Received: 29 October 2023 | Revised: 23 December 2023 | Accepted: 28 January 2024

DOI: 10.1111/aogs.14803

AOGS Acta Obstetricia et Gynecologica Scandinavica

ORIGINAL RESEARCH ARTICLE

Surgical evacuation combined with Shirodkar cervical suture and selective uterine artery embolization: A fertility preserving treatment for 10–15 weeks' live cesarean scar ectopic pregnancies

Simrit Nijjar[1] | An Ngo[2,3] | Lucrezia V. de Braud[1] | Conrad Von Stempel[2,3] | Cecilia Bottomley[1] | Eric Jauniaux[1] | Davor Jurkovic[1]

[1]Department of Obstetrics and Gynaecology, EGA Institute for Women's Health, Faculty of Population Health Sciences, University College London, London, UK

[2]Department of Interventional Radiology, University College Hospital, London, UK

[3]Division of Surgery and Interventional Science, University College London, London, UK

Correspondence
Davor Jurkovic, EGA Institute for Women's Health, Faculty of Population Health Sciences, University College London, 235 Euston Road, London NW1 2BU, UK.
Email: davor.jurkovic@nhs.net

Abstract

Introduction: Cesarean scar ectopic pregnancies (CSEPs) are associated with significant maternal morbidity and termination is often recommended in the early first trimester. Management of more advanced cases is challenging due to higher risks of major intraoperative hemorrhage. Hysterectomy is currently the intervention of choice for advanced cases. This study aimed to investigate if advanced live CSEPs could be managed effectively conservatively using suction curettage and interventional radiology.

Material and methods: A retrospective single-center cohort study was performed. A total of 371 women diagnosed with CSEP were identified between January 2008 and January 2023. A total of 6% (22/371) women had an advanced live CSEP with crown-rump length (CRL) of ≥40 mm (≥10 weeks' gestation). Of these, 77% (17/22) opted for surgical intervention, whilst the remaining five continued their pregnancies. A preoperative ultrasound was performed in each patient. All women underwent suction curettage under ultrasound guidance and insertion of Shirodkar cervical suture as a primary hemostatic measure combined with uterine artery embolization (UAE) if required. The primary outcome was rate of blood transfusion. Secondary outcomes were estimated intraoperative blood loss, UAE, intensive care unit admission, reintervention, hysterectomy, hospitalization duration and rate of retained products of conception. Descriptive statistics were used to describe these variables.

Results: Median CRL of the 17 patients included was 54.1 mm (range: 40.0–85.7) and median gestational age based on CRL was 12 + 3 weeks (range: 10 + 6–15 + 0). On preoperative ultrasound scan placental lacunae were recorded in 76% (13/17) of patients and color Doppler score was ≥3 in 67% (10/15) of patients. At surgery, Shirodkar cervical suture was used in all cases. It was successful in achieving hemostasis by

Abbreviations: CSEP, cesarean scar ectopic pregnancy; CRL, crown-rump length; CDI, color Doppler imaging; UAE, uterine artery embolization; IR, interventional radiology.

tamponade in 76% (13/17) of patients. In the remaining 24% (4/17) patients tamponade failed to achieve complete hemostasis and UAE was performed to stop persistent arterial bleeding into the uterine cavity. Median intraoperative blood loss was 800 mL (range: 250–2500) and 41% (7/17) women lost >1000 mL. 35% (6/17) needed blood transfusion. No women required hysterectomy.

Conclusions: Surgical evacuation with Shirodkar cervical suture and selective UAE is an effective treatment for advanced live CSEPs.

KEYWORDS
cesarean scar pregnancy, fertility preservation, second trimester, suction curettage, uterine artery embolization

1 | INTRODUCTION

Cesarean scar ectopic pregnancy (CSEP) is the most common type of uterine ectopic pregnancy, defined by implantation of the pregnancy into a myometrial defect caused by dehiscence of the anterior lower uterine segment cesarean scar.[1] The incidence of CSEP has been reported as 1.5 per 10 000 maternities, but it is estimated that as many as 1 in 531 women with a history of cesarean delivery will have a CSEP.[2,3] The true incidence is still likely underestimated, but as the number of cesarean deliveries increases globally so will the incidence of CSEP.[4]

CSEPs are known to be associated with high maternal morbidity, particularly massive obstetric hemorrhage, uterine rupture, placenta accreta syndrome and emergency hysterectomy.[5–7] Termination of pregnancy is often offered to women in the early first trimester to prevent these complications. Treatment of early first trimester CSEPs is usually effective and safe, and primary surgical treatment modalities involve suction evacuation and sometimes with resection of the niche containing the pregnancy via laparoscopy and hysteroscopy.[5] However the management of more advanced cases is challenging, because the associated risk of maternal morbidity increases beyond the first trimester, particularly 9–11 weeks' gestation.[6,7] As the pregnancy develops in the cesarean scar, the placenta is directly perfused by the radial or arcuate arteries.[8] Exposure to higher pressure blood flow from larger branches of the uterine arteries, with limited or absent contractibility of the remaining scarred myometrium means that severe intraoperative hemorrhage is probable.

Allowing for these risks, the American Society for Maternal-Fetal Medicine released a consensus paper in 2020 recommending that hysterectomy should be considered as the primary treatment of choice for early second trimester CSEPs.[9] This is controversial because as well as hysterectomy being a major surgical procedure with inherent risk, it deprives the woman of any chance of carrying a further pregnancy. Any treatment for CSEPs can be associated with major blood loss and need for blood transfusion, but intervention in the early second trimester is generally considered better as it avoids both the potentially worse maternal morbidity at later gestations (associated with massive obstetric hemorrhage and often complex emergency hysterectomy) and the chance of late fetal loss or neonatal morbidity and mortality from severe preterm delivery.

Key message

More advanced live cesarean scar ectopic pregnancies, those in the late first and early second trimester can be managed effectively and safely with ultrasound-guided suction curettage combined with selective uterine artery embolization, thus avoiding hysterectomy.

Ultrasound-guided transcervical suction curettage combined with insertion of a cervical suture (cerclage) to secure hemostasis has been shown to be an effective and safe management of first trimester CESPs.[6,10,11] Uterine artery embolization (UAE) has also been described as a treatment that can be used alone or in combination with suction curettage, methotrexate or hysteroscopy to minimize blood loss.[12] UAE is minimally invasive and as its use has increased in the treatment of postpartum hemorrhage and uterine fibroids, it is now generally considered safe with minimal risks of sepsis, injury to blood vessels, deep vein thrombosis and pulmonary embolism.[13]

There are limited data on the management of late first trimester and early second trimester CSEP. The objective of our study was to report on the management of live CSEPs between 10 and 15 weeks' of gestation.

2 | MATERIAL AND METHODS

2.1 | Study design and participants

This was a retrospective single-center cohort study of consecutive women diagnosed with a CSEP. We included women presenting with a live 10–15 weeks' CSEP on ultrasound who opted to undergo surgical management at University College Hospital London between 2008 and 2023. Women were identified retrospectively from a cohort of pregnant patients attending the Early Pregnancy Assessment Unit at University College Hospital London.

Demographic data, previous obstetric and gynecological history of patients, clinical findings, ultrasound data and images and symptoms at the time of the first examination were recorded and stored in a specialized database (Viewpoint version 5, Bildverargeritung GmbH, Munich, Germany). All ultrasound records were examined within the hospital and basic clinical data were collected using a standard anonymized clinical audit protocol.

2.2 | Ultrasound assessment

Transvaginal ultrasound and transabdominal examination were carried out for all women by experienced operators using high-resolution ultrasound equipment with two- and three-dimensional diagnostic modalities (Voluson 730 and E8 Expert, GE Medical Systems, USA). In all cases the diagnosis was confirmed by an expert level III ultrasound examiner.[14] A CSEP was diagnosed if the pregnancy was implanted within the cesarean scar of the lower uterine segment, according to previously published ultrasound criteria.[15] Gestational age was calculated by measuring the crown-rump length (CRL). An advanced live CSEP was defined by a CRL of ≥40 mm and visualization of cardiac activity. Color Doppler imaging (CDI) with a default pulse repetition frequency of 0.9 kHz, gain of 0.8 and low wall motion filter (40 Hz) was used to map vascularity around and within the gestational sac. A semi-quantitative color score method with a scale from 1 to 4 was used to describe perigestational sac blood supply, as previously described.[16] Presence or absence of placental lacunae was recorded, defined as large and irregular fluid filled spaces often containing turbulent visible flow.[8]

2.3 | Management

All women were counseled regarding their management options; surgery in the form of ultrasound-guided transcervical suction curettage or if they were clinically stable and committed to the pregnancy following risk counseling, expectant management.

Transcervical suction curettage was performed under transabdominal or transrectal ultrasound guidance, as described previously.[10] At induction of anesthesia women were given misoprostol 800 μg PR and ergometrine 500 mg IM. Cervical preparation was not used due to risk of provoking preoperative hemorrhage. For more advanced pregnancies dilatation evacuation using ovum forceps was performed in addition to suction. A Shirodkar cervical suture (Mersilene 5 mm, polyester fiber ligature, Ethicon, Johnson & Johnson, UK) was inserted at the start of the procedure as a primary hemostatic measure and tied following evacuation of the pregnancy to secure hemostasis.[11] Completeness of uterine evacuation was confirmed on intraoperative ultrasound scan. Secondary hemostatic measures included UAE. Total intraoperative blood loss was calculated from a combination of the aspirated volume, weighed surgical swabs and the amount of blood collected on surgical drapes.

All women who had Shirodkar cervical suture inserted during the surgical procedure were reviewed in the outpatient clinic 2–3 days after their operation for ultrasound examination and suture removal under local anesthesia. A follow-up ultrasound assessment at 6–8 weeks postoperatively was offered to all women routinely to assess their recovery and the size of the uterine defect.

UAE was performed initially prior to surgery but after the first two patients our protocol was adapted to "selective UAE," with the procedure being performed post-evacuation, if hemostasis was not achieved surgically, as this was found to be a more effective and possibly a safer approach. Following evacuation of pregnancy and tying of the Shirodkar cervical suture, transvaginal ultrasound was carried out to look for signs of persistent pulsating arterial hemorrhage into the uterine cavity and to identify which side of the uterus this vessel originated from (right or left) to aid the interventional radiology (IR) team, as described below. The patient was transferred under general anesthesia from the operating theater to the neighboring IR suite for catheter angiography if persistent pulsating arterial bleeding (>10 min) was confirmed on Doppler ultrasound post evacuation.

At our institution radial artery access is preferred over the femoral artery in this setting to enable rapid catheter manipulation in localizing the internal iliac arteries, to facilitate patient positioning for post-procedural transvaginal ultrasound, and to permit early ambulation post operatively.

Angiography is performed to interrogate the bilateral internal iliac artery territories for active hemorrhage, pseudoaneurysm formation (inferring arterial injury), or the presence of traumatic arteriovenous fistulae. In the event of any such positive finding, arterial embolization is performed.

In our unit, in hemodynamically stable patients, selective catheterization of the uterine artery branch(es) is attempted and embolization to complete stasis performed using a permanent embolic, usually polyvinyl alcohol particles measuring from 500 to 1100 μM. Embolization coils may be used in addition to polyvinyl alcohol particles to augment their effect depending on operator preference or used solely in the context of arteriovenous shunting where the use of a particulate embolic may risk crossing to the systemic circulation. In hemodynamically unstable patients, where expeditious hemostatic control is crucial, nonselective embolization of the affected internal iliac artery or uterine artery may be performed with a gelatine sponge, a rapid nonpermanent embolic agent.

2.4 | Statistical analyses

The primary outcome was the rate of blood transfusion following surgical evacuation of CSEP. The secondary outcomes were the total blood loss during surgery, need for UAE, admission to intensive care unit, length of hospitalization, rate of retained products of conception, need for reintervention, and hysterectomy rate.

SPSS version 28.0.1.1 (IBM Corporation, Armonk, USA) was used to analyze the data. A standard kurtosis analysis indicated that some values were not normally distributed, and the data are therefore

presented as median and range. Descriptive statistics were used to describe the primary and secondary variables.

3 | RESULTS

A total of 17 women were included. During the study period, 371 women were diagnosed with CSEP, of which 22 (6%) had a diagnosis of a live, advanced CSEP. After discussion of the available treatment options 17/22 (77%) women opted for surgical management in the form of transcervical suction curettage. The remaining five women opted to continue their pregnancy.

Table 1 summarizes patient demographics. A total of 14 of 17 (82%) patients were referred from their local hospital for a second opinion and management. In two (12%) women CSEP occurred after a previous CSEP and in one (6%) woman the pregnancy was heterotopic (a normally sited and a CSEP). The median CRL was 54.1 mm (range: 40.0–85.7) and the median gestational sac diameter was 52.7 mm (range: 41.0–82.7). The median gestational age based on CRL was 12 + 3 weeks (range: 10 + 6 weeks and 15 + 0 weeks). On preoperative ultrasound placental lacunae were recorded in 13 (76%) patients (Figure 1) and color Doppler score was ≥3 in 10 (67%) patients. In nine (69%) of these patients, the presence of placental lacunae was associated with increased blood flow and vascularity score of 4 (Figure 2).

A Shirodkar cervical suture, our normal protocol for advanced CSEP, was used in all 17 patients to limit bleeding. Six women (35%) required blood transfusion (Figure 3). The median blood loss at the time of surgery was 800 mL (range: 250–2500), with blood loss >1000 mL in seven (41%) women. The median amount of intraoperative blood loss increased with higher CDI scores (Table 2). Three of the patients required repeated surgical and IR procedures to control the bleeding.

TABLE 1 Key demographics of patients ($n = 17$).

Demographics	Median (range)
Age	34 (26–41)
Gravidity	4 (2–11)
Parity	1 (1–4)
Number of previous cesarean deliveries	1 (1–4)
Gestational age at decision for surgery	12^{+3} (10^{+6} to 15^{+0})
Presenting symptoms	
Vaginal bleeding (*n*, %)	3 (18%)
Abdominal pain (*n*, %)	0 (0%)
Vaginal bleeding and pain (*n*, %)	7 (41%)
Asymptomatic (*n*, %)	6 (35%)
Other[a] (*n*, %)	1 (6%)

[a]Syncope.

Table 3 presents the primary and main secondary outcomes. The Shirodkar cervical suture was successful in achieving hemostasis by tamponade in 13/17 (76%) patients. In the remaining four (24%) patients, tamponade failed to achieve a complete hemostasis and UAE was performed to control persistent arterial bleeding into the uterine cavity and avoid an emergency hysterectomy. UAE was performed preoperatively in two patients. In one patient there was no bleeding after surgical evacuation, but the second patient required another UAE immediately after surgical evacuation of pregnancy to achieve hemostasis. In three patients the primary surgeon was able to locate the site and laterality of the bleeding arterial vessels after pregnancy evacuation using transvaginal color Doppler ultrasound and the IR team were then able to perform targeted embolization and success was confirmed immediately with repeat CDI. All women who had UAE required admission to the intensive care unit (24%).

In seven patients (41%), the procedure was performed as day surgery, while 10/17 (59%) women were admitted overnight for monitoring due to a combination of reasons; surgery was performed late in the day, volume of blood loss, postoperative pain, patient choice or they were referred from out of the local region. For these women, median admission time was 4 days, but one particularly challenging case (Case 7) was associated with admission for 17 days; preoperatively she was considered to be at high risk of bleeding, based on ultrasound parameters, size of the pregnancy, presence of multiple placental lacunae and a succenturiate placental lobe. Four units of packed red blood cells were crossmatched and the IR team were on standby with UAE if required. After suction curettage she continued to have heavy vaginal bleeding and underwent UAE; however, she required a second procedure 7 days later for ongoing bleeding.

All women made a good postoperative recovery and there were no cases of uterine perforation or hysterectomy in our study group. No cases of retained products of conception were found in the women (11/17) who returned for their follow-up scan at our unit. During the study period four women are known to have had subsequent spontaneous pregnancies, all of which were normally sited within the uterine cavity. Two had a term cesarean delivery and two underwent surgical termination of pregnancy for fetal abnormalities (trisomy 13 and fetal acrania).

4 | DISCUSSION

The data from our study confirm that suction curettage at an advanced gestational age is associated with an increased blood loss, particularly if CDI scores are high. However, we show that these patients can be successfully managed conservatively using suction curettage, cervical cerclage and UAE. Out of the 17 patients that were managed in our unit over a 15-year period, there was no need for emergency hysterectomy. Our data also highlight the importance of preoperative ultrasound assessment in helping to predict which pregnancies will be at higher risk of major blood loss and therefore allows the surgical team to plan accordingly, with IR available when required. Our data, in accordance with the recent study by Ban

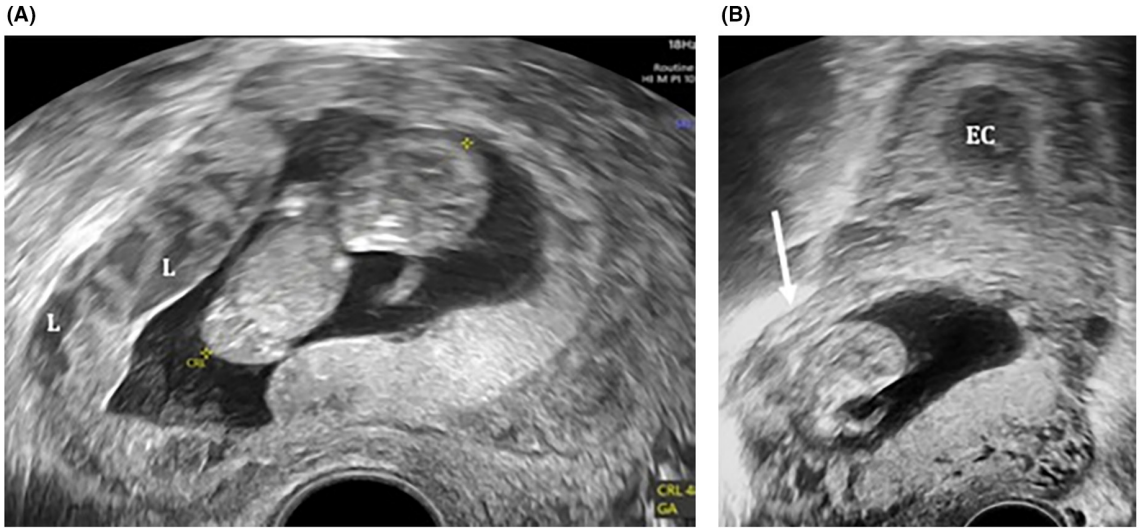

FIGURE 1 Transvaginal ultrasound views of a gestational sac containing a live fetus at 11^{+1} weeks of gestation showing (A) multiple placental lacunae (L) and (B) herniation of the pregnancy into the right broad ligament (arrow). EC, endometrial cavity.

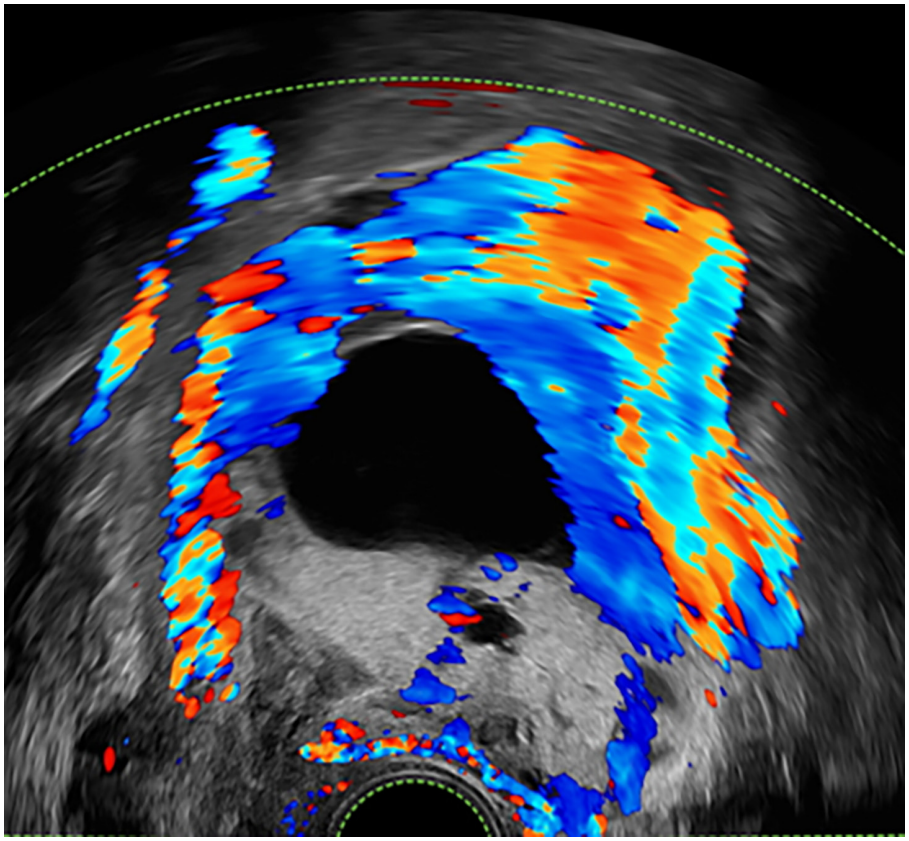

FIGURE 2 Transvaginal view of the uterus at 11^{+1} weeks gestation showing increased placental vascularity (CDI score of 4). CDI, color Doppler imaging.

et al.,[17] also shows that the risk of bleeding increases with the size of the pregnancy.

There have only been a few studies in the medical literature that describe the management of advanced CSEPs, particularly live pregnancies.[6,18–23] This distinction between live and failing pregnancies is important as in live pregnancies the risk of severe hemorrhage tends to increase with gestational age, whilst in failing pregnancies the vascularity of pregnancy is the strongest predictor

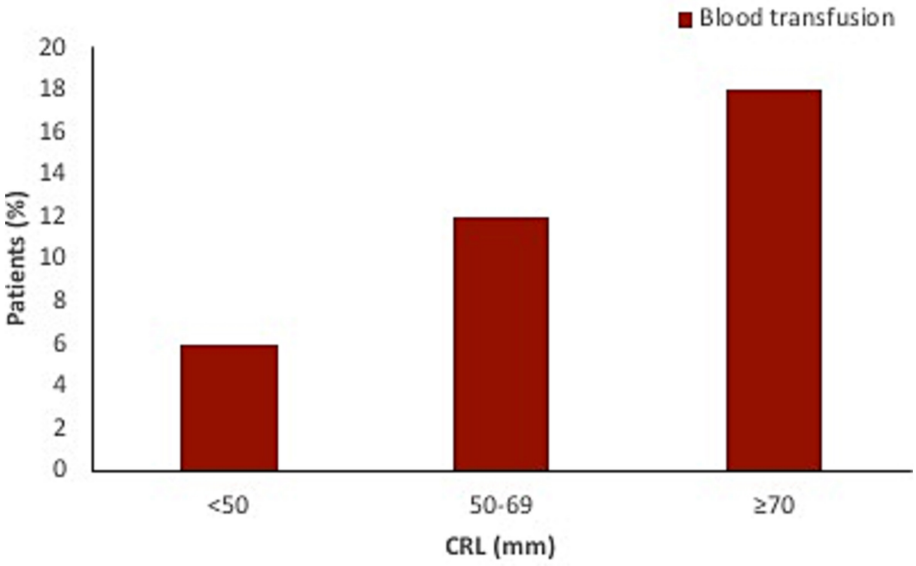

FIGURE 3 Crown-rump length (CRL) and blood transfusion. Proportion of women who received a blood transfusion following surgical evacuation, divided into three groups according to CRL size.

TABLE 2 Color Doppler score (CDI) and intraoperative blood loss during surgical evacuation of cesarean scar ectopic pregnancy ($n = 15$).

Color Doppler score	*n* (%)	Estimated blood loss (mL)[a]
1, 2	5 (33)	400 (300–600)
3, 4	10 (67)	1400 (250–2500)

[a]Data are expressed as median (range).

of intraoperative blood loss.[24] A few individual case reports and small case series from other groups have described management of advanced CSEPs ranging from 11 + 5–18 + 0 weeks' gestation.[18–23,25] Conservative management strategies have been described such as local potassium chloride followed by systemic methotrexate,[20,23] preoperative UAE followed by posterior isthmic hysterotomy,[18] stand-alone UAE,[23] and dilatation and curettage.[25] In one short series, two of the three cases of CSEP underwent emergency hysterectomy because of significant bleeding after dilatation and curettage.[25] Several authors, however, also report on hysterectomy as a primary treatment, without attempt at a more conservative approach.[19,21–23]

The use of the Shirodkar cervical suture was first described in 2002 by Mashiach et al.[26] as the method of choice for surgical hemostasis in the treatment of cervical ectopic pregnancy. We adapted their method for use in CSEP 15 years ago[11] and have been using it successfully ever since. The Shirodkar cervical suture creates a temporary tamponade at the cesarean scar implantation site and most importantly, with the suture in situ bleeding is confined to the uterine cavity with no blood exiting through the external cervical os. The uterine cavity is relatively small in the early second trimester, and the uterine corpus is contracted with uterotonics. The cervical occlusion forces blood into the cesarean scar defect and creates an evenly distributed pressure on the deficient myometrium. In most cases that is enough to achieve a complete hemostasis.

However, in some cases there is continuing arterial bleeding into the cavity, which over time can overcome the suture resistance and vaginal bleeding would commence. With the cervical suture in situ the bleeding is contained within a high-pressure compartment, which stems the blood loss. The bleeding is thus temporarily suppressed to facilitate patient transfer and IR catheter placement, which helps to avoid taking more extreme measures, such as hysterectomy.

Suction evacuation is the most widely used treatment for CSEP in the UK,[2] with the Shirodkar cervical suture used as an additional hemostatic measure in a significant proportion of patients (41%). The recognition of Shirodkar cervical suture has also increased internationally, as demonstrated by a recent study by Kaelin Agten et al.[27] on behalf of the international Cesarean Scar Pregnancy Registry. The study found that of the 258 surgically managed patients, suction evacuation was the most common form of treatment and was combined with prophylactic temporary Shirodkar cervical suture in 15.3% of patients, demonstrating there is a shift in the international community towards the use of cervical suture as an adjunct during surgery.

All four cases that required UAE also needed blood transfusions and were recovered in the intensive care unit; the increased morbidity correlates to the particularly advanced gestations of these particular pregnancies.

It is difficult to compare our results to those of mini-case series where dilatation and curettage was reported to be complicated by emergency hysterectomy,[25] as our study was conducted in a tertiary referral center for uterine ectopic pregnancies, with expertise in both diagnosis and management of such challenging cases. We are

TABLE 3 Summary of outcomes of advanced cesarean scar ectopic pregnancies managed surgically ($N = 17$).

Case	GA (weeks)	Mean GSD (mm)	CRL (mm)	Placental lacunae (±)	CDI score	Total EBL (mL)	Blood transfusion (±)	UAE (±)	ICU admission (±)
1	10+6	45.0	40.1	+	4	1500	–	–	–
2	11+3	46.3	46.5	+	NR	800	–	–	–
3	12+0	58.0	54.0	–	2	600	–	–	–
4	12+0	54.7	54.1	+	4	800	–	–	–
5	12+3	45.7	59.8	–	2	500	–	–	–
6	13+1	55.3	69.0	+	4	300	–	–	–
7	13+4	62.0	76.0	+	NR	2300	+	+	+
8	13+4	58.7	76.0	+	2	400	–	–	–
9	15+0	82.7	85.7	+	4	1800	+	–	–
10	11+4	60.3	48.3	+	4	2000	+	+	+
11	12+1	50.0	55.9	+	4	2000	+	–	–
12	11+4	50.7	49.6	+	4	350	–	–	–
13	10+6	41.0	40.0	+	2	300	–	–	–
14	11+0	41.7	42.8	–	3	250	–	–	–
15[a]	14+4	–	–	+	4	1300	+	+	+
16	11+5	49.3	50.1	+	4	2500	+	+	+
17	12+3	58.0	60.0	–	2	300	–	–	–

Abbreviations: CDI, color Doppler imaging; CRL, crown rump length; EBL, estimated blood loss; GA, gestational age; GSD, gestational sac diameter; ICU, intensive care unit; NR, not recorded; UAE, uterine artery embolization.

[a]This was a case of a heterotopic twin pregnancy. Biparietal diameter (29.7 mm) measurements were taken instead of CRL given the size of the pregnancy.

aware that this may mean that our results may not be widely reproducible in all units, but the techniques are valid and can be adopted by other operators even in less complex cases.

The most commonly used embolic agents in the literature for UAE are a gelatine sponge and polyvinyl alcohol particles.[28] The embolic agents are introduced into the uterine artery and may cause platelet coagulation, and formation of thrombi, which then block the blood supply to the uterus and therefore the pregnancy, resulting in hemostasis.[29] The extent of arterial occlusion is determined, in part, by the type of embolic agent used; a gelatine sponge is considered a temporary agent, with varying absorption of the material occurring 2–3 weeks later allowing recanalization of the uterine arteries and theoretically leading to better preservation of future fertility as a result.[30] In comparison polyvinyl alcohol particles are a permanent embolic resulting in permanent occlusion of the treated uterine arteries. Shunting to the ovarian arteries may occur in certain settings which may adversely affect ovarian function. The effect this has on fertility has yet to be determined. In our study both permanent and temporary embolic agents were used, according to the hemodynamic status of the patient. In women desiring preservation of fertility, selective embolization while protecting the ovarian circulation is paramount. With this in mind, a gelatine sponge is preferred when performing rapid nonselective embolization of the anterior divisions of the iliac arteries in the emergent setting. Studies on UAE treatment have reported pelvic pain (25%), fever or infection (18%), nausea and, or vomiting (8%) and limb pain (4%) after use.[31] In our study none of the participants who underwent UAE reported these complications.

There remains a lack of evidence-based consensus about the optimal role of UAE with surgical management of CSEP, particularly regarding whether embolization should be used routinely, only in advanced cases, only if blood loss is excessive and whether embolization should occur pre- or post-surgery. Historically, most studies describe UAE as performed prior to dilatation and curettage, usually 24–48 h before surgery with a range of 0–7 days.[31] However, prophylactic insertion of arterial sheaths for embolization prior to surgery has been shown to increase the risk of arterial thrombus formation, as it remains in situ for longer.[32,33] A higher incidence of thrombosis is also found when a hematoma is present. Cannulation of the vessels can also be associated with immediate complications of vessel injury, rupture and pseudoaneurysm formation at the puncture site.[34] We therefore propose that our selective UAE approach is both pragmatic and effective. The approach requires close collaboration between the IR and surgical teams, with the IR team on "standby" so that if the surgeon deems that post-evacuation UAE is required, the vessel is only then cannulated (while the Shirodkar cervical suture maintains sufficient tamponade for partial hemostasis). In our setting the gynecological operating theater and IR suite are located next to each other resulting in transfer of the patient in a matter of minutes preventing rapid decompensation. The primary surgeon routinely performs an ultrasound assessment post-surgery and if on color Doppler assessment of the uterine vessels there is

evidence of sustained pulsating arterial blood flow a decision is only then made to proceed with UAE. Detection of persistent arterial bleeding is an early warning that major hemorrhage is likely to occur within an hour or two, which facilitates timely preparations for embolization and transfer to the IR suite. It also enables the clinician to identify the depth (i.e., helicine, uterine) and laterality of the pulsating vessel(s) allowing for targeted emobolization.

The diagnostic value of color Doppler during embolization has also been demonstrated in other specialties, such as urological emergencies.[35] Presurgical planning and multidisciplinary work between gynecologists and IR is therefore key in managing these high-risk cases. However, we recognize that UAE requires advanced infrastructure and trained staff, and therefore may not be widely available.

The longstanding implications of UAE on future fertility has been difficult to assess as high quality evidence has been not been available. The Royal College of Obstetricians and Gynecologists and the Royal College of Radiologists of the UK suggested some time ago that UAE may be offered to women who want to be able to become pregnant in the future, after an informed discussion.[36] Additionally the findings of a recent systematic review of the impact of UAE on fertility concluded that fertility and miscarriage rates after UAE are comparable to that of the age-matched general population.[37]

The main strength of our study was that it is the largest series of advanced CSEPs published in the English language literature. Furthermore we only included women with live CSEPs, which are the subgroup of pregnancies that are at higher risk of maternal morbidity; hemorrhage and therefore hysterectomy, as more than two thirds of CSEPs with no cardiac activity are likely to resolve spontaneously without any further intervention.[24]

The primary limitation of our study was its retrospective design and the lack of mid-late second trimester cases identified. We also had limited data on the impact of UAE on future pregnancy outcomes, with only one of the four subsequent pregnancies in women who underwent UAE. Although there were no cases of emergency hysterectomy, this study was conducted in a tertiary referral center, with surgeons experienced in surgically managing uterine ectopic pregnancies and using Doppler ultrasound to assess continuing bleeding into the uterine cavity; therefore, the results may not be widely replicable in units with less expertise.

5 | CONCLUSION

Surgical evacuation with a Shirodkar cervical suture was effective in avoiding further bleeding and/or hysterectomy in 76% of cases of advanced live CSEPs. An additional selective UAE was required in 24% of cases due to the failure of the Shirodkar cervical suture to control hemorrhage, and this combination avoided a hysterectomy in all cases. However, this treatment needs to be studied in a prospective manner with a larger sample size to validate these findings. We therefore propose, given the small number of advanced live CSEPs in the literature, that a multicenter prospective study is performed to ensure reliable and valid results. The ability to perform second trimester surgical terminations of pregnancy under ultrasound guidance requires both surgical expertise and gynecological ultrasound skills. We therefore recommend that women with suspected or confirmed advanced CSEPs are referred to specialist tertiary level units with expertise in managing uterine ectopic pregnancies.

AUTHOR CONTRIBUTIONS

Davor Jurkovic conceived the idea. Simrit Nijjar and Lucrezia V. de Braud collected the data. Simrit Nijjar and Davor Jurkovic wrote the draft manuscript with support from all coauthors. An Ngo, Conrad Von Stempel, Cecilia Bottomley and Eric Jauniaux edited and provided critical input to improve the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

ETHICS STATEMENT

Ethical committee approval (UK NHS Health Research Authority, Research Ethical committee approval reference 18/WM/0328) was obtained on October 26, 2018, prior to the start of this study. The protocol and a waiver of consent were granted a favorable opinion as all records were examined within the center and basic clinical data were collected using a standard clinical audit protocol.

ORCID

Simrit Nijjar https://orcid.org/0000-0001-8002-0981
Eric Jauniaux https://orcid.org/0000-0003-0925-7737
Davor Jurkovic https://orcid.org/0000-0001-6487-5736

REFERENCES

1. Jordans IPM, Verberkt C, De Leeuw RA, et al. Definition and sonographic reporting system for cesarean scar pregnancy in early gestation: modified Delphi method. *Ultrasound Obstet Gynecol*. 2022;59:437-449.
2. Harb HM, Knight M, Bottomley C, et al. Caesarean scar pregnancy in the UK: a national cohort study. *BJOG*. 2018;125:1663-1670.
3. Birch Petersen K, Hoffmann E, Rifbjerg Larsen C, Svarre Nielsen H. Cesarean scar pregnancy: a systematic review of treatment studies. *Fertil Steril*. 2016;105:958-967.
4. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. *BMJ Glob Health*. 2021;6:e005671.
5. Nijjar S, Jauniaux E, Jurkovic D. Surgical evacuation of cesarean scar ectopic pregnancies. *Best Pract Res Clin Obstet Gynaecol*. 2023;89:102361.
6. De Braud LV, Knez J, Mavrelos D, Thanatsis N, Jauniaux E, Jurkovic D. Risk prediction of major haemorrhage with surgical treatment of live cesarean scar pregnancies. *Eur J Obstet Gynecol Reprod Biol*. 2021;264:224-231.
7. Timor-Tritsch I, Buca D, Di Mascio D, et al. Outcome of cesarean scar pregnancy according to gestational age at diagnosis: a systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. 2021;258:53-59.
8. Jauniaux E, Zosmer N, De Braud LV, Ashoor G, Ross J, Jurkovic D. Development of the utero-placental circulation in cesarean scar pregnancies: a case-control study. *Am J Obstet Gynecol*. 2022;226:399.e1-399.e10.

9. Miller R, Timor-Tritsch IE, Gyamfi-Bannerman C. Society for Maternal-Fetal Medicine (SMFM) consult series #49: cesarean scar pregnancy. *Am J Obstet Gynecol*. 2020;222:B2-b14.
10. Jurkovic D, Knez J, Appiah A, Farahani L, Mavrelos D, Ross JA. Surgical treatment of cesarean scar ectopic pregnancy: efficacy and safety of ultrasound-guided suction curettage. *Ultrasound Obstet Gynecol*. 2016;47:511-517.
11. Jurkovic D, Ben-Nagi J, Ofilli-Yebovi D, Sawyer E, Helmy S, Yazbek J. Efficacy of Shirodkar cervical suture in securing hemostasis following surgical evacuation of cesarean scar ectopic pregnancy. *Ultrasound Obstet Gynecol*. 2007;30:95-100.
12. Noël L, Thilaganathan B. Caesarean scar pregnancy: diagnosis, natural history and treatment. *Curr Opin Obstet Gynecol*. 2022;34:279-286.
13. NICE. Uterine artery embolisation for fibroids. Interventional procedures guidance [IPG367]. 2010. https://www.nice.org.uk/guidance/ipg367
14. Education and Practical Standards Committee, European Federation of Societies for Ultrasound in Medicine and Biology. Minimum training recommendations for the practice of medical ultrasound. *Ultraschall Med*. 2006;27:79-105.
15. Diagnosis and Management of Ectopic Pregnancy: green-top guideline No. 21. *BJOG*. 2016;123:e15-e55.
16. Timmerman D, Valentin L, Bourne TH, Collins WP, Verrelst H, Vergote I. Terms, definitions and measurements to describe the sonographic features of adnexal tumors: a consensus opinion from the international ovarian tumor analysis (IOTA) group. *Ultrasound Obstet Gynecol*. 2000;16:500-505.
17. Ban Y, Shen J, Wang X, et al. Cesarean scar ectopic pregnancy clinical classification system with recommended surgical strategy. *Obstet Gynecol*. 2023;141:927-936.
18. Sroussi J, Panchbhaya N, Boujlel S, Dautry R, Tigaizin A, Benifla JL. Cesarean scar pregnancy with deep serosal invasion at 16 weeks: uterus-sparing surgery with posterior hysterotomy after transcatheter arterial embolization. *J Obstet Gynaecol Res*. 2018;44:1824-1827.
19. Morente LS, León AIG, Reina MPE, Herrero JRA, Mesa EG, López JSJ. Cesarean scar ectopic pregnancy-case series: treatment decision algorithm and success with medical treatment. *Medicina (Kaunas)*. 2021;57:362.
20. Pirjani R, Bayani L, Shirazi M. Successful local and systemic medical treatment of cesarean scar pregnancy and a subsequent term pregnancy after treatment: a case series. *Iran J Reprod Med*. 2015;13:445-450.
21. Kwaśniewska A, Stupak A, Krzyzanowski A, Pietura R, Kotarski J. Cesarean scar pregnancy: uterine artery embolization combined with a hysterectomy at 13 weeks' gestation—a case report and review of the literature. *Ginekol Pol*. 2014;85:961-967.
22. Holtzman S, Kiernan ML, Huntly J, Kolev V, Zakashansky K. Cesarean section scar ectopic pregnancy in the second trimester: an Underrecognized complication of cesarean deliveries. *Case Rep Obstet Gynecol*. 2021;2021:8888019.
23. Agarwal N, Gainder S, Chopra S, Rohilla M, Prasad G, Jain V. The Management of Scar Ectopic: a single-center experience. *Cureus*. 2021;13:e15881.
24. Calì G, Timor-Tritsch IE, Palacios-Jaraquemada J, et al. Outcome of cesarean scar pregnancy managed expectantly: systematic review and meta-analysis. *Ultrasound Obstet Gynecol*. 2018;51:169-175.
25. Dickerhoff LA, Mahal AS, Stockdale CK, Hardy-Fairbanks AJ. Management of cesarean scar pregnancy in the second trimester: a report of three cases. *J Reprod Med*. 2015;60:165-168.
26. Mashiach S, Admon D, Oelsner G, Paz B, Achiron R, Zalel Y. Cervical Shirodkar cerclage may be the treatment modality of choice for cervical pregnancy. *Hum Reprod*. 2002;17:493-496.
27. Kaelin Agten A, Jurkovic D, Timor-Tritsch I, et al. First-trimester cesarean scar pregnancy: a comparative analysis of treatment options from the international registry. *Am J Obstet Gynecol*. 2023;S0002-9378(23):00758-5. doi:10.1016/j.ajog.2023.10.028
28. Li C, Li C, Feng D, Jia C, Liu B, Zhan X. Transcatheter arterial chemoembolization versus systemic methotrexate for the management of cesarean scar pregnancy. *Int J Gynaecol Obstet*. 2011;113:178-182.
29. Zhu W, Zhang X, Liu C, Liu Y, Xu W. Uterine artery embolization on serum β-HCG levels, fertility function and clinical efficacy in patients with cesarean uterine scar pregnancy. *Front Surg*. 2022;9:838879.
30. Chua GC, Wilsher M, Young MP, Manyonda I, Morgan R, Belli AM. Comparison of particle penetration with non-spherical polyvinyl alcohol versus trisacryl gelatin microspheres in women undergoing premyomectomy uterine artery embolization. *Clin Radiol*. 2005;60:116-122.
31. Maheux-Lacroix S, Li F, Bujold E, Nesbitt-Hawes E, Deans R, Abbott J. Cesarean scar pregnancies: a systematic review of treatment options. *J Minim Invasive Gynecol*. 2017;24:915-925.
32. Ojala K, Perälä J, Kariniemi J, Ranta P, Raudaskoski T, Tekay A. Arterial embolization and prophylactic catheterization for the treatment for severe obstetric hemorrhage*. *Acta Obstet Gynecol Scand*. 2005;84:1075-1080.
33. Scheer B, Perel A, Pfeiffer UJ. Clinical review: complications and risk factors of peripheral arterial catheters used for haemodynamic monitoring in anaesthesia and intensive care medicine. *Crit Care*. 2002;6:199-204.
34. Wei X, Zhang J, Chu Q, et al. Prophylactic abdominal aorta balloon occlusion during caesarean section: a retrospective case series. *Int J Obstet Anesth*. 2016;27:3-8.
35. Bartsch G Jr, Kuefer R, Engel O, Volkmer BG. High-flow priapism: colour-Doppler ultrasound-guided supraselective embolization therapy. *World J Urol*. 2004;22:368-370.
36. Royal College of Obstetricians and Gynaecologists. *Clinical recommendations on the use of uterine artery embolisation (UAE) in the management of fibroids*. 3rd ed. RCOG and RCR; 2013.
37. Mailli L, Patel S, Das R, et al. Uterine artery embolisation: fertility, adenomyosis and size—what is the evidence? *CVIR Endovasc*. 2023;6:8.

How to cite this article: Nijjar S, Ngo A, de Braud LV, et al. Surgical evacuation combined with Shirodkar cervical suture and selective uterine artery embolization: A fertility preserving treatment for 10–15 weeks' live cesarean scar ectopic pregnancies. *Acta Obstet Gynecol Scand*. 2024;00:1-9. doi:10.1111/aogs.14803