

# Laparoscopic abdominal cerclage: a highly effective option for refractory cervical insufficiency

Nisse V. Clark, M.D., M.P.H.<sup>a</sup> and Jon I. Einarsson, M.D., Ph.D., M.P.H.<sup>b</sup>

<sup>a</sup> Division of Minimally Invasive Gynecologic Surgery, Department of Obstetrics and Gynecology, Massachusetts General Hospital, Boston; <sup>b</sup> Division of Minimally Invasive Gynecologic Surgery, Department of Obstetrics and Gynecology, Brigham and Women's Hospital, Boston, Massachusetts

Laparoscopic abdominal cerclage is emerging as the preferred treatment option for patients with refractory cervical insufficiency. Laparoscopic abdominal cerclage reduces second-trimester loss and preterm birth with success rates similar to open abdominal cerclage. Increasing evidence also suggests improved neonatal survival rates with abdominal cerclage compared with repeat vaginal cerclage in patients who delivered prematurely despite a vaginal cerclage. The option to perform a highly effective treatment using minimally invasive techniques suggests laparoscopic abdominal cerclage will become the standard of care for refractory cervical insufficiency. This review examines the literature with regard to the indications and outcomes of abdominal cerclage, highlighting the laparoscopic technique. (*Fertil Steril*® 2020;113:717–22. ©2020 by American Society for Reproductive Medicine.)

**Key Words:** Cervical insufficiency, laparoscopic cerclage, preterm birth, transabdominal cerclage

**Discuss:** You can discuss this article with its authors and other readers at <https://www.fertstertdialog.com/users/16110-fertility-and-sterility/posts/59746-29593>

Cervical insufficiency is an important cause of preterm birth and is estimated to complicate up to 1% of pregnancies (1). A cerclage, or purse-string suture around the cervix, can be used to treat cervical insufficiency and prevent second-trimester loss and preterm birth. Traditionally, a cerclage is placed vaginally; however, a cerclage may instead be placed abdominally in more severe cases where a vaginal cerclage has failed or the cervix is extremely short. An abdominal cerclage allows for placement of the suture at the internal os, providing greater structural support to the cervix. The absence of a foreign body in the vagina may also reduce the risk of ascending infection and resulting preterm labor or ruptured membranes (2). Despite these advantages, an abdominal cerclage is rarely the first-

line treatment for cervical insufficiency because it necessitates a cesarean delivery. The procedure is also viewed as a more morbid option due to the risk of bleeding from the uterine vessels and traditional reliance on laparotomy for placement.

Increasingly, an abdominal cerclage is placed laparoscopically, often as a prophylactic surgery before conception. High rates of success in preventing preterm birth are reported for both the open and laparoscopic approaches, with laparoscopy offering the advantages of minimally invasive surgery (3–5). Newer data even suggest slightly improved neonatal survival rates with the laparoscopic method compared with an open one (5). This review discusses the indications, outcomes, and techniques of laparoscopic abdominal cerclage.

## HISTORY

Vaginal cerclage was first described a half a century ago as a preventive measure for patients with an extremely short cervix due to müllerian anomalies or cervical surgery (6). Two notable techniques were described by Shirodkar (7) and McDonald (8) in the 1950s. The Shirodkar method involves placing a vaginal cerclage as close to the internal os as possible by dissecting the vesicocervical before suture placement (7). The McDonald technique employs a simple purse-string suture at the cervicovaginal junction and is the most common type of vaginal cerclage performed today (8). Although there is no evidence that one vaginal cerclage or suture type is superior, the McDonald vaginal cerclage using 5 mm of Mersilene polyester tape (Ethicon) is the most frequently reported (9–11).

The first abdominal cerclage was reported by Benson and Durfee (12) in 1965 as an alternative to vaginal cerclage for patients with extreme cervical shortening. The indications were later expanded to include the most common present-day use for patients who have

Received January 1, 2020; revised February 14, 2020; accepted February 16, 2020; published online March 5, 2020.

N.V.C. has nothing to disclose. J.I.E. has nothing to disclose.

Reprint requests: Nisse V. Clark, M.D., M.P.H., Massachusetts General Hospital, Founders 5, 55 Fruit Street, Boston, Massachusetts 02114 (E-mail: [nvclark@mgh.harvard.edu](mailto:nvclark@mgh.harvard.edu)).

*Fertility and Sterility*® Vol. 113, No. 4, April 2020 0015-0282/\$36.00

Copyright ©2020 American Society for Reproductive Medicine, Published by Elsevier Inc. <https://doi.org/10.1016/j.fertnstert.2020.02.007>

had second-trimester loss or preterm birth despite a vaginal cerclage, commonly termed a “failed” vaginal cerclage (13). An abdominal cerclage is placed higher on the cervix and is felt to provide added integrity to the cervix in patients with cervical insufficiency. The laparoscopic approach was first performed by Lesser et al. (14) in 1998 and is increasingly used as the preferred method of abdominal cerclage placement.

## INDICATIONS FOR ABDOMINAL CERCLAGE

A vaginal cerclage is indicated in patients with a history of cervical deficiency as guided by history, physical examination, or ultrasound findings. A history of cervical insufficiency is suggested by one or more second-trimester losses related to painless cervical dilation in the absence of labor or placental abruption. The findings considered to be concerning for cervical insufficiency include examination-evidence of painless cervical dilation in the second trimester or ultrasound evidence of a cervical length of <25 mm in a patient with a history of preterm birth before 34 weeks of gestation (15). When an ultrasound-indicated vaginal cerclage is placed, preterm delivery before 35 weeks of gestation has been shown to be reduced from 41% to 28% (16). For the subset of patients who have a very early spontaneous preterm delivery despite a vaginal cerclage, an abdominal cerclage may be of benefit.

Obstetricians have traditionally had a high threshold for placement of an abdominal cerclage given the morbidity of an open procedure and the need for a cesarean delivery. An abdominal cerclage has therefore typically been offered to patients who have had at least two prior failed vaginal cerclages. The open procedure is also more commonly performed after conception, given the hesitation to perform major surgery as a preventative measure before conception (5). Increasingly an abdominal cerclage is being offered after only one prior failed vaginal cerclage, given the ability to place the cerclage laparoscopically with a shorter recovery and fewer complications. Newer evidence also supports an abdominal cerclage as a more effective treatment than repeated vaginal cerclage in patients with one prior failed vaginal cerclage (11).

Other indications for an abdominal cerclage include extreme cervical shortening or cervical deformity that is suspected to compromise the cervix. This may be the result of congenital anomalies, cervical laceration, recurrent loop electrosurgical excision procedures, cervical conization, or trachelectomy. An abdominal cerclage performed for these indications is considered prophylactic. An abdominal cerclage in the emergent setting, when the cervix is painlessly dilating or shortening, has not been reported.

## ABDOMINAL CERCLAGE OUTCOMES

Most studies measure the success of a cerclage by the neonatal survival rate, defined as the percentage of pregnancies with neonates surviving until hospital discharge. First-trimester losses are typically excluded from the denominator as they are unlikely the result of cervical insufficiency. According to the literature, neonatal survival rates after a laparoscopic

or open abdominal cerclage range from 71% to 100% (2, 13, 17–25).

The first multicenter randomized control trial comparing abdominal and vaginal cerclage was recently published with impressive results in favor of an abdominal cerclage after a failed vaginal cerclage (11). The study included 111 patients who had a second-trimester loss or preterm birth between 14 and 28 weeks of gestation with a low vaginal cerclage in place (excluding rescue procedures). Patients were randomized before conception as well as after conception before 14 weeks of gestation, and the first pregnancy after randomization was examined. All abdominal cerclages in the trial were performed using an open approach. This study found that preterm birth before 32 weeks of gestation was statistically significantly lower in patients who received an abdominal cerclage compared with a low vaginal cerclage (8% vs. 38%, respectively;  $P=.008$ ). This was also the first study to compare high versus low vaginal cerclage (Shirodkar vs. McDonald method) in a randomized fashion and found no difference in outcomes between the groups.

Large observational studies have also evaluated abdominal cerclage outcomes and found high neonatal survival rates. The largest cohort study retrospectively reviewed 300 patients who underwent an open or laparoscopic procedure using the patients' prior pregnancy as a control (19). The neonatal survival rate after abdominal cerclage was 98%, and the average gestational age at delivery was greater after abdominal cerclage than in the prior pregnancy (37 compared with 24 weeks of gestation;  $P<.001$ ).

The second largest cohort study exclusively examined laparoscopic abdominal cerclage before conception in a prospective cohort of 225 patients with cervical insufficiency (26). The neonatal survival rates were similarly high at 98.5%. Additionally, 80% of pregnancies delivered after 34 weeks of gestation, and the mean gestational age at delivery was 35 weeks. Other smaller cohort studies have also demonstrated similar or improved outcomes with abdominal compared with vaginal cerclage for refractory cervical insufficiency (18, 27).

## LAPAROSCOPIC APPROACH

The obvious advantages of laparoscopic abdominal cerclage relate to the minimally invasive nature of the procedure. The laparoscopic approach is favored for many procedures given reduced blood loss, fewer wound complications, a shorter length of stay, and a faster return to normal activities compared with an open approach (28–30). These advantages likely apply to laparoscopic abdominal cerclage, and one study confirmed reduced blood loss and reduced length of stay with a robotic-assisted laparoscopic abdominal cerclage compared with an open abdominal cerclage (31). Laparoscopy lends improved visualization of the pelvic anatomy, aiding in avoidance of uterine vessel injury, a feared complication of abdominal cerclage. Many patients with cervical insufficiency have also had one or more cesarean deliveries, resulting in uterine adhesions that may be more carefully lysed with the laparoscopic method. Additionally, most patients can be

discharged home the same or next day after laparoscopic abdominal cerclage.

The reported complication rates vary according to the literature but are generally lower for laparoscopic abdominal cerclage, ranging between 0 and 11% compared with 0 and 25% for open abdominal cerclage (5, 19, 23, 32, 33). Conversion to laparotomy has been reported in up to 5.2% of laparoscopic cases, and may be more likely to occur during pregnancy given the increased bleeding risk and challenges with uterine manipulation (3). Other complications, including uterine perforation, pelvic infection, bowel injury, or bladder injury, are overall rare (1.1% of laparoscopic cerclages) (5). Single case reports have documented suture migration through the cervix, erosion into the vagina, or uterine rupture with an abdominal cerclage in place (34, 35).

In the hands of an experienced laparoscopist, a laparoscopic abdominal cerclage is a short, uncomplicated procedure that results in a high neonatal survival rate. Our experience with 137 patients who underwent laparoscopic abdominal cerclage at Brigham and Women's Hospital in Boston is shown in Table 1. The majority of patients had at least one prior second-trimester loss (70.8%), with many having also failed a transvaginal cerclage (56.9%). Thirteen (9.5%) of the 137 patients were pregnant at the time of cerclage placement. The mean operative time was 51 minutes, and the mean estimated blood loss was 18 mL when no additional procedures were performed. There was one complication in a pregnant patient who had a seemingly uncomplicated laparoscopic abdominal cerclage procedure but was found to have a missed abortion postoperatively. Most patients (95.6%) were discharged home on the same day as surgery. In the 80 pregnancies that followed and extended beyond the first trimester (some patients with multiple pregnancies with the cerclage in place), the neonatal survival rate was 93.8%, and the mean gestational age at delivery was 36.9 weeks.

According to multiple observational studies, neonatal survival rates with laparoscopic abdominal cerclage are similar or improved compared with an open procedure, ranging from 75% to 100% (3, 20, 22–25). The largest systematic review analyzed 31 studies involving 1,844 patients who underwent either laparoscopic or open abdominal cerclage (5). The neonatal survival rate was comparable in the laparoscopic and open groups when first-trimester losses were included (90% vs. 91%, respectively;  $P=.80$ ). When first-trimester losses were excluded from the analysis, the neonatal survival rates were statistically significantly greater in the laparoscopic group (97% vs. 90% in the laparotomy group;  $P\leq .01$ ). The laparoscopic group also had a higher rate of deliveries after 34 weeks of gestation (83% vs. 76%;  $P\leq .01$ ). Because first-trimester losses are arguably unrelated to cervical integrity, this is the first systematic review to demonstrate improved obstetric outcomes with laparoscopic compared with laparotomic abdominal cerclage.

All other cohort studies have found laparoscopic abdominal cerclage to be effective with success rates comparable with open abdominal cerclage. It is interesting that neonatal survival rates with laparoscopy have tended to increase over the last two decades, suggesting improved surgeon

TABLE 1

## Laparoscopic abdominal cerclage in 137 patients.

Parameters	Values
Patient characteristics (n = 137)	
Mean age (y) <sup>a</sup>	34.8 ± 4.5
History	106 (77.4)
Preterm delivery	
Second-trimester loss	97 (70.8)
"Failed" transvaginal cerclage(s) <sup>b,c</sup>	78 (56.9)
Cervical surgery or injury	81 (59.1)
Procedural outcomes (n = 137)	
Mean operative time (min) <sup>a</sup>	
All cases	64 ± 37
No additional procedures	51 ± 27
Mean estimated blood loss (mL) <sup>a</sup>	
All cases	25 ± 20
No additional procedures	18 ± 12
Complications <sup>b</sup>	1 (0.7)
Same-day discharge <sup>b</sup>	131 (95.6)
Obstetric outcomes (n = 80)	
Neonatal survival rate <sup>b,d</sup>	75 (93.8)
Mean gestational age (wk) <sup>a</sup>	36.9 ± 1.5
Mean birth weight (g) <sup>a</sup>	2,925 ± 600

<sup>a</sup> Mean ± standard deviation.

<sup>b</sup> Number and percentage.

<sup>c</sup> Loss or delivery between 14 0/7 and 33 6/7 weeks.

<sup>d</sup> Neonates surviving until hospital discharge.

Clark. Laparoscopic abdominal cerclage. *Fertil Steril* 2020.

techniques over time. Most studies conclude that the laparoscopic approach is safe and effective and advocate for this method given the benefits of minimally invasive surgery.

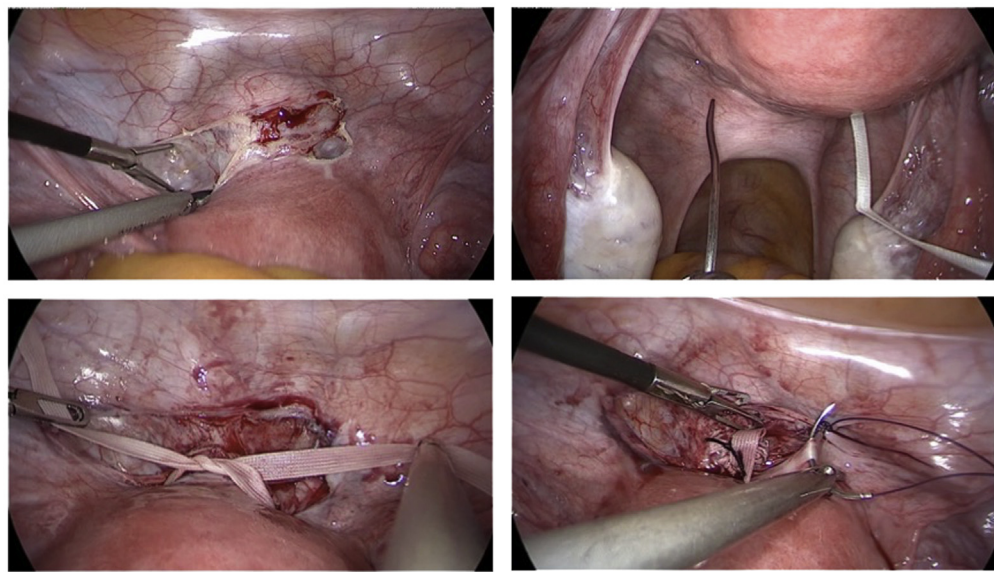
## ABDOMINAL CERCLAGE BEFORE VERSUS AFTER CONCEPTION

An abdominal cerclage can be placed before conception or during early pregnancy, typically before 14 to 16 weeks of gestation. Laparoscopic abdominal cerclage is often performed before pregnancy when the uterus is normal in size and there is no risk of miscarriage. The less invasive nature of laparoscopic abdominal cerclage is also more appealing as a preventative measure when a future pregnancy is not guaranteed. A systematic review found that 71% of laparoscopic abdominal cerclages are placed before conception compared with only 19% of open abdominal cerclages (5). The open approach may be more common during early pregnancy to help overcome the challenges of inserting the cerclage in the setting of a gravid uterus.

Literature comparing preconception and postconception abdominal cerclage is limited as most studies are either underpowered or the results are confounded by a disproportionate number of laparoscopic versus open procedures in the comparison groups. Two larger studies that compared abdominal cerclage outcomes before and after pregnancy for each surgical approach had mixed results (4, 36). The first, a systematic review of 16 studies and 678 patients examined laparoscopic and open cases independently (4). No differences in the rate of third-trimester delivery or live birth were found between the



## FIGURE 1



Laparoscopic abdominal cerclage technique. Top left: Opening the peritoneum to reveal the cervicoisthmic junction. Top right: Inserting a straightened needle of the double-arm Mersilene polyester tape at the internal cervical os. Bottom left: Securing the cerclage knot anterior to the cervix. Bottom right: Closing the overlying peritoneum.

Clark. Laparoscopic abdominal cerclage. *Fertil Steril* 2020.

preconception and postconception groups for either surgical approach.

The second study compared preconception versus postconception abdominal cerclage in 161 patients who exclusively underwent open procedures, with the results favoring preconception insertion (36). Both groups had a prior mid-trimester loss and at least one prior failed vaginal cerclage. Delivery at after 34 weeks of gestation was statistically significantly higher in the preconception group compared with the postconception group (90% vs. 74%;  $P=.02$ ). No surgical complications occurred in the preconception cerclage group whereas 3 of 65 patients (5%) in the first-trimester group had a surgical complication (bladder and bowel injury) and 32 of 65 (50%) had an estimated blood loss >500 mL.

Additionally, postconception cerclage carries a unique risk of fetal demise or miscarriage, estimated to occur in 1.2% of laparoscopic cases and 3% of open cases (difference not statistically significant) (5). Preconception cerclage is not thought to impair fertility, with 78% of laparoscopic cases and 74% of open cases achieving a future pregnancy (difference also not statistically significant) (5).

Despite the lack of strong evidence supporting preconception or postconception cerclage, most investigators have concluded that preconception placement is associated with reduced surgical and obstetric risk. There may also be something inherently different about cases performed during pregnancy. For example, cervical shortening at the time of postconception cerclage placement or perioperative inflammation may negatively impact the outcomes of an abdominal cerclage placed during pregnancy.

## SURGICAL TECHNIQUE

Standard laparoscopic principles for patient positioning, trocar placement, and equipment are applied during laparoscopic abdominal cerclage. The procedure typically requires three to four ports. One port is placed in the umbilicus for the camera, two ports are placed in the bilateral lower quadrants, and an optional ipsilateral or suprapubic port is placed to facilitate dissection and knot tying. We recommend a port arrangement that will allow the primary surgeon to comfortably tie a secure knot with two hands, which in our case is achieved with ipsilateral ports. If the procedure is performed during a pregnancy, care must be taken to avoid injury to the gravid uterus during entry and port placement. If the patient is not pregnant, a uterine manipulator is placed to aid in dissection and passage of the suture.

Various dissection techniques have been described before placing the suture (Fig. 1). Most procedures start by opening the peritoneum overlying the anterior uterine isthmus. We use this technique to help reflect the bladder caudad and identify the cervicoisthmic junction and uterine vessels. Some describe carrying the dissection laterally to create a window in the broad ligament and better identify the uterine vessels (23). We have not found this step to be necessary because the suture is placed medial to the uterine vessels without a need to skeletonize the vessels' lateral border. Alternatively, one study describes forging this dissection altogether and simply passing the suture (25). While this technique may be permissible in some cases, it is not advised when bladder adhesions are present.

After dissection, a nonabsorbable suture is passed between the uterine vessels and cervical stroma at the level of the internal os. The suture needle can be inserted posteriorly or anteriorly, with the knot secured anteriorly or posteriorly, respectively. We prefer to insert the suture posteriorly at the level of the internal os just above the insertion of the uterosacral ligaments. Careful technique is required to pass the suture between the uterine vessels and cervical stroma: too lateral a placement can result in injury to the uterine vessels whereas too medial a placement can result in a weak cerclage. In nonpregnant patients, the uterine manipulator can be used to antevert then retrovert the uterus simultaneously with posterior insertion of a straightened suture needle. Twisting the uterus with the uterine manipulator during this step can be helpful because it facilitates the correct angulation of the needle. By twisting the uterus, the surgeon can simultaneously see the insertion of the needle as well as the exit point of the needle.

Our preferred suture is the double-armed 5-mm Mersilene polyester tape with taper-point CTX or blunt-tip BP-1 needles (Ethicon). This is also the most commonly reported suture type. We straighten the needles extracorporeally before passing through the trocars and carefully inserting between the uterine vessels and cervix. Some studies also report using a No. 1 Prolene suture on a CT-1 needle (Ethicon) (23, 37, 38). Alternatively, a technique has been described where the needles are removed and an endoscopic suturing device is passed through the abdominal wall, piercing the cervix anteriorly and grasping each end of the suture posteriorly before pulling it through the cervix (39). One study also describes placing the suture lateral to the uterine vessels, which in a series of 80 patients did not seem to compromise fetal growth (40).

Once the suture is in place, we remove the uterine manipulator and secure the Mersilene tape with six square knots anterior to the cervix. We routinely tag the suture ends with a silk suture to aid in knot identification during future cerclage removal. We then close the overlying vesicouterine peritoneum with running 2-0 Monocryl (Ethicon) suture.

Laparoscopic abdominal cerclage can also be placed with robotic assistance, depending on the surgeon's preference. Several case reports and series have used the da Vinci robotic system (Intuitive Surgical) with good outcomes (21, 41–46). Robotic techniques to reduce bleeding have been described, including complete skeletonization of the uterine vessels to allow needleless introduction of the suture (47).

## DELIVERY AND CERCLAGE REMOVAL

Patients with an abdominal cerclage require a cesarean delivery. This is performed electively between 37 and 39 weeks of gestation, with some obstetricians recommending an early term delivery to reduce the risk of labor with the cerclage in situ. If the patient has completed childbearing, the cerclage is removed at that time; otherwise, it can be left in place for a future pregnancy. Subsequent pregnancies with an abdominal cerclage in place are rarely reported but are generally favorable. One small study of 22 patients with second and third pregnancies with a laparoscopic abdominal cerclage in

situ demonstrated neonatal survival rates of 86% in the second pregnancy and 100% in the third pregnancy (48).

In the event of previable fetal loss, a dilation and evacuation procedure can be performed without abdominal cerclage removal and has been described up to 18 weeks of gestation (49). Before viability, an abdominal cerclage can also be removed laparoscopically and has been described up to 19 weeks of gestation (50).

## CONCLUSION

Laparoscopic abdominal cerclage is a highly effective intervention for refractory cervical insufficiency. The procedure has similar or improved neonatal survival rates compared with an abdominal approach and offers the benefits of minimally invasive surgery. Given new, high-quality evidence in favor of an abdominal cerclage over a repeat vaginal cerclage in patients who have failed one prior vaginal cerclage, it is reasonable to conclude that a laparoscopic abdominal cerclage should be the first-line treatment for refractory cervical insufficiency. Furthermore, placement before conception may improve the feasibility of the procedure and decrease complications.

## REFERENCES

- Ludmir J. Sonographic detection of cervical incompetence. *Clin Obstet Gynecol* 1988;31:101–9.
- Debbs RH, DeLa Vega GA, Pearson S, Sehdev H, Marchiano D, Ludmir J. Transabdominal cerclage after comprehensive evaluation of women with previous unsuccessful transvaginal cerclage. *Am J Obstet Gynecol* 2007; 197:317.e1–4.
- Burger NB, Brölmann HA, Einarsson JI, Langebrenke A, Huirne JA. Effectiveness of abdominal cerclage placed via laparotomy or laparoscopy; systematic review. *J Minim Invasive Gynecol* 2011;18:696–704.
- Tulandi T, Alghanaim N, Hakeem G, Tan X. Pre and post-conceptual abdominal cerclage by laparoscopy or laparotomy. *J Minim Invasive Gynecol* 2014;21:987–93.
- Moawad GN, Tyan P, Bracke T, et al. Systematic review of transabdominal cerclage placed via laparoscopy for the prevention of preterm birth. *J Minim Invasive Gynecol* 2018;25:277–86.
- Lash AF, Lash SR. Habitual abortion: the incompetent internal os of the cervix. *Am J Obstet Gynecol* 1950;59:68–76.
- Shirodkar VN. A new method of operative treatment for habitual abortions in the second trimester of pregnancy. *Antiseptic* 1955;52:299–300.
- McDonald IA. Suture of the cervix for inevitable miscarriage. *J Obstet Gynaecol Br Emp* 1957;64:346–50.
- Harger JH. Comparison of success and morbidity in cervical cerclage procedures. *Obstet Gynecol* 1980;56:543–8.
- Berghella V, Szychowski JM, Owen J, Hankins G, Iams JD, Sheffield JS, et al. Suture type and ultrasound-indicated cerclage efficacy. *J Matern Fetal Neonatal Med* 2012;25:2287–90.
- Shennan A, Chandiramani M, Bennett P, et al. MAVRIC: A multicentre randomised controlled trial of transabdominal versus transvaginal cervical cerclage. *Am J Obstet Gynecol*. Published online October 1, 2019. Available at: <https://doi.org/10.1016/j.ajog.2019.09.040>.
- Benson RC, Durfee RB. Transabdominal cervicouterine cerclage during pregnancy for the treatment of cervical incompetency. *Obstet Gynecol* 1965;25: 145–55.
- Novy MJ. Transabdominal cervicoisthmic cerclage: a reappraisal 25 years after its introduction. *Am J Obstet Gynecol* 1991;164:1635–41.
- Lesser KB, Childers JM, Surwit EA. Transabdominal cerclage: a laparoscopic approach. *Obstet Gynecol* 1998;91:855–6.

15. American College of Obstetricians and Gynecologists. ACOG Practice Bulletin No. 142: Cerclage for the management of cervical insufficiency. *Obstet Gynecol* 2014;123:372–9.
16. Berghella V, Rafael TJ, Szychowski JM, Rust OA, Owen J. Cerclage for short cervix on ultrasonography in women with singleton gestations and previous preterm birth: a meta-analysis. *Obstet Gynecol* 2011;117:663–71.
17. Fick AL, Caughey AB, Parer JT. Transabdominal cerclage: can we predict who fails? *J Matern Fetal Neonatal Med* 2007;20:63–7.
18. Witt MU, Joy SD, Clark J, Herring A, Bowes WA, Thorp JM. Cervicoisthmic cerclage: transabdominal vs transvaginal approach. *Am J Obstet Gynecol* 2009;201:105.e1–4.
19. Foster TL, Moore ES, Sumners JE. Operative complications and fetal morbidity encountered in 300 prophylactic transabdominal cervical cerclage procedures by one obstetric surgeon. *J Obstet Gynaecol* 2011;31:713–7.
20. Ades A, Dobromilsky K. Transabdominal cervical cerclage: laparoscopy versus laparotomy. *J Minim Invasive Gynecol* 2015;22:968–73.
21. Tyan P, Mourad J, Wright B, et al. Robot-assisted transabdominal cerclage for the prevention of preterm birth: a multicenter experience. *Eur J Obstet Gynecol Reprod Biol* 2019;232:70–4.
22. Carter JF, Soper DE, Goetzl LM, Van Dorsten JP. Abdominal cerclage for the treatment of recurrent cervical insufficiency: laparoscopy or laparotomy? *Am J Obstet Gynecol* 2009;201:111.e1–4.
23. Whittle WL, Singh SS, Allen L, Glaude L, Thomas J, Windrim R, et al. Laparoscopic cervico-isthmic cerclage: surgical technique and obstetric outcomes. *Am J Obstet Gynecol* 2009;201:364.e1–7.
24. Luo L, Chen SQ, Jiang HY, Niu G, Wang Q, Yao SZ. Successful treatment of cervical incompetence using a modified laparoscopic cervical cerclage technique: a cohort study. *Eur J Obstet Gynecol Reprod Biol* 2014;179:125–9.
25. Huang X, Ma N, Li TC, Guo Y, Song D, Zhao Y, et al. Simplified laparoscopic cervical cerclage after failure of vaginal suture: technique and results of a consecutive series of 100 cases. *Eur J Obstet Gynecol Reprod Biol* 2016;201:146–50.
26. Ades A, Parghi S, Aref-Adib M. Laparoscopic transabdominal cerclage: outcomes of 121 pregnancies. *Aust NZ J Obstet Gynaecol* 2018;58:606–11.
27. Davis G, Berghella V, Talucci M, Wapner RJ. Patients with a prior failed transvaginal cerclage: a comparison of obstetric outcomes with either transabdominal or transvaginal cerclage. *Am J Obstet Gynecol* 2000;183:836–9.
28. American College of Obstetricians and Gynecologists, Committee on Gynecologic Practice. Committee Opinion No. 701: Choosing the route of hysterectomy for benign disease. *Obstet Gynecol* 2017;129:e155–9.
29. Aarts JW, Nieboer TE, Johnson N, Tavender E, Garry R, Mol BW, Kluivers KB. Surgical approach to hysterectomy for benign gynaecological disease. *Cochrane Database Syst Rev* 2015;8:CD003677.
30. Bhawe Chittawar P, Franik S, Pouwer AW, Farquhar C. Minimally invasive surgical techniques versus open myomectomy for uterine fibroids. *Cochrane Database Syst Rev* 2014;10:CD004638.
31. Smith RB, Brink J, Hu C, Gerkin R, Perlow JH, Mourad J. Robotic transabdominal cerclage vs laparotomy: a comparison of obstetric and surgical outcomes. *J Minim Invasive Gynecol*. Published online August 15, 2019. Available at: <https://doi.org/10.1016/j.jmig.2019.08.014>.
32. Burger NB, Einarsson JJ, Brölmann HA, Florentien EM, Vree MD, McElrath TF, et al. Preconceptional laparoscopic abdominal cerclage: a multicenter cohort study. *Am J Obstet Gynecol* 2012;207:273.e1–12.
33. Chen Y, Liu H, Gu J, Yao S. Therapeutic effect and safety of laparoscopic cervical cerclage for treatment of cervical insufficiency in first trimester or non-pregnant phase. *Int J Clin Exp Med* 2015;8:7710–8.
34. Hawkins E, Nimaroff M. Vaginal erosion of an abdominal cerclage 7 years after laparoscopic placement. *Obstet Gynecol* 2014;123:420–3.
35. Dandapani M, Pflugner LP, Fanning NS. Uterine rupture at term in a patient with abdominal cerclage. *Obstet Gynecol* 2019;133:940–2.
36. Dawood F, Farquharson RG. Transabdominal cerclage: preconceptual versus first trimester insertion. *Eur J Obstet Gynecol Reprod Biol* 2016;199:27–31.
37. Rust OA, Atlas RO, Jones KJ, Benham BN, Balducci J. A randomized trial of cerclage versus no cerclage among patients with ultrasonographically detected second-trimester preterm dilatation of the internal os. *Am J Obstet Gynecol* 2000;183:830–5.
38. Groom KM, Jones BA, Edmonds DK, Bennett PR. Preconception transabdominal cervicoisthmic cerclage. *Am J Obstet Gynecol* 2004;191:230–4.
39. Al-Fadhli R, Tulandi T. Laparoscopic abdominal cerclage. *Obstet Gynecol Clin North Am* 2004;31:497–504.
40. Shin SJ, Chung H, Kwon SH, Cha SD, Lee HJ, Kim AR, et al. The feasibility of a modified method of laparoscopic transabdominal cervicoisthmic cerclage during pregnancy. *J Laparoendosc Adv Surg Tech A* 2015;25:651–6.
41. Barmat L, Glaser G, Davis G, Craparo F. Da Vinci-assisted abdominal cerclage. *Fertil Steril* 2007;88:1437.e1–3.
42. Wolfe L, DePasquale S, Adair CD, Torres C, Stallings S, Briery C, et al. Robotic-assisted laparoscopic placement of transabdominal cerclage during pregnancy. *Am J Perinatol* 2008;25:653–5.
43. Fechner AJ, Alvarez M, Smith DH, Al-Khan A. Robotic-assisted laparoscopic cerclage in a pregnant patient. *Am J Obstet Gynecol* 2009;200:e10–1.
44. Moore ES, Foster TL, McHugh K, Addleman RN, Sumners JE. Robotic-assisted transabdominal cerclage (RoboTAC) in the non-pregnant patient. *J Obstet Gynaecol* 2012;32:643–7.
45. Foster TL, Addleman RN, Moore ES, Sumners JE. Robotic-assisted prophylactic transabdominal cervical cerclage in singleton pregnancies. *J Obstet Gynaecol* 2013;33:821–2.
46. Menderes G, Clark M, Clark-Donat L, Azodi M. Robotic-assisted abdominal cerclage placement during pregnancy and its challenges. *J Minim Invasive Gynecol* 2015;22:713–4.
47. Mourad J, Burke YZ. Needleless robotic-assisted abdominal cerclage in pregnancy and nonpregnant patients. *J Minim Invasive Gynecol* 2016;23:298–9.
48. Ades A, Hawkins DP. Laparoscopic transabdominal cerclage and subsequent pregnancy outcomes when left in situ. *Obstet Gynecol* 2019;133:1195–8.
49. Chandiramani M, Chappell L, Radford S, Shennan A. Successful pregnancy following mid-trimester evacuation through a transabdominal cerclage. *BMJ Case Rep* 2011.
50. Carter JF, Savage A, Soper DE. Laparoscopic removal of abdominal cerclage at 19 weeks' gestation. *JSL* 2013;17:161–3.