

## ORIGINAL ARTICLE

# Hysterectomy through the looking glass: iHysterectomy frugal by iPhone

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## ABSTRACT

This study aims to demonstrate the feasibility of a frugal approach to an endoscopic hysterectomy: the iHysterectomy. An iPhone with endoscope-i adaptor and a portable light source were used instead of a laparoscopic camera, video processor, monitor and light source. A vaginally assisted natural orifice transluminal endoscopic surgery (NOTES) hysterectomy (VANH) was performed by Poor Man's NOTES technique using a self-constructed glove port and standard reusable instruments. Ten iHysterectomies were successfully performed by a single surgeon (JBa). No conversion to a laparoscopic tower, standard multi incision laparoscopy, or laparotomy was necessary. Mean operation time was 52 min (40–75); mean serum haemoglobin drop was 0.8 g/dL (0.2–2.1). There were no operative complications, and postoperative pain scores were low. The iHysterectomy technique enables surgeons to perform a minimally invasive hysterectomy in a low-resource setting without the need to invest in a laparoscopic tower. The investment required for endoscopic hardware is a fraction of that for conventional laparoscopy or robotic surgery. This is an Idea Development Exploration Assessment Long-term (IDEAL) stage 1 study: iHysterectomy is a novel approach requiring further validation. This is the first report on the use of an iPhone to perform a hysterectomy or any other major operation.

## INTRODUCTION

Conrad Langebeck performed the first reported elective hysterectomy in 1813 (see online supplementary table S1), using a vaginal approach.<sup>1</sup> Charles Clay performed the first elective abdominal (subtotal) hysterectomy in 1863. During the nineteenth and twentieth century these two approaches remained the gold standard for hysterectomies. Owing to technical innovations, there has been a

spectacular evolution in hysterectomy techniques in the First World during the last 25 years. Harry Reich performed the first laparoscopically assisted vaginal hysterectomy in 1989 and the first total laparoscopic hysterectomy in 1993.<sup>2</sup> More recently, surgical robots have been introduced into daily practice in most First World countries and the incidence of robotic hysterectomies is increasing.<sup>3 4</sup> With the introduction of transvaginal natural orifice transluminal endoscopic surgery (vNOTES) hysterectomies in 2012, it is now possible to perform an endoscopic hysterectomy leaving no visible scars.<sup>5</sup> Owing to high equipment expenses many of these technical innovations and new techniques are not accessible for Third World patients, for whom the classical abdominal or vaginal hysterectomy remains the only options. In this feasibility study we assess a low-cost endoscopic hysterectomy approach using a Poor Man's NOTES technique<sup>6–8</sup> and an iPhone instead of a laparoscopy tower.

## MATERIAL AND METHODS

### Patients

A single surgeon (JBa) performed 10 vaginally assisted NOTES hysterectomies (VANHs) by iHysterectomy between September 2015 and January 2016 with the aim of evaluating technical feasibility. Patients were selected for hysterectomy due to benign gynaecological disease; selection was based on the following criteria: no contraindication for general anaesthesia, pneumoperitoneum or Trendelenburg position; no fixed uterus, strong pelvic adhesions or nodularity in the pouch of Douglas on clinical examination; no history of severe pelvic inflammatory disease (PID); no suspicion for

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## ASSISTIVE TECHNOLOGIES

malignancy. Obesity (Body Mass Index (BMI)>30)) and absence of vaginal delivery were not considered to be an exclusion criteria, whereas virginity was.

The following data were collected and retrospectively analysed: patient age, BMI, parity, history of vaginal delivery, previous pelvic surgery, type of surgery, total operating time, serum haemoglobin (Hb) drop (change between the preoperative Hb and postoperative Hb 1 day after surgery), weight of the uterus and postoperative pain score.<sup>9</sup>

Surgery duration was defined as the time from the placement of the Foley catheter to the end of vaginal closure. Bowel, bladder, ureteral or vascular injuries, as well as blood loss >300 mL, were considered to be intraoperative complications. Short-term postoperative complications were identified to be urinary tract infection, postoperative ileus, vaginal vault bleeding or infection, or haematuria.

The visual analogue pain scale (VAS) (scoring from 0= no pain, to 10= worst imaginable pain) was used to assess postoperative pain and was evaluated at 6 and 24 h postoperatively. Intravenous paracetamol 1000 mg and ketorolac trometamol 20 mg were given intraoperatively to all patients. Postoperative pain was managed by paracetamol 1000 mg, and ketorolac trometamol was administered on patient's demand.

Prophylactic intravenous antibiotic therapy, cefazolin 2 g and metronidazole 500 mg, was administered during surgery.

No vaginal intercourse was allowed for 6 weeks after the procedure. Each patient was reassessed at the postoperative consultation 6 weeks after surgery.<sup>10</sup>

#### Surgical technique: iHysterectomy

The patient was placed in lithotomy position under general anaesthesia. A rectovaginal examination was performed to exclude pelvic adhesions or obliteration of the pouch of Douglas.<sup>7</sup>

#### Construction of the low-cost NOTES port

An Alexis Wound Protector/Retractor (Applied Medical, Rancho Santa Margarita, California, USA) attached to a size 8 surgical glove was used to

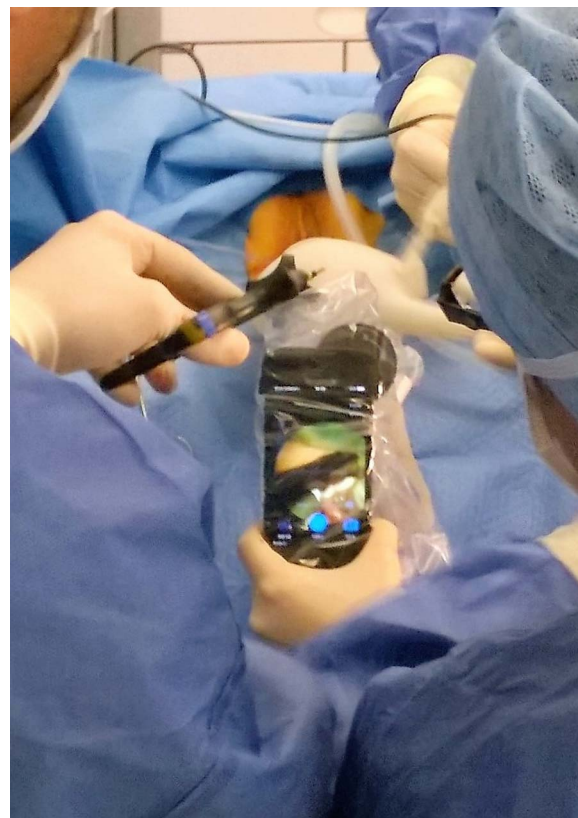


**Figure 1** The Poor Man's natural orifice transluminal endoscopic surgery (NOTES) technique uses a self-constructed glove port and standard reusable instruments.

construct a port. A size S Alexis Wound Protector/Retractor fits most patients; in patients with a very narrow vagina or small cervix, a size XS can be used. One finger of the surgical glove was incised to place a 10 mm reusable trocar for CO<sub>2</sub> insufflation and laparoscope insertion. Four 5 mm reusable trocars were placed through the remaining fingers for insertion of the reusable laparoscopic instruments<sup>7</sup> (figure 1). The trocars are fixed to the fingers of the glove with a suture, providing a good CO<sub>2</sub> seal for working at 15 mm Hg.

#### Endoscopic equipment

Only three reusable conventional laparoscopic instruments were used: a bipolar forceps, a pair of cold scissors and an atraumatic forceps. No disposable instruments or sealing devices were used. A standard CO<sub>2</sub> insufflator and a standard rigid 0° 10 mm laparoscope were used. An iPhone with endoscope-i adaptor and portable light source (endoscope-i, West Midlands, UK) were used instead of a laparoscopic camera, video processor, monitor and light source (figure 2). The non-sterile iPhone with the endoscope-i adaptor are placed in a sterile plastic bag and clip onto the sterile endoscope in the same way that a camera unit clips onto an endoscope for conventional laparoscopy.



**Figure 2** An iPhone with endoscope-i adaptor and portable light source were used instead of a laparoscopic camera, video processor, monitor and light source.

#### Procedure description

The operation field was disinfected and draped. A Foley catheter was placed and a circular incision made around the cervix using a cold knife.<sup>9</sup> The pouch of Douglas and the vesicouterine peritoneum were opened using cold scissors. Both uterosacral ligaments were transected using cold scissors and tied off with a resorbable suture. The self-constructed glove port was inserted into the peritoneal cavity. The internal ring of the wound protector is placed intraperitoneally around the cervix, anteriorly behind the bladder and posteriorly in the pouch of Douglas. CO<sub>2</sub> was used to inflate the peritoneal cavity. A laparoscope, attached to an iPhone, was inserted and the peritoneal cavity was inspected. The patient was then placed in the Trendelenburg position and the small intestine was lifted out of the pelvis.

The ureter was identified, but not routinely dissected. The uterine artery, the ovarian ligament and the meso of the fallopian tube were coagulated using a bipolar grasper and transected.<sup>9</sup> The infundibulopelvic ligament was coagulated using a bipolar grasper and transected in patients requiring an adnexectomy. Haemostasis was checked and the peritoneal cavity was rinsed. The NOTES port and the uterus were removed transvaginally and the pneumoperitoneum was deflated. The colpotomy was closed with a resorbable suture.

#### RESULTS

Ten VANH's were successfully performed by iHysterectomy. A Poor Man's vNOTES technique<sup>7</sup> was used and an iPhone with endoscope-i adaptor and a portable light source were used instead of a laparoscopic camera, video processor, monitor and light source. No conversion to a laparoscopic tower or to standard multi incision laparoscopy, or laparotomy, was necessary. In all patients the fallopian tubes were removed with the uterus; in two patients both ovaries were removed as well.

Online supplementary table S2 presents an overview of patient and perioperative data. Mean age was 49 year (36–54); mean BMI was 25.7 kg/m<sup>2</sup> (20.8–30.8); mean operating time was 52 min (40–75); mean serum Hb drop was 0.8 g/dL (0.2–2.1); mean postoperative pain score was 1.9 (1–2) 6 h after surgery and 1.7 (1–2) 24 h after surgery; mean weight of the uterus was 187 g (53–546).

Individual patient details are presented in online supplementary table S3. Two nulliparous patients were included. Two patients had a history of a caesarean section and three patients had a history of a large loop excision of the transformation zone. Three patients were operated for menorrhagia; two patients for dysmenorrhoea; two patients for cervical dysplasia; one for adenocarcinoma in situ of the cervix; and two for a myomatous uterus. The pathology report showed adenomyosis in six patients, a myomatous uterus in one patient, cervical intraepithelial neoplasia

(CIN) 2 in one patient, an adenocarcinoma of the cervix in one patient and a stromal tumor of uncertain malignant potential (STUMP) in one patient. No perioperative complications occurred.

#### DISCUSSION

In this study, 10 iHysterectomies were successfully performed. Instead of a laparoscopic tower, an iPhone with endoscope-i adaptor and a portable light source were used. In all patients a VANH was performed by Poor Man's NOTES technique using a self-constructed glove port and standard reusable instruments. There were no conversions to a disposable port type, a laparoscopic tower, a conventional laparoscopy or a laparotomy. There were no perioperative complications and the procedures were completed within acceptable operating times. Patients scored low-pain scores at 6 and 24 h, postoperatively. This is the first report on the use of an iPhone to perform a hysterectomy or any other major operation. The use of an iPhone to construct a low-cost laparoscopic trainer in a laboratory setting has been described.<sup>11</sup>

Online supplementary table S4 presents the different methods for performing a hysterectomy (see online supplementary table S4). A classical vaginal hysterectomy is a total hysterectomy performed entirely via vaginal access under direct vision using conventional surgical instruments. A VANH is a total hysterectomy where first the caudal part of the uterus is dissected vaginally under direct vision (as in a classical vaginal hysterectomy), and thereafter the rest of the hysterectomy is performed via vNOTES using an endoscopic camera and endoscopic instruments.<sup>10</sup>

The Cochrane Database presents conventional vaginal surgery as the preferred technique to perform a hysterectomy. Where vaginal hysterectomy is not possible, performing a laparoscopic hysterectomy may avoid an abdominal hysterectomy.<sup>1</sup> The vNOTES hysterectomy technique makes use of the advantages of endoscopic surgery, broadening the indications for vaginal hysterectomy and helping to overcome its limitations; the NOTES approach avoids abdominal wall wounds and trocar related complications.<sup>12</sup> A study on vNOTES appendectomies also reported shorter hospitalisation periods, quicker recovery, less analgesic requirement and better cosmetic satisfaction.<sup>13</sup>

In a low-resource setting, women with a non-prolapsed uterus in need of a hysterectomy for benign indication are candidates for an iHysterectomy. Contra-indications are history of rectal surgery, suspected rectovaginal endometriosis or malignancy, history of severe PID, active lower genital tract infection, virginity and pregnancy.

When comparing vNOTES to single incision laparoscopic surgery (SILS), comparable technical difficulties appear related to instrument collision, limited triangulation and reduced traction of tissue.<sup>14 15</sup> These difficulties are found less restrictive when compared with



SILS, as the colpotomy provides a more flexible entry when compared with the infraumbilical fascia opening.<sup>12</sup>

The use of robotic and laparoscopic techniques has increased over the last few years in the First World, while traditional vaginal and abdominal hysterectomies have been performed less frequently.<sup>4</sup> In recent years, surgical innovations mostly go hand in hand with technological innovations which, being industry driven, are geared for a First World market. The aim of this study was to assess whether a new hysterectomy technique via vNOTES can be adapted for use in a low-resource setting.

Solutions designed specifically for low-income market segments fall under the banner of frugal innovation, whereas reverse innovation involves products developed in emerging markets, which are then modified for sale in developed countries.<sup>16</sup>

The surgical technique described in this article is a very frugal approach to performing a minimally invasive hysterectomy. The investment needed for endoscopic hardware is only a fraction of that for conventional laparoscopy or robotic surgery. The investment needed to set up an operating theatre to start performing robotic surgery with the latest state of the art surgical robot is about €1.9 million (excluding VAT); per procedure a significant cost in disposable instruments is to be added. The investment needed to set up an operating theatre with the latest state of the art laparoscopic tower (excluding insufflator) is around €100 000 (excluding VAT). The investment needed to set up an operating theatre with a new standard laparoscopic tower (excluding insufflator) is around €50 000 (excluding VAT). The cost for disposable instruments per laparoscopic procedure is dependent on the surgical technique, but can be very low if the surgeon chooses a frugal laparoscopic approach.

The investment needed to start performing this very frugal iPhone hysterectomy technique is around €1000: iPhone + endoscope-i adaptor + portable light source. This also enables the surgeon to take high definition (HD) videos and photos of the procedure. The only extra cost in disposable material over an abdominal or vaginal hysterectomy (techniques currently most frequently used in low-resource settings) is the sterilisation cost of one transparent plastic bag to cover the iPhone and one disposable wound protector. No disposable instruments are used. The reusable laparoscopic equipment needed consists of one bipolar grasper, one pair of cold scissors and one atraumatic grasper. One CO<sub>2</sub> insufflator and one electrosurgical generator and a standard 0° 10 mm laparoscope are also needed. To the best of our knowledge there are no similar endoscope adaptors for windows or android phones available on the market.

In our standard practice of VANH, we use a disposable vNOTES port, a disposable sealing device, a chip

on the tip laparoscope and an HD laparoscopic tower. The most important difference with our initial experience with iHysterectomy is the lower depth perception on an iPhone screen. This led to a slower, more careful dissection and a longer operating time. Besides the difference in depth perception, a classic iPhone offers a bright and large-enough view of the pelvis for surgery. Another minor challenge was a slight increase in instrument collision due to the size of the iPhone. In spite of this, the iHysterectomy technique enabled us to perform 10 successful hysterectomies. We advise surgeons to follow a VANH course using a laparoscopic tower before performing iHysterectomy. This ensures maximal depth perception during their learning curve.

## CONCLUSION

In this study, 10 endoscopic hysterectomies were successfully performed using this frugal iHysterectomy technique. A Poor Man's NOTES VANH using a self-constructed glove port and reusable instruments was combined with the use of an iPhone with endoscope-i adaptor and a portable light source, instead of a laparoscopic tower. The iHysterectomy technique enables surgeons to perform a minimally invasive hysterectomy in a low-resource setting without the need to invest in a laparoscopic tower. This is an IDEAL stage 1 study: iHysterectomy is a novel approach requiring further validation.<sup>17</sup>

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**Contributors** JBaekelandt developed the iHysterectomy technique, conceived the study, operated all the patients, collected the data and wrote the paper. JBosteels reviewed the paper.

**Competing interests** None declared.

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