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**HYSTERECTOMY, A COMPARATIVE STUDY OF THE
DIFFERENT HYSTERECTOMY ROUTES 2002- 2010
A RETROSPECTIVE ANALYSIS FOR 954 PATIENTS**

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Abbreviations

ACOG	American Committee on Gynecologic Practice
AGE	Arbeitsgemeinschaft Gynäkologische Endoskopie e.V. der Deutschen Gesellschaft für Gynäkologie und Geburtshilfe.
AH	Abdominal Hysterectomy
AQUA	AQUA-Institut für angewandte Qualitätsförderung und Forschung im Gesundheitswesen GmbH
ASF	Arbeitsgemeinschaft Schweizerischer Frauenkliniken
BMI	Body Mass Index
CDC	Centre for Disease Control and Prevention
DUB	Dysfunctional uterine bleeding
ESGE	European Society for Gynaecological Endoscopy
GnRH	Gonadotropin-releasing hormone
LASH	Laparoscopic Assisted Supracervical Hysterectomy
LAVH	Laparoscopic Assisted Vaginal Hysterectomy
PAP	Papanicolaou

TLH | Total Laparoscopic Hysterectomy

VH | Vaginal Hysterectomy

1. Introduction

Hysterectomy is the most frequently performed major gynecologic surgical procedure (Altgassen et al. 2004; Briese V. et al. 2002). The overall rate of hysterectomy in Germany in 2005 - 2006 was 362.9 (295.0 for benign diseases of the genital tract and 44.0 for primary malignant tumors of the genital tract) per 100,000 person-year. Hysterectomy rates varied considerably across federal states: the rate for benign disease was lowest in Hamburg (213.8 per 100 000 women per year) and highest in Mecklenburg–West Pomerania (361.9 per 100 000 women per year) (Stang et al. 2012). The CDC (Centre for Disease Control and Prevention) reported that in USA, the rate of the hysterectomy operation in 2000 - 2004 was 5.4/ 1000 per year (Whiteman et al. 2008). The art of surgery has developed and changed with the advancement of technology so that hysterectomy nowadays is mostly a minimal invasive operation.

The history of hysterectomy started in England with Charles Clay, passing over to Ellis Burnham who performed the first successful abdominal hysterectomy (Graham 1951; Benrubi 1988). The development of hysterectomy in the German speaking countries is to be granted to the following names; Osiander (1759–1822), Sauter (1776–1840), Freund (1833–1917) and Czerny (1872–1916) (Zubke W. et al. 2006; Zubke W. et al. 2006; Zubke W. et al. 2006). The Development of anesthesia and antibiotics led the way to the establishment of VH and AH as the standard operation routes for hysterectomy. In 1988 Harry Reich succeeded in performing the first laparoscopic hysterectomy (Reich 1992) followed by Kurt Semm with the first CISH (Classic Intrafascial Supracervical Hysterectomy) (Semm K. 1991) and then Donnez in 1993 with the traditional laparoscopic hysterectomy which is still performed today (Donnez, J. et al. 1993). The evolvement and development of the advantages of the laparoscopic technique resulted in decreasing the AH by 6-7% annually (Brandner et al. 1995; Neis K.J. et al. 1993).

Benign indications of hysterectomy are symptomatic or growing uterine myomas, adenomyosis uterus, dysfunctional uterine bleeding, endometriosis and prolapse of the uterus (Hornemann A. et al. 2008; Kaufmann M. et al. 2006). Uterine myomas are the most common indication of hysterectomy (Müller A. et al. 2004), myomas cause three main symptoms: pain, bleeding symptoms and infertility (Müller A. et al. 2004; Müller A. et al. 2007). In 2010 the indications for hysterectomy in Germany according to the AQUA- Institute were myomas

60.5%, prolapse 26.7%, menstrual disorders 25.8%, hyperplasia of the uterus and cervix 2.0% and endometriosis 12.9%.

Three hysterectomy approaches can be distinguished: abdominal, vaginal, and laparoscopic. Traditionally, abdominal hysterectomy was used with gynecological malignancy or if the uterus was enlarged. It remains the 'fallback option' if the uterus cannot be removed by another approach. Vaginal hysterectomy was originally used for prolapse and dysfunctional uterine bleeding when the uterus was of fairly normal size (Johnson et al. 2006). The LH was known as an alternative to abdominal hysterectomy, however in the 1990s, most gynecologists 'adopted' the alternative laparoscopic-assisted vaginal hysterectomy (LAVH), an operation requiring more technical skills than the vaginal or abdominal method (Reich 2007). The choice of the hysterectomy route is dependent on many factors; the size and mobility of the uterus, the BMI, preoperative history and anatomical variation, level of experience of the surgeon and the patient's wish (Johnson et al. 2006).

Socioeconomic factors hinder the indications for vaginal hysterectomy as later first deliveries, fewer vaginal deliveries and more caesarean operations are all obstacles for vaginal delivery and put more pressure on the surgeons to achieve a safe laparoscopic surgery. These factors amplify the crucial need for better training programs for laparoscopic surgery.

The ACOG agreed with the AGE that VH is the method of choice of all hysterectomy routes for benign indications (2009; Reich et al. 1999). VH has the shortest operation duration, shortest hospital stay, a lower complication rate and fastest postoperative convalescence (Schindlbeck et al. 2008). On the other hand, a large uterus, a narrow vaginal space, a planned adnectomy and endometriosis excisions are limiting factors for a the VH (Hornemann A. et al. 2008; Schindlbeck et al. 2008). The laparoscopic hysterectomy is the method of choice whenever a VH is not possible (Muller et al. 2010; Kovac et al. 2002). The least blood loss, the shortest hospital stay and better cosmetic results are the well-known advantages of laparoscopic hysterectomy (Müller A. et al. 2005; Schindlbeck et al. 2008).

A well-trained operative team is necessary to achieve a safe surgery with a lower complication rate and a shorter operation time (Schindlbeck et al. 2008; Lyons 2000). In 2010, the VH represented 59.9 % and AH 19.3 % in Germany ; while in the USA VH represented 22%, AH 64% and LAVH 14% (Jacobson et al. 2009). More complications occurred after abdominal compared to vaginal and laparoscopic hysterectomies. The amount of blood loss depended on the type of hysterectomy. More blood loss and a slower

convalescence were recorded during abdominal hysterectomy, so that the trend worldwide is to limit the incidence of AH (2009; Aniuliene et al. 2007; David-Montefiore et al. 2007).

Non-operative treatment or alternatives to hysterectomy are a preferred option for many patients seeking a uterus-preserving therapy such as myoma enucleation or medical treatment. Hysteroscopic myoma removal is to be advised for submucous myoma with 50% invasion of the uterus cavity (ESGE Typ 0 and I). GnRH analogues are recommended for myomas > 3cm to decrease the circumference of the myoma (Al-Mahrizi et al. 2007; Mukhopadhaya et al. 2008); however, the risk of perforation and reoperation must be considered. Ipristal acetate is a first-in-class, orally active, selective progesterone receptor modulator. It reversibly blocks the progesterone receptors in target tissues. As recently published in the New England Journal of Medicine, the 12 week once-a-day oral therapy (vs. injectable GnRH agonist) is effective in stopping uterine bleeding, correcting anaemia and shrinking myoma volume. It improves the quality of life and has no castration side effects, unlike GnRH agonists. There are no data available on treatment duration longer than 3 months. The localization and size of the myoma are the main determining factors for the decision to undertake a laparoscopic myoma enucleation. The less blood loss, less postoperative pain and faster reconvelescence are the main advantages of that technique (Palomba et al. 2007). Uterine artery embolization is an alternative to operative treatment (Bradley 2009; Fennessy et al. 2011). The Cochrane review showed an advantage of a short hospital stay and a shorter convalescence period (Gupta et al. 2012). Medical treatment with long usage of contraceptives could also be advised as a treatment alternative; oral contraceptives can lead to a reduction in bleeding symptoms of up to 40% (2010).

The aim of this study is to investigate the different operative routes and methods of hysterectomy. Different factors seem to influence the decision for the desired hysterectomy procedure.

This study has the following specific aims:

- To outline the indications for the hysterectomy operations
- To outline the development of the hysterectomy procedures
- To compare the different complication rates and outcomes and their association with the operation route

2. Material and Methods

2.1 Patients

Between January 2002 and October 2010 954 patients underwent hysterectomy at the Department of Gynecology and Obstetrics, University Hospitals, Campus Kiel Schleswig-Holstein, for the indication of a benign disease. Indications varied from fibroids (with symptomatic complains and growing fibroid) to dysfunctional uterine bleeding, adenomyotic formations, endometriosis and precancerous lesions of the uterus or the cervix. The relevant criteria of this group of patients were collected and analyzed including the operation indications, operation duration, length of hospital stay, body mass index, weight of the extracted uterus, histopathological results from the excised specimen, PAP results, complications (intra and post- operative) and the hemoglobin fall after the operation.

All patients with malignant histopathological results were excluded from the study. The precancerous lesion of the cervix was identified by the Papanicolaou test (also called Pap smear), which is a screening test used to detect potentially pre-cancerous and cancerous processes in the endocervical canal (transformation zone) of the female reproductive system.

2.2. Operative techniques

2.2.1. Vaginal Hysterectomy (VH)

1. Setting of the patient

After appropriate general anesthesia the patient is placed in the dorsal lithotomy position with the buttocks well off the end of the table. The vulva and vagina are fully prepped with a surgical soap solution. A thorough bimanual examination is necessary prior to performing a hysterectomy. Placing a weighted posterior vaginal retractor into the vagina exposes the cervix. A small right-angle retractor is used to elevate the anterior vaginal wall; a second right-angle retractor displaces one lateral vaginal wall and exposes the cervix. Two Jacobs tenacula are used to grasp the anterior and posterior lips of the cervix and pull them into the vaginal introitus.

2. Injection of vasoconstricting agent

This solution should not be used on patients with hypertension or cardiac arrhythmias but is most useful in healthy premenopausal patients, as it reduces bleeding during dissection.

After the injection of Pitressin into the vaginal mucosa the mucosa is incised with an electrical scalpel around the entire cervix.

3. Bladder dissection

While downward traction is applied on the Jacobs tenacula, the handle of the knife is used to dissect the bladder off the anterior lower uterine segment. A right-angle retractor is placed under the vaginal mucosa and bladder. Strong downward traction is applied to the Jacobs tenacula on the cervix and the peritoneal vesicouterine fold is grasped with pickup forceps and incised with sharp curved Cooper scissors. By elevating the peritoneal vesicouterine fold with the pickup forceps, a definite hole can be seen.

4. Exposure of Cul-de-sac

The Jacobs tenacula are brought acutely up toward the pubic symphysis, exposing the cul-de-sac. Pickup forceps are used to retract the posterior vaginal cuff, thereby placing the peritoneum of the cul-de-sac on tension. The peritoneum of the cul-de-sac is incised with curved Cooper scissors.

5. Securing the uterosacral ligament

The weighted posterior vaginal retractor is removed. With the two Heaney retractors the broad ligament is exposed from the uterosacral ligament to the tubo-ovarian round ligament. With the cervix on upward and lateral retraction via the Jacobs tenacula, a curved Heaney clamp is placed in the posterior cul-de-sac with one blade underneath the uterosacral ligament and the opposite blade over the uterosacral ligament. The clamp is placed immediately next to the uterine cervix so that some tissue of the cervix is included in this clamp.

6. Securing the cardinal ligament

With the uterus on upward and lateral retraction via the Jacobs tenacula on the cervix, the cardinal ligament is clamped adjacent to the lower uterine segment and incised. The cardinal ligament is suture-ligated with 0 synthetic absorbable suture.

7. Securing the broad ligament

When the uterosacral and cardinal ligaments on each side have been clamped, incised and suture-ligated, the remaining portion of the broad ligament attached to the lower uterine segment containing the uterine artery is clamped adjacent to the cervix.

8. Delivery of the uterus

With the uterosacral ligament, the cardinal ligament and the uterine artery pedicle on both sides now clamped, incised and suture-ligated, the cervix is retracted upward in the midline via the Jacobs tenacula. Thyroid clamps are used to grasp the posterior uterine wall and the fundus is delivered posteriorly.

9. Ligation of round ligament

Two Heaney clamps are applied to the tubo-ovarian round ligament and it is incised close to the fundus. The tubo-ovarian round ligament is tied twice. A tie of 0 synthetic absorbable sutures is placed behind the second clamp. The tubo-ovarian round ligament is tied with a simple 0 synthetic absorbable suture. After the clamp at the rear of the pedicle is removed, the forward clamp is "flashed" (i.e. slightly opened and immediately closed), to allow the suture to securely ligate all the structures in this pedicle. A second suture ligature is tied in a fixation stitch, placing the suture in the midportion of its pedicle. The suture is tied in front of and behind the pedicle prior to removing the first clamp. The pedicle is tied and the second suture is held in a straight clamp for traction.

10. Vaginal Closure

The final step is to observe the upper vaginal area for hemorrhage. We prefer to catheterize the bladder at the end rather than at the beginning of the procedure.

2.2.2 Abdominal Hysterectomy (AH)

1. Patient setting

The patient is placed in the dorsal lithotomy position and thorough pelvic examination is performed with the patient under general anesthesia. It is recommended to administer a Single dose of prophylactic antibiotics at the beginning of the operation. The patient is then put in approximately a 15° Trendelenburg position. A Foley catheter is left in the bladder and connected to straight drainage. For benign diseases the Pfannenstiel incision is an adequate alternative to the midline incision. After the abdomen is entered, it should be thoroughly explored; including the liver, gallbladder, stomach, kidneys and aortic lymph nodes.

2. Opening of abdomen

Self-retaining retractors are placed in the abdominal incision and the bowel is packed off with warm, moist gauze packs. A 0 synthetic absorbable suture is placed in the fundus of the uterus and used for uterine traction with two long clamps. The uterus is deviated to the patient's right. The left round ligament is placed on stretch and incised between clamps.

3. Securing of round ligament

The distal stump of the round ligament is ligated with 0 synthetic absorbable sutures. The proximal stump is held with a straight clamp. At this point the leaves of the broad ligament are opened both anteriorly and posteriorly.

4. Opening of leaflets of broad ligament

While retracting the uterus cephalad, the surgeon opens the anterior leaf of the broad ligament to the vesicouterine fold. Steps 2-4 are carried out on the opposite side.

5. Bladder dissection

The vesicoperitoneal fold is elevated and the fine filmy attachments of the bladder to the pubovesical cervical fascia are visible. The bladder can be dissected off the lower uterine segment of the uterus and cervix by either blunt or sharp dissection.

6. Ligation and securing of broad and suspensory ligament

If the ovaries are to be preserved, the uterus is retracted toward the pubic symphysis and deviated to one side with the infundibulopelvic ligament, tube, and ovary on tension. A finger should be inserted through the peritoneum of the posterior leaf of the broad ligament under the suspensory ligament of the ovary and fallopian tube. The tube and suspensory ligament are doubly clamped, incised and tied with 0 synthetic absorbable suture. The distal stump of this structure is best doubly tied, first with a single tie of 0 synthetic absorbable suture and then with a ligature of 0 synthetic absorbable suture. The same procedure is carried out on the opposite side.

7. Ligation and securing of uterine artery pedicle

The uterus is then retracted cephalad and deviated to one side of the pelvis with the lower broad ligament on stretch. Three curved clamps are placed at the junction of the lower uterine segment on the uterine vessels. An incision is made between the upper Ochsner clamp and the two lower Ochsner clamps. This is suture-ligated with two 0 synthetic absorbable sutures, placing the first suture at the tip of the lower Ochsner clamp and tying the suture behind the base of the clamp. The middle Ochsner clamp is left in place and is similarly suture-ligated by a second ligature placed at the tip of the Ochsner clamp and tied behind the base of the clamp.

The same procedure is carried out on the opposite side.

A delicate, transverse, curved incision is made in the pubovesical cervical fascia overlying the lower uterine segment.

8. Mobilization of uterus

The uterus is held in traction in the cephalad position and the handle of the knife is used to dissect the pubovesical cervical fascia inferiorly. This step mobilizes the ureter laterally and caudally.

9. Ligation and securing of cardinal ligament

Two straight clamps are applied to the cardinal ligament within a distance of approximately 2 cm. The cardinal ligament is incised between the two clamps and the distal stump is ligated with 0 synthetic absorbable sutures. The suture is tied at the base of the clamp. The same procedure is carried out on the opposite cardinal ligament.

The posterior leaf of the broad ligament is incised down to the uterosacral ligaments and across the posterior lower uterine segment between the rectum and cervix.

10. Ligation and securing of uterosacral ligament

The uterosacral ligaments on both sides are clamped between straight Ochsner clamps, incised and ligated with 0 synthetic absorbable sutures.

11. Opening of vaginal vault

The uterus is placed on traction cephalad, and the lower uterine segment. The vagina is entered by a stab wound with a scalpel and is cut across with either a scalpel or scissors. The uterus is removed.

12. Closure of vaginal vault

The edges of the vaginal mucosa are sutured with a running locking 0 synthetic absorbable suture starting at the edges of the vagina underneath the bladder and carried around to the stumps of the cardinal and uterosacral ligaments, which are sutured closing the vagina.

13. Closure of the abdominal wall

At this point the pelvis is thoroughly washed with sterile saline solution. Meticulous care is taken to ensure that hemostasis is present throughout the dissected area.

The pelvis is reperitonealized with running 2-0 synthetic absorbable sutures from the anterior to the posterior leaf of the broad ligament.

The choice of leaving drainage for 2 or 3 days after the operation is usually decided by the surgeon at the end of the operation.

2.2.3 Total Laparoscopic Hysterectomy (TLH)

1. Patient setting

After the induction of anesthesia, the patient's legs are placed in padded Allen stirrups. The buttocks must protrude a few centimeters from the edge of the table to allow uterine manipulation. It is recommended to administer a single dose of prophylactic antibiotics at the beginning of the operation. The abdomen, perineum and vagina are prepared with a suitable bactericidal solution and a Foley catheter is inserted.

2. Insertion of uterine manipulator

The Hohl uterine manipulator (Fa. Karl Storz, Tuttlingen, Germany) is inserted. Five safety measures are performed before insertion of the Veress needle; the aorta palpation test, the needle Flow test, the snap test, the hiss phenomenon and the aspiration test. The primary

trocars (umbilicus for camera entry) and the secondary trocars (right and left iliac fossa) are placed under vision to allow the exploration of the abdominal and pelvic anatomy.

3. Separation of adnexa

Stepwise, without bilateral salpingo-oophorectomy (BSO): The 2nd assistant retracts the uterus to the right without any antelexion and with the utmost traction. Coagulation of the round, ovarian ligaments and the tube.

4. Dissection of broad ligament and uterine artery

With BSO, coagulate and cut the infundibular pelvic ligament to remove the ovaries. This is followed by separation of the broad ligament by stepwise coagulation from the uterus and then coagulation and cutting of the uterine arteries with visualization of the ureter.

5. Dissection of the bladder peritoneum

The vesicouterine space is opened. At the vesico-uterine junction coagulate lightly and retract the bladder down and away from uterus. Urinary bladder dissection is not necessary using the Hohl manipulator.

6. Excision of the uterus

The surgeon coagulates and cuts laterally to the cervix to release the sacrouterine ligaments. This is followed by pushing up the uterine manipulator to visualise the vagina. The vagina is cut with the monopolar hook, using the manipulator as a guide to free the uterus completely.

7. Retrieval of the uterus or morcellation

The uterus is pushed through the vagina and may be left in the vagina until the cuff is closed or a large gauze swab in a glove is placed into the vagina to prevent gas loss. In cases of large uteri a Rotocut G1 morcellator (Fa. Karl Storz, Tuttlingen, Germany) is used.

8. Vaginal closure

The rest of the vaginal cuff is closed with a polydioxanone (PDS) suture on a curved needle using an extracorporeal Roeder knot secured by 2-3 intracorporeal safety knots. The surgeon starts with the corner stitch performing the Te Linde suture adapted by van Herendael.

The pelvic sidewall is inspected for bleeding. Successive irrigation and suction are performed to ensure the removal of small morcellated parts. All instruments are then removed, the fascia and the port entries are sutured under vision.

Figure 1. Separation of the round ligament with NightKNIFE[®] (BOWA, Gomaringen, Germany)

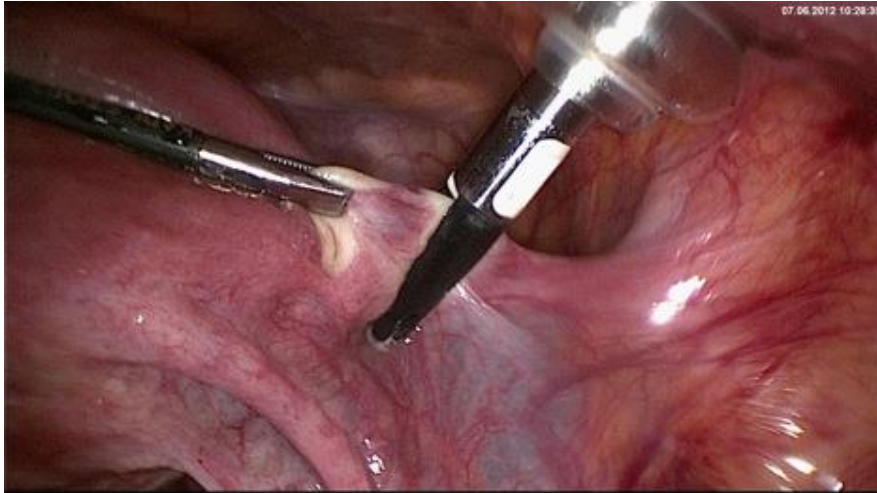


Figure 2. Division of the broad ligament

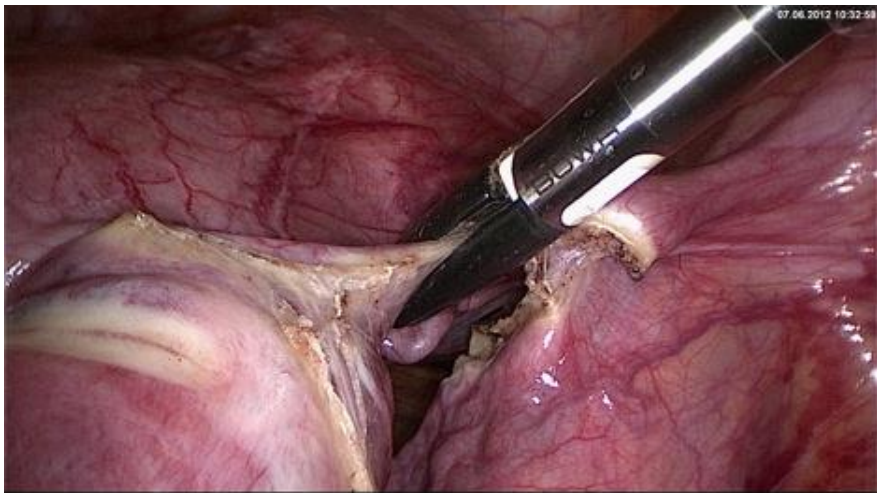


Figure 3. Opening of the vagina following the landmarks between the vessel's root



Figure 4. First corner stitch on the right

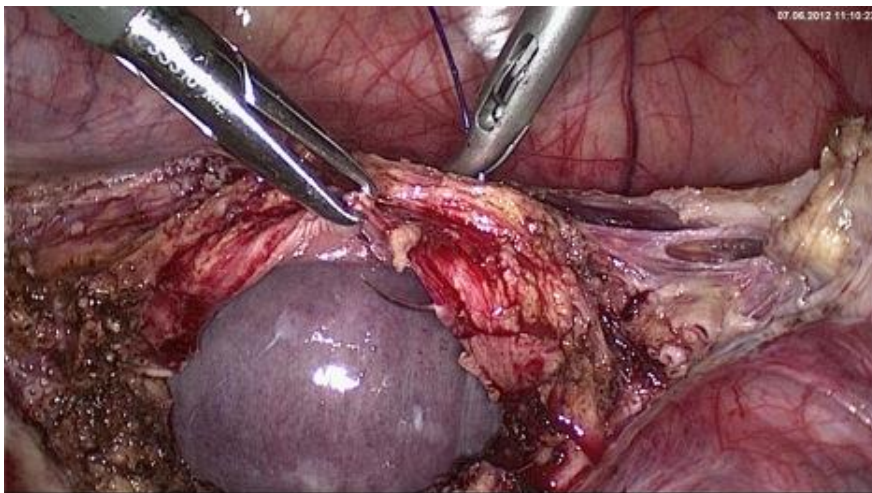
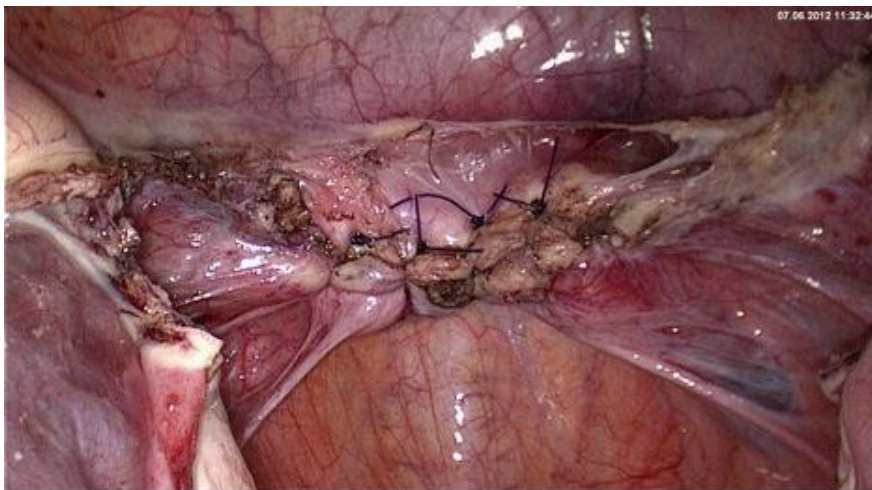


Figure 5. Situs at the end



2.2.4. Laparoscopic Supracervical Hysterectomy (LASH)

1. Patient setting

After the induction of anesthesia, the patient's legs are placed in padded Allen stirrups. The buttocks must protrude a few centimeters from the edge of the table to allow uterine manipulation. It is always recommended to administer a single dose antibiotic at the beginning of the operation. The five safety measures are performed before insertion of the Veress needle; aorta palpation test, needle Flow test, snap test, hiss phenomenon and aspiration test. The primary trocar (umbilicus for camera entry) and the secondary trocar (right and left iliac fossa) are placed under vision to allow exploration of abdominal and pelvic anatomy. In an enlarged uterus the usage of two 10mm ports at a slightly higher position is to be considered.

2. Separation of adnexa

Without BSO (bilateral salphingo-oophrectomy): The uterus is pulled to the respective side by grasping forceps, followed by coagulation and cutting of the round ligament and ovarian ligament. With BSO, coagulate and cut the infundibulopelvic ligament, the tubes and the proper ovarian ligament (ligamentum ovarii proprium) to remove the ovaries and the tubes. The adnexa can be left adjacent to the uterus. It is necessary to visualize the ureter during and after removal.

3. Dissection of broad ligament and uterine artery

The broad ligament is dissected by alternative coagulation and sharp dissection. After identification and skeletonization of the uterine vessels, bleeding is controlled by bipolar coagulation and the vessels are dissected using Metzenbaum scissors.

4. Dissection of the bladder peritoneum

Grasping forceps are used to pull the uterus to the contralateral side. Bipolar coagulation zone is placed on the bladder peritoneum. The vesicouterine fold of the peritoneum is coagulated and then opened with scissors. It is not necessary to push away the bladder.

5. Excision of the uterus

The corpus of the uterus is severed from the cervix with a monopolar hook or loop, or harmonic hook, slowly layer by layer. Hemostasis is achieved by coagulating the cervix stump; the endocervical canal is also coagulated to achieve efficient hemostasis.

6. Peritonisation of the cervix

Peritonisation is performed by taking the peritoneum anteriorly and continuing in a purse string manner, including the sacro- uterine ligaments posteriorly. In this manner the cervix is covered by the peritoneum.

7. Morcellation of the uterus

The incision on the left side is widened for the morcellator, which is introduced under direct vision, and the corpus is removed by morcellation. The remaining small pieces of the uterus or the myoma are retrieved using the grasping forceps. The peritoneum is then closed using bipolar forceps. Gas is released. Closure of the fascia is required if the incision is larger than 10mm. Successive irrigation and suction are performed to ensure removal of smaller morcellated parts. The instruments are afterwards removed and the port incisions closed.

2.2.5 Laparoscopic Assisted Vaginal Hysterectomy (LAVH)

1. Patient setting

After the induction of anesthesia, the patient's legs are placed in padded Allen stirrups. The abdomen, perineum and vagina are prepared with a suitable bactericidal solution and a Foley catheter is inserted.

The Veress needle, primary trocar (umbilicus for camera entry) and the secondary trocar (right and left iliac fossa) are inserted to allow exploration of abdominal and pelvic anatomy. In an enlarged uterus the usage of two 10mm ports at a slightly higher position is to be considered. It is always recommended to administer a single dose of prophylactic antibiotics.

2. Separation of adnexa

Steps for surgery, without BSO (bilateral salpinx-ophorectomy): The uterus is pulled to the respective side by grasping forceps followed by coagulation and cutting of the round ligament and ovarian ligament. With BSO, coagulate and cut the infundibulopelvic ligament to remove the ovaries.

3. Dissection of broad ligament

The round ligaments must be coagulated with bipolar forceps and cut. If preservation of the adnexa is preferred, a dissection of the utero-ovarian ligament close to the ovary must be preserved. The leaves of the broad ligament are opened and the anterior broad ligaments are opened downward and towards the bladder.

4. Dissection of the bladder peritoneum

The uterovesical junction is identified, grasped and elevated with grasping forceps and then cut with scissors. The bladder pillars are first coagulated and cut, completely freeing the bladder from the uterus by pushing downwards.

5. Transformation to the vaginal route

The cervix is grasped with two single-toothed tenacula. A circular incision around the cervix about 5 mm above the external os is performed followed by separation of the vaginal wall from the cervix. The border between the anterior wall of the uterus and the bladder must be identified. The bladder is pushed up, always as close as possible to the uterus. It separates and moves up until the anterior peritoneum is opened.

The posterior peritoneum is opened after separating the vaginal epithelium posteriorly. The paracervical tissues and the uterosacral ligaments are then clamped together, cut, ligated and the suture material is left in full length.

6. Dissection of uterine artery

This is repeated on the other side. The Cardinal ligaments and uterine arteries on either side are clamped, cut and ligated separately. The anterior peritoneum is opened, followed by the delivery of the uterus. After fixing the uterosacral ligaments and the cardinal ligaments to the vault, the vault is closed.

2. 3. Methods

2.3.1. Data collection

The data were retrospectively collected from patient records and analyzed. The operation information lists were collected from the operation recording archive data backup for the period January 2002- October 2010. The patient's data were collected from files and organised in a spreadsheet according to the evaluated data including patient's age, BMI, parities, former operations, indications of operation, duration of hospital stay, operating time, weight of uterus, histopathological report of removed specimen, hemoglobin decrease and intra- and postoperative complications. The operating time was calculated from the first incision till the final stitches. The body mass index (BMI) was calculated using the formula weight in kilograms divided by the patient's height in square meters. The Hemoglobin level was measured one day preoperatively and remeasured one day post operatively and the difference was recorded. The uterus weight was recorded from the pathology reports. Thirty patients were completely excluded from the comparison criteria due to improper or incomplete recording of the patient data. The perioperative score was recorded by 785 patients.

2.3.2. Criteria of comparison

All patients who underwent a hysterectomy in the period from January 2002 to October 2010 for benign uterine disease were included in our comparison criteria. In order to have clear comparison parameters, we decided to define a preoperative score and to classify the intraoperative and postoperative complications into major and minor.

Preoperative score

All patients who had undergone a previous laparoscopy were given 1 point, for a previous laparotomy 2 points, for (1x) caesarian section 3 points, for (2x) caesarian sections 4 points, for (3x) caesarian sections 5 points and for no previous operation 0 points.

Intraoperative complications

Injury to blood vessels requiring a blood transfusion, the intestines, rectum and urinary tract injury, including ureter and urinary bladder, are classified as intraoperative complications.

Postoperative complications

Postoperative complications were categorized into major and minor. The major included postoperative bleeding and revision operation and the minor postoperative complications included haematoma, vaginal bleeding, wound infection, burning sensation, urinary tract infection and fever.

2.3.3. Statistic analysis

The data were registered in the computer by creating a spreadsheet. The IBM SPSS statistics program were used to log and analyze the data. We received statistical advice from the Medistat GmbH office. The statistical analyses were used to examine differences within the five groups concerning the analyzed parameters. The tests used for statistical calculations were as follows: 1) Chi-Square Test for use in the analysis of the difference between two proportions 2) T-test to test the for the significance of the difference between two proportions or percentages and 3) U-Test from Mann Withney and Wilcoxon to compare one quantitative value between two groups of patients. Demographic and surgical data were analyzed by analysis of variance (ANOVA), Kruskal-Walis-, Chi-square- or Fischer's test. For the parameters age, BMI, hospital stay, operation duration, uterus weight and hemoglobin decrease an average value was obtained and a calculation of standard deviation was done. A p value less than 0.05 was considered to be statistically significant. We also used the Lilliefors significance correlation, where a significant correlation R value of more than 0.2 was considered to be statistically correlated.

3. Results

3.1 Indications for the Operations

Uterine myoma (65.19%), adenomyosis (11.21%), dysfunctional uterine bleeding (12.99%), endometriosis (5.03%), hyperplasia of the endometrium of the cervix (1.99%) and total uterine prolapse (14.79%) were the six most common reasons for the hysterectomy procedure in the period from 2002 – 2010 (Table 1).

A total of 296 AH were performed, 9 (3.2%) operations were excluded from our study due to malignant histopathological findings. Overall 405 VH were performed, 12 (2.9%) operations were excluded as a result of malignant findings (vulvar and ovarian carcinoma) and 10 due to incomplete records. A total of 190 LASH were performed, 15 operations were excluded due to incomplete records and 7 (3.6%) patients due to malignant histopathological criteria. Seventy-six TLH were performed, 3 (3.9%) were excluded as a result of malignant histopathological findings and 5 due to incomplete records.

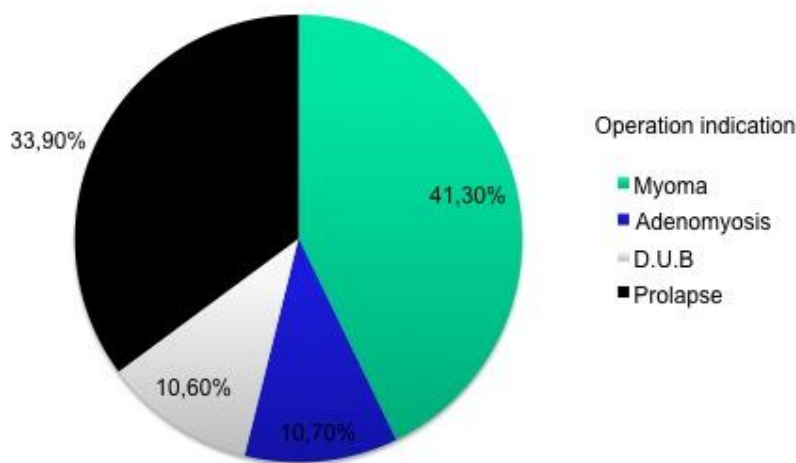
Table. 1. Overview of the operation indications

Operation indication	AH	VH	LASH	TLH	LAVH	Total
Uterine myoma	238	158	145	50	31	622
	82.9%	41.30%	85.7%	73.5%	66%	65.19%
Adenomyosis	22	41	25	12	7	107
	7.7%	10.7%	14.7%	17.6%	14.9%	11.21%
Dysfunctional uterine bleeding	37	40	39	3	5	124
	12.9%	10.4%	23.1%	25.0%	10.6%	12.99%
Hyperplasia of the uterus, cervix	6	11	0	1	1	19
	2.0%	2.9%	0.0%	1.5%	2.1%	1.99%
Prolapse	3	131	4	0	3	141
	1%	34.1%	2.5 %	0	6.4%	14.79%
Endometriosis	12	6	17	7	6	48
	4.2%	1.6%	10.1%	10.3%	12.8%	5.03%
						954

3.1.1. Indications for VH

The main indications for vaginal hysterectomy were uterine myomas 158 (41.3%), adenomyosis 41 (10.7%), dysfunctional uterine bleeding 40 (10.6%), diffuse hyperplasia of the uterus and cervix 11 (2.9%), total prolapse 131 (33.9%) and endometriosis 6 (1.6%). Other indications (completed family planning) represented 20 cases (5.2%) (Table 1, Figure 1).

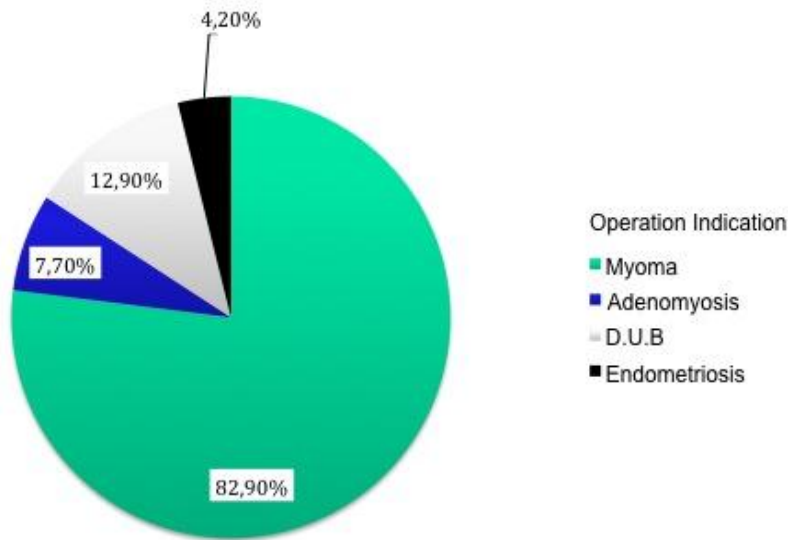
Figure 1. Operation indication for VH



3.1.2. Indications for AH

The main indications for abdominal hysterectomy were uterine myomas 238 (82.9%), adenomyosis 22 (7.7%), dysfunctional uterine bleeding 37(12.9%), diffuse hyperplasia of the uterus and cervix 6 (2.0%), total prolapse 3 (1.0%) and endometriosis 12 (4.2%). Other indications (completed family planning) represented 7 cases (2.4%) (Table 1, Figure 2).

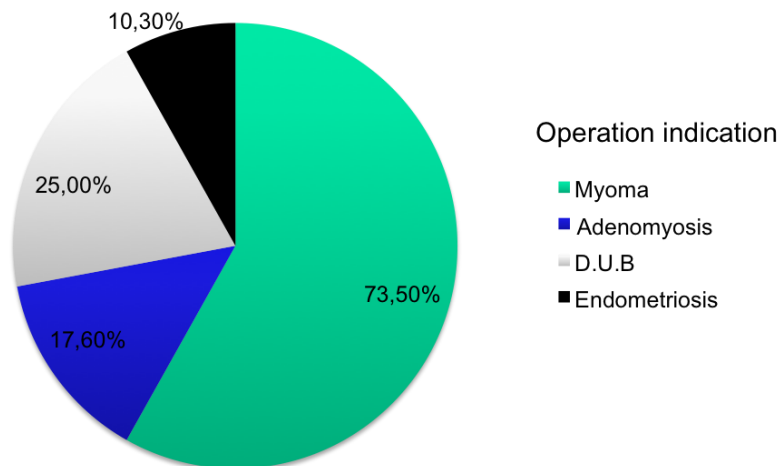
Figure 2. Operation indication for AH



3.1.3. Indications for TLH

The main indications for TLH were uterine myomas 50 (73.5%), adenomyosis 12 (17.6%), dysfunctional uterine bleeding 3 (25.0%), diffuse hyperplasia of the endometrium 1 (1.5%), and endometriosis 7 (10.3%). Other indications, such as completed family planning represented 4 cases (5.9%) (Table 1, Figure 3).

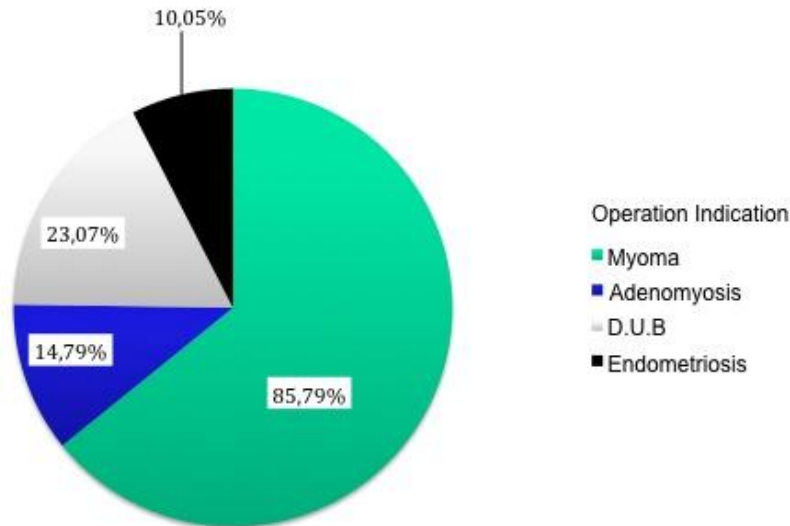
Figure 3. Percentage of operation indication by TLH



3.1.4 Indications for LASH

The main indications for LASH were uterine myomas 145 (85.79%), adenomyosis 25 (14.79%), dysfunctional uterine bleeding 39 (23.07%), total prolapse 4 (2.50%) and endometriosis 17 (10.05%) (Table 1, Figure 4).

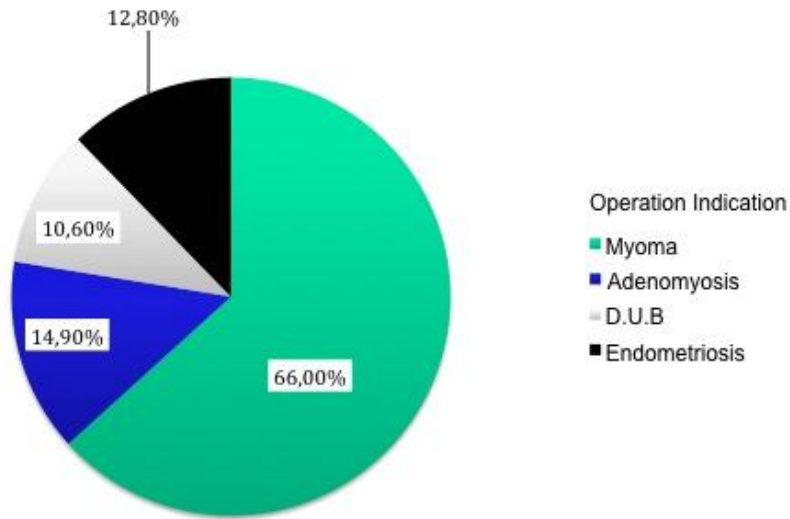
Figure 4. Operation indication for LASH



3.1.5. Indications for LAVH

The main indications for LAVH were uterine myoma 31 (66.0%), adenomyosis 7 (14.9%), dysfunctional uterine bleeding 5 (10.6%), diffuse hyperplasia of the uterus and cervix 1 (2.1%), total prolapse 3 (6.4%) and endometriosis 6 (12.8%). Other indications, such as completed family planning, represented 2 cases (4.3%) (Table 1, Figure 5).

Figure 5. Operation indication for LAVH



3.2. Patient age at the hysterectomy operation

The average age of the patients at the time of the hysterectomy was 47.95 years (Figure 6). The average age for the AH was 44.84 years (40.00- 48.00), for the VH 52.97 years (43.00- 64.00), for the LASH 44.38 years (41.00- 47.00), for the LAVH 44.53 years (41.00- 47.00), and for the TLH 44.13 (40.25- 47.75) (Figures 6, 7).

Figure 6. Patient age at the time of hysterectomy operation

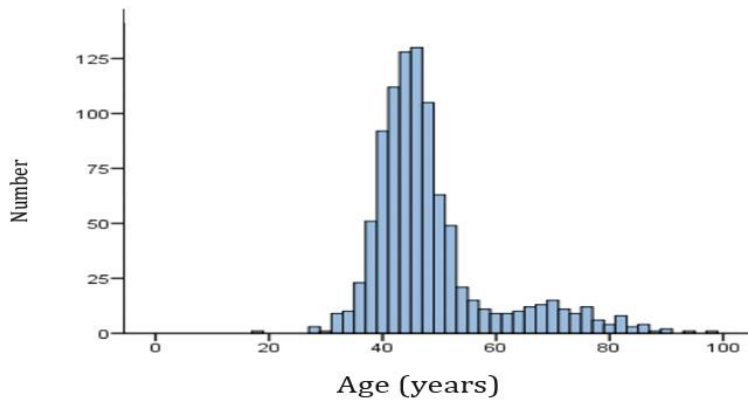
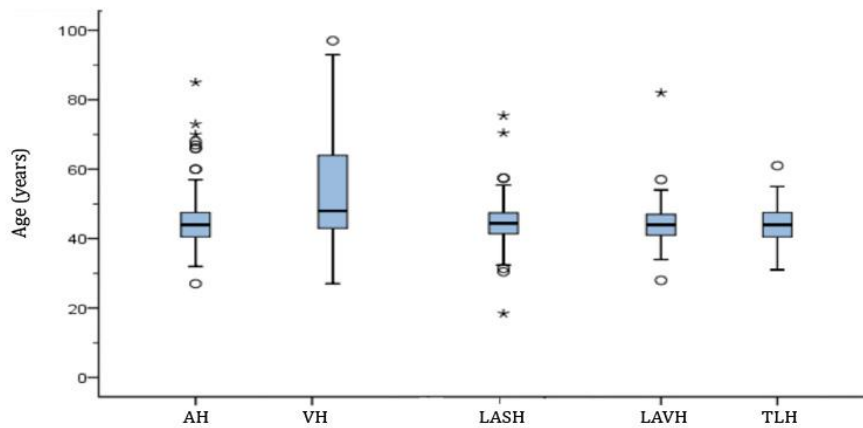


Figure 7. Patient age by the different routes of hysterectomy



3.3. BMI at the hysterectomy operation

The average BMI of the patients at the time for the hysterectomy was 25.85 (22.12- 28.15) (Figure 8). The average BMI for AH was 26.49, for VH 26.19, for LASH 24.27, for LAVH 25.73 and for TLH 25.35. Furthermore, no significant correlation was found between BMI, uterus weight and operation duration (Figures 9, 10).

Figure 8. Distribution of BMI at hysterectomy

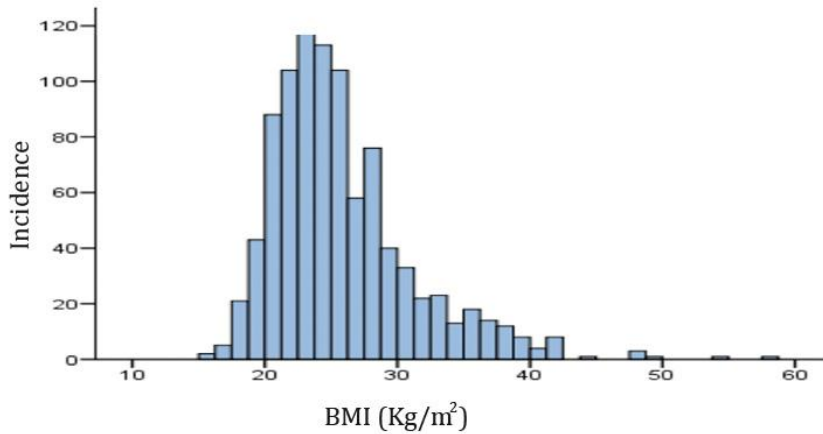


Figure 9. Correlation between BMI and operation duration

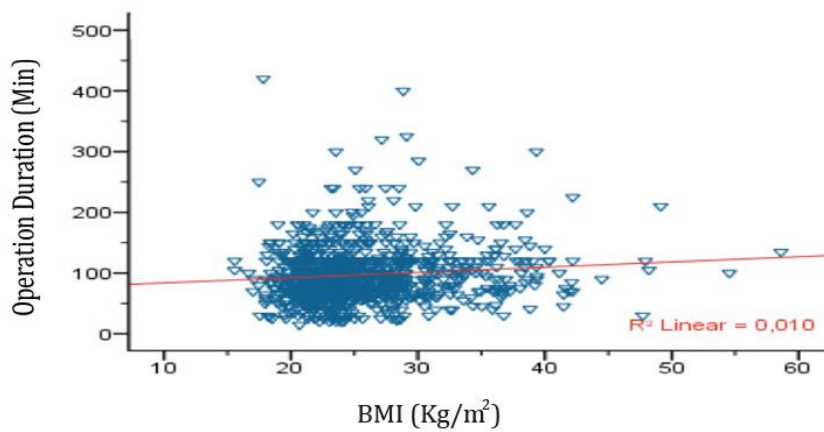
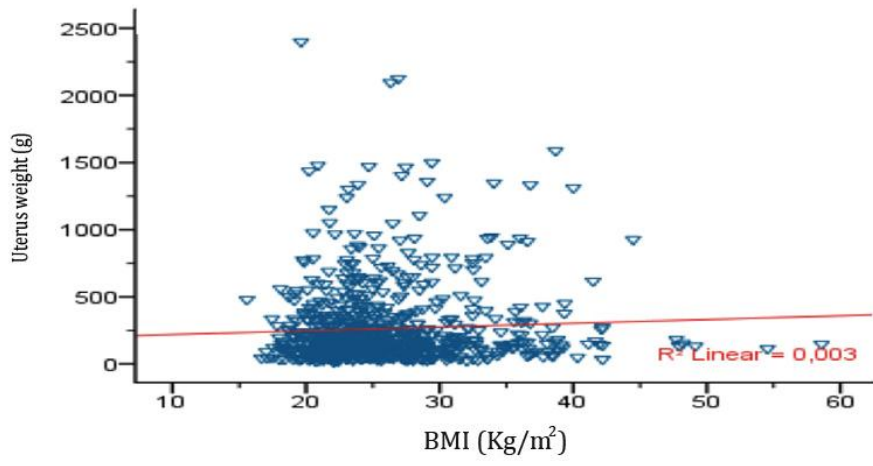


Figure 10. Correlation between BMI and uterus weight



3.4. Parity at the hysterectomy operation

From 203 abdominal hysterectomies, 86 (42.6%) patients were nullipara, 95 (46.5%) uni-bipara and 22 (10.9%) more than bipara and From 291 vaginal hysterectomies 16 (5.5%) patients were nullipara, 172 (59.1%) uni-bipara and 103 (35.4%) more than bipara. From 163 LASH operations, 68 patients (41.7%) were nullipara, 76 (46.6%) uni-bipara and 19 (11.7%) more than bipara. From 43 LAVH operations, 7 (16.3%) patients were nullipara, 19 (44.7%) uni-bipara and 17 more than bipara. From 66 TLH operations, 17 (25.8%) were nullipara, 38 (57.6%) uni-bipara and 11 (16.7%) more than bipara (Figure 11).

The operation duration increased with a higher parity for all operation routes (Figure 12). Significant differences by the multipara by the VH in comparison to all others routes were found.

Figure 11. Parity distribution by the different operation routes

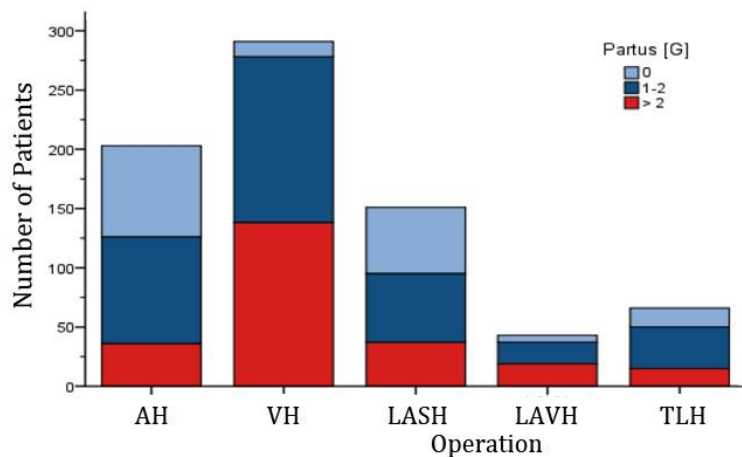
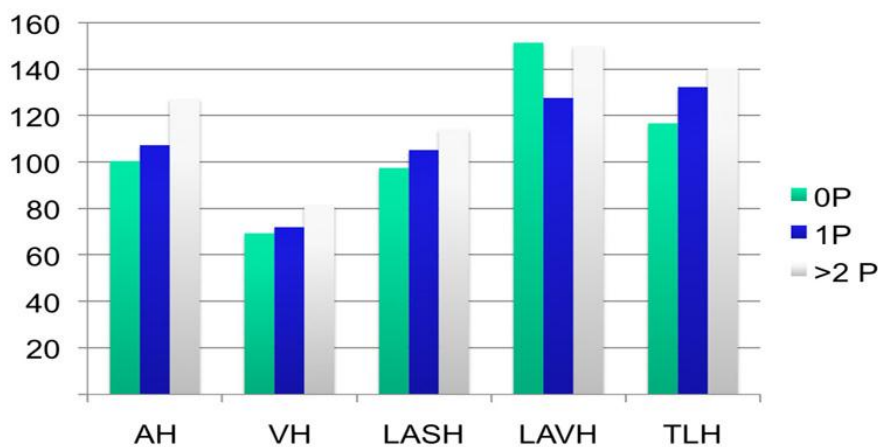


Figure 12. Association between operation duration and parity by different operation routes



3.5. Preoperative score at the hysterectomy operation

The average preoperative score for the AH was 1.09, for the VH 0.75, for the LASH 1.04, for the LAVH 1.0 and the highest preoperative score was recorded by the TLH 1.38 (Figure 12). The prevalent scores in the VH were 0 and 1, the LASH and TLH showed a prevalence over VH in the preoperative scores 3 and 4 and AH showed a prevalence over the other methods in the preoperative score 3 - 8 (Table 2).

Figure 12. Distribution of the preoperative score according to the hysterectomy

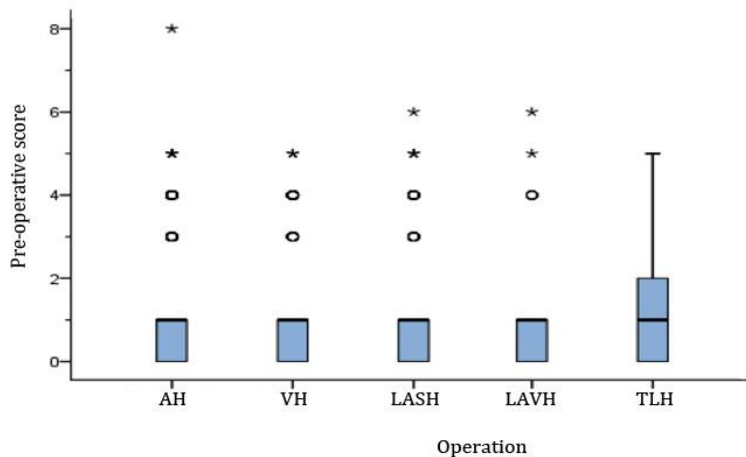


Table 2. Preoperative score distribution according to the hysterectomy operation

Pre-operative score	AH	VH	LASH	LAVH	TLH	Total
0	98 29,5%	130 39,2%	64 19,3%	18 5,4%	22 6,6%	332 100,0%
1	66 19,2%	151 43,9%	78 22,7%	20 5,8%	29 8,4%	344 100,0%
3	15 40,5%	6 16,2%	11 29,7%	0 0,0%	5 13,5%	37 100,0%
4	20 36,4%	10 18,2%	12 21,8%	3 5,5%	10 18,2%	55 100,0%
5	5 35,7%	3 21,4%	3 21,4%	1 7,1%	2 14,3%	14 100,0%
6	0 0,0%	0 0,0%	1 50,0%	1 50,0%	0 0,0%	2 100,0%
8	1 100,0%	0 0,0%	0 0,0%	0 0,0%	0 0,0%	1 100,0%
Total	205 26,1%	300 38,2%	169 21,5%	43 5,5%	68 8,7%	785 100,0%

3.6. Length of hospital Stay for the Hysterectomy

The average hospital stay for the AH was 7.92 days, for the VH 6.74 days, for the LASH 3.88 days, for the LAVH 5.85 days and for the TLH 4.32 days (Figure 13).

The hospital stay was statistically tested against the BMI. However, the two tested parameters showed no significant correlation (Figure 14).

Figure 13. Length of Hospital stays for the different hysterectomy route

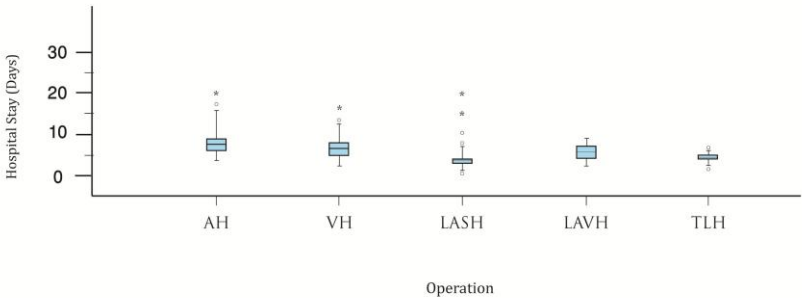
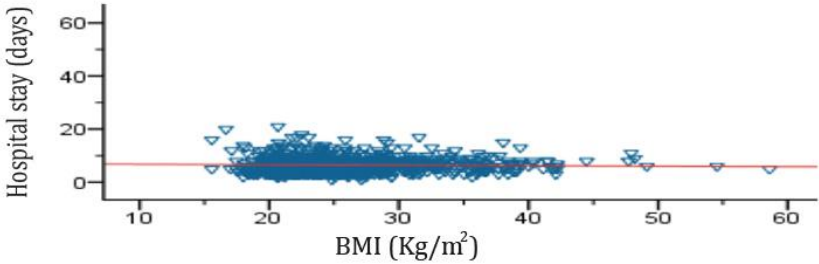


Figure 14. Correlation between the BMI and length of hospital stay

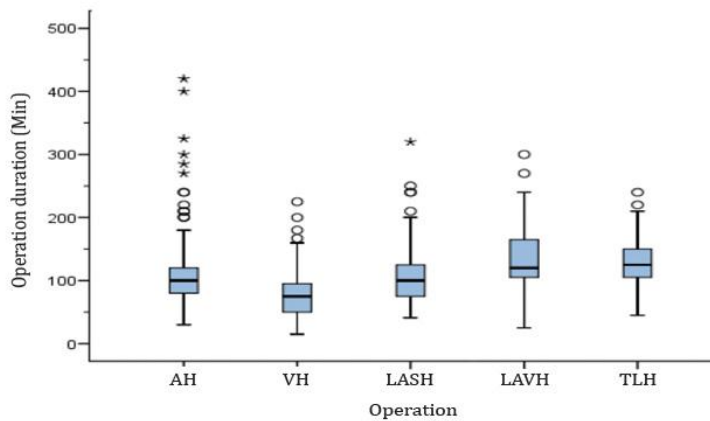


3.7. Operation duration for the Hysterectomy operation

The average operation duration for the AH was 107.71 minutes, for LASH 106.59, for LAVH 137.00 and for TLH 130.24 minutes. The shortest operation duration was recorded for VH 76.03 minutes (Figure 15).

The operating time of the TLH was shortened by 50 minutes in the period from 2007-2010, 161.67 minutes in 2007 and 108.93 minutes in 2010.

Figure 15. Operation duration of different hysterectomy



3.8. Uterus weight for the hysterectomy operation

The average uterus weight after the hysterectomy was 263.89 grams (Figure 16). The average uterus weight for AH was 518.58 grams, for LASH 244.92 grams, for LAVH 159.24 grams and for TLH 205.11 grams. The lightest average uterine weight was for VH 127.77 grams (Figure 17).

Figure 16. Uterus weight distribution

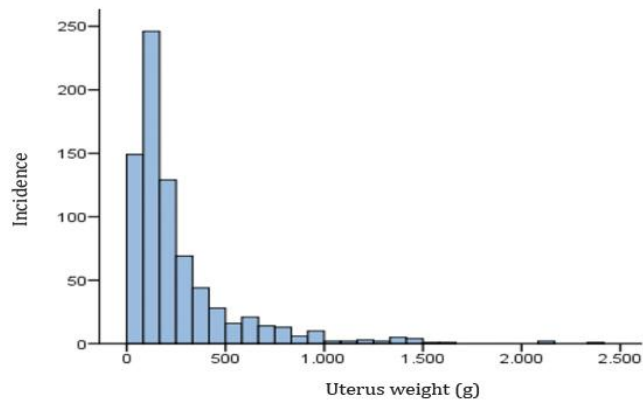
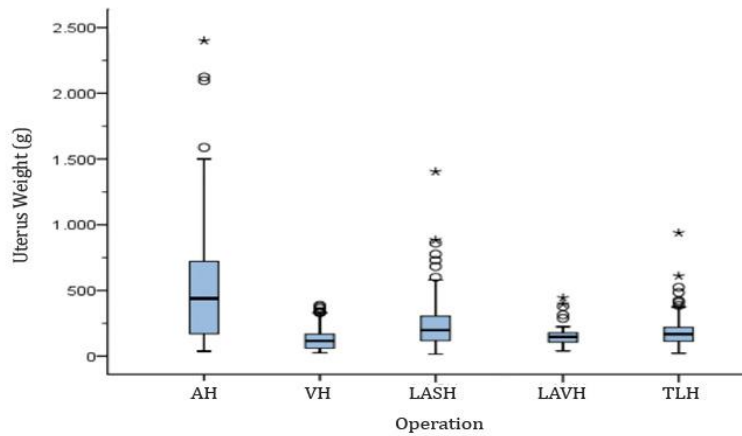


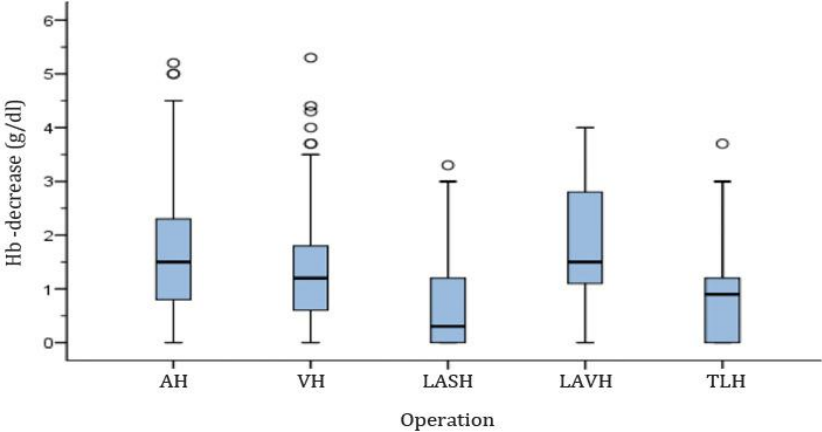
Figure 17. Distrubtion of uterus weight for the hysterectomy operation



3.9. Hemoglobin decrease for the hysterectomy operation

The average hemoglobin decrease for AH was 1.63 g/dl, for the VH 1.29 g/dl, for LASH 0.70 g/dl, for LAVH 1.83 g/dl and for the TLH 0.82 g/dl (Figure 18).

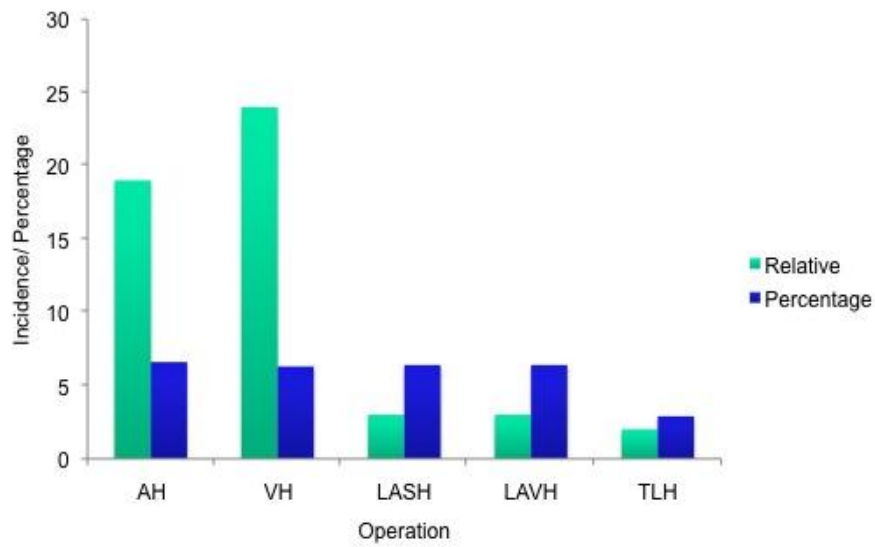
Figure 18. Hemoglobin decrease for the hysterectomy operation



3.10. Complications

From a total of 953 hysterectomies, 52 (5.5%) complications were recorded. Complications occurred in 24 (6.3%) cases of VH and in 19 (6.6%) cases of AH. Complications were recorded in 4 cases (2.4%) of the LASH, 3 (6.4%) cases of the LAVH and 2 (2.9%) cases of the TLH (Figure 19).

Figure 19. Complication occurrence by hysterectomy



3.10.1. Minor Complications

Minor complications were recorded in 56 (5.87%) of 953 hysterectomies. In 23 (6.0%) cases of the VH and in 24 (8.4%) of the AH complications occurred. Complications were recorded in 3 (1.8%) of the LASH, 3 (6.4%) of LAVH and in 3 (4.4%) of the TLH (Figure 20). Haematoma were recorded in 15 of the AH, wound infection and urinary tract infection complications occurred in 5 cases of the VH (Table 3).

Figure 20. Minor complication by the hysterectomy operation

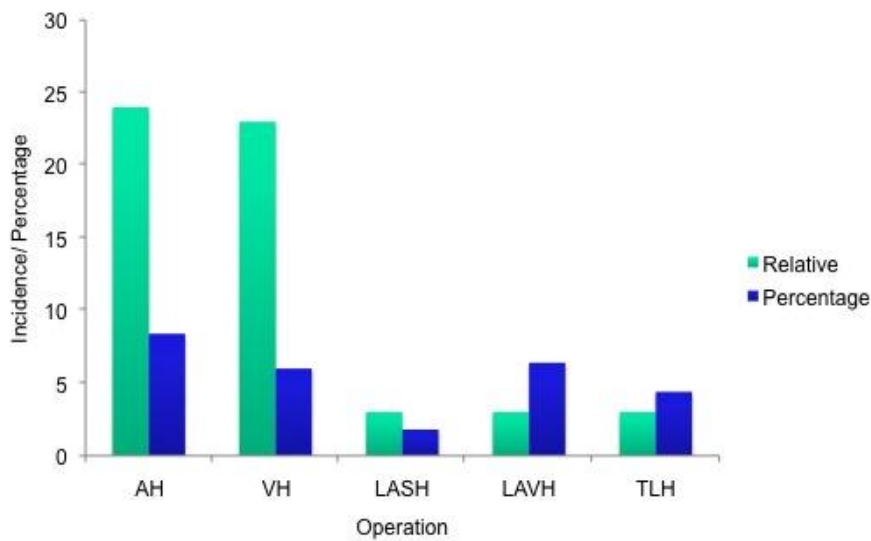


Table 3. Minor postoperative complications

Minor post operative complication	AH	VH	LASH	LAVH	TLH
Haematoma	15	13	2	1	1
Vaginal bleeding	0	1	0	2	0
Wound infection	3	5	0	0	0
Burning	1	0	0	0	1
Fever	5	2	0	0	1
Urinary tract infection	1	5	1	0	1

3.10.2. Major Complications

From a total of 953 hysterectomies, 18 (1.78%) Major complications were recorded. It occurred in 7 (1.8%) at the VH and 4 (1.4%) at the AH. Complications were recorded in 3 (1.2%) of the LASH, in 3 cases of LAVH (6.4%) and in only 1 (1.5%) case of the TLH (Figure 21). Major postoperative complications, such as bleeding and a revision operation were recorded in 3 cases by the LASH (Table 4).

Figure 21. Distribution of major complications by hysterectomy operation

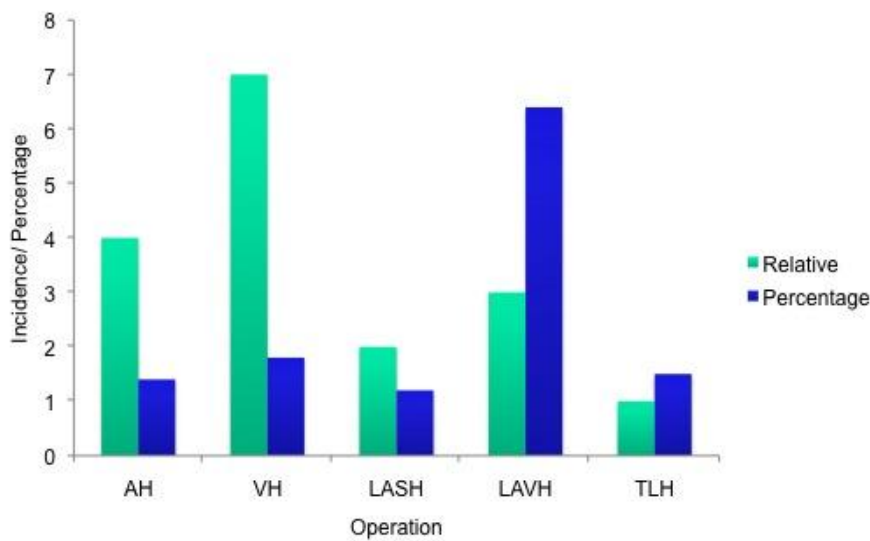


Table 4. Major postoperative complications

Major post operative complicaton	AH	VH	LASH	LAVH	TLH
Bleeding	0	1	1	0	0
Revision	4	6	2	3	1

3.10.3. Intraoperative Complications

Intraoperative complications were recorded in 28 (2.93%) of 953 hysterectomies. The distribution of intraoperative complications was as follows: 10 (2.6%) of the VH, 13 (4.5%) of the AH, 3 (1.8%) of the LASH, 1 (2.1%) of the LAVH and 1 (1.5%) of the TLH (Figure 22). Intraoperative complications, such as urinary tract lesion and intestinal lesion, occurred in 3 cases of the LASH. Blood loss requiring transfusion was more often recorded at the AH (Table 5).

Figure 22. Distrubtion of intraoperative complications by hysterectomy

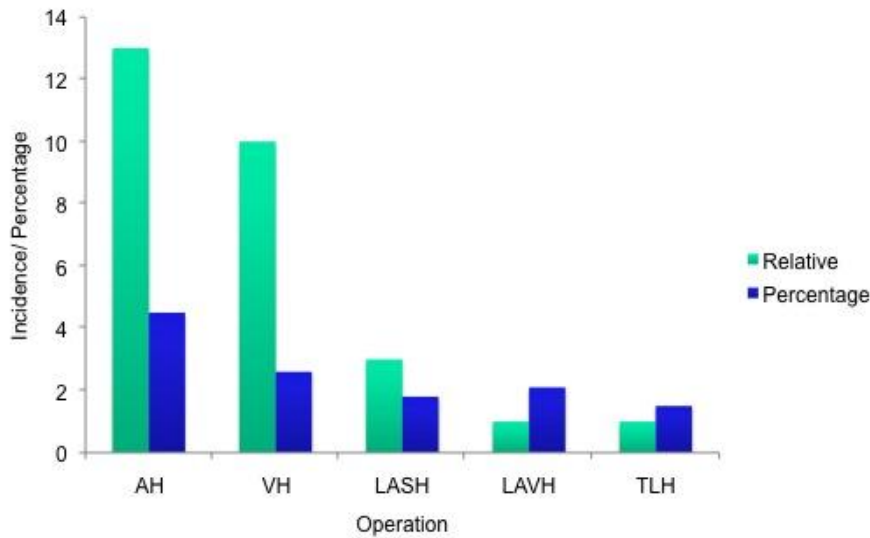


Table 5. Intraoperative complications

Intraoperative complication	AH	VH	LASH	LAVH	TLH
Urinary tract lesion	2	3	2	0	0
Intestine lesion	2	0	1	0	0
Blood loss requiring transfusion	9	7	0	1	1

3.10.4. Complication association

Intraoperative complications occurred more frequently with increasing the uterine weight. Hemoglobin decline increased in the presence of intraoperative complications (Figures 23, 24). Hospital stay and operation duration were prolonged in the presence of intraoperative complications showing a direct correlation, while the increase of BMI and uterine weight showed no correlation with postoperative complications (Figure 25, 26).

Figure 23. Intraoperative complication correlation by uterine weight at hysterectomy

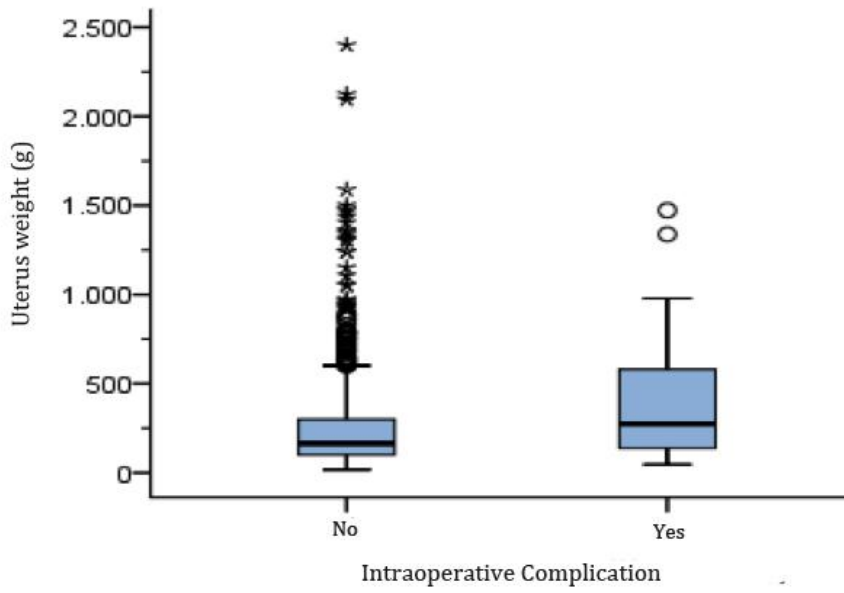


Figure 24. Intraoperative complication correlation with hemoglobin decline at hysterectomy

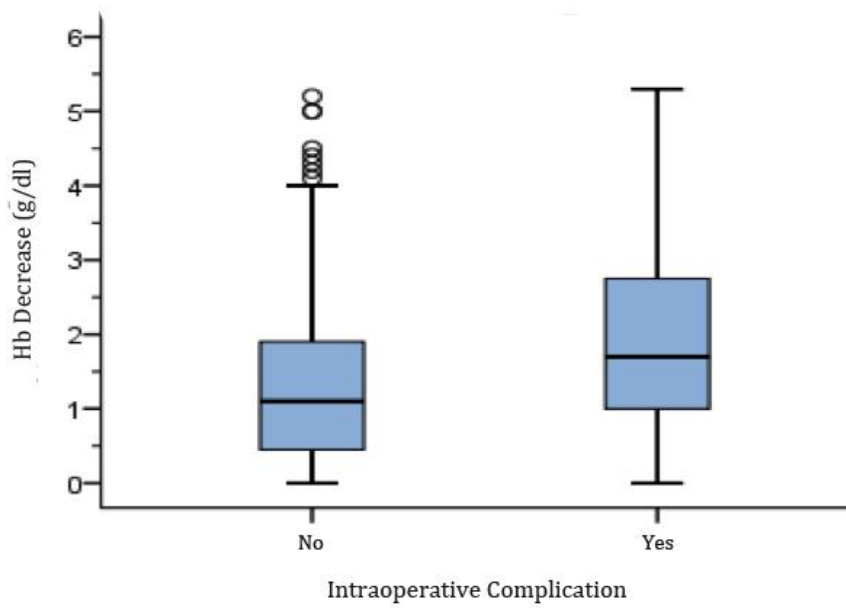


Figure 25. Post operative complication correlation with age at hysterectomy

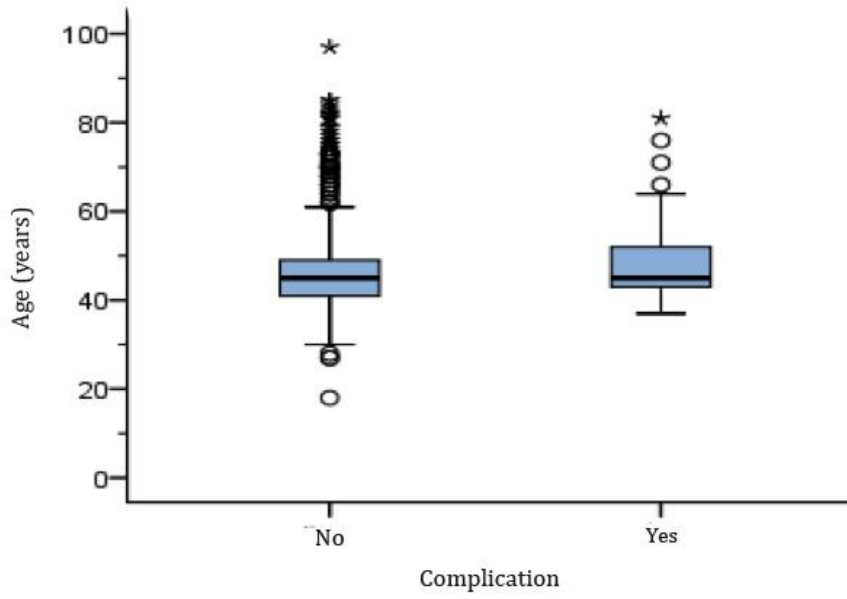
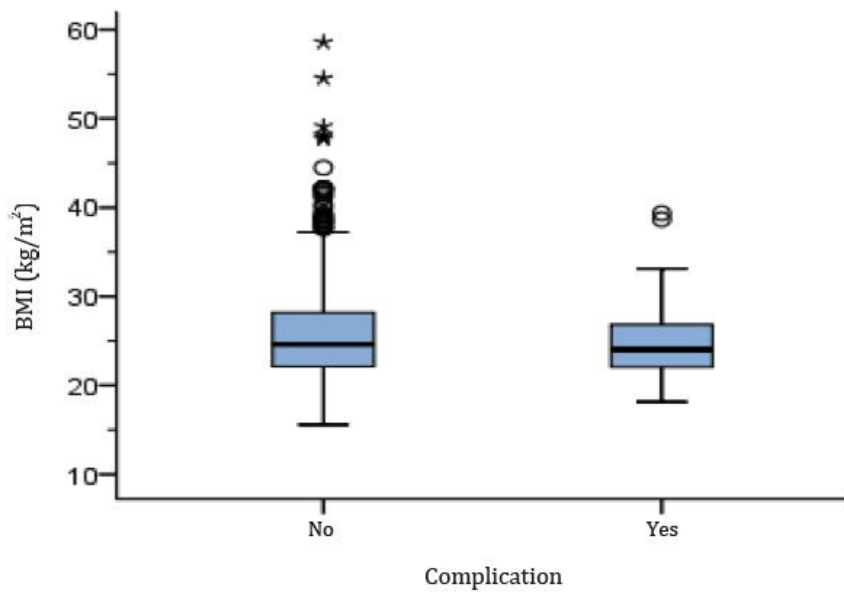


Figure 26. Post operative complication association with BMI by hysterectomy



3.11. Significant statistical analysis

A p value less than 0.05 were considered to be statistically significant. We also used the Lilliefors significance correlation, where a significant correlation R-value of more than 0.2 was considered to be statistically correlated.

The statistical analysis of VH compared to all other operation routes showed a significant difference regarding the patient's age on the day of the operation ($P < 0.05$), while no significant changes were found within the other methods. The statistical analysis was significant by BMI between the LASH and VH and AH ($P < 0.05$) and no further significant findings were observed by the other operation routes. The preoperative score showed a significant difference in comparing the VH to LASH and TLH ($P < 0.05$). The hospital stay was significant by LASH and TLH in comparison to all other routes ($P < 0.05$). The operative duration of VH was significant in comparison to all the other routes and the LASH was statistical significant in comparison to the TLH and LAVH ($P < 0.05$). The uterus weight showed a significant difference between the various operation routes. The hemoglobin decline was statistical significant by the LASH and TLH in comparison to all others routes ($P < 0.05$) (Table 6).

Table. 6. Statistical significance between the different hysterectomy routes

	Significant appraisal	Mann- Whitney Kruskal- Wallis Test (p value)
Age	VH-AH VH-LASH VH-LAVH VH-TLH	,000 ,000 ,000 ,000
BMI	AH-LASH VH-LASH	,000 ,000
Preoperative score	AH-TLH VH-LASH VH-TLH	,045 ,036 ,003
Hospital stay	AH-VH AH-LASH AH-LAVH AH-TLH VH-TLH VH-LASH VH-LAVH LASH-LAVH LASH-TLH LAVH-TLH	,000 ,000 ,000 ,000 ,000 ,000 ,011 ,000 ,000 ,000
Operation duration	AH-VH AH-LAVH VH-LASH VH-LAVH VH-TLH LASH-LAVH LASH-TLH	,000 ,000 ,000 ,000 ,000 ,000 ,000
Uterus weight	AH-VH AH-LASH AH-LAVH AH-TLH VH-LASH VH-LAVH VH-TLH LASH-LAVH	,000 ,000 ,000 ,000 ,000 ,023 ,000 ,003
Hemoglobin decline	AH-VH AH-LASH AH-TLH VH-LASH VH-LAVH VH-TLH LASH-LAVH LAVH-TLH	,002 ,000 ,000 ,000 ,003 ,002 ,000 ,000

3.12. Main outcome results

Patients with uterine myomas, endometriosis, additional adnexal pathology and high BMI benefit from the laparoscopic access route in comparison to AH and VH.

Patients with prolapse, a higher parity score and a low preoperative score benefit from VH compared to LH and AH.

VH is a safe natural orifice route for patients with a large number of vaginal deliveries and a low uterine weight. The operation duration is significantly shorter and postoperative results are comparable to laparoscopic hysterectomies.

LASH and TLH are minimally invasive methods showing the lowest intraoperative and postoperative complication rate especially for patients with a high preoperative score and a high uterine weight. Laparoscopic hysterectomies showed the lowest hemoglobin decline and the shortest hospital stay and therefore should be the method of choice if VH is not possible.

Intraoperative complications correlated with the increase in uterine weight, while no important correlations between BMI, age and uterine weight were observed.

LASH and TLH are associated with a generally lower rate of complications in comparison to AH and VH. The increase of BMI and uterine weight showed no correlation with postoperative complications.

The growing prevalence of obesity, late first delivery and the increase in the preoperative score have contributed to an increased rate of laparoscopic hysterectomies.

4. Discussion

This retrospective study is designed to investigate the different routes and methods of hysterectomy and aims to outline the indications for the hysterectomy operations, the development of the procedures, compare the different complication rates and outcomes and their associations with the operation route. Different factors seem to influence the decision for the desired hysterectomy procedure.

Benign indications of hysterectomy include symptomatic or growing uterus myomas, dysfunctional uterine bleeding, endometriosis, adenomyosis and prolapse of the uterus (Stang et al. 2012; Schindlbeck et al. 2008). Uterus myoma is the most common indication for a hysterectomy (Müller A. et al. 2004). Myomas cause three main symptoms: pain, bleeding symptoms and infertility (Müller A. et al. 2004; Müller A. et al. 2007). In our study the main indications for hysterectomy were uterine myoma (65.2 %), adenomyosis (11.2%), prolapse (14.8%), hyperplasia of uterus and cervix (2.0%), menstrual disorder (14.8%) and endometriosis (5.0%). According to the AQUA-institute in 2010 in Germany the indications for hysterectomy operation were the following myomas 60.5%, prolapse 26.7%, menstrual disorders 25.8%, hyperplasia of the uterus and cervix 2.0% and endometriosis 12.9%.

In our study the shortest hospital stay, the lowest hemoglobin decline and lowest complication rate were recorded by LASH and TLH. LASH and TLH had the advantage of a shorter hospital stay (4 days) in comparison to AH and VH (6 and 7 days, respectively). In comparison to our study; Schindlbeck's study agrees with our results that LH has a shorter hospital stay than VH and AH (Schindlbeck et al. 2008). The shorter hospital stay is one of the factors explaining the increase in the numbers of laparoscopic procedures compared to AH.

The number of laparoscopic operations is increasing steadily in our department whereas the number of VH and AH is decreasing steadily (Figures 27, 28). The literature shows that the number of AH started to decrease by 6-7% (Brandner et al. 1995) after the development of the first laparoscopic hysterectomy by Harry Reich 1988, the CISH by Semm and the LASH by Donnez in 1993. Johnson's study (Cochrane database syst Rev.) agrees with the benefits of LH over AH and VH over AH (Johnson et al. 2006).

In the last three years in our department the number of AH and VH significantly decreased due to the increase of LASH and TLH operations. In the year 2010 LASH (37.9%) and TLH (15.3%) represented 53.1% of the total hysterectomies, while the VH and AH represented 25% and 21.7% respectively (Figure 28). The AQUA Institute showed that the percentage of AH in Germany was 19.3%, whereas the ASF in Switzerland reported a percentage of 26%. The distribution of hysterectomies in Switzerland in 2010 was 41% VH, 27% TLH, 26% AH, 2% LAVH and 2% LASH. The early establishment of the TLH and LASH techniques in our department in 2003 and 2004 and the standardization of the techniques through continuous training in the Kiel endoscopy school resulted in a decrease in the incidence of complications. This in turn led to an increase in the number of laparoscopic hysterectomies in our department.

The operation duration was shortest by VH and longest by TLH. The mean operating time by VH (75 min) showed a 50-minute difference to TLH. LASH and AH operations showed a mean operating time of (100 min), which is still 20 minutes shorter than LAVH. Many factors could be responsible for the variation in the operation duration; e.g the VH has practised for many years, which makes surgeons more familiar with the technique. A relatively large uterus or the presence of adhesions could result in prolonging the operation time of the TLH and AH. The time required for morcellation is one of the reasons for the lengthier operating time of LASH and TLH (Condous et al. 2009). The change in the route of operation by LAVH (from the abdominal route to the vaginal route) could be the main reason for the extended operating time (Chen et al. 2008). In the coming years a shorter operating duration is to be expected for laparoscopic operations as the experience of surgeons with this technique increases (Tan et al. 2009).

The statistical analysis did not show any correlation between the increase of uterus weight and a lengthier hospital stay or prolonged operating duration. The results of our study disagree with the Schindlbeck study (Schindlbeck et al. 2008).

The lowest complication rate was recorded for LASH (2.4%), and the highest complication rate for AH (6.6%). The complication rate for VH was 6.3%, which is higher than for TLH (2.9%) and slightly less than for LAVH (6.4%). The two well established laparoscopic techniques for hysterectomy (LASH and TLH) showed a lower complication rate than VH and AH due to the development of laparoscopic instruments, techniques and continuous surgical training by training modules. These could be the decisive factors for achieving a safe

surgery with fewer complications in the near future. The availability of different sealing vessel coagulation systems and manipulators has resulted in easing the performance of LASH and TLH techniques (Mueller et al. 2012; Ou et al. 2004). Moreover, increased surgeon experience with the laparoscopic technique has resulted in a low complication rate.

The FINHYST study showed a complication rate for AH of 19%, VH of 12% and for LH of 15% (Brummer et al. 2011). An audit on hysterectomies in Hong Kong hospitals in 2002 also showed similar results where the complication rate was lower for VH compared to AH compared to LH (Leung et al. 2007); several authors have also reported the low complication rate by the LASH (Bojahr et al. 2006; Brill 2006; Lethaby et al. 2012; Lyons et al. 2004). A wide range of variation was found in the literature, Donnez, reported that LH did not show a significantly higher rate of complications in comparison to AH and VH (Donnez, O. et al. 2009).

The intra-operative complication rate for hysterectomies in 2010 in our department was 2.9%. The highest intra-operative complication rate occurred at abdominal hysterectomy (4.5%) and the lowest recorded at TLH (1.5%). In a retrospective single-center study in the period 2002–2008 at the Department of Obstetrics and Gynecology, Erlangen University Hospital and the eVALuate study showed a variation of 1-2% for the intraoperative complication rate (Muller et al. 2010; Canis et al. 2004). In contrast the VALUE study reported a higher intraoperative complication for AH than for VH (McPherson et al. 2004).

In our study the most commonly occurring intraoperative complications were urinary bladder lesions (7 cases). They occurred in 3 of VH (42.9%) and in 2 of AH (28.6%) and LASH (Table 5). In Finland the complication rate of urinary bladder lesion was 0.8% (Brummer et al. 2011). The literature study showed that urinary track lesions occur more frequently at LH (Nieboer et al. 2009; Muller et al. 2010; Schindlbeck et al. 2008).

Injury to the intestine occurred twice at AH and once at LASH in our study. In comparison of the literature the complication rate for injury to the intestine was 0.24 % in Germany (Table 7) and 0.2% in Finland (Brummer et al. 2011). Injury to blood vessels and intra-operative bleeding occurred 9 times at AH, 7 times at VH, once at the LAVH and once at TLH representing an overall complication rate of 1.89%. In the FINHYST study intraoperative bleeding and injury to blood vessels represented 3.0% (Brummer et al. 2011).

In our study, an association was found between intraoperative complications and the increase of uterine weight (Figure 23). This finding is in agreement with the literature (Hillis et al.

1996). The BMI and age of the patient did not show a direct correlation to intraoperative complications. The percentage of intraoperative complications for nullipartus is 26.1%, for partus 1-2 43.5% and for partus >2 30.4%.

Postoperative complications are classified into two groups, major and minor complications. The major postoperative complication rate was 1.8% and the minor postoperative complication rate was 5.9%. According to the AQUA Institute the postoperative complication rate by the hysterectomies in Germany in 2010 was 4.5%. In our study the highest incidence of major complications was recorded for LAVH (6.4%) and the lowest incidence for LASH (1.2%). The lowest minor postoperative complication rate was recorded for LASH (1.8%) and highest for AH (8.4%). Revision-operation was done 6 times by VH, representing the highest incidence in the major complications, 3 times by LAVH, 2 times by LASH and once by TLH. Haematoma formation was the most commonly occurring minor postoperative complication in our study representing 3.36%. In comparison in the literature, a minor postoperative complication rate of 0.94% was recorded in Germany 2010 (Table 7). In our study fever accounted for 0.84% compared to 0.28% in the AQUA Institute study. Table 7 shows a detailed comparison between the incidence rates of complications by hysterectomies. The mortality rate in the AQUA Institute study was recorded as 35 of 112,618 hysterectomies; in our study no mortality case was recorded.

LASH and TLH showed the lowest hemoglobin decrease (0.70g/dl, 0.82g/dl), while AH showed the highest hemoglobin decrease 1.63g/dl. The hemoglobin loss at VH was 1.29g/dl, which is higher than for LASH or TLH. The development of coagulation systems and the greater magnification at laparoscopy gives an advantage over other methods. By comparing the literature the Hwang study also showed more blood loss by VH than by AH (Hwang et al. 2002). Candiani showed the lowest hemoglobin loss for LH than by VH (Candiani et al. 2009). Many discrepancies between studies concerning hemoglobin loss are to be noticed.

The question nowadays is whether the LH is taking over or replacing VH. In our study LH (TLH and LASH) has advantages by the hospital stay, complication rates and haemoglobin decline over VH and AH (Table 8). The literature shows that VH has various advantages over LH and AH (Johnson et al. 2006; Muller et al. 2010). We are also aware that different parameters (post operative pain, speedy convalescence and economic factors) were not included in our study. From the literature point of view the natural orifice hysterectomy (VH) is still the method of choice (Johnson et al. 2006; Canis et al. 2004; Ark et al. 2009) especially

in combination with small uterus or correction of prolapse. The indication for LAVH is restricted, whenever TLH or LASH not technically possible or if vaginal corrective surgery is planned at the same time.

In a comparison of LASH and TLH, there was only a very narrow range of difference regarding operation duration and hospital stay. Moreover, the well known disadvantages of the subtotal hysterectomy to the total hysterectomy remain (Bojahr et al. 2006; Thakar et al. 2002; Washington 2005; Grosse-Drieling et al. 2012); risks of cervical cancer, regular examination, cyclic scanty bleeding (Theben et al. 2012). A more detailed evaluation of life quality and prolapse after LASH is required. In recent literature, the TLH in the hand of experienced surgeons showed no increase in the complication rate compared to LASH (Donnez, O. et al. 2009; Wattiez et al. 2002; Grosse-Drieling et al. 2012).

The ACOG, the Canadian and the European councils, despite a minimal significant difference, still consider VH to be the method of choice, followed by LH. AH should be performed when LH is not possible (Johnson et al. 2006; 2008; Kives et al. 2010).

To sum up, the decision for the route of hysterectomy is dependent on the surgeon's experience and the indication for the operation. Shared decision-making and consent between the surgeon and patient is highly recommended. This decision should be individualized for each patient case to find the best route for hysterectomy.

5. Summary

Background and aims

The aim of this study is to compare the data of patients and the operating parameters of the five different surgical techniques of hysterectomy (VH = vaginal hysterectomy, AH = abdominal hysterectomy, TLH = total laparoscopic hysterectomy, LASH = laparoscopic supracervical hysterectomy, LAVH = laparoscopic-assisted vaginal hysterectomy).

Methods

Patients

A total of 954 patients underwent a hysterectomy in the period from January 2002 to October 2010 for benign uterine disease.

Material

The data were retrospectively collected from patients' records and analyzed. The evaluated data included patient's age, BMI, parities, former operations, indications of operation, duration of hospital stay, operating time, weight of uterus, histopathological report of removed specimen, hemoglobin fall and intra- and postoperative complications.

Statistical analysis

A statistical analysis was used to examine differences within the five groups concerning the analyzed parameters. Demographic and surgical data were analyzed by ANOVA, Kruskal-Wallis-, Chi-square- or Fisher's test.

Results

The average age recorded for all hysterectomies was 47.95 years and the average BMI was 25.85. By comparing all methods, the most common indications for hysterectomy were uterine myoma (65.2%), adenomyosis (11.2%), prolapse (14.8%), hyperplasia of uterus and cervix (2.0%), menstrual disorder (14.8%) and endometriosis (5,0%).

The hospital stay was the longest for AH (7.92 days) and the shortest for LASH (3.88). For VH the average hospital stay was 6.74 days, for LAVH 5.85 and for TLH 4.32 days. The shortest operating time was for VH (76.03 minutes) and the longest for LAVH (137 minutes). For AH the average operating time was AH 107.71 minutes, for LASH 106.59 and for TLH 130.24 minutes.

The average uterine weight was heaviest for AH 518.58 (170.00- 721.50) grams and lightest for VH 127.77 (59.50-168.50). The average uterine weight for LASH was 244.92 (118.00-310.00), for LAVH 159.24 (100.50- 181.00) and for TLH 205.11 (114.00- 224.00). The lowest average hemoglobin decrease for LASH was 0.70 g/dl, for AH 1.63 g/dl, where as for VH it was 1.29 g/dl, for LAVH 1.83 g/dl and for TLH 0.82 g/dl.

The lowest complication rate was recorded for LASH (2.4%) and the highest for AH (6.6%). The complication rate for VH was 6.3%, which was higher than TLH (2.9%) and slightly lower than LAVH (6.4%). The two well established laparoscopic techniques for hysterectomy (LASH and TLH) showed a lower complication rate than VH and AH.

The intraoperative complication rate for hysterectomies operations was 2.9%. The highest intraoperative complication rate occurred at abdominal hysterectomy (4.5%) and the lowest at TLH (1.5%).

Postoperative complications are classified into two major groups; major and minor complications. The major postoperative complication rate was 1.8% and the minor postoperative complication rate was 5.9 %.

The highest incidence of major complications was recorded by LAVH (6.4%) and the lowest by LASH (1.2%). The lowest minor postoperative complication rate was recorded by LASH (1.8%) and the highest by AH (8.4%).

Conclusions

Patients with uterine myomas, endometriosis, additional adnexal pathology and high BMI benefit from the laparoscopic access route in comparsion to AH and VH.

Patients with prolapse, a higher parity score and a low preoperative score benefit from VH compared to LH and AH.

VH is a safe natural orifice route for patients with a large number of vaginal delieveries and a low uterine weight. The operation duration is significantly shorter and postoperative results are comparable to laparoscopic hysterectomies.

LASH and TLH are minimally invasive methods showing the lowest intraoperative and postoperative complication rate especially for patients with a high preoperative score and a high uterine weight. Laparoscopic hysterectomies showed the lowest hemoglobin decline and the shortest hospital stay and therefore should be the method of choice if VH is not possible.

Intraoperative complications correlated with the increase in uterine weight, while no important correlations between BMI, age and uterine weight were observed. The hospital stay was statistically tested against the BMI. However, showed no significant correlation

LASH and TLH are associated with a generally lower rate of complications in comparison to AH and VH.

The growing prevalence of obesity, late first delivery and the increase in the preoperative score have contributed to an increased rate of laparoscopic hysterectomies.

6. Additions

Figure 27. Development of hysterectomy operation

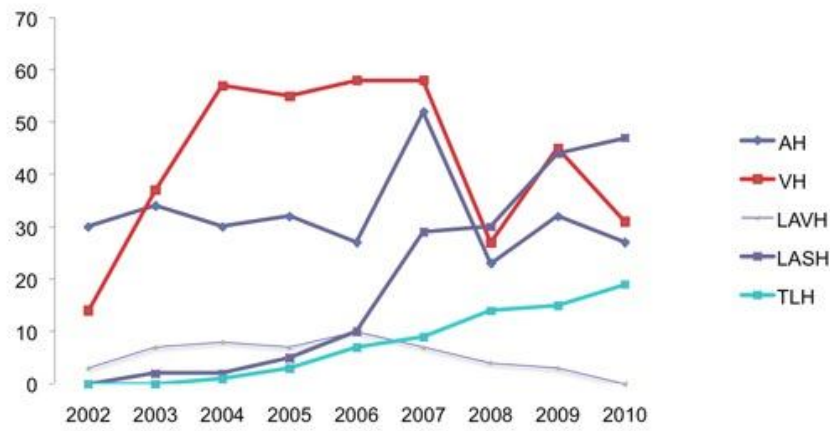


Figure 28. Percentile distribution of hysterectomy operation

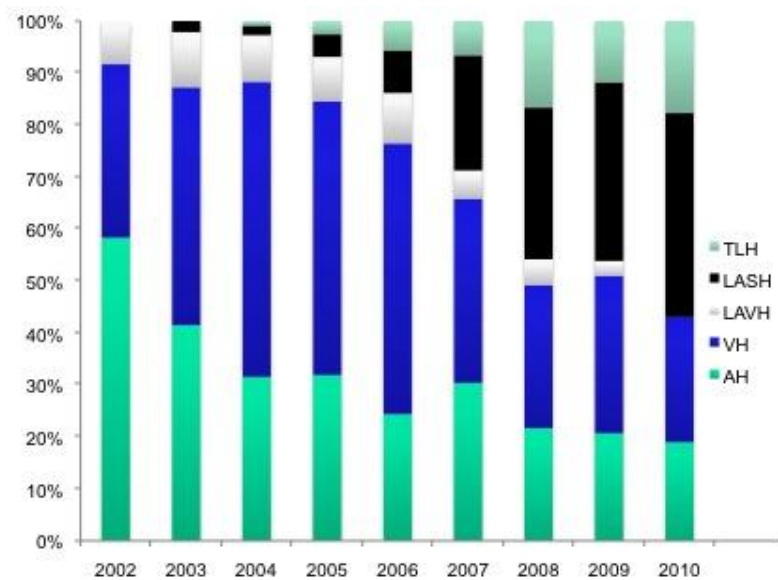


Table 7. Incidence of intra- and postoperative complications (AQUA 2010. n = 112.618 independent from the hysterectomy route. UKSH 2010. n= 953 independent from the hysterectomy route)

Complication (%)	AQUA 2010	UKSH
Intraoperative Blood lost requiring Transfusion	N/S	1,88 %
Urinary tract Injury	0,74%	0,73%
Bowel Injury	0,24%	0,31%
Post operative Bleeding	0,94%	0,20%
Heamatoma	0,94%	3,36%
Urinary tract infection	1,3%	0,84%
Wound infection	N/S	0,84%

Table 8. Advantages of operation methods, the number of (+) indicates the advantage of the technique

	Hospital stay	Operation duration	Complication	Hemoglobin decrease
AH	+	++	++	+
VH	++	++++	+	++
LASH	++++	+++	+++	++++
TLH	+++	+	++++	+++
LAVH	++	+	+++	+

7. Literature

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This thesis is dedicated to my parents, who taught me that even the largest task can be accomplished if it is done one step at a time. It is also dedicated to Dr. med. M. Ibrahim who taught me that the best kind of knowledge to have is that which is learned for its own sake.

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