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Dr. Advincula reports serving as a consultant to AbbVie, ConMed, CooperSurgical, Eximis Surgical, Intuitive Surgical, and Titan Medical and receiving royalties from CooperSurgical. Dr. Guan reports that he is a speaker for Applied Medical. The other authors report no financial relationships relevant to this article.

Requiring a very particular set of surgical skills, the cutting edge vNOTES technique for hysterectomy incorporates conventional laparoscopic instrumentation in a vaginal approach. Here, its pioneers describe how it's done.

Through the years, the surgical approach to hysterectomy has expanded from its early beginnings of being performed only through an abdominal or transvaginal route with traditional surgical clamps and suture. The late 1980s saw the advent of the laparoscopic-assisted vaginal hysterectomy (LAVH), and from that point forward several additional hysterectomy methods evolved, including today's robotic approaches.

Although clinical evidence and societal endorsements support vaginal hysterectomy as a superior high-value modality, it remains one of the least performed among all available routes.[1-3] In an analysis of inpatient hysterectomies published by Wright and colleagues in 2013, 16.7% of hysterectomies were performed vaginally, a number that essentially has remained steady throughout the ensuing years.[4]

Attempts to improve the application of vaginal hysterectomy have been made.[5] These include the development of various curriculum and simulation-based medical education programs on vaginal surgical skills training and acquisition in the hopes of improving utilization.[6] An interesting recent development is the rethinking of vaginal hysterectomy by several surgeons globally who are applying facets of the various hysterectomy methods to a transvaginal approach known as vaginal natural orifice transluminal endoscopic surgery (vNOTES).[7,8] Unique to this thinking is the incorporation of conventional laparoscopic instrumentation.

Although I have not yet incorporated this approach in my surgical armamentarium at Columbia University Medical Center/New York–Presbyterian Hospital, I am intrigued by the possibility that this technique may serve as a rescue for vaginal hysterectomies that are at risk of conversion or of not being performed at all.[9]

At this time, vNOTES is not a standard of care and should be performed only by highly

specialized surgeons. However, in the spirit of this Update on minimally invasive surgery and to keep our readers abreast of burgeoning techniques, I am delighted to bring you this overview by Dr. Xiaoming Guan, one of the pioneers of this surgical approach, and Dr. Tamisa Koythong and Dr. Juan Liu. I hope you find this recent development in hysterectomy of interest.

—ARNOLD P. ADVINCULA, MD

Development and evolution of NOTES

Over the past few decades, emphasis has shifted from laparotomy to minimally invasive surgery because of its proven significant advantages in patient care, such as improved cosmesis, shorter hospital stay, shorter postoperative recovery, and decreased postoperative pain and blood loss.[10] Advances in laparoendoscopic surgery and instrumentation, including robot-assisted laparoscopy (RAL), single-incision laparoscopic surgery (SILS), and most recently natural orifice transluminal endoscopic surgery (NOTES), reflect ongoing innovative developments in the field of minimally invasive surgery.

Here, we provide a brief literature review of the NOTES technique, focus on its application in gynecologic surgery, and describe how we perform NOTES at our institution.

FAST TRACK

With NOTES, peritoneal access is gained through a natural orifice—the mouth, vagina, urethra, or anus—to perform endoscopic surgery

NOTES application in gynecology

With NOTES, peritoneal access is gained through a natural orifice (such as the mouth, vagina, urethra, or anus) to perform endoscopic surgery, occasionally without requiring an abdominal incision. First described in 2004, transgastric peritoneoscopy was performed in a porcine model, and shortly thereafter the first transgastric appendectomy was performed in humans.[11,12] The technique has further been adopted in cholecystectomy, appendectomy, gastrectomy, and nephrectomy procedures.[13]

Given rapid interest in a possible paradigm shift in the field of minimally invasive surgery, the Natural Orifice Surgery Consortium for Assessment and Research (NOSCAR) was formed, and the group published an article on potential barriers to accepted practice and adoption of NOTES as a realistic alternative to traditional laparoscopic surgery.[14]

While transgastric and transanal access to the peritoneum were initially more popular, the risk of anastomotic leaks associated with incomplete closure and subsequent infection were thought to be prohibitively high.[15] Transvaginal access was considered a safer and simpler alternative, allowing for complete closure without increased risk of infection, and this is now the route through which the majority of NOTES procedures are completed.[16,17]

The eventual application of NOTES in the field of gynecology seemed inevitable. The American College of Obstetricians and Gynecologists stated that transvaginal surgery is the most minimally invasive and preferred surgical route in the management of patients with benign gynecologic diseases.[18] However, performing it can be challenging at times due to limited visualization and lack of the required skills for single-site surgery. NOTES allows a gynecologic surgeon to improve visualization through the use of laparoendoscopic instruments and to complete surgery through a transvaginal route.

In 2012, Ahn and colleagues demonstrated the feasibility of the NOTES technique in gynecologic surgery after using it to successfully complete benign adnexal surgery in 10 patients.[19] Vaginal NOTES (vNOTES) has since been further developed to include successful hysterectomy, myomectomy, sacrocolpopexy, tubal anastomosis, and even

CONTINUED ON PAGE 18

CONTINUED FROM PAGE 16

WHAT THIS EVIDENCE MEANS FOR PRACTICE

Clearly, vNOTES is the next exciting development in minimally invasive surgery, improving patient outcomes and satisfaction with truly scarless surgery. Compared with traditional transvaginal surgery, vNOTES has the advantage of improved visualization with laparoendoscopic guidance, and it may be beneficial even for patients previously thought to have relative contraindications to successful completion of transvaginal surgery, such as nulliparity or a narrow introitus.

lymphadenectomy in the treatment of early-stage endometrial carcinoma.[20-26] vNOTES also can be considered a rescue approach for traditional vaginal hysterectomy in instances in which it is necessary to evaluate adnexal pathology.[9] Most recently, vNOTES hysterectomy has been reported with da Vinci Si or Xi robotic platforms.[27,28]

Operative time, post-op stay shorter in NAOC-treated patients

Few studies have compared outcomes with vNOTES to those with traditional laparoscopy. In 2016, Wang and colleagues compared surgical outcomes between NOTES-assisted ovarian cystectomy (NAOC) and laparoscopic ovarian cystectomy (LOC) in a case-matched study that included 277 patients.[29] Although mean (SD) blood loss in patients who underwent LOC was significantly less compared with those who underwent NAOC (21.4 [14.7] mL vs 31.6 [24.1] mL; P = .028), absolute blood loss in both groups was deemed minimal. Additionally, mean (SD) operative time and postoperative stay were significantly less in patients undergoing NAOC compared with those having LOC (38.23 [10.19] minutes vs 53.82 [18.61] minutes; $P \leq .001$; and 1.38 [0.55] days vs 1.82 [0.52] days; $P \leq .001$; respectively).[29]

FAST TRACK

In a study of vNOTES versus TLH, vNOTES hysterectomy was associated with shorter operative time, shorter hospital stay, and lower postoperative analgesic requirement

How vNOTES hysterectomy stacked up against TLH

In 2018, Baekelandt and colleagues compared outcomes between vNOTES hysterectomy and total laparoscopic hysterectomy (TLH) in a noninferiority single-blinded trial of 70 women.[8] Compared with TLH, vNOTES hysterectomy was associated with shorter operative time (41 vs 75 minutes; P<.001), shorter hospital stay (0.8 vs 1.3 days; P = .004), and lower postoperative analgesic requirement (8 vs 14 U; P = .006). Additionally, there were no differences between the 2 groups in postoperative infection rate, intraoperative complications, or hospital readmissions within 6 weeks.[8]

Approach for performing vNOTES procedures

At our institution, Baylor College of Medicine, the majority of gynecologic surgeries are performed via either transumbilical robot-assisted single-incision laparoscopy or vNOTES. Preoperative selection of appropriate candidates for vNOTES includes:

- low suspicion for or prior diagnosis of endometriosis with obliteration of the posterior cul-de-sac
- no surgical history suggestive of severe adhesive disease, and
- adequate vaginal sidewall access and sufficient descent for instrumentation for entry into the peritoneal cavity.

In general, a key concept in vNOTES is "vaginal pull, laparoscopic push," which means that the surgeon must pull the cervix while performing vaginal entry and then push the uterus back in the peritoneal cavity to

increase surgical space during laparoscopic surgery.

Overview of vNOTES steps

Below we break down a description of vNOTES in 6 sections. Our patients are always placed in dorsal lithotomy position with TrenGuard (D.A. Surgical) Trendelenburg restraint. We prep the abdomen in case we need to convert to transabdominal surgery via transumbilical single-incision laparoscopic surgery or traditional laparoscopic surgery.

1. Vaginal entry

Accessing the peritoneal cavity through the vagina initially proceeds like a vaginal hysterectomy. We inject dilute vasopressin (20 U in 20 mL of normal saline) circumferentially in the cervix (for hysterectomy) or in the posterior cervix in the cervicovaginal junction (for adnexal surgery without hysterectomy) for vasoconstriction and hydrodissection.

We then incise the vaginal mucosa circumferentially with electrosurgical cautery and follow with posterior colpotomy. We find that reapproximating the posterior peritoneum to the posterior vagina with either figure-of-8 stitches or a running stitch of polyglactin 910 suture (2-0 Vicryl) assists in port placement, bleeding at the peritoneal edge, and closure of the cuff or colpotomy at the end of the case. We tag this suture with a curved hemostat.

Depending on whether a hysterectomy is being performed, anterior colpotomy is made. Again, the anterior peritoneum is then tagged to the anterior vaginal cuff in similar fashion, and this suture is tagged with a different instrument; we typically use a straight hemostat or Sarot clamp (**FIGURE 1**).

FIGURE 1 Reapproximation of the anterior peritoneum to the anterior vaginal cuff

FAST TRACK

Reapproximating the posterior peritoneum to the posterior vagina with either figure-of-8 stitches or a running stitch of polyglactin suture assists in port placement, bleeding at the peritoneal edge, and closure of the cuff or colpotomy at the end of the case

FIGURE 2 The GelPOINT Mini advanced access platform (Applied Medical) displayed with included trocars and Alexis wound protector before (left) and after assembly (right)

CONTINUED ON PAGE 20

CONTINUED FROM PAGE 19

FIGURE 3 Delivering the cervix through the Alexis wound protector. Once delivered, the cervix is regrasped. The assistant surgeon holds the previously tagged sutures parallel to the longitudinal axis of the vagina while the surgeon places the green rigid ring of the Alexis wound protector in the peritoneal cavity.

FIGURE 4 Securement of the GelSeal cap on the Alexis wound protector. Location of ports, including a 5-mm AirSeal system port (CONMED), is shown.

2. Traditional vaginal hysterectomy

After colpotomy, we prefer to perform progressive clamping of the broad ligament from the uterosacral and cardinal ligaments to the level of uterine artery as in traditional vaginal hysterectomy, if feasible.

3. Single-site port placement

The assembled GelPOINT Mini advanced access platform (Applied Medical) (**FIGURE 2**, page 21) is introduced through the vagina after the Alexis wound protector (included with the kit) is first placed through the colpotomy with assistance of Babcock clamps (**FIGURE 3**).

After ensuring that the green rigid ring of the Alexis wound protector is contained and completely expanded within the peritoneal cavity, we cross our previously tagged sutures as we find this helps with preventing the GelPOINT Mini access platform from inadvertently shifting out of the peritoneal cavity during surgery. The GelSeal cap is then secured and pneumoperitoneum is established (**FIGURE 4**).

FIGURE 5 Laparoscopic instruments used in vNOTES prior to complete assembly (left) and their use during surgery with 2 surgeons (right). The laparoscopic instruments are of different lengths, which is paramount to successful vNOTES.

4. Laparoendoscopic surgery

Instruments used in our surgeries include a 10-mm rigid 30° 43-cm working length laparoscope; a 44-cm LigaSure device (Medtronic); a 5-mm, 37-cm laparoscopic cobra grasping forceps and fenestrated grasper (Karl Storz); and a 5-mm, 45-cm laparoscopic suction with hydrodissection tip (Stryker) (**FIGURE 5**).

vNOTES allows a gynecologic surgeon the unique ability to survey the upper abdomen. The remainder of the surgery proceeds using basic laparoscopic single-site skills.

During vNOTES, as with all single-site

CONTINUED ON PAGE 28

CONTINUED FROM PAGE 20

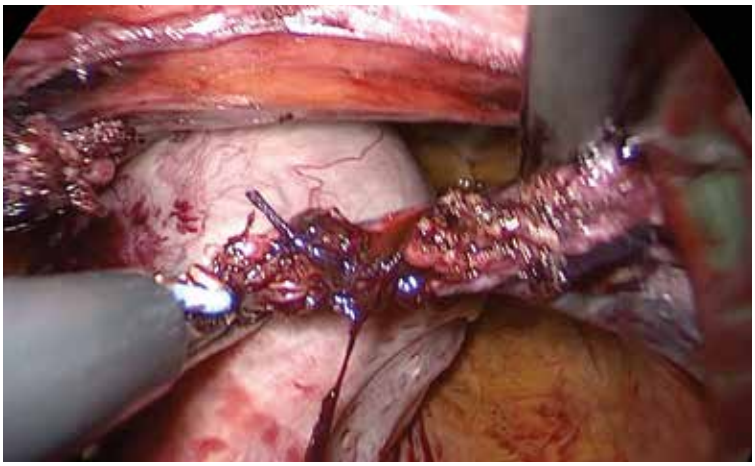

FIGURE 6 Crossed instruments while securing the left uterine artery

FIGURE 7 Placement of specimen that requires morcellation in a 15-mm Endo Catch specimen retrieval bag

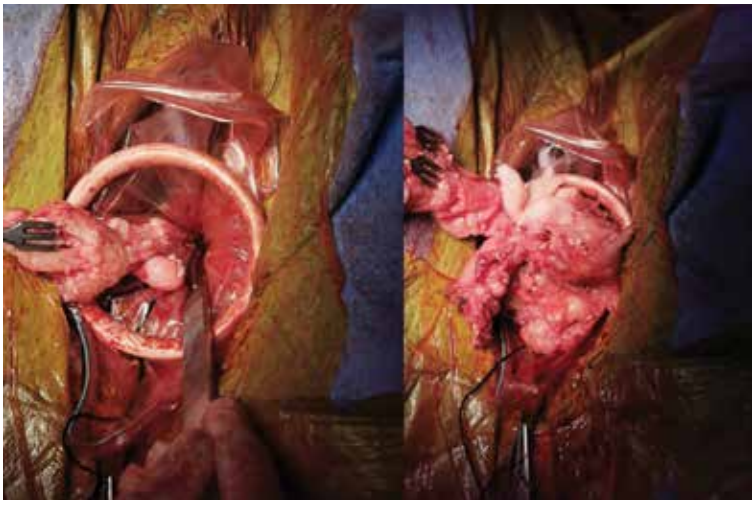

FIGURE 8 Contained bag morcellation with "big C" technique

surgical procedures, understanding the optimal placement of crossed instruments is important for successful completion. For example, when securing the right uterine artery, the surgeon needs to push the cervix toward the patient's left and slightly into the peritoneal cavity using a laparoscopic cobra grasper with his or her left hand while then securing the uterine pedicle using the LigaSure device with his or her right hand. This is then reversed when securing the left uterine artery, where the assistant surgeon pushes the cervix toward the patient's right while the surgeon secures the pedicle ("vaginal pull, laparoscopic push") (**FIGURE 6**).

This again is reiterated in securing the ovarian pedicles, which are pushed into the peritoneal cavity while being secured with the LigaSure device.

5. Specimen removal

For large uteri or specimens that need morcellation, a 15-mm Endo Catch specimen retrieval bag (Medtronic) is introduced through the GelPOINT Mini system. The specimen is then placed in the bag and delivered to the vagina, where contained bag morcellation is performed in standard fashion (**FIGURES 7 AND 8**). We utilized the "big C" technique by first grasping the specimen with a penetrating clamp. The clamp is then held in our nondominant hand and a No. 10 blade scalpel is used to create a reverse c-incision, keeping one surface of the specimen intact. This is continued until the specimen can be completely delivered through the vagina.

Specimens that do not require morcellation can be grasped laparoscopically, brought to the GelPOINT Mini port, which is quickly disassembled, and delivered. The GelSeal cap is then reassembled.

6. Vaginal cuff closure

The colpotomy or vaginal cuff is closed with barbed suture continuously, as in traditional vaginal hysterectomy cuff closure. Uterosacral ligament suspension should be performed for vaginal cuff support. ●

WHAT THIS EVIDENCE MEANS FOR PRACTICE

vNOTES is the most recent innovative development in the field of minimally invasive surgery, and it has demonstrated feasibility and safety in the fields of general surgery, urology, and gynecology. Adopting vNOTES in clinical practice can improve patient satisfaction and cosmesis as well as surgical outcomes. Gynecologic surgeons can think of vNOTES hysterectomy as "placing an eye" in the vagina while performing transvaginal hysterectomy. The surgical principle of "vaginal pull, laparoscopic push" facilitates the learning process.

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