1998). The risk is almost the same in diagnostic (0.2/1000) as in operative laparoscopy (0.3/1000) (Chapron et al. 1998).

Twenty-one major vascular injuries to 17 patients have been reported to the complication register of The French Society of Gynecological Endoscopy (24% external iliac vessels, 24% vena cava, 19% aorta, 19% common iliac vessels, 10% mesenteric vessels and 4% not specified). Seventy-seven percent occurred during the setting up

phase of laparoscopy and 33% during the operative procedure. The injury was repaired by way of laparotomy in 94% of cases and 12% died (Chapron et al. 1997a).

Other injuries

Carbon dioxide insufflation may cause potential complications by elevation of blood carbon dioxide level and elevation of intra-abdominal pressure. These changes may cause increase in blood pressure and cardiac output but decrease in venous return from the lower part of the body by vena caval compression leading to deep venous thrombosis. Vagal stimulation from peritoneal manipulation may produce severe bradycardia. Other rare complications have been reported during laparoscopy such as brachial plexus, peroneal and saphenous nerve paresis, gas embolism, and subcutaneous and preperitoneal emphysema (Chantigian and Chantigian 1993, Koivusalo 1997, Li et al. 1997).

Complications of hysterectomy

Complications of abdominal and vaginal hysterectomy

Most studies of complications between 1950 and 1980 were descriptive, single-center retrospective studies. These studies generally found vaginal hysterectomy to be associated with more morbidity than abdominal hysterectomy. The febrile morbidity rate has been 16-36% in abdominal and 26-55% in vaginal hysterectomy. The rate of ureteral injury has been 0.1-0.3% versus 0-0.1%, bladder injury 0.3-0.4% versus 0.2-0.3%, bowel injury 0.2% versus 0% and mortality 0.3-1.0% versus 0.2-0.3% in abdominal versus vaginal hysterectomy, respectively (White et al. 1971; Amirikia and Evans 1979). In Austria, where 60% of hysterectomies were performed vaginally in 1958-1985, the total complication rate was only 3.1%, the urinary tract injury rate was 0.6% and the mortality rate was 0.03% in over 6000 vaginal hysterectomies (Gitsch et al. 1991).

A prospective, multicenter, observational study to compare 1283 abdominal and 568 vaginal hysterectomies was performed from 1978 through 1981 in the United States and its results were opposite to those of earlier studies. The total complication rate was 42.8% in abdominal and 24.5% in vaginal hysterectomy and the febrile morbidity rate was 32.3% in abdominal and 15.3% in vaginal hysterectomy. The ureteral injury rate was 0.2% versus 0%, bladder injury 0.3% versus 1.6%, bowel injury 0.3% versus 0.6%, unintended major surgical procedures 1.7% versus 5.1% and mortality 0.1% versus 0.2% in abdominal versus vaginal hysterectomy, respectively

(Dicker et al. 1982).

Complications of laparoscopic hysterectomy

After the first laparoscopic hysterectomy many series of operations by mainly skilled gynecologists were reported. Four meta-analyses of these studies from 1989 to 1995 have been carried out (Munro and Deprest 1995; Garry and Phillips 1995; Harris and Daniell 1996; Meikle et al 1997). According to the results, the mean major complication rate was 3%-4% (Munro and Deprest 1995; Meikle et al. 1997), the mean total complication rate was 11.6%-15.6% (Garry and Phillips 1995; Munro and Deprest 1995) and the mortality rate was 0-6/100,000 (Munro and Deprest 1995; Hulka et al. 1997). A total complication rate as low as 5.8% has been reported by two experts in total laparoscopic hysterectomy (Liu and Reich 1994). A nationwide membership survey by the AAGL in 1995 evaluated complications of laparoscopic hysterectomies when 49% of the uterine vessels were secured vaginally. The overall complication rate was 6% but the response rate to the questionnaires was only 18% (Hulka et al. 1997).

Table 5. Complications of laparoscopic hysterectomy

Study	Cases	Total	Major	Urinary tract	Intestinal	Vascular
Review: Munro et al. 1995	2975	11.6%	3.0%	1.5%	0.2%	1.0%
Review: Garry et al. 1995b	3189	15.6%	?	1.4%	0.5%	1.3%
Review: Harris et al. 1996	2412	?	?	1.6%	0.2%	0.4%
Review: Meikle et al. 1997	3112	?	4.0%	2.1%	0.4%	0.8%
Series: Liu and Reich 1994	518	5.8%	3.3%	1.4%	1.2%	0.6%
AAGL: Hulka et al.1997	14.91	6.0%	?	1.5%	0.5%	3.5%
Adelaide: O'Shea et al. 1996	760	17.0%	7.7%	2.5%	?	3.0%

All laparoscopic hysterectomies in one region in Australia were analyzed to identify the true incidence of complications among gynecologists with different experience during the learning phase and the total complication rate was 17% (O'Shea and Petrucco 1996) (Table 5).

The bladder and ureters are easily damaged during laparoscopic hysterectomy and urinary tract injuries have been the most common complication with an incidence rate of 1.4-2.5%. Ureteral injuries have been reported to occur in 0.3% of cases in meta-analyses (Liu and Reich 1994; Munro and Deprest 1995; Garry and Phillips 1995; Harris and Daniell 1996; Meikle et al. 1997; Hulka et al. 1997). However, in a small series of 70 LHs, the incidence of ureteral injury was as high

as 4.3% (Tamussino et al. 1998). Most of the ureteral injuries have occurred when securing uterine vessels laparoscopically. The risk of ureteral injury may be smaller in LAVH and LSH, as in series of 300 and 500 procedures no ureteral injuries have been encountered (Bolger et al. 1997; Donnez et al. 1997). Damage to the bladder is more common than that to the ureter because the bladder must always be dissected from the anterior surface of the uterus. The reported incidence of bladder injuries has been 1.0-1.8% (Liu and Reich 1994; Munro and Deprest 1995; Garry and Phillips 1995; Harris and Daniell 1996; Meikle et al. 1997; Hulka et al. 1997) and that of vesicovaginal fistulas 0.2% (Liu et al. 1994; Harris and Daniell 1996).

Bowel injuries may occur during adhesiolysis or electrocoagulation and are highly correlated with the difficulty of the operation. The average incidences of bowel injuries in four meta-analyses were 0.2-0.5% (Munro and Deprest 1995; Garry and Phillips 1995; Harris and Daniell 1996; Meikle et al. 1997) (Table 5) and with extensive bowel dissection or aggressive cul-de-sac dissection with endometriosis the incidence may be as high as 1.2-2.2% (Harris and Daniell 1996).

Two main types of vascular structure are at risk during laparoscopic hysterectomy: those lying in the abdominal wall and those lying retroperitoneally in the pelvic side wall and posterior abdominal wall. The injuries may occur during the entry phase of laparoscopy or during the procedure with instruments or diathermy (Phipps 1995). The incidences vary considerably depending on what kind of bleeding complications are counted. The risk was 0.4-1.3% in meta-analyses (Munro and Deprest 1995; Garry and Phillips 1995; Harris and Daniell 1996; Meikle et al. 1997) and 3.0-3.5% in AAGL and Adelaide surveys (O'Shea et al. 1996; Hulka et al. 1997) (Table 5).

Comparison of complications in three alternative types of hysterectomy

When laparoscopic hysterectomy became more popular, several comparative studies concerning different hysterectomy types were planned at the beginning of the 1990s. Retrospective, single-center studies revealed mean major complication rates and total complication rates of 1% and 9% in abdominal, 5% and 7% in vaginal and 3% and 8% in laparoscopic hysterectomy, respectively (Munro and Deprest 1995; Dorsey et al. 1996). This is in accordance with the results of a large analysis of over 160,000 hysterectomies among 180 hospitals in Ohio in 1988-1994, which revealed total complication rates of 9.1%, 7.8% and 8.8% in abdominal, vaginal and laparoscopic hysterectomy,

respectively (Weber and Lee 1996).

Ten randomized studies also involved total complication rates in laparoscopic hysterectomy versus abdominal or vaginal hysterectomy. No statistically significant differences were seen in any of the studies (Nezhat et al. 1992b; Summitt et al. 1992; Phipps and Nayak 1993; Raju and Auld 1994; Richardson et al. 1995; Langebrekke et al. 1996; Olsson et al. 1996; Summitt et al. 1998; Yuen et al. 1998; Marana et al. 1999). In one of the studies there was significantly more febrile morbidity in abdominal compared with laparoscopic hysterectomy (Yuen et al. 1998) and the same tendency (non-significant) was also seen in some other studies (Table 1).

AIMS OF THE PRESENT STUDY

The main purpose of this study was to evaluate the first years of laparoscopic hysterectomy in Finland. The specific aims were:

1. to evaluate the indications, personal learning curve, outcome and complications of laparoscopic hysterectomy in Finland (I,II)
2. to investigate differences of short term clinical outcome and tissue trauma after abdominal and laparoscopic hysterectomy (III)
3. to analyze and compare urinary tract injuries associated with laparoscopic hysterectomy with those associated with other types of hysterectomy and to compare major complications of laparoscopic hysterectomy with those of other laparoscopic procedures (IV,V,VI)
4. to evaluate time trends of complications after laparoscopic hysterectomy (V,VI)

MATERIALS AND METHODS

SUBJECTS (Studies I-III)

When evaluating the personal learning curve and outcome of laparoscopic hysterectomy, the first 100 consecutive patients operated on from October 1992 through December 1993 in Helsinki University Central Hospital were studied. Patient selection was carried out prospectively and for inclusion it was required that the approximate weight of the uterus should be less than 500 g, the patient should not be excessively obese and no severe adhesions should be expected. The hospital records were retrospectively studied on previous operations, operative bleeding, operating time (time from the first incision to the last suture), hospital stay (calculated by subtracting the admission date from the discharge date) and recovery time (written sick leave) after a follow-up visit at two to four weeks (Study I).

A national register was founded to analyze the nationwide outcome of laparoscopic hysterectomies. Questionnaires were sent to every hospital and information concerning previous operations, indications, surgical techniques and difficulties, operating time, hospital stay, recovery time (written sick leave), and complications was asked. The data were registered immediately after the operation and after the scheduled follow-up visit after one month. A total of 1165 patients were followed prospectively from January 1, 1993 to December 31, 1994. Information regarding the follow-up visit was available for 875 (75%) patients. The total number of laparoscopic hysterectomies checked from the hospital records was 1216 over the study period, so the response rate was 96% (Study II).

In study III, fifty women aged between 30 and 70 years scheduled for abdominal hysterectomy because of a benign condition were randomized to undergo abdominal or laparoscopic hysterectomy. Short-term clinical outcome, complications and tissue trauma were evaluated among patients operated on from March through September, 1997 in Jorvi Hospital. Exclusion criteria were major medical diseases, body mass index above 32 kg/m², size of uterus larger than that at 14 weeks of pregnancy or uterine width greater than 10 cm in transvaginal ultrasonography, severe adhesions or endometriosis, prolapse and any other contraindication for laparoscopy. Written informed consent was obtained and the study was approved by the local ethics committee. Women were advised to call to the hospital whenever any problems occurred and they were

followed-up until the sick leave ended and they were completely recovered.

REGISTERS (Studies IV-VI)

The Finnish Hospital Discharge Register and Care Register

From 1990 through 1993 the numbers of different laparoscopic procedures were acquired from the Finnish Hospital Discharge Register, which contains information regarding diagnosis, dates of admission and discharge, and surgical procedures on each inpatient. The accuracy of the main diagnosis has been 95% and that of the surgical procedures 90-95% (Keskimäki et al. 1994). The Register was used for research, administration, and planning, and it was maintained by the National Board of Health (Keskimäki and Aro 1991). From 1994 the data were collected more accurately on all inpatients and most outpatients to the Finnish Hospital Care Register, which is maintained by the National Research and Development Centre for Welfare and Health. Every hospital collects data using a standardized data sheet and sends it automatically to the Register at the end of each year. The diagnoses were coded according to the Finnish version of the International Classification of Diseases, 9th Revision (ICD-9) and according to the 10th Revision (ICD-10) from 1996. The surgical procedures were coded according to the classification by the Finnish Hospital League (Toimenpidenimikkeistö, 1983) and from 1997 according to the Nordic Classification of Surgical Procedures (Classification of Surgical Procedures, 1996).

Laparoscopic procedures were divided into three categories as they were coded in the register: diagnostic laparoscopies, laparoscopic sterilization, and operative laparoscopies. Diagnostic laparoscopies involved only procedures carried out in connection with infertility or dysmenorrhea without any extra procedure. Both the Filshie and the Hulka clips were used for laparoscopic sterilization and in a minority of cases tubal electrocoagulation was used. Operative laparoscopy was defined as procedures carried out in connection with endometriosis, ectopic pregnancy, adhesions, and ovarian cysts as well as myomectomy and laparoscopic hysterectomy. Up to 1996, the codes for laparoscopies included procedures carried out by both gynecologists and surgeons. To identify only gynecological laparoscopies we cross-examined the procedures with diagnoses and included only procedures with gynecological diagnoses.

The numbers of total and subtotal abdominal and vaginal

hysterectomies carried out in association with benign conditions were easy to obtain from the register because they all had a surgical code of their own. However, the number of laparoscopic hysterectomies was more difficult to find because the surgical procedure classification had no specific code for laparoscopic hysterectomy until 1997. The first laparoscopic hysterectomy was performed in 1992 in Finland and in the first year only eleven procedures were carried out (Mäkinen et al. 1994). The numbers of laparoscopic hysterectomies in 1993 and 1994 were taken from the national register of laparoscopic hysterectomies (see study II) and the number for 1995 was collected from all Finnish hospitals by means of questionnaires. In 1996, a national, prospective survey of all hysterectomies performed in Finland in one year was undertaken (the Finhyst study, Johansson et al., unpublished data) and it revealed the number of laparoscopic hysterectomies in that year. Since 1997 laparoscopic hysterectomy has had a unique code and it is easy to assess the numbers.

The National Patient Insurance Association

The Patient Injury Act was brought into force on the first of May 1987 in Finland. The Ministry of Social Affairs and Health agrees on the premium basis and the insurance terms. All insurance companies engaged in patient insurance are members of the Association and all compensation is paid from insurance premiums. In order to obtain full compensation for patient injury, proof of malpractice is no longer required. The Patient Injury Act ensures compensation for patient injury that 1) probably has arisen as a consequence of examination or treatment; 2) has been caused by an infection or inflammation that probably originated in circumstances connected with examination or treatment; 3) has been caused by an accident connected with examination or treatment or occurred during patient transport or resulted from a defect in medical care equipment or in a medical care device. However, inevitable complications, necessary risk-taking or drug-related injuries are not usually "patient injuries" with the exception of unreasonable consequences after any procedures. Patient Insurance covers all those engaged in the practice of health care or medical care, in both the public and private sectors, improving the legal protection of patients and medical staff. Most importantly, Patient Insurance effectively decreases the number of malpractice trials in courts. Every Finnish hospital has an official patient ombudsman, who helps the patient in preparing a claim when necessary. Patients are informed when coming to the hospital of the Patient Injury Act and the Association and it is the patient who reports the injury to the Association.

We tested the accuracy of the Association by comparing

complications reported to the national register of laparoscopic hysterectomies in 1993-1994 (study II) with complications reported to The National Patient Insurance Association. All major complications were in both registers but some bladder perforations sutured laparoscopically during the primary operation were not reported to The National Patient Insurance Association. In addition, we compared complications of laparoscopic hysterectomy in 1996 reported to The National Patient Insurance Association with those reported in one year's prospective survey on hysterectomies during the same year in Finland (Finhyst study, unpublished data). We found out that a higher number of ureteral injuries, the same number of intestinal injuries but a lower number of bladder injuries were reported to the Association than to the Finhyst study.

Complications were divided into minor and major complications. Minor complications were usually not compensated but almost all major complications were compensated by the Association. Minor complications included infections and hemorrhages requiring no hospitalization, and failed sterilizations. Major complications consisted of injuries to the gastrointestinal tract, urinary tract and large vessels, as well as nerve paresis, deep venous thrombosis, and unintended procedures such as those carried out in connection with postoperative hemorrhage and incisional hernias. The complication rates were analyzed separately in different laparoscopic procedures and according to different organs. In addition, urinary tract injuries after different techniques of hysterectomy were analyzed separately.

METHODS

Operative techniques (Studies I-III)

In study I, the ligaments were divided with staplers or electrocoagulation and uterine vessels were secured by using clips, staplers or electrocoagulation. The uterus was removed and the vaginal cuff was sutured vaginally. In study II, the operative technique varied among different hospitals but bipolar and monopolar electrocoagulation were used in all operations, staples in 28%, clips in 16%, and sutures in 4% of the procedures. Uterine vessels were cut laparoscopically in 86%, uterosacral ligaments in 80%, part of the cardinal ligaments in 65%, and the anterior or posterior vaginal fornix in 62% of the operations. In a randomized study (III), bipolar coagulation and scissors were used to cut ligaments and uterine vessels and the uterus was removed vaginally when performing laparoscopic hysterectomy. Patients randomized to undergo abdominal hysterectomy were operated on in a standard manner

through a lower midline or Pfannestiel incision as described by Thompson and Warshaw (1996). Diathermy was only used for hemostasis and no peritoneal closure was performed.

Analysis of biochemical markers (Study III)

Fasting venous blood samples were drawn preoperatively on the day of surgery and afterwards on the first, second and seventh postoperative day as well as during the first follow-up visit at four weeks. Urine samples were also examined every time to rule out urinary tract infection. Blood hemoglobin, hematocrit and serum CRP concentration were determined by standard laboratory procedures on the day of sampling. Serum CRP levels were measured by immunoturbidometric assay (Hitachi 911, Japan). The sera for IL-6, TATI and CA 125 measurements were stored at -20 °C in individual tubes and all samples were analyzed in the same assay. Concentrations of IL-6 were determined by enzyme immunoassay (hull-6 ELISA kit, Central Laboratory of The Netherlands Red Cross Blood Transfusion Service, Netherlands), those of TATI by radioimmunoassay (1277 GammaMaster®, EG & T Wallac, Finland) and those of CA 125 by immunoradiometric assay (IRMA-mat®, Byk-Sangtec Diagnostica GmbH & Co, Germany). The detection limit for IL-6 was 7.4 pg/mL and in calculations this was divided in half and a value of 3.7 pg/mL was used when the levels were below the detection limit. The detection limit for TATI was 5 ug/L and that for CA 125 was 10 kU/L. Values of 2.5 ug/L and 5 kU/L were used, respectively, when the levels were below the detection limit.

STATISTICS

Studies I and II were descriptive but we compared operating times against different variables by simple regression analysis in study I. Study III was randomized and for statistical analysis of variables between the two hysterectomy groups, and changes in the concentrations of biochemical markers between the groups, two-sample Student's *t*-tests assuming unequal variances were used. The χ^2 test was used for comparison of proportions among hysterectomy groups. A sample size was calculated to achieve statistical differences between two surgical groups (Peipert et al. 1995). Twenty-one women in each group would be needed for 90% study power and for differentiation of 10 mg/L (one standard deviation) between the means of CRP concentration when type I error is 5%. For 80% study power, 15 women in each group would be needed. Twenty-five women were enrolled in each group but tissue trauma was analyzed as regards 18 uncomplicated hysterectomies in each group. In study IV

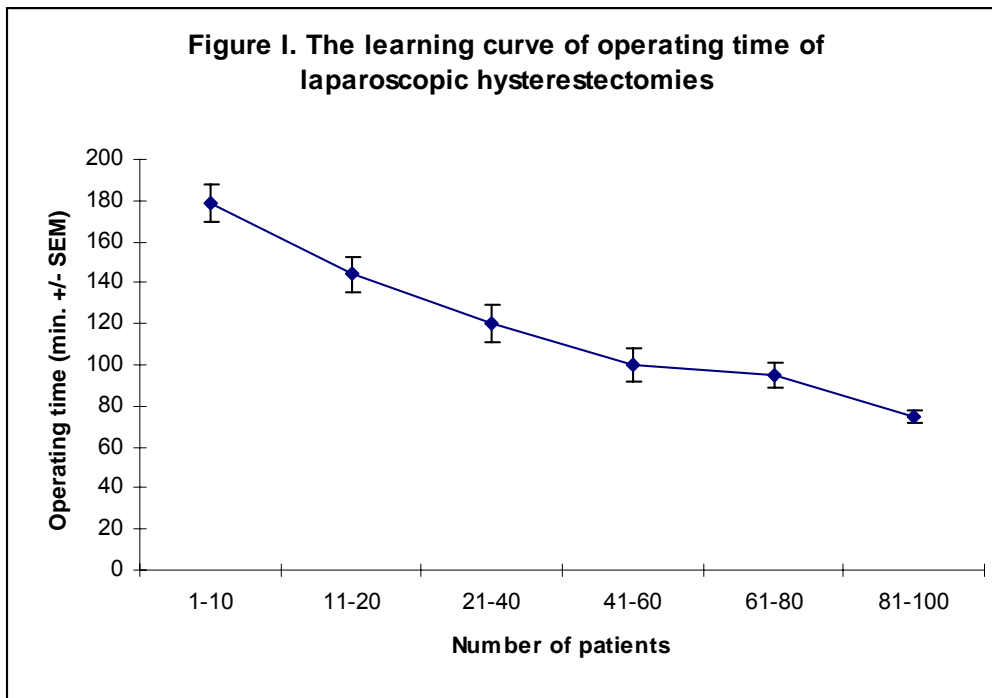
complications of hysterectomy were analyzed and for statistical analysis of variables between different hysterectomy groups, two-sample Student's t-test assuming unequal variances was used. Fisher's exact two-tailed test and the χ^2 test were used when comparison of proportions among hysterectomy groups was carried out. In studies V and VI complications of laparoscopy were analyzed and differences between complication rates were analyzed by the χ^2 test. Relative risk (RR) and 95% confidence intervals (95% CIs) were applied to complications following various operative laparoscopies, and 95% CIs were also applied when reporting percentages. In all studies statistical significance was defined as $P \leq 0.05$.

RESULTS

LEARNING CURVE AND RESULTS OF PERSONAL EXPERIENCE IN LAPAROSCOPIC HYSTERECTOMY (Study I)

The first one hundred laparoscopic hysterectomies were performed by one senior gynecologist. Sixty-four percent of the procedures were carried out because of uterine fibroids and laparoscopic removal of the uterus succeeded in all cases. The weight of the uterus ranged between 70 and 470 grams and the estimated operative blood loss ranged between 50 and 1400 ml. The average hospital stay was 1.3 days and recovery time was 10.9 days. Complications occurred in 10% of cases: intraoperative or postoperative bleeding in 5%, postoperative infection in 4%, bladder injury in 1%. No ureteral, intestinal or major vessel injuries occurred. One bladder perforation and one case of intraoperative heavy bleeding of 1400 ml occurred during the first 20 operations. Vaginal cuff bleeding, inferior epigastric vessel bleeding and pelvic infections occurred throughout study period and did not decrease with experience.

The operating time varied between 45 and 245 minutes, the average being 109 minutes. The operating time shortened consistently with increasing number of operations. The learning curve shows a reduction of the mean operating time from 180 minutes during the first ten procedures to 75 minutes during the last twenty procedures. The mean operating time was reduced to half after 80 operations (Figure I). The results of regression analysis revealed positive correlation between the operating time and the size of the uterus and the weight of the patient. The operating time was unaffected by removal of the adnexa or previous laparotomies. The use of clips or staplers did not shorten the operation time compared with the use of electrocoagulation only during the first 50 operations. After the first 50 laparoscopic hysterectomies the technique was stabilized and also the operating time was stabilized by using three puncture technique, Valtchev uterus manipulator (Conkin Surgical Instruments, Toronto, Canada) and only electrocoagulation and scissors.



NATIONWIDE EXPERIENCE OF THE FIRST TWO YEARS OF LAPAROSCOPIC HYSTERECTOMY (Study II)

According to the hospital records, a total of 1216 laparoscopic hysterectomies were performed in 1993 and 1994. Data was obtained on 1165 procedures (96%) via questionnaires. Most of the physicians were at the beginning of the learning phase, having performed less than ten operations per year during the two study years (Table 6).

Table 6. Gynecologists performing laparoscopic hysterectomies in 1993-1994

Number of operations per year	No. of gynecologists	
	1993	1994
<10	6	48
10-19	2	5
20-50	3	13
>50	2	2
All	13	68

Most of the operations were carried out because of uterine fibroids (54%) followed by menorrhagia (27%) and other reasons. In the whole country, the mean operating time was 132 minutes. The mean hospital stay was 3.3 days and the recovery time (written sick leave) ranged

between 4 and 42 days (mean 18 days). Complications were reported in 10.2% of cases and major complications in 3.5% of cases (Table 7). Unintended surgery was carried out in 3.0% of laparoscopic hysterectomies because of a complication. The most common complication was infection, accounting for over half of the complications, but the most severe were urinary tract injuries (2.7%). Of the 32 urinary tract injuries, 17 were bladder injuries (1.5%) and 15 were ureteral injuries (1.3%). No fatal complications occurred during the study period.

Table 7. Complications of 1165 laparoscopic hysterectomies in 1993-1994

Complication	n	N (%)
Bleeding		
14 (1.2%)		
Umbilical incision	1	
Epigastric artery	3	
Iliac artery	1	
Intra-abdominal, postoperative	5	
Vaginal cuff bleeding, postoperative	4	
Urinary tract		32 (2.7%)
Bladder		
during laparoscopy	14	
during vaginal part	3	
Ureter	15	
Bowel		5 (0.4%)
Infections		65 (5.6%)
Trocar incision	7	
Urinary tract	21	
Fever of unknown origin	19	
Hematoma of vaginal cuff and fever	15	
Abscess of vaginal cuff	3	
Other		3 (0.3%)
Thrombosis	1	
Nerve paresis	2	
All		119 (10.2%)

TISSUE TRAUMA AND CLINICAL OUTCOME IN LAPAROSCOPIC VERSUS ABDOMINAL HYSTERECTOMY (Study III)

Fifty women were recruited into the study, of whom 25 were operated upon laparoscopically and 25 abdominally. There were no differences in patient characteristics, indications for operation or uterine weight between the study groups. The mean operating time (85 min in LH versus 58 min in TAH) and anesthetic time (122 min in LH versus 83 min in TAH) were significantly longer in the laparoscopic group. On the other hand, there was less blood loss and a smaller decrease in blood hemoglobin concentration, and the times of hospital stay (2.1 days in LH versus 3.4 days in TAH) and sick leave (21 days in LH versus 39 days in TAH) were significantly shorter in association with the LH group. There were no significant differences in postoperative complications (24% in LH versus 28% in TAH) between the study groups.

For tissue trauma analysis 18 uncomplicated hysterectomies in both groups were included. Six women with the above-mentioned complications were excluded from the LH group and in addition, one woman with an elevated preoperative CA 125 level (216 kU/L), for no apparent reason. In the TAH group seven women with postoperative complications were excluded. The circulating concentrations of IL-6, CRP, TATI and CA 125 increased significantly in both groups. The increase in IL-6 was greatest on the first postoperative day in both groups, that of CRP on the second postoperative day in both groups, that of TATI on the seventh postoperative day in the LH group and on the second postoperative day in the TAH group and that of CA 125 on the seventh postoperative day in both groups. Serum concentrations of L-6 and CRP were significantly lower in the LH group on the first and second postoperative day, compared with the TAH group. No differences were seen in TATI and CA 125 levels between the groups (Table 8, Figure II).

Table 8. Tissue trauma markers in LH and AH

Variable	Day	LH (n=18)	AH (n=18)	P (LH vs AH)
IL-6 (pg/mL)	0	3.7 (0)	4.4 (2.8)	NS
	1	10.4 (8.8)*	21.6 (15.1)*	0.01
	2	5.5 (3.9)	17.0 (18.4)*	0.02
	7	4.4 (2.2)	4.8 (3.6)	NS
	28	3.7 (0)	3.7 (0)	NS
CRP (mg/L)	0	1.4 (1.9)	0.7 (0.9)	NS
	1	12.1 (14.1)*	21.8 (12.0)*	0.03
	2	26.5 (21.3)*	55.3 (26.0)*	<0.001
	7	10.4 (13.2)*	15.0 (15.9)*	NS
	28	1.8 (2.3)	1.4 (1.3)	NS
TATI (ug/L)	0	5.8 (2.9)	5.7 (3.5)	NS
	1	5.9 (3.6)	8.2 (6.9)*	NS
	2	7.5 (3.4)*	15.2 (18.7)*	NS
	7	9.0 (5.9)*	7.7 (4.7)	NS
	28	7.4 (3.0)*	7.0 (3.5)*	NS
CA 125 (kU/L)	0	16.1 (8.9)	15.1 (9.9)	NS
	1	15.6 (10.4)	11.5 (8.7)	NS
	2	16.4 (9.7)	13.9 (11.6)	NS
	7	23.1 (11.2)*	22.8 (17.6)*	NS
	28	17.1 (10.2)	13.1 (8.6)	NS

Values are given as means (standard deviation)

* statistically significant change from preoperative value
paired two-sample Student's t-test

IL-6: LH-0 vs LH-1:P=0.005 / AH-0 vs AH-1:P=0.002 / AH-0 vs AH-2:P=0.01

CRP: LH-0 vs LH-1:P=0.002 / LH-0 vs LH-2:P<0.001 / LH-0 vs LH-7:P=0.01

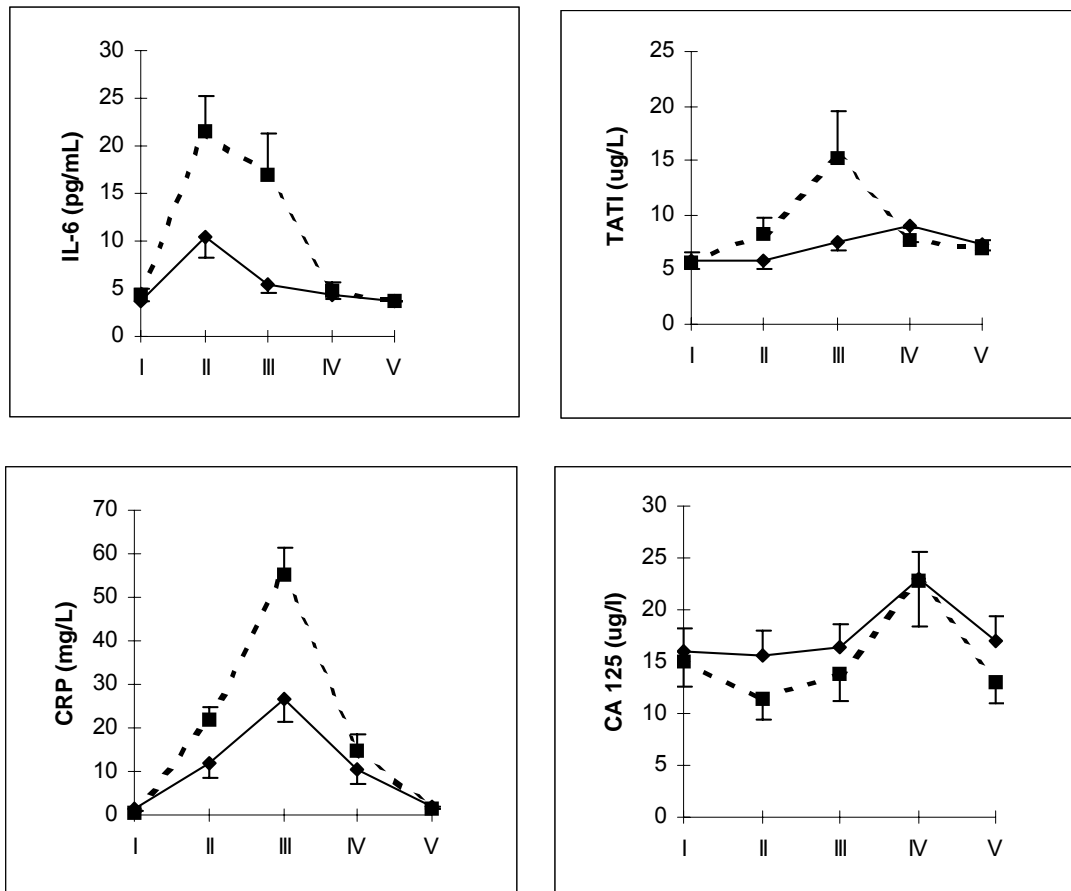
AH-0 vs AH-1:P<0.001 / AH-0 vs AH-2:P<0.001 / AH-0 vs AH-7:P=0.001

TATI: LH-0 vs LH-2:P=0.03 / LH-0 vs LH-7:P=0.007 / LH-0 vs LH-28:P=0.002

AH-0 vs AH-1:P=0.05 / AH-0 vs AH-2:P=0.03 / AH-0 vs AH-28:P=0.02

CA 125: LH-0 vs LH-7:P=0.001 / AH-0 vs AH-7:P=0.02

Figure II. Changes in serum IL-6, CRP, TATI and CA 125 concentrations in laparoscopic (—) and abdominal(- - -) hysterectomy.



Values are given as means plus or minus standard errors (SE).
 I: Before surgery, II: 1st, III: 2nd, IV: 7th, and V: 28th postoperative day.

URINARY TRACT INJURIES AFTER HYSTERECTOMY IN FINLAND (Study IV)

In Finland, 62,379 hysterectomies were carried out from 1990 through 1995. In 1990, 93% of hysterectomies were performed abdominally, and only 7% vaginally. In 1995, the proportion of abdominal hysterectomies had decreased to 75%, vaginal hysterectomies had increased to 11%, and 14% of hysterectomies were carried out laparoscopically.

One hundred and forty-two (0.2%) urinary tract injuries in 136 women

were reported: 60 ureteral injuries (0.10%) and 82 bladder injuries (0.13%), and 52 of the 82 bladder injuries resulted in vesicovaginal fistulas (0.08%). The rate of ureteral injury was low after vaginal, supracervical abdominal and total abdominal hysterectomy, but high after laparoscopic hysterectomy, with no significant decrease from 1993 to 1995. Bladder injuries were also rare after vaginal and supracervical hysterectomy, but more common after total abdominal hysterectomy. Again, bladder injuries were most common after laparoscopic hysterectomy (Table 9). Difficulties during an operation with ureteral injury were encountered in 51%, 76%, 100% and 100% of cases and with bladder injury in 53%, 37%, 100% and 0% of cases after laparoscopic, abdominal, supracervical abdominal and vaginal hysterectomy, respectively. Urinary tract injuries greatly prolonged the recovery time. The times taken before the patients were totally recovered were 7.5 months, 6.4 months, 2.7 months and 2.0 months after ureteral injury and 4.1 months, 4.7 months, 2.0 months and 4.0 months after bladder injury following laparoscopic, total abdominal, supracervical abdominal and vaginal hysterectomy, respectively.

Ureteral injuries

Thirty-eight ureteral injuries (1.4%) occurred in 37 patients following laparoscopic hysterectomy (Table 9). Uterine vessels and part of the cardinal ligament were dissected laparoscopically in most of the laparoscopic hysterectomies. The uterine vessels were electrocoagulated in all but four cases, where clips were used. Twenty-two gynecologists were involved in these 38 ureteral injuries. In only two cases was the occurrence of the injury suspected during the primary operation. All ureteral injuries were repaired by urologists, most commonly by ureteroneocystotomy (53% of cases). The failure rate of primary repair was 5%: one patient had to undergo two operations and another had three operations before the injury was repaired.

Eighteen ureteral injuries (0.04%) occurred in 17 patients undergoing total abdominal hysterectomy (Table 9). All uterine vessels were ligated with sutures and each gynecologist encountered ureteral injury only once. None of the ureteral injuries were noticed during the primary operation and all except one were repaired by urologists (ureteroneocystostomy in 67% of cases). The failure rate of primary repair was 12%: one patient had to undergo two operations and the patient with bilateral ureteral injury had four operations.

Table 9. Urinary tract injuries associated with hysterectomy in Finland

Injury	1990	1991	1992	1993	1994	1995	Total
LH							
Ureter	-	-	0 (0)	7 (19.1)	8 (10.0)	23 (14.1)	38 (13.9)
Bladder	-	-	0 (0)	5 (13.7)	10 (12.5)	3 (1.9)	18 (6.6)
Fistula	-	-	0 (0)	2 (5.5)	0 (0)	4 (2.6)	6 (2.2)
All	-	-	0 (0)	14 (38.3)	18 (22.5)	30 (19.2)	62 (22.6)
TAH							
Ureter	4 (0.6)	2 (0.3)	1 (0.1)	5 (0.7)	4 (0.6)	2 (0.3)	18 (0.4)
Bladder	1 (0.1)	2 (0.3)	1 (0.1)	2 (0.3)	2 (0.3)	1 (0.1)	9 (0.2)
Fistula	9 (1.5)	9 (1.3)	8 (1.1)	6 (0.8)	5 (0.7)	8 (1.1)	45 (1.0)
All	14 (2.1)	13 (1.8)	10 (1.3)	13 (1.7)	11 (1.5)	11 (1.6)	72 (1.7)
SAH							
Ureter	0 (0)	1 (0.5)	0 (0)	2 (1.1)	0 (0)	0 (0)	3 (0.3)
Bladder	0 (0)	0 (0)	1 (0.4)	1 (0.5)	1 (0.6)	0 (0)	3 (0.3)
Fistula	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
All	0 (0)	1 (0.5)	1 (0.4)	3 (1.6)	1 (0.6)	0 (0)	6 (0.6)
VH							
Ureter	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.9)	0 (0)	1 (0.2)
Bladder	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fistula	0 (0)	1 (1.2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)
All	0 (0)	1 (1.2)	0 (0)	0 (0)	1 (0.9)	0 (0)	2 (0.4)

Values are given as numbers (numbers/1000 procedures)

Three ureteral injuries (0.03%) were reported following supracervical abdominal hysterectomy (Table 9). One ureteral lesion was diagnosed during the primary operation and ureteral anastomosis was performed by a surgeon. Primary healing was achieved in all three patients (ureterolysis and stenting, ureteral anastomosis and transureteroureterostomy).

Only one ureteral injury (0.02%) following vaginal hysterectomy was reported (Table 9). The injury was noticed postoperatively and repaired by ureteroneocystostomy.

Bladder injuries

Twenty-four bladder injuries (0.9%) were reported following laparoscopic hysterectomy (Table 9). Of these, 18 were simple bladder perforations repaired with sutures, without any further complications. Six bladder injuries resulted in vesicovaginal fistulas after the primary suturation of bladder injury; the incidence was 0.2%.

Fifty-eight percent of bladder perforations were recognized during the primary procedure. Seventeen percent of these bladder injuries were repaired by urologists and 83% by gynecologists. Altogether, 17 simple bladder perforations were repaired with one operation and one perforation was treated only by means of a Foley catheter. Four fistulas were successfully repaired using an abdominal approach. Three of them were operated upon within 6 weeks and one after 18 weeks. One fistula was repaired first vaginally after 8 weeks and again abdominally after almost 5 months. One fistula was treated only by means of a Foley catheter. The failure rates of primary bladder and vesicovaginal fistula repair in the laparoscopy group were 5% and 17%, respectively.

Fifty-four bladder injuries (0.1%) were reported following total abdominal hysterectomy (9 simple bladder perforations and 45 (0.1%) vesicovaginal fistulas) (Table 9). Eight patients with simple bladder perforation recovered with no sequelae after suturing the defect and one perforation was handled with a Foley catheter. Thirty-two vesicovaginal fistulas were repaired in one operation, six fistulas required two operations, three fistulas required three operations and one patient had to undergo four different operations before the fistula was repaired. Three fistulas healed with catheters. The failure rates of bladder and vesicovaginal fistula repair following total abdominal hysterectomy were 18% and 20%, respectively. Twenty-four percent of fistulas were repaired before six weeks, the failure rate being 40%, and the remaining 76% were repaired after six weeks, with a failure rate of 16%. Urologists were involved in 62% of these operations.

Three bladder injuries (0.03%) occurred during supracervical abdominal hysterectomy (Table 9). Two of them were noticed and sutured during the primary operation. No fistulas occurred and all patients recovered without any further complications.

During vaginal hysterectomy, one vesicovaginal fistula (0.02%) occurred (Table 9). Urinary incontinence was detected one month after the vaginal fistula operation and there was no response to a sling procedure or to physiotherapy.

COMPLICATIONS OF LAPAROSCOPY IN FINLAND (Studies V-VI and some unpublished material)

Major complications

A total of 102,812 gynecological laparoscopies were performed from

1990 through 1996 (Table 10). During these seven years, 227 major complications were reported, at an incidence of 2.2/1000 in all laparoscopies; 0.4/1000 in diagnostic laparoscopies, 0.5/1000 in sterilization laparoscopies and 9.0/1000 in operative laparoscopies. The incidence was stable in diagnostic and sterilization laparoscopies but increased from 0/1000 in 1990 to 14.0/1000 in 1996 in operative laparoscopies (Figure III). Eighty-two percent of major complications occurred in operative laparoscopies, and 69% of these occurred in laparoscopic hysterectomy with laparoscopic hysterectomy accounting for 57% of all major complications (Tables 10 and 11). Operative laparoscopies other than hysterectomies also became more difficult during the study years and major complications increased in these procedures from 0/1000 in 1990 to 6.9/1000 in 1996 (Figure III).

Table 10. Major complications of laparoscopy in Finland in 1990-1996

	Diagnostic	Sterilization	Operative	Total
Procedures (n)	25.059	56.989	20.764	102.812
Intestinal	6 (0.2)	23 (0.4)	38 (1.8)	67 (0.7)
Bladder	1 (0.04)	1 (0.02)	40 (1.9)	42 (0.4)
Ureteral	0 (0)	2 (0.04)	74 (3.6)	76 (0.7)
Major vascular	1 (0.04)	2 (0.04)	8 (0.4)	11 (0.1)
Incisional hernia	0 (0)	0 (0)	8 (0.4)	8 (0.08)
Other	1 (0.04)	3 (0.05)	18 (0.9)	22 (0.2)
Death	0 (0)	0 (0)	1 (0.05)	1 (0.01)
All	9 (0.4)	31 (0.5)	187 (9.0)	227 (2.2)

Values given as numbers and numbers/1000 procedures

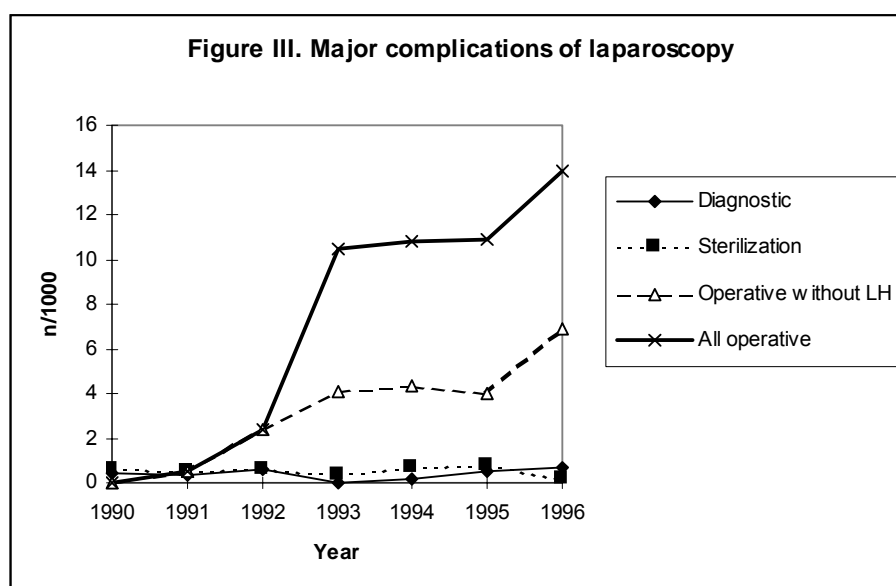


Table 11. Laparoscopic procedures where major complications occurred in Finland

Type of injury	n
Intestinal injury (n=67)	
diagnostic laparoscopy	6
sterilization laparoscopy	23
operative laparoscopy	38
myomectomy (1)	
ectopic pregnancy (2)	
adhesiolysis (4)	
endometriosis (5)	
hysterectomy (10)	
adnexal surgery (16)	
Bladder injury (n=42)	
diagnostic laparoscopy	1
sterilization laparoscopy	1
operative laparoscopy	40
adnexal surgery (3)	
colposuspension (3)	
hysterectomy (34)	
Ureteral injury (n=76)	
diagnostic laparoscopy	0
sterilization laparoscopy	2
operative laparoscopy	74
adhesiolysis (1)	
colposuspension (1)	
endometriosis (2)	
adnexal surgery (3)	
hysterectomy (67)	
Major vascular injury (n=11)	
diagnostic laparoscopy	1
sterilization laparoscopy	2
operative laparoscopy	8
endometriosis (1)	
hysterectomy (1)	
ectopic pregnancy (2)	
adnexal surgery (4)	
Incisional hernias (n=8)	
diagnostic laparoscopy	0
sterilization laparoscopy	0
operative laparoscopy	8
ectopic pregnancy (1)	
hysterectomy (3)	
adnexal surgery (4)	
Other injuries (n=23)	
diagnostic laparoscopy	1
sterilization laparoscopy	3
operative laparoscopy	19
ectopic pregnancy (1)	
endometriosis (1)	
colposuspension (2)	
adnexal surgery (2)	
hysterectomy (13)	
Total	227

Figure IV. Major complications in operative laparoscopy

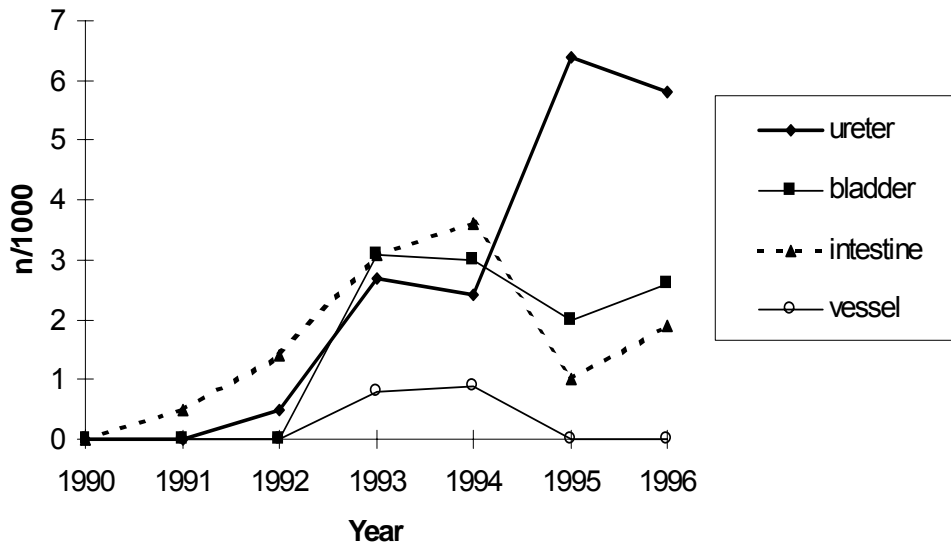
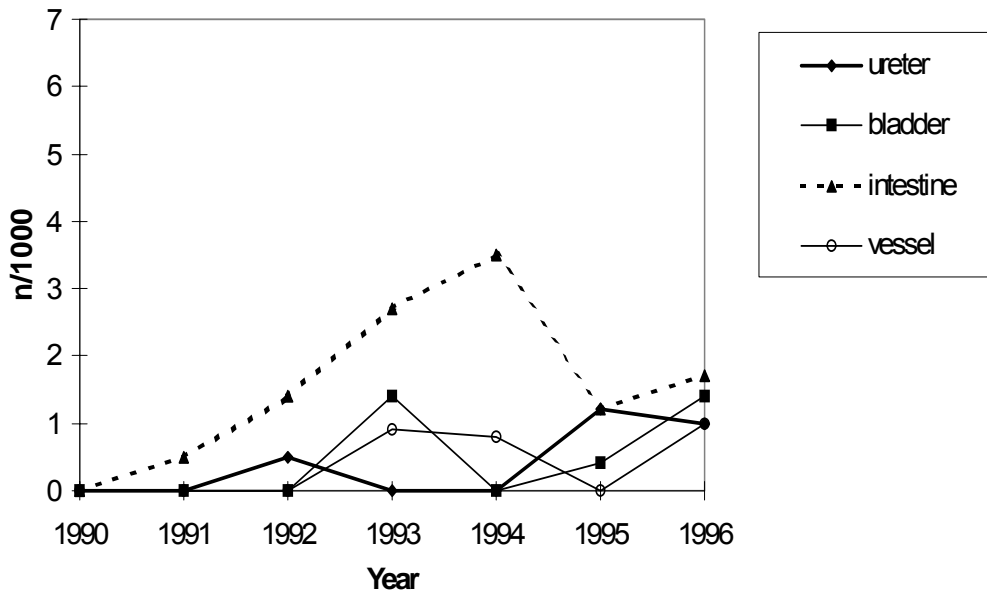


Figure V. Major complications in operative laparoscopy excluding LH



Entry-related complications (unpublished data)

Twenty-two percent (51 of 227) of all major complications were caused by a Veress needle or a trocar, at an average incidence of 0.5/1000 procedures: 0.4/1000 in diagnostic and sterilization laparoscopies and 0.9/1000 in operative laparoscopies ($\chi^2=7.37$, $P=0.007$). The total incidence increased from 0.4/1000 in 1990 to 0.8/1000 in 1996 but the change was not statistically significant. In 1990, 83% of major complications were entry-related injuries and in 1996, only 18% ($\chi^2=13.6$, $P < 0.001$). Altogether, 18% of entry-related complications occurred during diagnostic laparoscopies, 45% during sterilisation laparoscopies and 37% during operative laparoscopies. Difficulties in entering the abdominal cavity were encountered in only 10% of cases when injuries occurred, previous abdominal surgery was reported in 38% of cases and laparotomy was performed in 92% of cases to repair the injury (Table 12).

Table 12. Entry-related laparoscopic injuries in Finland in 1990-1996

Injury	n	%
Bowel injury	29	57
Incisional hernia	8	15
Large vessel injury	6	12
Small vessel injury	5	10
Bladder injury	3	6
Ureteral injury	0	0
All injuries	51	100

Gastrointestinal injuries

The incidence of gastrointestinal injury was 0.7/1000 in all laparoscopies: lowest in diagnostic and highest in operative laparoscopies (Table 10). The incidence increased until 1994 and decreased after that in operative laparoscopies (Figure IV). Gastrointestinal injuries were the most common major complications in operative laparoscopies excluding hysterectomies (Figure V). Forty-three percent of gastrointestinal injuries were related to laparoscopic entry (unpublished data).

Damage to the small bowel was the most common gastrointestinal complication (58%), followed by damage to the large bowel (34%), rectum (5%) and stomach (3%). Only 21% of these injuries were diagnosed and managed during the primary operation. The time from

injury to diagnosis was longer after perforation as a result of electrocoagulation (range 0-38 days) than after perforation with a Veress needle or trocar (range 0-5 days). All gastrointestinal injuries but one were treated by means of laparotomy; one stomach injury healed without any procedure. Sixty-six percent of injuries were primarily repaired by suturation of the bowel, followed in numbers by resection and anastomosis of the bowel, and enterostomy. Of 67 women, eleven (16%) had to undergo two operations, one woman underwent three operations and one woman six operations before the bowel injury was repaired.

Urinary tract injuries

The incidence of urinary tract injury was 1.1/1000 in all laparoscopies, again being most common in operative laparoscopies (Table 10). The risk of ureteral injury increased significantly in the 1990s in operative laparoscopies, but after subtracting the number of laparoscopic hysterectomies, the incidence rate was stable (Figures IV and V). Eighty-eight percent (67 of 76) of all ureteral injuries took place in laparoscopic hysterectomies and none of them were entry-related injuries. Bladder injuries also increased after 1992 but the incidence was stable in operative laparoscopies other than hysterectomies (Figures IV and V). Seven percent of bladder injuries were entry-related (unpublished data).

Seventy-six ureteral injuries occurred and 84% were caused by electrocoagulation, followed by injuries caused by clips, scissors, staplers and sutures. Three bilateral injuries occurred after laparoscopic hysterectomy. Ureteroneocystostomy was the most common method of repair, followed by ureteral stenting, end-to-end anastomosis, nephrectomy, pyelostomy, transureteroureterostomy and splitting the stricture by ureteroscopy. Two patients were operated on twice.

Forty-two bladder injuries were reported. Thirty of them were simple bladder perforations which were sutured with no further delay. Bladder perforations were sutured by means of laparotomy in thirteen cases, laparoscopically in twelve cases, vaginally in three cases and two patients were successfully treated by use of a Foley catheter. Twelve vesicovaginal fistulas occurred after suturation of bladder perforation and all of them occurred in laparoscopic hysterectomies. One fistula was treated with a Foley catheter, eight fistulas were repaired in one procedure and three patients had to undergo two operations before the fistula was closed.

Major vascular injuries

Major vascular injuries were rare, at an incidence of 0.1/1000 in all laparoscopies (Table 10). Half of these injuries occurred during laparoscopic entry (unpublished data) and they were also rare in laparoscopic hysterectomies. Altogether, eleven major vascular injuries were reported: nine to the iliac vessels and two to the aorta. All were sutured by way of laparotomy and all cases except one recovered without further complications. Three years after the primary operation, a fistula between the iliac artery and vein was repaired.

Incisional hernias

Only eight hernias associated with trocar incisions were reported, at an incidence of 0.08/1000 in all laparoscopies and 0.4/1000 in operative laparoscopies where secondary trocars are usually used (Table 10). Diagnosis was made between the 2nd and 14th postoperative day. The size of the trocars ranged from 5 to 12 mm (one 5 mm, five 10 mm, and two 12 mm), and 5-30 cm of small intestine were prolapsed into the hernia. In three cases bowel resection was carried out and in the others the intestine was merely repositioned.

Other injuries

The incidence of other injuries was 0.2/1000 in all laparoscopies (Table 10). Twenty-two injuries were reported: nine hemorrhages from small vessels (epigastric, mesenteric, uterine, vaginal cuff, umbilical trocar incision, and retroperitoneal small vessels), six cases of paresis of the brachial plexus or peroneal nerve, three laparotomies were carried out because of peritoneal abscesses, there were two cases of deep venous thrombosis, one case of persistently elevated human chorionic gonadotropin concentration after ectopic pregnancy, leading to laparotomy, and one case of persistent pain after laparoscopic clip sterilization, leading to supracervical abdominal hysterectomy.

Mortality

During the seven study years the mortality rate was 1/100,000, consisting of one fatal pulmonary embolism following laparoscopic supracervical hysterectomy. The patient had received no anticoagulant medication and after her death a positive family history of thromboembolism was reported.

COMPLICATIONS OF LAPAROSCOPIC HYSTERECTOMY IN FINLAND

(Studies II, IV-VI and some unpublished material)

From 1992 through 1998, 10,998 laparoscopic hysterectomies were performed in Finland. The proportion of abdominal hysterectomies declined from 93% in 1990 to 45% in 1998. At the same time the proportions of laparoscopic and vaginal hysterectomies increased to 28% and 27% in 1998, respectively (Table 13). Laparoscopic hysterectomies were the main source of laparoscopic complications in the 1990s but the major complications of laparoscopic hysterectomies decreased significantly from 4.9% in 1993 to 1.4% in 1998 (Table 14).

Table 13. The number of hysterectomies in Finland

Year	AH	VH	LH	All
1990	8474 (93%)	621 (7%)	0 (0%)	9095
1991	9291 (92%)	815 (8%)	0 (0%)	10106
1992	9676 (92%)	822 (8%)	11 (0.1%)	10508
1993	9371 (87%)	1030 (10%)	366 (3%)	10767
1994	8841 (81%)	1110 (10%)	799 (9%)	10750
1995	8350 (75%)	1238 (11%)	1565 (14%)	11153
1996	5875 (58%)	1801 (18%)	2424 (24%)	10100
1997	5401 (51%)	2242 (21%)	2887 (28%)	10531
1998	4804 (45%)	2873 (27%)	2946 (28%)	10623

Table 14. Major complications of laparoscopic hysterectomy in Finland

	1992	1993	1994	1995	1996	1997	1998	Total
LH (n)	11	366	799	1565	2424	2887	2946	10.998
Ureteral injury	0	7 (1.9%)	8 (1.0%)	23 (1.4%)	29 (1.2%)	24 (0.8%)*	20 (0.7%)*	111 (1.0%)
Bladder injury	0	5 (1.4%)	10 (1.3%)	3 (0.3%)*	4 (0.2%)*	13 (0.5%)*	4 (0.1%)*	39 (0.4%)
Vesicovaginal fistula	0	2 (0.6%)	0 (0%)	4 (0.3%)	6 (0.2%)	5 (0.2%)	8 (0.3%)	25 (0.2%)
Intestinal injury	0	2 (0.6%)	3 (0.4%)	1 (0.1%)*	5 (0.2%)	3 (0.1%)	4 (0.1%)	18 (0.2%)
Incisional hernia	0	0 (0%)	0 (0%)	1 (0.1%)	2 (0.1%)	1 (0.03%)	0 (0%)	4 (0.04%)
Major vascular injury	0	0 (0%)	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	1 (0.04%)	2 (0.002%)
Other injury	0	2 (0.6%)	1 (0.1%)	2 (0.1%)	7 (0.3%)	7 (0.2%)	3 (0.1%)*	23 (0.2%)
Death	0	0 (0%)	0 (0%)	0 (0%)	1 (0.04%)	0 (0%)	0 (0%)	1 (0.01%)
All	0	18 (4.9%)	23 (2.9%)	34 (2.2%)*	54 (2.2%)*	53 (1.8%)*	40 (1.4%)*	222 (2.0%)

* statistically significant change compared with the value in 1993 (Chi square test):

ureteral injury 93 vs 97: P = 0.04; 93 vs 98: P = 0.02

bladder injury 93 vs 95: P = 0.002; 93 vs 96: P < 0.001; 94 vs 95: P < 0.001; 93 vs 97: P = 0.02; 93 vs 98: P < 0.0001

intestinal injury 93 vs 95: P = 0.03

other injury 93 vs 98: P = 0.02

all injuries 93 vs 95: P = 0.004, 93 vs 96: P = 0.002, 93 vs 97: P < 0.0001, 93 vs 98: P < 0.0001

Table 15. Ureteral injuries of laparoscopic hysterectomy in different Finnish hospitals

Hospital	1992	1993	1994	1995	1996	Total
University hospital	0% 0 of 11	1.3% 4 of 297	1.1% 5 of 444	0.9% 6 of 679	0.6% 5 of 886	0.9% 20 of 2317
Central hospital	0% 0 of 0	0% 0 of 33	0% 0 of 250	1.5% 9 of 581	1.1% 9 of 839	1.1% 18 of 1703
Local hospital	0% 0 of 0	8.3% 3 of 36	2.9% 3 of 105	2.6% 8 of 305	2.3% 15 of 638	2.7% 29 of 484

Values given as percents and number of injuries / number of procedures

Statistically significant changes (Chi square test):

Local hospital: 93 vs 96 P = 0.03

1993: university vs local hospital
P = 0.02

1994: central vs local hospital P
= 0.007

1995: university vs local hospital
P = 0.03

1996: university vs local hospital
P = 0.003

Total injuries: university vs local
hospital P < 0.001; central vs
local hospital P < 0.0001

Altogether, 175 urinary tract injuries were reported during these seven years. One hundred and eleven ureteral injuries occurred and they accounted for 50% of all major complications in laparoscopic hysterectomies. The average risk of ureteral injury during these seven years was 1.0% and the incidence decreased from 1.9% in 1993 to 0.7% in 1998. Ureteral injuries were least common in university hospitals and most common in local hospitals (Table 15). Fifty-five percent of operating gynecologists were involved once and 31% twice in ureteral injuries. The ureteral complications were associated with ligation of uterine vessels in all but one cases. In that case, ureter was injured when suturing a large bladder perforation vaginally. In 107 cases the uterine vessels were ligated laparoscopically most often with electrocoagulation (96 cases), followed by clips (6 cases), scissors (3 cases), staplers (1 case) and an ultrasonic scalpel (1 case). The uterine vessels were ligated vaginally in only three cases when ureteral injury occurred. The injury was bilateral in five cases (5%). As a result of 111 ureteral injuries, three nephrectomies were performed but most often the injury was repaired with ureteroneocystostomy (59% of cases). Seven percent of women had to undergo several operations before ureteral injury was repaired.

Thirty bladder injuries took place during a laparoscopic part of the operation and were sutured by way of laparotomy in 17 cases, by way of laparoscopy in 12 cases and with a Foley catheter in one case. Nine bladder injuries occurred during a vaginal part of the operation and were sutured vaginally during the primary operation. Twenty vesicovaginal fistulas occurred during a laparoscopic part and five during a vaginal part of the operation. Three of them were treated with a Foley catheter and the rest needed a repair.

Of 18 intestinal injuries, seven were small bowel, five were large bowel and six were rectum perforations. Fifteen injuries were caused by electrocoagulation, two were entry-related and one was caused by scissors. Small bowel perforations were sutured in five cases and bowel resection was done in two cases. Large bowel perforations were treated by suturation (2 cases), resection (2 cases) and enterotomy (1 case). One of the three rectovaginal fistulas healed spontaneously and two required enterotomy. Three rectum perforations were treated by way of enterotomy.

Major vascular injuries (two iliac arteries) and incisional hernias were rare complications throughout the study period. Other injuries consisted of twelve hemorrhages of small vessels in abdominal wall, rectoperitoneum, vaginal cuff or uterine vessels as well as five nerve

paresis, two abdominal severe infections, two deep venous thrombosis, one non fatal pulmonary embolism and one rupture of vaginal sutures. One death occurred because of a massive pulmonary embolism.

DISCUSSION

Almost every gynecologist is aware of the approaches to effective and safe abdominal, vaginal and laparoscopic hysterectomy and should also be aware of the correct indications for performing each of these procedures. However, there is a great difference in the proportions of these hysterectomy types worldwide (Garry 1998). Approximately 70-80% of hysterectomies have been performed abdominally in the United States (Easterday et al. 1983), the United Kingdom (Garry 1998), and in Finland (Vuorma et al. 1998), but only 30% in Austria (Gitsch et al. 1991). In one center in France 80% of hysterectomies have been performed vaginally (Cosson et al. 1997), while in another center, 80% of hysterectomies in nulliparous women have been performed laparoscopically (Chapron et al. 1996). These wide variations between different countries, between different units and indeed between different gynecologists, indicate that after more than 100 years' experience of hysterectomy, there is no worldwide consensus how to perform a hysterectomy in different situations. The choice of method depends more upon the experience and biases of the gynecologist than upon a critical evaluation of the operative and outcome data (Dorsey et al. 1995, Garry 1998).

Every new surgical technique leads to a learning curve. A clear shortening of operating time and to some extent also, decreasing complications with experience, have been noticed in laparoscopic hysterectomies (Ikhena et al. 1999). Laparoscopic hysterectomy was safe in experienced hands with a low complication rate in our personal series of first laparoscopic hysterectomies, even in the learning period. The operating time was reduced to a half after 80 procedures and a plateau was achieved after 60 operations, compared with the Belcohyst study, where a plateau was seen after 40 procedures (Deprest et al. 1996). Both studies were performed soon after introduction of this new and unfamiliar technique and at the beginning several operative techniques were tested before surgery was standardized. Another study showed a plateau as early as after 10 TLH with an experienced surgeon who was already familiar with laparoscopic hysterectomy technique (Rosen et al. 1998). On the other hand, in another study, no shortening of operating time was

seen after the first 30 operations during the learning period in one center (Angle et al. 1995). In the two-years survey of 1165 laparoscopic hysterectomies, which covered all hospitals in Finland and not only specialized centers, it was seen that this new procedure was quickly adopted by several hospitals. The average operating time, hospital stay, convalescence time, total complication rate (10.2%) and overall major complication rate (3.5%) were similar but the rate of ureteral injuries was higher (1.3%) than reported in review articles mainly concerning experts in laparoscopy (0.3%) (Garry and Phillips 1995, Munro and Deprest 1995, Harris and Daniell 1996, Meikle et al. 1997). On the other hand, even higher ureteral injury rates (2% and 4.3%) have been reported when gynecologists have been at the beginning of their learning period (Garry 1998, Tamussino et al. 1998). Overall, the nationwide incidence of ureteral injuries decreased from 1.9% in 1993 to 0.7% in 1998 and major complications of laparoscopic hysterectomy also decreased in Finland. No long-term outcome of laparoscopic hysterectomy was analyzed, but the forthcoming years will certainly yield information about possible difference between the alternative types of hysterectomy.

Laparoscopic hysterectomy offers many advantages over abdominal hysterectomy in published randomized studies (Nezhat et al. 1992, Phipps and Nayak 1993, Raju and Auld 1994, Langebrenne et al. 1996, Olsson et al. 1996, Summitt et al. 1998, Yuen et al. 1998, Falcone et al. 1999, Marana et al. 1999). On the other hand, no real advantage has been found in randomized studies when comparing laparoscopic with vaginal hysterectomy (Summitt et al. 1992, Richardson et al. 1995), but laparoscopy offers a better view when performing hysterectomy with salpingo-oophorectomy, or in the presence of endometriosis or adhesions (Wood and Mahet 1997). In our study a somewhat longer operating time but less operative blood loss, and a shorter hospital stay and convalescence time were discovered after laparoscopic compared with abdominal hysterectomy. In addition, a clear elevation in the concentrations of biochemical tissue trauma markers was noticed after both types of hysterectomy but the increase was more marked after abdominal hysterectomy, suggesting more tissue trauma. This finding confirms the results of one earlier report (Yuen et al. 1998). However, in another study no tissue trauma differences between these two types of hysterectomy were found (Ellström et al. 1996). In that study the operating time was one hour longer in the laparoscopy group and it has been shown that the length of an operation is associated with increases in the concentrations of acute phase proteins (Ohzato et al. 1992).

Great variations in the length of hospital stay and convalescence time were seen in Finland, as also noticed between different countries. These parameters have been longest in abdominal hysterectomy but almost equal in laparoscopic and vaginal hysterectomy (Summitt et al. 1992, Johns et al. 1995, Munro and Deprest 1995, Deprest et al. 1996, Meikle et al. 1997). A size of the scar, postoperative pain and tissue trauma may be the most important factors affecting the convalescence time. The mean hospital stay was 1.3 days compared with 3.3 days and sick leave was 10.9 days compared with 17.9 days in a personal series and in a national survey of laparoscopic hysterectomy, respectively. In our randomized study the convalescence time was 21.4 days, when the women themselves estimated the recovery time after which they were able to return to normal work. These figures are usually defined according to surgical tradition and are not based on critical evaluation of surgical outcome, and therefore need re-evaluation.

Two reliable Finnish registers covering the whole country were used to study the nationwide incidences of laparoscopic complications. Other studies of complications have been based on reports concerning specialized centers (Chapron et al. 1998) or surveys with low response rates (Hulka et al. 1995, Peterson et al. 1993, Levy et al. 1994), and another nationwide survey from the Netherlands included 55% of hospitals (Jansen et al. 1997). In Finland, major complications of laparoscopy were low in diagnostic and sterilization laparoscopies but they increased steeply from 1990 to 1996 in operative laparoscopies. Eighty-two percent of major complications occurred in operative laparoscopies and 69% of these in laparoscopic hysterectomies. The growing tendency towards major complications in advanced laparoscopy has also been noticed by others (Hulka et al. 1995, Jansen et al. 1997, Chapron et al. 1998), as more difficult procedures are carried out laparoscopically. The mortality rate (1/100,000) in laparoscopic procedures was the same as mortality after gynecological surgery in Finland (Virtanen et al. 1995b).

As laparoscopic hysterectomies were the main source of laparoscopic ureteral complications in Finland, urinary tract injuries associated with all types of hysterectomy were compared. The rate of ureteral injury was low in connection with vaginal, supracervical abdominal and total abdominal hysterectomy, but high in laparoscopic hysterectomy. The incidence associated with abdominal hysterectomy (0.04%) was 5 times lower and the incidence in vaginal hysterectomy (0.02%) was 2.5-5 times lower than reported in the literature (Dicker et al. 1982, Harris and Daniell 1996). In contrast, the incidence of ureteral injury

during laparoscopic hysterectomy (1.4%) was 4.5 times higher than reported in review articles concerning experts (0.3%) (Garry and Phillips 1995, Munro and Deprest 1995, Harris and Daniell 1996, Meikle et al. 1997). However, the rate of ureteral injuries in association with laparoscopic hysterectomy in the whole country appears to be high but it is decreasing. Bladder injuries were also rare during vaginal (0.02%) and supracervical hysterectomy (0.03%), and more common during total abdominal hysterectomy (0.1%), but most common during laparoscopic hysterectomy (0.9%). Again, the incidence rates in association with traditional hysterectomies were lower but those of laparoscopic hysterectomies were the same as in review articles (Garry and Phillips 1995, Munro and Deprest 1995, Harris and Daniell 1996, Meikle et al. 1997). The rate of bladder injuries decreased during the study years but some minor bladder injuries, repaired laparoscopically during the primary operation, may not have been reported as they are not always compensated. According to the national register of laparoscopic hysterectomies in Finland in 1993-1994 and the Finhyst study in 1996 (Johansson, unpublished data), all major complications except some simple bladder perforations occurring in connection with laparoscopic hysterectomies were reported to the Patient Insurance Association. Complications occurring in connection with traditional hysterectomies may be under-reported because a higher number of urinary tract injuries were described in the Finhyst study in 1996 (Johansson, unpublished data) than were reported the Patient Insurance Association in the same year. Also in another Finnish study, 0.17% urinary tract injury rate and a 0.1% ureteral injury rate have been reported after total abdominal hysterectomy for benign reasons in 1983-1992 (Virtanen et al. 1995a). However, the accuracy of the data from the Patient Insurance Association has not been validated and some complications may not have been reported because of improper information of the patient.

We have demonstrated that the laparoscopic method of hysterectomy can be carried out at a national level and can result in faster and less painful recovery but may result in serious complications. Benefits as regards the size of scars, postoperative pain and recovery times will be irrelevant if the ureteral complication rates remain high (Garry 1998). Laparoscopic subtotal hysterectomy (Donnez et al. 1997) has been presented as being associated with fewer complications, but the ureters are still very close to the point at which the uterus is separated from the cervix. Visualization or dissection of the ureters (Reich et al. 1993) during the operation is essential. In most cases, electrocoagulation was the main cause of ureteral injury in Finland, as a result of a thermal effect. Ultrasonic coagulation with an

ultrasonically activated scalpel may cause less lateral thermal damage (McCarus 1996) than electrocoagulation (Phipps 1994). A laparoscopic suturing technique (Reich et al. 1993) may reduce the risk of ureteral injury but it requires practice and is time-consuming. Stapling devices offer speed but are expensive and are also associated with ureteral injuries (Woodland 1992). The use of ureteral catheters has been recommended to prevent ureteral injuries (Phipps 1995) but they have been also associated with significant morbidity (Kadar 1995). Hence, one way to decrease ureteral injuries would be to cut the uterine vessels vaginally (Mencaglia et al. 1994), especially during the learning phase. In Finland, only three of 111 ureteral injuries did occur when uterine vessels were ligated vaginally.

If ureteral or bladder injury is suspected during surgery, ureteral stenting or intravenous indigo carmine injection can be carried out. Recently, laparoscopic ultrasonographic examination has been studied during gynecologic surgery and it may offer another way to diagnose ureteral injuries, even intraoperatively (Helin et al. 1998, Helin-Martikainen et al. 1998). If ureteral injury is suspected postoperatively the best diagnostic method is excretory urography and it should be carried out without hesitation.

When a new surgical technique is introduced, it is always a challenge to learn it without causing harm to patients. Patients' expectations are also high when coming to minimal access surgery and they easily seek compensations if a complication occurs. Whereas, a similar injury occurring during open surgery is accepted as inevitable. When risks of complications in gynecological laparoscopy have been predicted it has appeared that the difficulty of the procedure is the strongest predictor of complications (Mirhashemi et al. 1998). Further, the rate of complications can be decreased by additional post-residency training courses and teamwork and an inverse correlation can be seen between a surgeon's complication rate and the number of laparoscopies performed (See et al. 1993). In Finland, ureteral injuries tended to be more common in local hospitals, where the expertise is not as extensive as in university hospitals. Residents in training programs usually become skilled at advanced laparoscopic surgery, but personnel at smaller hospitals must acquire their skills by themselves. Hence, a very important aspect is proper training by means of videotapes, courses, visiting experts and at the beginning, operations supervised by experienced colleagues, before starting to perform procedures independently (Gates 1997, Chapron et al. 1997b, Garry 1998). In Finland, this means that university hospitals should arrange post-residency training, allow colleagues from smaller

hospitals to participate in operations and take the responsibility to ensure that the new surgical technique is safely adopted. Otherwise, we will follow the United States, where in response to a high rate of complications resulting from the rapid adoption of laparoscopic cholecystectomy, The New York State Health Department made it mandatory that a surgeon should show adequate skill in at least 15 supervised cases before being allowed to perform the operations independently (Gates 1997).

Since the lifetime risk of hysterectomy is 30% in the United States, 20% in the United Kingdom (Vessey et al. 1992) and Finland (Vuorma et al. 1998) and 10% in Denmark (Settnes and Jorgensen 1996), it is very important to choose a safe, effective, but economical method of hysterectomy. Hysterectomy rates have already decreased in the United States (Weber and Lee 1996) and they have been stable in Finland in the 1990s. The incidence has decreased among young women but has increased among postmenopausal women, as a result of fibroids and uterine bleeding after increasing use of estrogen replacement therapy (Vuorma et al. 1998). Laparoscopic hysterectomy has had an influence on hysterectomy patterns in the last decade. The proportion of abdominal hysterectomies has decreased and those of laparoscopic and vaginal hysterectomies have increased in the United States (Harris and Olive 1994, Johns et al. 1995, Weber and Lee 1996), Australia (Wood et al. 1997) and Finland, but the changes have been minor in the United Kingdom (Hill et al. 1998). An important trend in the next millennium could be to avoid abdominal hysterectomy and change the pattern to laparoscopic and vaginal hysterectomies. As these approaches are less painful, are associated with a more rapid recovery and are even cost-effective when using reusable instruments, they appear to be the preferred methods (Garry 1998). The patient's symptoms as well as the gynecologist's skills influence the choice between these two methods, but everybody should have experience of all techniques of hysterectomy to offer the best treatment to the patient.

SUMMARY AND CONCLUSIONS

Laparoscopic hysterectomy was performed for the first time in 1988 in the United States and in 1992 in Finland. To evaluate how soon a gynecologist experienced in laparoscopic surgery can learn a new technique from the beginning, the first one hundred laparoscopic hysterectomies performed by a single senior gynecologist were analyzed. Laparoscopic removal of the uterus succeeded in all cases and the operating time was on average 109 minutes and the mean operating time was reduced to half after 80 operations. The average hospital stay was 1.3 days, sick leave 10.9 days and complications occurred in 10% of cases. In addition, the nationwide outcome of laparoscopic hysterectomy was evaluated and a national register was founded for a prospective multicenter survey. From 1993 through 1994, 1165 procedures were performed by 68 gynecologists at 30 hospitals. Most of the operations were carried out because of fibroids and the mean operating time was 132 minutes. The patients stayed in hospital for an average of 3.3 days, and the mean sick leave was 17.9 days. Complications occurred in 10.2% of the procedures: infections in 5.6%, vascular injuries in 1.2%, urinary tract injuries in 2.7% and bowel injuries in 0.4%.

Laparoscopic hysterectomy has been said to be a substitute for abdominal hysterectomy, not necessarily for vaginal hysterectomy. Laparoscopic hysterectomy was compared with abdominal hysterectomy in one study. The mean operating time and anesthetic time were significantly longer in the laparoscopic group. On the other hand, there was less blood loss, and the times of hospital stay and sick leave were significantly shorter in association with laparoscopic hysterectomy. There were no significant differences in complications between the study groups. Postoperative tissue trauma was evaluated by assay of serum IL-6, CRP, TATI and CA 125. Postoperative increases in the concentrations of all these markers were seen in laparoscopic and abdominal hysterectomies but the increase was more marked in the abdominal group suggesting more tissue trauma.

To compare complications of laparoscopic hysterectomy with those of other laparoscopic procedures, data files of both the Finnish Hospital Discharge Register and Care Register and the National Patient Insurance Association were used. The incidence of major complications was low in diagnostic and sterilization laparoscopies but it increased steeply in the 1990s in operative laparoscopies. Eighty-two percent of major complications occurred in operative laparoscopies and 69% of these were in laparoscopic hysterectomies.

The incidence of major complications in laparoscopic hysterectomies decreased from 4.9% in 1993 to 1.4% in 1998. Half of the major complications were ureteral injuries, occurring on average in 1% of procedures. However, this incidence also decreased, from 1.9% in 1993 to 0.7% in 1998. As laparoscopic hysterectomies were the main source of laparoscopic ureteral complications in Finland, urinary tract injuries among all types of hysterectomy were analyzed. The rate of ureteral injury was low after vaginal, supracervical abdominal and total abdominal hysterectomy, but high after laparoscopic hysterectomy. In addition, bladder injuries were rare after vaginal and supracervical hysterectomy, but more common after total abdominal hysterectomy. Again, bladder injuries were most common after laparoscopic hysterectomy.

In conclusion, laparoscopic hysterectomy offers many advantages over abdominal hysterectomy, with minimal operative blood loss and pain and a short hospital stay and recovery time. The incidence of ureteral injuries has been unacceptably high. Although the incidence is decreasing it is mandatory to obtain proper experience before performing laparoscopic hysterectomies independently. Laparoscopic and vaginal hysterectomy should be the preferred techniques and the gynecologist's skills and experience influence the choice between these methods.

ACKNOWLEDGEMENTS

This study was carried out at the Department of Obstetrics and Gynecology, Helsinki University Central Hospital and at the Department of Obstetrics and Gynecology, Jorvi Hospital, during the years 1994-1999.

I am very grateful to Professor Olavi Ylikorkala, M.D., Ph.D., and Professor Markku Seppälä M.D., Ph.D., Heads of the Department of Obstetrics and Gynecology, Helsinki University Central Hospital, for providing me with the facilities to carry out this study and for their interest in my scientific work.

I want to express my deepest gratitude to my supervisor, Docent Aila Tiitinen M.D., Ph.D., first of all for guiding me in scientific research as well as for introducing me to the interesting world of gynecological endocrinology. I am lucky to know her also as a friend and she has the ability to create a positive atmosphere for work and research and she never pushed me too hard to finish my studies.

I am especially grateful to my second supervisor, Jari Sjöberg M.D., Ph.D., for teaching me all that I know about laparoscopy. I admire his experience and talent and he has been an example to me in gynecological surgery. I will never forget the enthusiasm which captured us all during the first years of laparoscopic hysterectomy. He also let me have enough freedom to carry out this thesis.

I want to extend my my thanks to Docent Erkki Kujansuu, M.D., Ph.D., and Docent Risto Mokka, M.D., Ph.D., the official reviewers, for their interest and careful review of the final manuscript. Their valuable comments and constructive criticism greatly improved the text.

I thank warmly Docent Juhani Toivonen, M.D., Ph.D., Head of the Department of Obstetrics and Gynecology, Jorvi Hospital, for continuous support and encouragement. He was always there to help me if something seemed to go wrong and his ideas and stimulating criticism of the manuscripts have been of essential importance for accomplishment of this study. I also want to thank him for his humanity and discussions about life itself.

I am most grateful to Docent Tapio Kurki, M.D., Ph.D., for his cooperation in the Patient Insurance Association. Without his help it would have been impossible to collect all the data concerning the complications. He voluntarily collected many of the patient records and

surgical reports for me and he made many valuable comments to improve our manuscripts.

I also thank Docent Ulf-Håkan Stenman, M.D., Ph.D. for his good advise concerning tissue trauma biochemical markers.

I want to express my special thanks to all the members in the working group of gynecological endoscopy, especially Professor Juha Mäkinen, M.D., Ph.D., Professor Pentti Heinonen, M.D., Ph.D., Docent Timo Laatikainen, M.D., Ph.D., Minna Kauko, M.D., Ph.D. and Eija Tomás, M.D., Ph.D., for their collaboration and interest in my work. I have benefited from their wide experience in laparoscopy and enjoyed their pleasant company during many congress trips.

I thank Ms. Anneli Rajamäki for organizing the collection, storage and analysis of the serum samples with such care. I also thank Docent Pentti Kuusela, M.D., Ph.D. for taking care of the interleukin-6 assays and Ms. Liisa Ahola for taking care of the TATI assays.

I also thank Mr. Jari-Matti Lifländer, Ms. Anja Lindholm and Ms. Irma Enroth in the Patient Insurance Association for their cooperation in collecting many patient records from their files.

I am also grateful to Mr. Seppo Pelanteri for calculating the numbers of laparoscopic procedures and hysterectomies from the files of the Finnish Hospital Discharge Register.

I wish to thank Nicholas Bolton, Ph.D., for revising the language of most of my manuscripts and also this doctoral thesis.

I want to express my special thanks to my friends and colleagues in gynecology, Hille Eroila, M.D., Docent Mervi Halttunen, M.D., Ph.D., Maija Harrela, M.D., Riitta Meri, M.D., Päivi Pakarinen, M.D., Ph.D., Raila Suomi, M.D., and Leila Unkila-Kallio, M.D., for their friendship, support and stimulating discussions over twenty years.

I also want to thank all colleagues and other staff in the Departments of Obstetrics and Gynecology in Helsinki University Central Hospital, Jorvi Hospital and the South Karelian Central Hospital for creating a positive attitude for work.

I owe my deep gratitude to my mother, Riitta and my deceased father, Seppo, for giving me a happy childhood in order to succeed in life. I am also very happy to have a brother, Jyrki, and a sister, Reetta, and

their families with whom it is possible to share ups and downs. I also thank all my friends, because without them life would have been very boring.

Finally, I want to give heartfelt thanks to Jukka, my husband, for everyday assistance in computer programs when we both tried to survive with our theses and for the twenty-three years we have shared. My two sons, Petteri and Joonas, have brought such happiness to my life that it is impossible to describe.

This study was financially supported by grants from the Research Foundation of Jorvi Hospital, the Clinical Research Institute of Helsinki University Central Hospital and Jorvi Hospital, the Research Foundation of Obstetrics and Gynecology, the Finnish Medical Foundation and the Research Foundation of Orion Corporation.

Helsinki, September 1999

Päivi Härkki-Sirén

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