ISSN 0857-6084



THAI JOURNAL OF OBSTETRICS AND GYNAECOLOGY

THE OFFICIAL JOURNAL OF
THE ROYAL THAI COLLEGE OF OBSTETRICIANS AND GYNAECOLOGISTS

VOL. 34 NO. 6 November - December 2026



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ISSN 0857-6084 E-ISSN 2673-0871

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Thai Journal of Obstetrics and Gynaecology

The Official Journal of the Royal Thai College of Obstetricians and Gynaecologists

ISSN 0857-6084 E-ISSN 2673-0871

Vol. 34 No. 6 (November - December 2026)

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EDITORIAL

Intriguing Review and Topics in Sixth Issue of Thai Journal of Obstetrics and Gynaecology 2026

Vorapong Phupong, M.D., FRTCOG.*

** Editor in Chief, Thai J Obstet Gynaecol, The Royal Thai College of Obstetricians and Gynaecologists*

For Proof Only

This sixth issue of Thai Journal of Obstetrics and Gynaecology 2026 contains many interesting articles. The special article is "Selective fetal growth restriction in monochorionic twin pregnancy: A practical framework for intervention". The authors reviewed selective fetal growth restriction in monochorionic twin pregnancy in the aspect of diagnosis, pathophysiology, classification and natural history, surveillance and timing of delivery, and management options and the evidence[1].

This issue also contains six original articles.

Mueangchang performed a prospective diagnostic accuracy study to evaluate the diagnostic accuracy of an artificial intelligence (AI)-assisted colposcopy imaging system for detecting cervical precancerous lesions (CIN2+ and CIN1+) compared with conventional colposcopy. The results revealed AI-assisted colposcopy demonstrated less diagnostic performance for CIN2+ compared with conventional colposcopy but comparable performance for CIN1+[2].

Uatrongjit performed a three-arm randomized, placebo-controlled trial to compare the analgesic efficacy of 2% lidocaine gel, 10% lidocaine spray, and placebo during office-based endometrial sampling. The results showed neither topical 2% lidocaine gel nor 10% lidocaine spray significantly reduced pain compared with placebo during endometrial sampling[3].

Gonzalezrubio-Altamar et al performed a retrospective cohort study to evaluate the prognostic performance of the FullPIERS (full Pre-eclampsia Integrated Estimate of RiSk) model in predicting severe maternal and perinatal complications in patients with severe preeclampsia. They found a FullPIERS-estimated probability ≥ 1% was associated with an 11-fold higher risk of severe maternal complications [odds ratio 11.09, 95% confidence interval 3.87, 31.72] (sensitivity 55%, specificity 90.08%, positive predictive value 45.83%, negative predictive value 92.91%)[4].

Phontham et al performed a double-blind, randomized, placebo-controlled trial to study the efficacy of curcumin for preventing postoperative bowel ileus after total abdominal hysterectomy for benign gynecologic surgery. They found the incidence of ileus symptoms in the intervention group was shown to be significantly lower when compared to the control group[5]. The results were similar to other interventions such as oral ginger powder and metoclopramide[6, 7].

Sangsitong et al performed a diagnostic predictive model study to develop prediction score for positive surgical margins after loop electrosurgical excision procedure (LEEP) in women with high-grade cervical

intraepithelial neoplasia. The results showed at a cutoff score of ≥ 4, the model yielded a sensitivity of 83.18%, specificity of 58%, positive predictive value of 67.9%, and negative predictive value of 76.3%[8].

Triniti et al performed a randomized controlled trial to compare early cesarean scar morphology between three-layer anatomical uterine closure and conventional two-layer closure, using the residual- to-adjacent myometrial thickness ratio (RMT/AMT) at 6 weeks postpartum. They found three-layer anatomical uterine closure was associated with a higher RMT/AMT ratio and lower niche depth and niche depth/AMT ratio at 6 weeks postpartum than conventional two-layer closure[9].

Finally, the 41st Annual Meeting of the Royal Thai Colleague of Obstetricians and Gynecologists (RTCOG) already held from October 27-30, 2026 at the Dusit Thani Pattaya Hotel, Chonburi Province, Thailand. The theme of the meeting is "Women's Health in a Changing World." This meeting was successful with 1,400 delegates.

References

1. Phithakwatchara N, Nawapun K, Watananirun K, Auwattanamongkol T, Kaewsrinual S, Viboonchart S, et al. Selective fetal growth restriction in monochorionic twin pregnancy: A practical framework for intervention. Thai J Obstet Gynaecol 2026;34:427-35.
2. Mueangchang M. Diagnostic accuracy of AI-assisted colposcopy for detection of cervical precancerous lesions at Buddhachinaraj Hospital. Thai J Obstet Gynaecol 2026;34:436-48.
3. Uatrongjit N. Pain control during endometrial sampling: A three-arm randomized controlled trial comparing lidocaine gel, spray, and placebo. Thai J Obstet Gynaecol 2026;34:449-58.
4. Gonzalezrubio-Altamar C, Turizo-Lengua MF, Sundhein-Carretero JP, Morales-Moncada K, Rivas-Perdomo E. Performance of the FullPIERS model for the determination of maternal and perinatal complications in patients with severe preeclampsia in cartagena, Colombia. Thai J Obstet Gynaecol 2026;34:459-69.
5. Phontham S, Tangsiriwatthana T. The efficacy of curcumin for preventing postoperative bowel ileus after total abdominal hysterectomy for benign gynecologic surgery: A randomized controlled trial. Thai J Obstet Gynaecol 2026;34:470-79.
6. Lorsirirat W, Srinil S. The efficacy of oral ginger powder in prevention of postoperative ileus after benign gynecologic hysterectomy: A randomized controlled trial. Thai J Obstet Gynaecol 2025;33:266-75.
7. Sillapasa C, Jeerasap R, Tangsiriwatthana, T. Metoclopramide for preventing ileus after benign gynecologic surgery: A randomized controlled trial. Thai J Obstet Gynaecol 2023;31:192-200.
8. Sangsitong N, Rodpenpear N. The new scoring system for predicting positive surgical margins of high-grade cervical intraepithelial neoplasia after loop electrosurgical excision procedure. Thai J Obstet Gynaecol 2026;34: 480-90.
9. Triniti A, Riratanapong P. Three-layer anatomical uterine closure versus conventional two-layer closure for early cesarean scar sonographic morphology: A randomized controlled trial. Thai J Obstet Gynaecol 2026;34:491-501.

For Proof Only

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 427-435.

SPECIAL ARTICLE

Selective Fetal Growth Restriction in Monochorionic Twin Pregnancy: A Practical Framework for Intervention

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ABSTRACT

Selective fetal growth restriction (sFGR) complicates 10–15% of monochorionic twin pregnancies. Because the twins share one placenta connected by vascular anastomoses, the smaller twin depends on its co-twin, and the death of one twin puts the survivor at risk of death and brain injury. sFGR is therefore not simply fetal growth restriction with an extra fetus. This review provides a practical framework for clinicians. Diagnosis should rely on the Delphi consensus criteria and twin-appropriate growth standards. The Gratacós classification, based on umbilical artery Doppler of the smaller twin, separates three clinical behaviors: type I is usually low risk, type II is usually severe and type III is unpredictable. Onset before or after 24 weeks adds information about placental anatomy and the likelihood of twin anemia-polycythemia sequence. The three management options are expectant management, fetoscopic laser coagulation of the anastomoses and selective reduction. None is free of risk. Expectant management is preferred for type I. In types II and III, laser increases the loss of the smaller twin but may protect the larger twin, while selective reduction prolongs pregnancy and improves intact survival of the larger twin in selected cases. We suggest considering intervention when demise of the smaller twin appears imminent, particularly before viability. When sFGR coexists with twin-twin transfusion syndrome, laser treats the transfusion imbalance but not the unequal placental share. Counseling should begin by agreeing with parents on the outcome they most wish to protect.

Keywords: selective fetal growth restriction, monochorionic twins, umbilical artery Doppler, fetoscopic laser surgery, selective reduction, twin-twin transfusion syndrome.

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Received: 8 October 2026, **Revised:** 14 October 2026, **Accepted:** 21 October 2026

Introduction

When we hear the term fetal growth restriction (FGR), we usually think of one small fetus. In a singleton pregnancy, management balances the risk of fetal death against the complications of prematurity. Selective FGR (sFGR) in monochorionic (MC) twins is a different physiological situation: two fetuses share one placenta, and that shared placenta changes almost everything.

sFGR affects 10–15% of MC diamniotic pregnancies[1, 2]. The shared circulation produces two broad groups of complications. Imbalance of intertwin blood flow causes twin-twin transfusion syndrome (TTTS), twin anemia-polycythemia sequence (TAPS) and twin reversed arterial perfusion sequence. Dependence, where the wellbeing of one twin directly affects the other, is the mechanism of sFGR. If one MC twin dies, the survivor faces about a 15% risk of death and a 26% risk of neurological impairment, compared with 3% and 2% in dichorionic (DC) twins[3]. In DC twins, each fetus has its own placenta, so sFGR behaves much like singleton FGR, and the main dilemma is when to deliver without harming the normally grown co-twin through prematurity[4]. This review therefore focuses on MC twins.

In MC sFGR, doing nothing may allow the smaller twin to deteriorate and die, and that death may also harm the apparently healthy twin. Intervening too early, however, introduces its own risks, often at a gestational age when delivery is not an option. The challenge is not only to diagnose sFGR, but to decide when it is safe to keep watching and when intervention should be considered. Drawing on current evidence and our experience at the Siriraj Fetal Therapy Center, this review offers a practical framework for that decision and for counseling families.

Diagnosis

Twins should not be treated as two singletons in one uterus. Twin growth follows singleton growth until about 28–30 weeks and then slows, so singleton charts label many healthy twins as growth restricted in the third trimester[5]. Chorionicity-specific twin charts reduce this overdiagnosis without missing twins at risk of stillbirth[6]. Our group has gone a step further with a conditional, customized standard for twin growth trajectory. It uses linear mixed-effects models adjusted for maternal characteristics, fetal sex and chorionicity, and calculates the expected estimated fetal weight (EFW) from the fetus's own earlier measurement[7]. Each twin thus serves as its own reference, which helps separate physiological slowing from true placental insufficiency.

Size alone is not enough to diagnose sFGR. A modest weight difference is common in MC twins, and a small twin may be constitutionally small. What raises concern is the combination of small size, intertwin discordance and evidence of placental insufficiency. The international Delphi consensus, now adopted by the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG), defines sFGR in MC twins by a solitary criterion or by contributory criteria[8, 9]. The solitary criterion is an EFW of one twin below the 3rd centile. Otherwise, at least two of four contributory criteria are required: an EFW of one twin below the 10th centile, an abdominal circumference of one twin below the 10th centile, an EFW discordance of 25% or more, and an umbilical artery pulsatility index of the smaller twin above the 95th centile. EFW discordance is calculated as the difference between the two EFWs divided by the EFW of the larger twin.

In MC twins, sFGR must be distinguished from

the other complications of the shared circulation, because their treatment differs. TTTS is defined by amniotic fluid discordance, with oligohydramnios in the donor and polyhydramnios in the recipient, and is staged by the Quintero system[10]. In isolated sFGR, fluid may be reduced around the small twin, but polyhydramnios is absent around the larger twin. TAPS is defined by a large intertwin difference in hemoglobin without fluid discordance and is diagnosed antenatally by a difference in middle cerebral artery peak systolic velocity (MCA-PSV) above 0.5 multiples of the median (MoM)[11]. As in any small fetus, structural, chromosomal and infectious causes should also be considered, particularly when growth restriction begins very early.

Pathophysiology

Two placental features govern MC sFGR. The first is unequal placental sharing. The smaller twin is allotted a smaller placental territory, and the degree of birthweight discordance correlates with the degree of unequal sharing[12]. The second is the network of intertwin vascular anastomoses: arterio-arterial (AA), veno-venous and unidirectional arterio-venous connections. These allow blood from the larger twin's territory to reach the smaller twin. This partly compensates for the small territory, which is why many growth-restricted MC twins survive far longer than a singleton with the same Doppler findings would[2, 13].

A helpful image is two islands joined by bridges. The bridges support the smaller twin, but they also expose each twin to events in the other. If the smaller twin becomes bradycardic or dies, blood can shift rapidly from the larger twin into the low-resistance circulation of its co-twin. The larger twin then suffers acute hypotension and hypoperfusion, which can cause its death or ischemic brain injury[3, 13]. Large-diameter AA anastomoses are particularly important. They are present in most placentas with intermittent absent or reversed umbilical artery flow, they are thought to produce that intermittent Doppler pattern, and they allow sudden, large intertwin transfusions[14]. Both twins also undergo cardiovascular remodeling. The smaller twin adapts to high placental resistance and hypoxemia. The larger twin perfuses part of its co-twin's placental territory and may develop volume and pressure loading; hypertrophic, cardiomyopathy-like changes have been reported, particularly in type III disease[15]. Our recent work on cardiovascular and hemodynamic adaptation in MC twins with sFGR adds to this evidence[16].

Classification and natural history

Once sFGR is diagnosed, the next step is classification. The Gratacós system is simple, because it is based on the end-diastolic flow in the umbilical artery of the smaller twin[17]. In type I, end-diastolic flow is positive. In type II, it is persistently absent or reversed. In type III, absent and reversed end-diastolic flow appear intermittently, in a cyclical pattern within the same recording, best seen with the sample volume near the placental cord insertion. The easiest way to remember the three types is by how they behave: type I is usually low risk, type II is usually severe and type III is unpredictable. The type can change, so it should be reassessed at every visit.

Type I has an excellent prognosis. Survival exceeds 95%, intrauterine death of the smaller twin occurs in only 2–4%, and most pregnancies reach 34–36 weeks[17, 18]. Type II behaves like severe early-onset singleton FGR, with a predictable sequence of arterial and then venous Doppler deterioration. Without intervention, up to 60% of smaller twins may die, and neurological injury in the larger twin has been reported in about 13%[17-19]. Type III creates a particularly uncomfortable situation. The smaller twin may look stable for weeks, yet carries a 10–20% risk of sudden death that Doppler cannot predict, and 15–30% of larger twins develop brain injury[17-19]. These events are attributed to acute transfusion across large AA anastomoses. Reassuring Doppler today therefore does not guarantee safety tomorrow, which is why counseling in type III is so difficult.

Within type II, outcomes vary widely. Signs of cardiovascular decompensation in the smaller twin, namely an MCA-PSV of 1.5 MoM or more, a persistently absent or reversed a-wave in the ductus venosus (DV),

or both, define type IIb and indicate a high risk of imminent demise. Pregnancies without these signs are classified as type IIa. In 177 pregnancies with stage III TTTS and type II growth restriction of the donor, donor survival after laser was 71.2% in type IIa but only 41.9% in type IIb[20].

Gestational age at onset provides a complementary view. Early-onset sFGR, diagnosed before 24 weeks, is mainly caused by markedly unequal sharing with large anastomoses and tends to be more severe[21, 22]. Because delivery is not an option before viability, fetal intervention is most relevant in this group. Late-onset sFGR, diagnosed at 24 weeks or later, usually arises in a more equally shared placenta with small anastomoses and is driven by chronic transfusion imbalance; about one-third of cases are associated with TAPS[21]. New growth discordance after 24 weeks in previously concordant MC twins should therefore prompt measurement of MCA-PSV in both twins.

Surveillance and timing of delivery

Accurate first-trimester determination of chorionicity is the foundation of care. Uncomplicated MC twins are scanned every 2 weeks from 16 weeks. Each scan assesses biometry with EFW discordance, the deepest vertical pocket in each sac and umbilical artery Doppler, with MCA-PSV added from 20 weeks to screen for TAPS[9].

Once sFGR is diagnosed, the intensity of surveillance follows the Doppler type and its trend. In type I, weekly ultrasound and Doppler are usually sufficient, and delivery is planned at 34–36 weeks[9, 18]. Types II and III need closer monitoring, typically Doppler once or twice weekly with growth assessment every 2 weeks, and delivery is planned at 32–34 weeks unless deterioration occurs earlier[9, 18]. Each examination should include umbilical artery, MCA and DV Doppler in the smaller twin; MCA-PSV, amniotic fluid and, where indicated, cardiac function in the larger twin.

No single measurement is decisive. Rising EFW discordance, slowing growth of the smaller twin and a sequence of worsening Doppler findings across serial scans carry far more weight than any one value. Greater discordance and abnormal umbilical artery Doppler at diagnosis are associated with adverse outcome, but predicting the course of an individual pregnancy remains imperfect[23]. Management of sFGR is not one-number medicine; it is trajectory medicine. When preterm delivery is anticipated, antenatal corticosteroids and, before 32 weeks, magnesium sulfate for neuroprotection should be given. Cesarean delivery is often preferred in types II and III, because the smaller twin tolerates labor poorly and acute intrapartum transfusion can occur.

Management options and the evidence

Three strategies are available, and each protects something at a cost. Expectant management preserves the possibility that both twins survive, but accepts the risk of spontaneous death of the smaller twin. Selective reduction sacrifices the smaller twin to protect the larger one. Fetoscopic laser coagulation of the anastomoses attempts to save both, but it removes the compensatory flow the smaller twin receives through the shared circulation. This is a classic fetal therapy problem: there is no zero-risk option.

In MC twins, intracardiac potassium chloride cannot be used for selective reduction, because its effects would cross to the co-twin. Complete occlusion of the target twin's cord vessels is required, most often by radiofrequency ablation or bipolar cord coagulation. Both techniques disconnect the surviving twin from the hemodynamic consequences of a spontaneous death; co-twin survival is generally 80–90%, and the main complications are preterm prelabor rupture of membranes and preterm birth[18, 24]. Whether selective reduction is acceptable or legal differs between countries, cultures and religions, and this must be respected in counseling.

Laser surgery for sFGR follows the same principle as in TTTS. The anastomoses along the vascular equator are coagulated, and the Solomon technique joins the coagulation points with a

continuous line, functionally dichorionizing the placenta[25]. In terms of the island analogy, the laser does not change the islands; it closes the bridges, and each fetus must then survive on its own territory. This explains both the strength and the weakness of laser in sFGR. The procedure is also technically harder than in TTTS. Without polyhydramnios there is little operating space, the vascular equator may be difficult to see, and type III placentas often contain large atypical AA anastomoses[26].

A systematic review that analyzed outcomes by type and management illustrates these trade-offs[24]. In type I under expectant management, intrauterine death occurred in fewer than 5% of smaller and larger twins, whereas laser was followed by death of the smaller twin in about one-third. Expectant management is therefore preferred in type I; intervening only because of size discordance is not justified, and sometimes the best fetal intervention is careful observation. In types II and III under expectant management, the smaller twin died in about 21% of cases, and the larger twin in 15% (type II) and 8% (type III). After laser, death of the smaller twin rose to about 82% in type II and 60% in type III, but in type III, death of the larger twin was around 7%. After selective reduction in type II, the larger twin died in about 5% of cases. Laser thus increases the loss of the smaller twin but may protect the larger twin from ischemic events. In type III, selective reduction appeared to carry a lower risk to the co-twin than laser, probably reflecting the technical difficulties described above.

A recent international multicenter cohort of 246 MC pregnancies with type II or III sFGR added another perspective[27]. About one-quarter of the pregnancies underwent selective reduction and three-quarters were managed expectantly. Live birth of the larger twin at 32 weeks or later was achieved in 75% after selective reduction compared with 46% after expectant management. The difference was most marked in type II (73% vs 26%), and intact survival followed the same pattern. In selected cases, therefore, selective reduction can prolong pregnancy and improve the chance of a healthy larger twin. The study was not randomized, and patient selection strongly influences these figures. It does not mean that selective reduction should be offered to every type II or III pregnancy. A randomized comparison of intervention and expectant management in early-onset sFGR is currently being explored for feasibility[28].

When to intervene: a practical framework

The central question is when to intervene. Not simply because a fetus is small, and not automatically because the pregnancy is type II or III. The principle we use is to intervene when the risk of fetal demise has become high enough that continuing the shared circulation is more dangerous than the procedure. In simple terms, intervention should be considered when death of the smaller twin appears imminent.

In our practice, type I sFGR is managed expectantly with weekly surveillance and delivery at 34–36 weeks. Types IIa and III are also managed expectantly at first, with Doppler twice weekly and delivery at 32–34 weeks. Progression to type IIb, with an MCA-PSV of 1.5 MoM or more, an absent or reversed DV a-wave, or both, signals that demise may be imminent[20]. Before 24 weeks, when delivery cannot rescue either twin, this is the point at which we discuss intervention to protect the larger twin. After viability, delivery becomes the main alternative, weighing the risks of prematurity for both twins. (Fig. 1)

This is a framework, not an automatic algorithm. Defining “imminent” requires judgment and integrates gestational age, the progression of umbilical artery Doppler, DV and MCA findings, the evolution of growth discordance and the pattern across serial scans. Placental location and whether laser is technically feasible also matter, as do local expertise and legal context. Above all, the parents’ wishes and priorities shape the final decision. The question is not only “Can we intervene?” but “At this point, is intervention safer than waiting?”

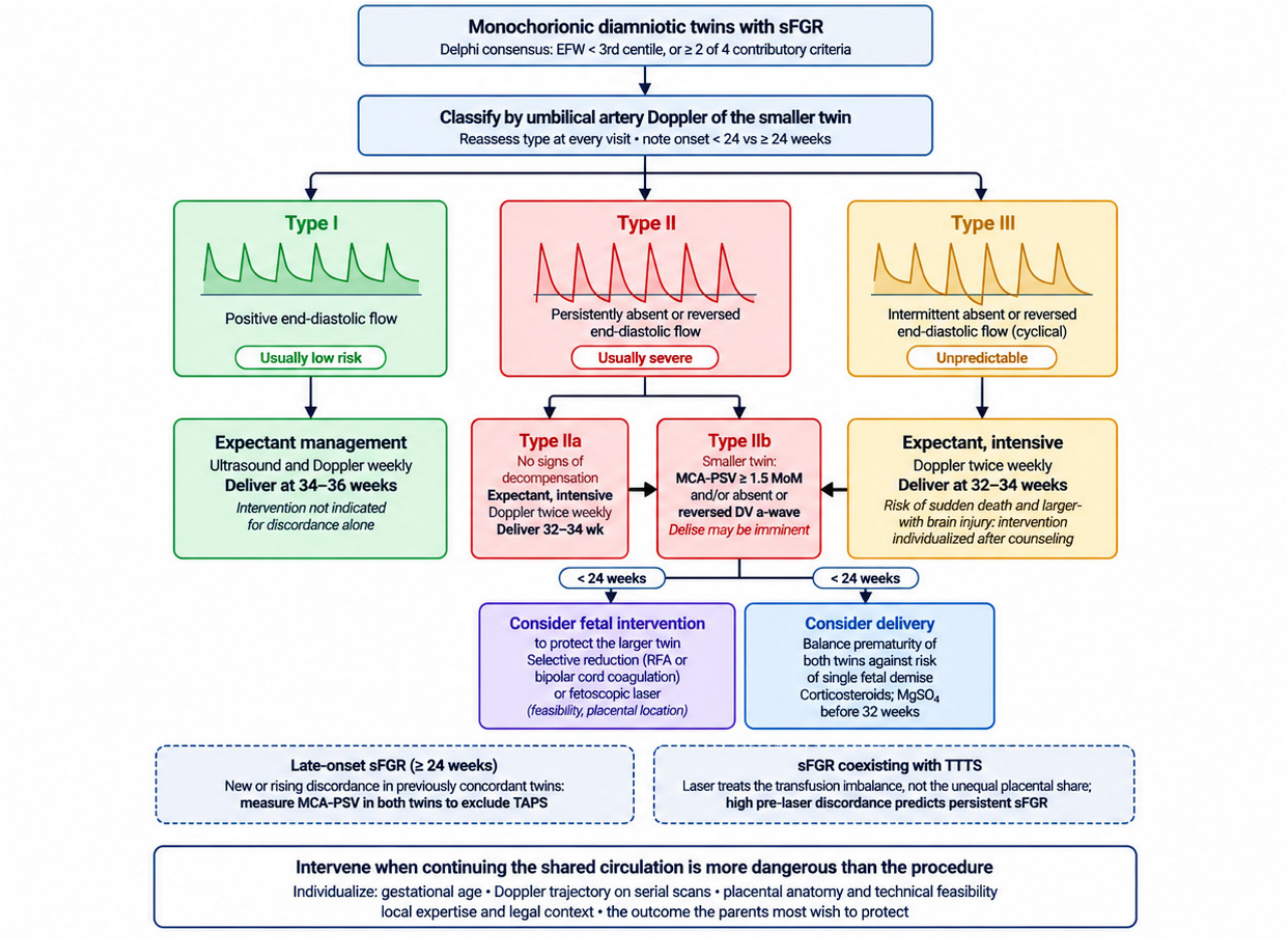


Fig. 2. Practical framework for the classification and management of selective fetal growth restriction (sFGR) in monochorionic diamniotic twins. sFGR is classified by the umbilical artery Doppler pattern of the smaller twin (schematic waveforms). Type I is managed expectantly. Types IIa and III receive intensive surveillance. Progression to type IIb (dashed arrow), defined by a middle cerebral artery peak systolic velocity (MCA-PSV) of 1.5 multiples of the median (MoM) or more and/or an absent or reversed ductus venosus (DV) a-wave, signals imminent demise. Before 24 weeks, fetal intervention is then considered; after viability, delivery is considered. Delivery timings are suggested in the absence of earlier indications.

RFA: radiofrequency ablation, TAPS: twin anemia-polycythemia sequence, TTTS: twin-twin transfusion syndrome.

sFGR coexisting with TTTS

In clinical practice, sFGR often accompanies TTTS, usually affecting the donor; reported prevalence ranges from about 28% to 65% of TTTS cases[29]. Consider a pregnancy that presents at 16 weeks with 30% weight discordance and concordant amniotic fluid, suggesting unequal placental sharing. By 20 weeks it meets the criteria for Quintero stage III TTTS together with type II sFGR. Which disease are we treating? The two processes overlap, but they are not the same. Laser is the established treatment for TTTS and corrects the transfusion imbalance, but it cannot give the smaller fetus more placental territory. Laser can close the abnormal vascular bridges, but it cannot redistribute the land.

A meta-analysis of five studies including 1710 MC twin pregnancies treated by laser for TTTS confirmed that coexisting sFGR worsens the

prognosis[29]. Fetal loss was 20.9% with sFGR compared with 14.4% without it, an odds ratio of about 1.6, and the excess was borne mainly by the donor. In donors, fetal loss rose from 16% to 26% and neurological morbidity from 6% to 12%, whereas recipients were affected only slightly. sFGR is therefore an independent risk factor that should be included in pre-operative counseling.

The course after technically successful laser is not uniform. In a series of 97 TTTS pregnancies with coexisting sFGR, about 35% showed resolution of sFGR, 35% had persistent sFGR and 30% had single or double fetal demise[30]. Weight discordance before the onset of TTTS predicted this course. It averaged about 9% where sFGR resolved, compared with 23% where it persisted and 24% where demise occurred, and each 1% increase in discordance reduced the odds of catch-up growth by about 7%. A large early discordance indicates that the problem did not arise from TTTS alone but from unequal placental sharing. Such a smaller twin is less likely to catch up after laser, and close surveillance must continue until delivery. A successful laser procedure is not the end point but a transition to the next phase of care: laser treats the vascular communication; it does not create new placenta.

Conclusion

sFGR in MC twins is defined by small size, discordance and placental insufficiency together, judged against twin-appropriate standards. The umbilical artery Doppler type of the smaller twin and the timing of onset guide prognosis and surveillance. Expectant management is appropriate for type I and for many pregnancies with type II and III disease. Intervention, by selective reduction or laser, should be considered when demise of the smaller twin appears imminent, particularly before viability. When sFGR coexists with TTTS, laser cures the transfusion imbalance but not the unequal placental share.

Three principles summarize the approach. Maximize outcomes through early diagnosis, correct classification, close monitoring and timely intervention. Minimize risk, remembering that deterioration of one twin endangers the other. Individualize care according to gestational age, Doppler trajectory, placental anatomy, technical feasibility, local expertise and, above all, what matters most to the family. In MC twins, we never care for one fetus in isolation; every decision must consider both lives.

Potential conflicts of interest

The authors declare no competing interests.

References

1. Lewi L, Jani J, Blickstein I, Huber A, Gucciardo L, Van Mieghem T, et al. The outcome of monochorionic diamniotic twin gestations in the era of invasive fetal therapy: a prospective cohort study. Am J Obstet Gynecol 2008;199:514 e1-8.
2. Valsky DV, Eixarch E, Martinez JM, Crispi F, Gratacos E. Selective intrauterine growth restriction in monochorionic twins: pathophysiology, diagnostic approach and management dilemmas. Semin Fetal Neonatal Med 2010;15:342-8.
3. Hillman SC, Morris RK, Kilby MD. Co-twin prognosis after single fetal death: a systematic review and meta-analysis. Obstet Gynecol 2011;118:928-40.
4. Townsend R, Khalil A. Fetal growth restriction in twins. Best Pract Res Clin Obstet Gynaecol 2018;49:79-88.
5. Hiersch L, Barrett J, Fox NS, Rebarber A, Kingdom J, Melamed N. Should twin-specific growth charts be used to assess fetal growth in twin pregnancies? Am J Obstet Gynecol 2022;227:10-28.
6. Kalafat E, Sebghati M, Thilaganathan B, Khalil A, Southwest Thames Obstetric Research C. Predictive accuracy of Southwest Thames Obstetric Research Collaborative (STORK) chorionicity-specific twin growth charts for stillbirth: a validation study. Ultrasound Obstet Gynecol 2019;53:193-9.
7. Jaingam S, Phithakwatchara N, Nawapun K, Viboonchart S, Watananirun K, Wataganara T. A conditional standard for the customized fetal growth trajectory in twin pregnancy. Am J Obstet Gynecol MFM 2024;6:101223.
8. Khalil A, Beune I, Hecher K, Wynia K, Ganzevoort W, Reed K, et al. Consensus definition and essential reporting parameters of selective fetal growth restriction in twin pregnancy: a Delphi procedure. Ultrasound Obstet Gynecol 2019;53:47-54.
9. Khalil A, Sotiriadis A, Baschat A, Bhide A, Gratacos E, Hecher K, et al. ISUOG Practice Guidelines

(updated): role of ultrasound in twin pregnancy. Ultrasound Obstet Gynecol 2025;65:253-76.
10. Quintero RA, Morales WJ, Allen MH, Bornick PW, Johnson PK, Kruger M. Staging of twin-twin transfusion syndrome. J Perinatol 1999;19(8 Pt 1):550-5.
11. Tollenaar LSA, Lopriore E, Middeldorp JM, Haak MC, Klumper FJ, Oepkes D, et al. Improved prediction of twin anemia-polycythemia sequence by delta middle cerebral artery peak systolic velocity: new antenatal classification system. Ultrasound Obstet Gynecol 2019;53:788-93.
12. Lewi L, Cannie M, Blickstein I, Jani J, Huber A, Hecher K, et al. Placental sharing, birthweight discordance, and vascular anastomoses in monochorionic diamniotic twin placentas. Am J Obstet Gynecol 2007;197:587 e1-8.
13. Lewi L, Deprest J, Hecher K. The vascular anastomoses in monochorionic twin pregnancies and their clinical consequences. Am J Obstet Gynecol 2013;208:19-30.
14. Gratacos E, Lewi L, Carreras E, Becker J, Higueras T, Deprest J, et al. Incidence and characteristics of umbilical artery intermittent absent and/or reversed end-diastolic flow in complicated and uncomplicated monochorionic twin pregnancies. Ultrasound Obstet Gynecol 2004;23:456-60.
15. Munoz-Abellana B, Hernandez-Andrade E, Figueroa-Diesel H, Ferrer Q, Acosta-Rojas R, Cabero L, et al. Hypertrophic cardiomyopathy-like changes in monochorionic twin pregnancies with selective intrauterine growth restriction and intermittent absent/reversed end-diastolic flow in the umbilical artery. Ultrasound Obstet Gynecol 2007;30:977-82.
16. Auwattanamongkol T, Phithakwatchara N, Nawapun K, Viboonchart S, Jaingam S, Watananirun K, et al. Cardiovascular and hemodynamic adaptations in selective fetal growth restriction: A cohort study of Mmonochorionic twins. Prenat Diagn 2026. In press.
17. Gratacos E, Lewi L, Munoz B, Acosta-Rojas R, Hernandez-Andrade E, Martinez JM, et al. A classification system for selective intrauterine growth restriction in monochorionic pregnancies according to umbilical artery Doppler flow in the smaller twin. Ultrasound Obstet Gynecol 2007;30:28-34.
18. Bennasar M, Eixarch E, Martinez JM, Gratacos E. Selective intrauterine growth restriction in monochorionic diamniotic twin pregnancies. Semin Fetal Neonatal Med 2017;22:376-82.
19. Buca D, Pagani G, Rizzo G, Familiari A, Flacco ME, Manzoli L, et al. Outcome of monochorionic twin pregnancy with selective intrauterine growth restriction according to umbilical artery Doppler flow pattern of smaller twin: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2017;50:559-68.
20. Nguyen MT, Masri J, Monson MA, Chon AH, Korst LM, Chmait RH. Subclassification of fetal growth restriction type IIa vs type IIb applied to twin-twin transfusion syndrome. Am J Obstet Gynecol MFM 2023;5:101082.
21. Lewi L, Gucciardo L, Huber A, Jani J, Van Mieghem T, Done E, et al. Clinical outcome and placental characteristics of monochorionic diamniotic twin pairs with early- and late-onset discordant growth. Am J Obstet Gynecol. 2008;199:511 e1-7.
22. Curado J, Sileo F, Bhide A, Thilaganathan B, Khalil A. Early- and late-onset selective fetal growth restriction in monochorionic diamniotic twin pregnancy: natural history and diagnostic criteria. Ultrasound Obstet Gynecol 2020;55:661-6.
23. Monaghan C, Kalafat E, Binder J, Thilaganathan B, Khalil A. Prediction of adverse pregnancy outcome in monochorionic diamniotic twin pregnancy complicated by selective fetal growth restriction. Ultrasound Obstet Gynecol 2019;53:200-7.
24. Townsend R, D'Antonio F, Sileo FG, Kumbay H, Thilaganathan B, Khalil A. Perinatal outcome of monochorionic twin pregnancy complicated by selective fetal growth restriction according to management: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2019;53:36-46.
25. Slaghekke F, Lopriore E, Lewi L, Middeldorp JM, van Zwet EW, Weingertner AS, et al. Fetoscopic laser coagulation of the vascular equator versus selective coagulation for twin-to-twin transfusion syndrome: an open-label randomised controlled trial. Lancet 2014;383:2144-51.
26. Gratacos E, Antolin E, Lewi L, Martinez JM, Hernandez-Andrade E, Acosta-Rojas R, et al. Monochorionic twins with selective intrauterine growth restriction and intermittent absent or reversed end-diastolic flow (Type III): feasibility and perinatal outcome of fetoscopic placental laser coagulation. Ultrasound Obstet Gynecol 2008;31:669-75.
27. Noll ATR, van Hoogstraten A, Nulens K, van Geloven N, Van Mieghem T, Shinar S, et al. Outcome of monochorionic diamniotic twin pregnancy with selective fetal growth restriction and continuous or intermittent absent or reversed end-diastolic umbilical artery flow: international multicenter cohort study. Ultrasound Obstet Gynecol 2025;66:41-50.
28. Khalil A, Prasad S, Woolfall K, Mitchell TK, Kirkham JJ, Yaghi O, et al. FERN: is it possible to conduct a randomised controlled trial of intervention or

expectant management for early-onset selective fetal growth restriction in monochorionic twin pregnancy - protocol for a prospective multicentre mixed-methods feasibility study. BMJ Open 2024;14:e080021.
29. D'Antonio F, Marinceu D, Prasad S, Eltaweel N, Khalil A. Outcome following laser surgery of twin-twin transfusion syndrome complicated by selective fetal growth restriction: systematic review and meta-analysis. Ultrasound Obstet Gynecol 2023;62:320-7.
30. Uribe KA, Birk A, Shantz C, Miller JL, Kush ML, Olson S, et al. Resolution of selective fetal growth restriction after laser surgery for twin-to-twin transfusion syndrome can be predicted by predisease growth discordance. Ultrasound Obstet Gynecol 2025;65:47-53.

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 436-448.

GYNAECOLOGY

Diagnostic Accuracy of AI-Assisted Colposcopy for Detection of Cervical Precancerous Lesions at Buddhachinaraj Hospital

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ABSTRACT

Objectives: To evaluate the diagnostic accuracy of an artificial intelligence (AI)-assisted colposcopy imaging system for detecting cervical precancerous lesions (cervical intraepithelial neoplasia (CIN)) CIN2+ and CIN1+ compared with conventional colposcopy.

Materials and Methods: This prospective diagnostic accuracy study included women aged 25–60 years who had abnormal human papillomavirus (HPV) screening results requiring colposcopic evaluation at Buddhachinaraj Phitsanulok Hospital. The primary outcome was the diagnostic accuracy of AI-assisted versus conventional colposcopy for detecting CIN2+ lesions; the secondary outcome was diagnostic accuracy for detecting CIN1+ lesions. A total of 165 women underwent colposcopy. Histopathological findings from cervical biopsies served as the reference standard. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and the area under the receiver operating characteristic curve (AUROC).

Results: The mean age of participants was 39.5 ± 8.3 years. Histopathological examination identified CIN1 in 50.3% and CIN2+ lesions in 41.8% of participants. For CIN2+, AI-assisted colposcopy had an accuracy of 69.1%, sensitivity of 26.1%, specificity of 100%, PPV of 100%, and NPV of 65.3%, whereas conventional colposcopy had an accuracy of 77.6%, sensitivity of 50.7%, specificity of 96.9%, PPV of 92.1%, and NPV of 73.2%. The AUROC was 0.630 for AI-assisted colposcopy and 0.738 for conventional colposcopy. For CIN1+, AI-assisted colposcopy demonstrated an accuracy of 84.8%, sensitivity of 84.9%, specificity of 84.6%, PPV of 98.5%, and NPV of 32.4%, compared with 88.5%, 88.8%, 84.6%, 98.5%, and 39.3%, respectively, for conventional colposcopy. The AUROC values were 0.847 and 0.867 for AI-assisted and conventional colposcopy, respectively.

Conclusion: AI-assisted colposcopy demonstrated less diagnostic performance for CIN2+ compared with conventional colposcopy but comparable performance for CIN1+. AI-assisted colposcopy should therefore be considered an adjunct to, rather than a replacement for, conventional colposcopic assessment in clinical practice.

Keywords: cervical cancer screening, artificial intelligence, diagnostic accuracy, colposcopy.

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Received: 4 July 2026, **Revised:** 15 September 2026, **Accepted:** 22 September 2026

ความแม่นยำในการวินิจฉัยของการส่องกล้องปากมดลูกคอโปสโคปที่ใช้ปัญญาประดิษฐ์ สำหรับการตรวจหารอยโรคก่อนมะเร็งปากมดลูก ของโรงพยาบาลพุทธชินราช

มนวณี เมืองช้าง

บทคัดย่อ

วัตถุประสงค์*: เพื่อประเมินความแม่นยำในการวินิจฉัยของระบบภาพคอลโปสโคปีที่ใช้ปัญญาประดิษฐ์ (Artificial Intelligence; AI-assisted colposcopy) ในการตรวจหารอยโรคก่อนมะเร็งปากมดลูก เทียบกับการส่องกล้องคอลโปสโคปีแบบมาตรฐาน*

วัสดุและวิธีการ*: การศึกษานี้เป็นการศึกษาแบบไปข้างหน้า ในสตรีอายุ 25–60 ปี ที่มีผลการตรวจคัดกรองเชื้อ human papillomavirus ผิดปกติและมีข้อบ่งชี้ให้เข้ารับการตรวจคอลโปสโคปี ณ โรงพยาบาลพุทธชินราช พิษณุโลก ผลลัพธ์หลักของการศึกษา คือ การประเมินความแม่นยำของการส่องกล้องคอลโปสโคปีที่ใช้ปัญญาประดิษฐ์ เทียบกับคอลโปสโคปีแบบมาตรฐานในการตรวจหารอยโรคก่อนมะเร็งปากมดลูกชนิด cervical intraepithelial neoplasia grade 2 ขึ้นไป ส่วนผลลัพธ์รอง คือ ความแม่นยำในการตรวจหารอยโรคก่อนมะเร็งปากมดลูกชนิด cervical intraepithelial neoplasia grade 1 ขึ้นไป มีผู้เข้าร่วมการศึกษาทั้งหมด 165 รายที่ได้รับการตรวจคอลโปสโคปี โดยใช้ผลตรวจทางพยาธิวิทยาจากชิ้นเนื้อปากมดลูกเป็นมาตรฐานอ้างอิง ประเมินประสิทธิภาพการวินิจฉัยด้วยค่าความไว, ความจำเพาะ, ค่าพยากรณ์ผลบวก, ค่าพยากรณ์ผลลบ, ความถูกต้อง (accuracy) และพื้นที่ใต้กราฟ receiver operating characteristic (ROC)*

ผลการศึกษา*: อายุเฉลี่ยของผู้เข้าร่วมการศึกษาเท่ากับ 39.5 ± 8.3 ปี ผลตรวจทางพยาธิวิทยาพบ CIN1 ร้อยละ 50.3 และพบรอยโรค CIN2 ขึ้นไป ร้อยละ 41.8 ของผู้เข้าร่วมทั้งหมด โดยการส่องกล้องคอลโปสโคปีที่ใช้ปัญญาประดิษฐ์ช่วยตรวจหารอยโรค CIN 2 ขึ้นไป มีค่าความถูกต้อง, ความไว, ความจำเพาะ, ค่าพยากรณ์ผลบวก, ค่าพยากรณ์ผลลบ ร้อยละ 69.1, 26.1,100, 100, 65.3 ตามลำดับ ในขณะที่คอลโปสโคปีแบบมาตรฐานมีค่าความถูกต้อง, ความไว, ความจำเพาะ, ค่าพยากรณ์ผลบวก, ค่าพยากรณ์ผลลบ ร้อยละ 77.6, 50.7, 96.9, 92.1, 73.2 ตามลำดับ และค่าพื้นที่ใต้กราฟ ROC ของการส่องกล้องที่ปัญญาประดิษฐ์ และแบบมาตรฐาน คือ 0.630 และ 0.738 สำหรับการตรวจหา CIN1 ขึ้นไป การส่องกล้องคอลโปสโคปีที่ปัญญาประดิษฐ์ช่วย มีค่าความถูกต้อง, ความไว, ความจำเพาะ, ค่าพยากรณ์ผลบวก, ค่าพยากรณ์ผลลบ ร้อยละ*

84.8, 84.9, 84.6, 98.5, 32.4 เมื่อเปรียบเทียบกับคอลโปสโคปีแบบมาตรฐาน ซึ่งมีค่า 88.5, 88.8, 84.6, 98.5, 39.3 ตามลำดับ และค่าพื้นที่ใต้กราฟ ROC ของการส่องกล้องที่ปัญญาประดิษฐ์ และแบบมาตรฐาน คือ 0.847 และ 0.867 ตามลำดับ

***สรุป**: การส่องกล้องคอลโปสโคปีแบบมาตรฐานในการวินิจฉัย CIN2 ขึ้นไป มีประสิทธิภาพสูงกว่าการส่องกล้องที่ใช้ปัญญาประดิษฐ์ช่วย แต่ประสิทธิภาพในการตรวจหา CIN1 ขึ้นไป ไม่แตกต่างกัน ดังนั้น การส่องกล้องคอลโปสโคปีที่ใช้ปัญญาประดิษฐ์ ควรได้รับการพิจารณาเป็นเครื่องมือช่วยเสริมการประเมินด้วยคอลโปสโคปีแบบมาตรฐาน มากกว่าที่จะใช้ทดแทนการตรวจคอลโปสโคปีโดยผู้เชี่ยวชาญในเวชปฏิบัติจริง*

***คำสำคัญ**: การตรวจคัดกรองมะเร็งปากมดลูก, ปัญญาประดิษฐ์, ความแม่นยำในการวินิจฉัย, การส่องกล้องตรวจปากมดลูก*

Introduction

According to global cancer statistics in 2020, cervical cancer was the fourth most common cancer among women worldwide, accounting for approximately 660,000 new cases and 350,000 deaths annually[1]. In Thailand, cervical cancer is currently the second most common cancer among women, with approximately 5,866 new cases and 4,576 deaths reported each year[2]. The primary etiological factor for cervical cancer is persistent infection with human papillomavirus (HPV), a common sexually transmitted infection that affects the skin and mucosal surfaces, including the genital tract and oropharynx. Although most HPV infections are transient and cleared spontaneously by the immune system, persistent infection with high-risk HPV genotypes may lead to the development of cervical precancerous lesions and, eventually, cervical cancer[2].

Cervical cancer screening plays a pivotal role in reducing both the incidence and mortality of cervical cancer. Screening recommendations have been established by several organizations, including the United States Preventive Services Task Force (USPSTF) and the American Cancer Society (ACS). Screening strategies are tailored according to age, clinical history, and individual risk factors. Importantly, women who have received HPV vaccination are still advised to undergo routine cervical cancer screening because currently available vaccines do not protect against all oncogenic HPV types[3]. Early detection of cervical precancerous lesions through routine screening facilitates timely intervention and substantially reduces the risk of progression to invasive cancer[4].

Histopathological examination of cervical biopsy specimens remains the reference standard for confirming cervical precancerous and malignant lesions. Colposcopy is an essential diagnostic procedure that enables detailed visualization of the cervical epithelium following the application of acetic acid to highlight abnormal areas. This procedure plays a crucial role in identifying biopsy sites and guiding treatment decisions. Despite its clinical utility, access to colposcopy services and trained specialists remains limited in many regions, particularly in low-resource and remote settings. Previous studies have shown that anxiety and depression are common among women with abnormal cervical cancer screening results who are referred for colposcopy[5, 6]. The median colposcopy waiting time was 11.87 days, with 94.59% of patients with low-grade lesions

undergoing colposcopy within 6 weeks and 77.55% of patients with high-grade lesions undergoing colposcopy within 2 weeks. The main factor associated with waiting times that did not meet recommended standards was the default rate[7]. Therefore, the development of accessible and effective diagnostic technologies that can be operated by personnel with basic training may be important for improving the early detection of cervical precancerous lesions and cervical cancer[8-10]. Such technologies may also help reduce anxiety and referral delays among patients with normal or low-grade findings, particularly those living outside the referral center.

Artificial intelligence (AI) has emerged as a promising technology for enhancing the detection and diagnosis of cervical precancerous lesions. AI-based image analysis systems can process colposcopic images and assist clinicians in identifying suspicious lesions efficiently. These systems may facilitate the detection of high-grade lesions, improve biopsy-site selection, and support diagnostic decision-making. Furthermore, AI-assisted colposcopy has the potential to expand cervical cancer screening and diagnostic services in underserved areas where access to advanced medical equipment and specialized expertise is limited. Consequently, AI technologies may contribute to earlier detection and potentially reduce the burden of advanced cervical cancer and disease-related mortality[11, 13]. However, most studies evaluating the efficacy of AI-assisted colposcopy to date have been retrospective[11]. Prospective evaluation of diagnostic accuracy is therefore important for determining the clinical utility of this emerging technology and assessing its potential integration into cervical cancer prevention and management programs.

The objective of this study was to evaluate the diagnostic accuracy of an AI-assisted colposcopy imaging system for detecting cervical precancerous lesions (cervical intraepithelial neoplasia grade 2 (CIN2) + and CIN1+) compared with conventional colposcopy.

Materials and Methods

Study design and participants

This prospective diagnostic accuracy study was conducted at Buddhachinaraj Phitsanulok Hospital, Thailand, between November 2024 and November 2025. The study was approved by the Institutional Review Board of Buddhachinaraj Phitsanulok Hospital (Approval No. HREC 142-2567). The study population consisted of women aged 25–60 years who underwent cervical cancer screening using HPV testing in Phitsanulok Province and were subsequently referred for colposcopic evaluation. Eligible participants included women with HPV type 16, HPV type 18, or other high-risk HPV infections accompanied by cytological abnormalities requiring further colposcopic investigation. Patients were excluded if they had a previous history of cervical precancerous lesions, pregnancy, prior cervical treatment or cervical surgery, poor or inadequate colposcopic image quality, inadequate visualization of the cervix during examination, or visual findings suggestive of low-grade squamous intraepithelial lesion (LSIL) or high-grade squamous intraepithelial lesion (HSIL) without histopathological confirmation.

Sample size calculation

The sample size was determined based on the precision of the area under the receiver operating characteristic curve (AUC), following the approach described by Hajian-Tilaki[12]. A pilot study of 30 participants was conducted to obtain a preliminary estimate of the diagnostic performance of AI-assisted colposcopy. The ordinal AI diagnostic categories were used to construct the receiver operating characteristic (ROC) curve, yielding an estimated AUC of 0.776. The sample size

calculation assumed a two-sided 95% confidence level and a desired precision corresponding to a 95% confidence interval half-width of approximately 0.075. Because the numbers of participants with and without CIN2+ were not expected to be equal, the variance of the AUC was estimated using the Hanley–McNeil approximation[13], which allows the numbers of diseased and non-diseased participants to be incorporated separately. This approach is appropriate when estimating the precision of an AUC and accounting for the ratio of controls to cases. For an expected AUC of 0.776, the quantities and were 0.634 and 0.678, respectively. The variance of the AUC was estimated as

$$Var(AUC) = \frac{AUC(1 - AUC) + (n_1 - 1)(Q_1 - AUC^2) + (n_0 - 1)(Q_2 - AUC^2)}{n_1 n_0},$$

where n1 and n0 denote the numbers of participants with CIN2+ and < CIN2, respectively. With 69 CIN2+ and 96 CIN1/normal participants (n = 165), the estimated variance was approximately 0.00144, corresponding to a standard error of approximately 0.038. The resulting half-width of the 95% confidence interval was approximately 0.075. Therefore, a total sample of 165 participants provided an anticipated precision of approximately ± 0.075 around the estimated AUC of 0.776.

Study procedures

1. Patient recruitment

Women with positive HPV screening results who met the eligibility criteria were invited to participate in the study. Written informed consent was obtained from all participants before enrollment.

2. Colposcopic examination

All participants underwent conventional colposcopy performed by one gynecologic oncologist. The cervix was initially inspected under low-power magnification (5× to 10×) for visible abnormalities. Normal saline was then applied using a sprayer, and excess fluid was removed to permit assessment of the cervical surface and vascular patterns. A green filter and higher magnification (15×) were used to enhance visualization of the blood vessels. A 5% acetic acid solution was liberally applied to the cervix using a cotton-tipped swab or sprayer and allowed to act for 1 minute. A Dr. Cervicam C20 portable colposcope was used to capture colposcopic images, and acetic acid was reapplied every 2–3 minutes during the examination and immediately before conventional colposcopic assessment. The cervix was carefully examined for abnormal epithelial changes and suspicious lesions. At least one targeted cervical biopsy was obtained from the most abnormal area identified, preferably closest to the squamocolumnar junction. Specimens were immediately placed in 10% formalin. Random biopsies at the 6- and 12-o'clock positions were performed when no abnormal lesion was identified. Endocervical curettage (ECC) was performed when the ectocervix showed no abnormality, cytology indicated a glandular lesion, the transformation zone was type 3, or colposcopy was unsatisfactory.

AI-assisted image analysis

The Dr. Cervicam C20 portable colposcope and CerviCARE AI (NTL Healthcare, Korea) comprise a commercial AI-assisted colposcopy system. The system captures high-resolution cervical images (13 megapixels/2K resolution) and processes them using a histogram-equalization algorithm and predefined image-recognition methods to assist in identifying cervical lesions. The system categorizes tissue risk levels as normal, atypical, or high-risk to support clinical triage and treatment decisions.

Histopathological assessment

Histopathological specimens were reviewed independently by three experienced pathologists. The final pathological diagnosis was determined by agreement between at least two of the three

pathologists and was used as the reference standard for evaluating diagnostic performance.

3. Follow-up

Participants received follow-up care according to standard clinical protocols. Treatment recommendations were based on histopathological findings and current clinical practice guidelines.

Study instruments

The study utilized three primary tools:

1. Demographic and clinical information were collected, including age, reproductive history, HPV testing results, cytological findings, colposcopic impressions, histopathological diagnoses, and biopsy results.

2. The AI-assisted colposcopy system analyzed cervical images and highlighted areas suspected of containing lesions. Diagnostic outputs were generated using image-recognition algorithms designed to detect abnormal cervical epithelial changes.

3. Histopathological assessment of cervical biopsy specimens served as the reference standard for diagnostic confirmation.

Data collection

Clinical information was collected through participant interviews and review of medical records. Cytology, HPV testing, and histopathological results were obtained from the hospital pathology database. Colposcopic findings and AI-generated assessments were automatically recorded by the system and subsequently verified by the research team.

Statistical analysis

Statistical analyses were performed using R. Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages, whereas continuous variables were summarized as means and standard deviations (SD). Diagnostic performance was evaluated using accuracy, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the area under the receiver operating characteristic curve (AUROC). Histopathological diagnosis was used as the reference standard for all analyses.

Results

Participant characteristics

A total of 165 women were included in the study. The mean age was 39.5 ± 8.3 years. The largest age group was 30–39 years (37.0%), followed by 40–49 years (33.3%). Most participants had a parity of 1–2 (60.0%), while 23.6% were nulliparous.

Regarding obstetric history, 64.2% of participants had experienced at least one vaginal delivery, whereas 12.1% had a history of cesarean section. Nearly half of the participants (44.2%) reported no contraceptive use, while 33.9% used hormonal contraception and 16.4% had undergone permanent sterilization.

Most participants were non-smokers (90.3%), and 92.7% reported no history of sexually transmitted diseases. Only 3.0% reported prior HPV vaccination. Self-collected HPV testing was the most common screening method (58.8%), followed by primary HPV testing (23.6%) and co-testing (17.6%).

Among HPV risk groups, HPV type 16 infection was the most prevalent (35.8%), followed by other high-risk HPV types (32.7%), multiple HPV infections (21.2%), and HPV type 18 infection (10.3%). The mean age at first sexual intercourse was 19.3 ± 3.6 years, and the median number of lifetime sexual partners was 2.

Histopathological examination revealed normal findings in 7.9% of participants, CIN1 in 50.3%, and CIN2+ lesions in 41.8% (Table 1).

Table 1. Baseline characteristics of the participants (n = 165).

Characteristics	n (%) or mean ± SD
Age (years)	39.5 ± 8.3
Age group (years)	
< 30	21 (12.7)
30–39	61 (37.0)
40–49	55 (33.3)
≥ 50	28 (17.0)
Parity	
0	39 (23.6)
1–2	99 (60.0)
≥ 3	27 (16.4)
Delivery history	
Nulliparous	39 (23.6)
Any vaginal delivery	106 (64.2)
Cesarean section	20 (12.1)
Contraception	
Self HPV	97 (58.8)
HPV testing	39 (23.6)
Co-testing	29 (17.6)
HPV risk groups	
HPV 16	59 (35.8)
HPV 18	17 (10.3)
Other high-risk HPV	54 (32.7)
Multiple HPV types	35 (21.2)
Age at first sexual intercourse (years)	19.3 ± 3.6
Median number of lifetime sexual partners	2
Comorbidity	
None	147 (89.1)
Any comorbidity	18 (10.9)
Histopathology	
Normal	13 (7.9)
CIN1	83 (50.3)
CIN2+ (CIN2, CIN3, AIS)	69 (41.8)

SD: standard deviation, HPV: human papillomavirus, CIN: cervical intraepithelial neoplasia

Diagnostic performance for detection of CIN2+ lesion

For high-grade lesions (CIN2+), AI-assisted colposcopy demonstrated an accuracy of 69.1%, sensitivity of 26.1%, specificity of 100%, PPV of 100%, and NPV of 65.3%. Conventional colposcopy demonstrated an accuracy of 77.6%, sensitivity of 50.7%, specificity of 96.9%, PPV of 92.1%, and NPV of 73.2% (Table 2). The AUROC was 0.630 for AI-assisted colposcopy and 0.738 for conventional colposcopy, indicating moderate discriminative ability, with conventional colposcopy showing better discrimination for CIN2+ lesions (Table 3).

Table 2. Diagnostic performance of AI-assisted and conventional colposcopy for detecting CIN2+ pathology.

Colposcopy method / result	CIN2+ pathology	Normal/CIN1 pathology
AI-assisted: CIN2+	18	0
AI-assisted: < CIN2	51	96
Conventional: CIN2+	35	3
Conventional: < CIN2	34	93

AI: artificial intelligence, CIN: cervical intraepithelial neoplasia

Table 3. Comparison of the diagnostic performance of AI-assisted and conventional colposcopy for detecting CIN2+ lesions.

Parameter	AI-assisted colposcopy	Conventional colposcopy
Sensitivity (%)	26.1	50.7
Specificity (%)	100	96.9
PPV (%)	100	92.1
NPV (%)	65.3	73.2
Accuracy (%)	69.1	77.6
AUROC	0.630	0.738

AI: artificial intelligence, CIN: cervical intraepithelial neoplasia, PPV: positive predictive value, NPV: negative predictive value, AUROC: area under the receiver operating characteristic curve

Diagnostic performance for detection of CIN1+ lesion

For the detection of any cervical intraepithelial neoplasia (CIN1+), AI-assisted colposcopy achieved an overall diagnostic accuracy of 84.8%, with a sensitivity of 84.9%, specificity of 84.6%, PPV of 98.5%, and NPV of 32.4%. Conventional colposcopy demonstrated a slightly higher diagnostic accuracy of 88.5%, with a sensitivity of 88.8%, specificity of 84.6%, PPV of 98.5%, and NPV of 39.3% (Table 4,5).

Table 4. Diagnostic performance of AI-assisted and conventional colposcopy for detecting CIN1+ lesions (n = 165).

Colposcopy method / result	CIN1+ pathology	Normal pathology	Total
AI-assisted: CIN1+	129	2	131
AI-assisted: normal	23	11	34
Conventional: CIN1+	135	2	137
Conventional: normal	17	11	28

AI: artificial intelligence, CIN: cervical intraepithelial neoplasia

Table 5. Comparison of the diagnostic performance of AI-assisted and conventional colposcopy for detecting CIN1+ lesions.

Parameter	AI-assisted colposcopy	Conventional colposcopy
Sensitivity (%)	84.9	88.8
Specificity (%)	84.6	84.6
PPV (%)	98.5	98.5
NPV (%)	32.4	39.3
Accuracy (%)	84.8	88.5
AUROC	0.847	0.867

AI: artificial intelligence, PPV: positive predictive value, NPV: negative predictive value, AUROC: area under the receiver operating characteristic curve

Comparison between AI-assisted and conventional colposcopy

Overall, conventional colposcopy showed slightly higher diagnostic performance than AI-assisted colposcopy. For CIN2+, conventional colposcopy also outperformed AI-assisted colposcopy in sensitivity (50.7% vs 26.1%) and AUROC (0.738 vs 0.630), although AI-assisted colposcopy demonstrated higher specificity (100% vs 96.9%). For CIN1+, conventional colposcopy had higher sensitivity than AI-assisted colposcopy (88.8% vs 84.9%), while specificity was identical (84.6% for both). The PPV was 98.5% for both approaches, whereas the NPV was 39.3% for conventional colposcopy and 32.4% for AI-assisted colposcopy. The AUROC values were 0.867 for conventional colposcopy and 0.847 for AI-assisted colposcopy, indicating good discrimination for CIN1+ with both methods.

Discussion

Conventional colposcopy remains a cornerstone in the evaluation and management of women with abnormal cervical cancer screening results. However, recent advances in AI have highlighted its potential role in the diagnosis and management of cervical precancerous lesions. In the present study, AI-assisted colposcopy demonstrated an accuracy of 69.1%, sensitivity of 26.1%, specificity of 100%, PPV of 100%, and NPV of 65.3% for CIN2+, whereas conventional colposcopy achieved an accuracy of 77.6%, sensitivity of 50.7%, specificity of 96.9%, PPV of 92.1%, and NPV of 73.2%. The AUROC values were 0.630 and 0.738 for AI-assisted and conventional colposcopy, respectively, indicating lower discriminatory ability for CIN2+ than for CIN1+. These findings differ from a recent meta-analysis reporting that AI-assisted colposcopy may achieve diagnostic performance

comparable to or superior to conventional colposcopy[14]. The plausible explanation for the lower performance of the AI system in the present study is the limited number of images captured at different stages of the examination. In this study, approximately two or three images were obtained, which may have provided insufficient information for AI-based assessment. Ogunlaja et al[15], reported capturing at least five images, including a pre-acetic acid image and four post-acetic acid images at 60, 90, 120, and 150 seconds. In addition, variations in image exposure or brightness, blur, specular reflection, blood, or mucus may mimic acetowhite changes or obscure abnormal lesions, thereby reducing diagnostic accuracy[16]. An autofocus camera with standardized image acquisition may improve consistency. A recently updated AI system using 48-megapixel/4K resolution (Dr. Cervicam C20 and CerviCARE AI, NTL Healthcare, Korea) has been reported to provide more satisfactory results[17]. Because AI-assisted colposcopy was newly established at our hospital, operator familiarity with the device and image-acquisition workflow may also have influenced performance. Furthermore, complete visualization of the cervix by an experienced colposcopist may improve image selection and AI assessment[14]. The findings are nevertheless within the range reported in previous study. Zimmer-Stelmach et al[18], who applied a convolutional neural network (CNN)-based algorithm, reported an accuracy of 60.4%, sensitivity of 66.7%, and specificity of 46.7%, which were lower than those of experienced colposcopists. The authors suggested that AI-assisted colposcopy may reduce subjective interpretation and interobserver variability while maintaining acceptable diagnostic performance[18].

Recent evidence from a systematic review and meta-analysis by Liu et al[14] demonstrated that AI-assisted colposcopy can achieve diagnostic performance comparable to, and in some settings superior to, conventional colposcopy for detecting and classifying CIN2+ lesions. However, diagnostic performance varies substantially according to algorithm architecture, training datasets, image quality, and validation methods[15, 18]. More advanced AI models incorporating lesion classification, automated acetowhite lesion segmentation, and multimodal data integration may improve diagnostic accuracy[20, 21]. Integration of clinical information, including HPV genotype, cytology findings, and molecular biomarkers, may provide a more comprehensive assessment of patient risk and enhance screening effectiveness, particularly in resource-limited settings[20, 21]. Hou et al[11] also reported that AI-based systems may reduce workload, decrease dependence on highly specialized personnel, and reduce subjective bias in clinical interpretation. Portable AI-assisted colposcopy devices may further expand access to diagnostic services in underserved areas. Nurmaini et al[19] demonstrated that mobile AI-assisted cervicography systems can provide real-time image interpretation, supporting their potential use in remote screening settings.

For the secondary outcome, AI-assisted colposcopy demonstrated an overall diagnostic accuracy of 84.8%, sensitivity of 84.9%, and specificity of 84.6% for detecting CIN1+. These findings were broadly comparable to conventional colposcopy, which achieved an accuracy of 88.5%, sensitivity of 88.8%, and specificity of 84.6%. The AUROC values were 0.847 for AI-assisted colposcopy and 0.867 for conventional colposcopy, indicating good discriminatory ability for both approaches. Our findings are consistent with those reported by Talathi et al[20], who demonstrated that the Smart Scope® AI system achieved both sensitivity and specificity of 83.3%, while conventional colposcopy showed the same sensitivity but lower specificity of 50%. The authors concluded that AI-assisted screening could serve as an effective triage tool in primary healthcare settings where colposcopy services are unavailable. Similarly, a systematic review by Takahashi et al[21] highlighted the growing role of AI-assisted colposcopy in cervical cancer screening and diagnosis.

Several studies have also demonstrated the potential educational value of AI-assisted colposcopy. Cho et al[22] reported that deep-learning algorithms

may support less-experienced clinicians in identifying cervical neoplasms on colposcopic images. Similarly, Wu et al[23] suggested that AI may improve diagnostic accuracy and biopsy efficiency among junior colposcopists. Furthermore, Xue et al[24] developed the colposcopic artificial intelligence auxiliary diagnostic system (CAIADS), which demonstrated higher accuracy than conventional colposcopy (82.2% vs 65.9%) and improved identification of optimal biopsy locations.

Accurate differentiation between CIN1 and CIN2+ lesions, including CIN2, CIN3, adenocarcinoma in situ (AIS), and invasive cervical cancer, is essential for clinical management. Mascarenhas et al[25] developed an AI model using multiple image frames obtained throughout the colposcopic examination, including native, acetic acid-enhanced, Lugol's iodine-enhanced, and post-manipulation images. Their model achieved a sensitivity of 99.7%, specificity of 98.6%, PPV of 97.8%, and NPV of 99.8%. Although our study demonstrated excellent specificity and PPV for CIN2+, the relatively low sensitivity suggests that future AI models may benefit from incorporating additional image frames and more sophisticated image-processing techniques. The International Agency for Research on Cancer (IARC) has also emphasized the need for standardized, high-quality image databases to facilitate the development, training, and validation of machine-learning and deep-learning algorithms for cervical lesion detection[26].

Despite these promising findings, several challenges remain. Variability in AI algorithms, differences in image-acquisition protocols, image quality, and the need for external validation across diverse populations may affect the generalizability of study findings. In addition, the low sensitivity observed for CIN2+ in the present study limits the suitability of the evaluated AI system as a stand-alone diagnostic tool. AI should therefore be considered an adjunctive technology rather than a replacement for clinical judgment, with physician expertise remaining essential for interpretation, biopsy decisions, and clinical management.

Implications

The findings of this study have several potential clinical and public health implications. AI-assisted colposcopy showed good diagnostic performance for CIN1+ and may therefore have potential as an adjunctive tool in cervical cancer screening and triage. In low-resource settings where access to experienced colposcopists is limited, portable AI-assisted systems may support image interpretation, standardize assessment, and potentially reduce dependence on specialist availability. However, the relatively low sensitivity for CIN2+ observed in this study indicates that the evaluated AI system should not currently replace conventional colposcopy or histopathological confirmation. AI-assisted systems may also have educational value for junior clinicians by supporting lesion recognition and biopsy-site selection. Future integration of AI with HPV genotyping, cytology, and other clinical or molecular information may improve risk stratification and help optimize cervical cancer screening pathways.

Strengths and limitations

The principal strengths of this study included its prospective design, which allowed standardized data collection in a real-world clinical setting, and the head-to-head evaluation of AI-assisted and conventional colposcopy in the same participants. Histopathological diagnosis was used as the reference standard, strengthening the validity of the diagnostic accuracy assessment. Several limitations should also be considered. First, the study was conducted in a referral population consisting predominantly of women with abnormal cervical screening results, which may introduce selection bias and limit generalizability to the general screening population. Second, the relatively small sample size may have reduced the precision of estimates, particularly for CIN2+. Third, variations in AI algorithms, image-acquisition protocols, image quality, and device specifications may limit reproducibility across clinical settings. Fourth, the AI-assisted colposcopy system had only recently been introduced at our hospital, and limited

operator familiarity may have affected image acquisition and system performance. Finally, the study was conducted at a single center and included assessment by one gynecologic oncologist; therefore, external validation in larger, multicenter populations and evaluation by multiple clinicians are warranted before widespread implementation.

Conclusion

AI-assisted colposcopy demonstrated less diagnostic performance for CIN2+ compared with conventional colposcopy. However, it had a comparable performance for CIN1+ detection. AI-assisted colposcopy should therefore be considered an adjunct to, rather than a replacement for, conventional colposcopic assessment in clinical practice. Further improvements in AI algorithms, standardized image acquisition, and multimodal data integration, together with external validation in larger and more diverse populations, are needed before widespread clinical implementation.

Potential conflicts of interest

The author declares no competing interests.

References

1. World Health Organization. Cervical cancer [Internet]. Geneva: World Health Organization; 2024 [cited 2024 Sep 24]. Available from: https://www.who.int/news-room/fact-sheets/detail/cervical-cancer
2. World Health Organization. Eradicating cervical cancer in Thailand: a journey of hope and progress. Nonthaburi: World Health Organization Thailand; 2025.
3. National Cancer Institute. Cervical cancer screening (PDQ®)–Patient Version [Internet]. Bethesda: National Cancer Institute; 2022 [cited 2024 Sep 24]. Available from: https://www.cancer.gov/types/cervical/screening
4. Mustafa WA, Ismail S, Mokhtar FS, Alquran H, Al-Issa Y. Cervical cancer detection techniques: A chronological review. Diagnostics 2023;13:1763.
5. Kanthiya K. Anxiety and depression in women with abnormal cervical cytology referred for colposcopy: A study at Suratthani cancer hospital. Thai J Obstet Gynaecol 2026;34:10-9.
6. Treewiriyanuphab B, Oranratanaphan S, Roomruangwong C. Proportion and factors associated with anxiety in women with abnormal cervical cancer screening at King Chulalongkorn Memorial Hospital (KCMH). Thai J Obstet Gynaecol 2021;29:358-69.
7. Tassananutriyakul P, Noothong S. Colposcopy waiting time for first-diagnosed abnormal cervical cytology patients: Experiences at Hatyai Hospital. Thai J Obstet Gynaecol 2020;28:16-23.
8. Najib FS, Hashemi M, Shiravani Z, Poordast T, Sharifi S, Askary E. Diagnostic accuracy of cervical pap smear and colposcopy in detecting premalignant and malignant lesions of cervix. Indian J Surg Oncol 2020;11:453–58.
9. Fowler JR, Maani EV, Dunton CJ, Gasalberti DP, Jack BW. Cervical cancer. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Sep 24]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK431093/
10. Kaya Terzi N, Yulek O. Assessment of cervicovaginal smear and HPV DNA co-test for cervical cancer screening: Implications for diagnosis and follow-up strategies. Diagnostics 2024;14:601.
11. Hou X, Shen G, Zhou L, Li Y, Wang T, Ma X. Artificial intelligence in cervical cancer screening and diagnosis. Front Oncol 2022;12:851367.
12. Hajian-Tilaki K. Sample size estimation in diagnostic test studies of biomedical informatics. J Biomed Inform 2014;48:193–204.
13. Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 1982;143:29–36.
14. Liu L, Liu J, Su Q, Chu Y, Xia H, Xu R. Performance of artificial intelligence for diagnosing cervical intraepithelial neoplasia and cervical cancer: a systematic review and meta-analysis. E Clin Med 2025;80:102992.
15. Ogunlaja AO, Adeleke OT, Ughonu PC, Oyelami MO, Ano-Edward G, Bakare YT, et al. A multi-magnification digital colposcopy image datasets for cervical cancer screening in Nigeria. Data Brief 2026;65:112633.
16. Zhao Y, Li Y, Xing L, Lei H, Chen D, Tang C, Li X. The performance of artificial intelligence in cervical colposcopy: A retrospective data analysis. J Oncol 2022;2022:4370851.
17. Ouh YT, Kim TJ, Ju W, et al. Development and validation of artificial intelligence-based analysis software to support screening system of cervical intraepithelial neoplasia. Sci Rep 2024;14:1957.
18. Zimmer-Stelmach A, Zak J, Pawlosek A, Rosner-Tenerowicz A, Budny-Winska J, Pomorski M, et al.

The application of artificial intelligence-assisted colposcopy in a tertiary care hospital within a cervical pathology diagnostic unit. Diagnostics (Basel) 2022;12:106.
19. Nurmaini S, Rachmatullah MN, Sanif R, Agustiansyah P, Sastradinata I, Legiran L, et al. Real time mobile AI-assisted cervicography interpretation system. Inform Med Unlocked 2023;42:101360.
20. Talathi MA, Dabhadkar S, Doke PP, Singh V. Accuracy of the AI-Based Smart Scope® test as a point-of-care screening and triage tool compared to colposcopy: A pilot study. Cureus 2025;17:e81212.
21. Takahashi T, Kobayashi Y, Sakurai R, Matsuoka K, Akatsuka J, Kisu I, et al. A systematic review of the application of artificial intelligence in colposcopy: Diagnostic accuracy for cervical intraepithelial neoplasia and cervical cancer. Clin Med Insights Oncol 2025;19:117955492512345.
22. Cho BJ, Choi YJ, Lee MJ, Kim JH, Son GH, Park SH, et al. Classification of cervical neoplasms on colposcopic photography using deep learning. Sci Rep 2020;10:13652.
23. Wu A, Xue P, Abulizi G, Tuerxun D, Rezhake R, Qiao Y. Artificial intelligence in colposcopic examination: A promising tool to assist junior colposcopists. Front Med 2023;10:1060451.
24. Xue P, Tang C, Li Q, Li Y, Shen Y, Zhao Y, et al. Development and validation of an artificial intelligence system for grading colposcopic impressions and guiding biopsies. BMC Med 2020;18:406.
25. Mascarenhas M, Alencão I, Carinhas MJ, Martins M, Cardoso P, Mendes F, et al. Artificial intelligence and colposcopy: Automatic identification of cervical squamous cell carcinoma precursors. J Clin Med 2024;13:3003.
26. International Agency for Research on Cancer. IARC cervical cancer image bank [Internet]. Lyon: IARC; 2026 [cited 2026 Jul 24]. Available from: https://screening.iarc.fr/cervicalimagebank.php

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 449-458.

GYNAECOLOGY

Pain Control during Endometrial Sampling: A Three-Arm Randomized Controlled Trial Comparing Lidocaine Gel, Spray, and Placebo

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ABSTRACT

Objectives: To compare the analgesic efficacy of 2% lidocaine gel, 10% lidocaine spray, and placebo during office-based endometrial sampling.

Materials and Methods: This three-arm randomized, placebo-controlled trial at Nakornping Hospital (Feb–Sep 2025) compared 2% lidocaine gel, 10% lidocaine spray, and placebo in women aged ≥ 35 undergoing endometrial sampling. Pain was evaluated using a 10-cm visual analog scale (VAS) across five procedural steps, both participants and operators' satisfaction were assessed via a 5-point Likert scale. Statistical analyses were performed using analysis of variance and multivariable linear regression.

Results: The study enrolled 115 women, randomized into three groups: 2% lidocaine gel (n = 37), 10% lidocaine spray (n = 39), and placebo (n = 39). Baseline characteristics were comparable, except for prior vaginal delivery history. Median pain scores at procedural points P3 – P5 (Endocell insertion, aspiration, and 10-minute recovery) were 12 (interquartile range (IQR) 5, 15), 13 (IQR 10, 17), and 11 (IQR 7, 17), respectively, with no statistically significant difference among the three groups (p = 0.611). Subgroup analysis showed that women aged 35 – 50 years (n = 73) experienced significantly lower pain with 2% lidocaine gel compared to 10% spray (p = 0.004). Participants and operators' satisfaction were similar across groups. No adverse events were reported.

Conclusion: In this study, neither topical 2% lidocaine gel nor 10% lidocaine spray significantly reduced pain compared with placebo during endometrial sampling. A post-hoc subgroup analysis among women aged 35 – 50 years showed lower pain scores with lidocaine gel than with lidocaine spray; however, neither intervention differed significantly from placebo. This exploratory finding requires confirmation in an adequately powered study. Both agents were well tolerated, with no reported adverse events or complications.

Keywords: Endometrial sampling, lidocaine gel, lidocaine spray, pain control, randomized controlled trial

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Received: 11 May 2026, **Revised:** 12 August 2026, **Accepted:** 19 August 2026

การบรรเทาปวดขณะตรวจชิ้นเนื้อโพรงมดลูก: การศึกษาแบบสุ่มและมีกลุ่มควบคุมเปรียบเทียบระหว่างการใช้ลิโดเคนชนิดเจล ชนิดสเปรย์ และยาหลอก

นงเยาว์ เอื้อตรงจิตต์

บทคัดย่อ

วัตถุประสงค์: *เพื่อเปรียบเทียบประสิทธิผลในการลดความปวดของเจลลิโดเคนความเข้มข้นร้อยละ 2 สเปรย์ลิโดเคน ความเข้มข้นร้อยละ 10 และยาหลอก ระหว่างการตรวจเก็บชิ้นเนื้อเยื่อบุโพรงมดลูกในคลินิกผู้ป่วยนอก*

วัสดุและวิธีการ: *การศึกษานี้เป็นการทดลองแบบสุ่มมีกลุ่มควบคุมด้วยยาหลอกแบบ 3 กลุ่ม (Three-arm randomized placebo-controlled trial) ดำเนินการในแผนกนรีเวชผู้ป่วยนอก โรงพยาบาลนครพิงค์ จังหวัดเชียงใหม่ ระหว่างเดือนกุมภาพันธ์ ถึง กันยายน พ.ศ. 2568 สตรีอายุ 35 ปีขึ้นไป ที่เข้ารับการตรวจเก็บชิ้นเนื้อเยื่อบุโพรงมดลูก ถูกสุ่มให้ได้รับเจลลิโดเคนร้อยละ 2 สเปรย์ลิโดเคนร้อยละ 10 หรือยาหลอก การประเมินความปวดใช้มาตรวัดแบบ visual analog scale (VAS) ขนาด 10 เซนติเมตรใน 5 ขั้นตอนของหัตถการ ความพึงพอใจของผู้ป่วยและผู้ปฏิบัติหัตถการประเมินด้วยแบบประเมิน Likert scale 5 ระดับ วิเคราะห์ข้อมูลด้วยสถิติการวิเคราะห์ความแปรปรวน (Analysis of variance) และการถดถอยเชิงเส้นพหุคูณ*

ผลการศึกษา: *การศึกษานี้มีผู้เข้าร่วม 115 ราย ถูกสุ่มแบ่งออกเป็น 3 กลุ่ม ได้แก่ กลุ่มที่ได้รับเจลลิโดเคนร้อยละ 2 (n = 37), สเปรย์ลิโดเคนร้อยละ 10 (n = 39) และยาหลอก (n = 39) ลักษณะพื้นฐานของผู้เข้าร่วมการศึกษาไม่แตกต่างกัน ยกเว้นประวัติการคลอดทางช่องคลอด ค่ามัธยฐานของคะแนนความปวดรวมในช่วง P3–P5 ได้แก่ ขณะสอดอุปกรณ์ Endocell ขณะดูดเก็บตัวอย่าง และหลังทำหัตถการ 10 นาที เท่ากับ 12 (interquartile range (IQR) 5, 15), 13 (IQR 10, 17), และ 11 (IQR 7, 17) ตามลำดับ โดยไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างทั้งสามกลุ่ม (p = 0.611) การวิเคราะห์แบบกลุ่มย่อยพบว่า ผู้หญิงอายุ 35 – 50 ปี (n = 73) มีคะแนนความปวดต่ำกว่าอย่างมีนัยสำคัญในกลุ่มเจลลิโดเคนร้อยละ 2 เมื่อเทียบกับสเปรย์ร้อยละ 10 (p = 0.004) คะแนนความพึงพอใจของผู้ป่วยและผู้ปฏิบัติไม่แตกต่างกันระหว่างกลุ่ม และไม่พบอาการไม่พึงประสงค์จากการใช้ยา*

สรุป: *ในการศึกษานี้ ลิโดเคนเจลร้อยละ 2 และลิโดเคนสเปรย์ร้อยละ 10 ไม่สามารถลดความปวดระหว่างการเก็บตัวอย่างเยื่อบุโพรงมดลูกได้อย่างมีนัยสำคัญเมื่อเทียบกับยาหลอก การวิเคราะห์กลุ่มย่อยภายหลังพบว่า ในสตรีอายุ 35 – 50 ปี ลิโดเคนเจลอาจช่วยลดความปวดได้มากกว่าลิโดเคนสเปรย์ อย่างไรก็ตาม ผลดังกล่าวเป็นเพียงข้อค้นพบเชิงสำรวจและควรได้รับการยืนยันในการศึกษาที่มีขนาดตัวอย่างเพียงพอ ทั้งสองวิธีมีความปลอดภัยและผู้ป่วยทนต่อการรักษาได้ดี โดยไม่พบภาวะแทรกซ้อน*

คำสำคัญ: *การตรวจเก็บชิ้นเนื้อเยื่อบุโพรงมดลูก, ลิโดเคนเจล, ลิโดเคนสเปรย์, การควบคุมความปวด, การทดลองแบบสุ่มมีกลุ่มควบคุม*

Introduction

Endometrial sampling is a common diagnostic procedure performed for histopathological evaluation in various gynecologic conditions, including abnormal uterine bleeding, postmenopausal bleeding, abnormal cytology, and infertility assessment[1, 2]. It is a simple, quick, safe, and cost-effective method that can be performed in an outpatient setting and provides diagnostic accuracy comparable to dilation and curettage[3, 4]. The Endocell device, a flexible, single-use, sterile suction catheter with a diameter of 3.1 mm, has been widely adopted for this purpose due to its convenience and high diagnostic reliability[5, 6].

Despite these advantages, pain during endometrial sampling remains a major concern, potentially affecting patient satisfaction and compliance with future procedures[5, 7, 8]. The pain primarily arises from cervical traction, uterine manipulation, and endometrial aspiration. The cervix and lower uterine segment are innervated by parasympathetic fibers from the Frankenhauser plexus [S2 – S4], while the uterine fundus is supplied by sympathetic nerves, suggesting that topical anesthesia may relieve pain mainly at the cervical level[1].

Various analgesic strategies have been investigated to mitigate procedural distress, including oral nonsteroidal antiinflammatory drugs (NSAIDs), paracervical blocks, and topical anesthetics. However, a standardized, evidence-based guideline for pain management during endometrial sampling has yet to be established[8, 9]. Patients frequently report moderate discomfort, with mean pain scores ranging from 4.6 to 6.9 on a 10-point visual analog scale (VAS) when no anesthesia is used[8].

Among available analgesic strategies, 2% lidocaine gel and 10% lidocaine spray have been investigated because of their ease of application and favorable safety profiles. Several randomized controlled trials have reported reductions in procedural pain with topical lidocaine gel or spray during endometrial sampling[5, 7, 12–15].

The study found that cervical 2% lidocaine gel effectively relieves pain during Pipelle sampling[7]. A previous study[12] confirmed its efficacy, highlighting its dual benefits of anesthesia and lubrication, with a rapid onset occurring within three minutes[10, 12].

Clinical trials have shown significant reductions in pain scores in participants receiving 10% lidocaine spray during office-based sampling[5,13]. Two studies[14-15] further highlight its rapid onset (1–2 minutes), making it highly effective for immediate mucosal anesthesia during minor gynecologic procedures such as intrauterine device (IUD) insertion and hysteroscopy[14,16].

While these topical agents are widely utilized, previous assessments, including meta-analyses[9-10] have yielded inconsistent findings regarding their overall efficacy[5, 7, 10-15]. Lidocaine gel demonstrates fewer infections than lidocaine spray.

Given the lack of consensus on the optimal analgesic approach, this randomized controlled trial was designed to compare the effectiveness of 2% lidocaine gel, 10% lidocaine spray, and placebo in reducing procedural pain during endometrial sampling among women at the Gynecologic Outpatient Department.

Materials and Methods

This three-arm randomized, single-blinded, placebo-controlled trial was conducted at the Gynecologic Outpatient Clinic, Nakornping Hospital, Chiang Mai, Thailand, between February and September 2025. The study protocol was approved by the Nakornping Hospital Ethics Committee for Research Involving Human Subjects and prospectively registered with the Thai Clinical Trials Registry (TCTR ID: TOTR2025916008). The trial adhered to the standards of the International Committee of Medical Journal Editors (ICMJE) and the World Health Organization (WHO) trial registration requirements .

The sample size was estimated based on previous studies[12,14]. Assuming a statistical power of 80%, a type I error (α) of 0.05, and a two-tailed one-way analysis of variance (ANOVA) model using

G*Power version 3.1.9, a minimum of 32 participants per group was required. Accounting for a 10% potential dropout rate, the final target sample size was 35 participants per group, yielding a total of 105 participants.

Women aged ≥ 35 years who required endometrial sampling for diagnostic purposes, including abnormal uterine bleeding, postmenopausal bleeding, abnormal cervical cytology, or infertility assessment, were eligible for participation. Women were excluded if they had confirmed or suspected pregnancy, known hypersensitivity to lidocaine or other amide-type local anesthetics, active cervical or pelvic infection, cervical stenosis or uterine distortion precluding cannula insertion, inability to understand or use the VAS, a history of seizure disorder, or significant cardiovascular, hepatic, or renal disease.

Written informed consent was obtained from all participants before enrollment. Eligible participants were randomly assigned in a 1:1:1 ratio to receive 2% lidocaine gel, 10% lidocaine spray, or placebo using a computer-generated randomization sequence prepared by the researcher. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes, which were opened by the physician performing the procedure only after participant enrollment. This was a single-blind study in which the participants were blinded to treatment allocation, whereas the physician performing the procedure and the assistant were not blinded to the assigned intervention. Group 1: 2% lidocaine gel, 3 mL applied directly to the ectocervix and endocervical canal, group 2: 10% lidocaine spray, 5 puffs applied to the same area, and group 3: K-Y gel, 3 mL of non-anesthetic lubricant gel. All procedures were performed by trained gynecology staff or supervised intern physicians following a standardized protocol (five procedural points, P1 - P5).

1. Participants were placed in the lithotomy position. (P1)

2. A bivalve speculum was inserted to visualize the cervix. (P2)

3. The assigned study agent was applied to the cervix, followed by a 3-minute waiting period to allow for anesthetic effect. The Endocell catheter was introduced through the cervical canal. Cervical traction with a tenaculum was performed only when necessary. (P3)

4. Endometrial sampling was performed using an Endocell suction device (3.1 mm, flexible, sterile, single-use catheter). The catheter was advanced to the uterine fundus and withdrawn toward the internal os with continuous manual suction to obtain endometrial tissue. (P4)

5. The device and speculum were removed, hemostasis was assessed, and participants were observed for 10 minutes after the procedure. (P5)

Pain intensity was self-reported by participants using a 10-cm VAS, ranging from 0 (“no pain”) to 10 (“worst imaginable pain”). A research assistant asked participants to rate their pain and recorded the scores at five predefined time points (P1 – P5). The same standardized sampling technique was used across all three groups.

Results

A total of 117 women were assessed for eligibility, of whom 115 participants met the inclusion criteria and were enrolled in the study. Two participants discontinued the procedure and were excluded from the final analysis, resulting in 115 participants being included: 37, 39, 39 in each group (2% lidocaine gel, 10% lidocaine spray, and placebo) (Fig.1.).

All procedures were completed successfully without any intraoperative or postoperative complications. No adverse drug reactions or allergic responses were observed in any of the participants.

The demographic and clinical characteristics of participants were comparable among the three groups, with no statistically significant differences observed in age, menopausal status, body mass index, or other baseline variables, except for the history of previous vaginal delivery, which differed significantly between groups (Table 1).

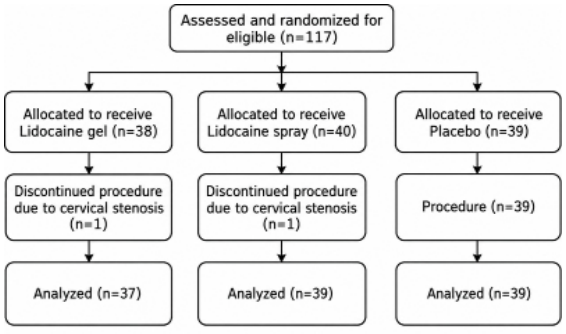


Fig. 1. The flowchart of participants during the study period.

Table 1. Clinical data and characteristics of the participants and procedure (n = 115).

Characteristics	Lidocaine gel (n = 37)	Lidocaine spray (n = 39)	Placebo (n = 39)	p value
Age	50.86 ± 10.49	48.38 ± 8.41	51.00 ± 8.37	0.368
Body mass index	26.46 ± 5.79	26.45 ± 5.79	26.19 ± 5.27	0.965
Time of procedure Median (Q1-Q3)	5 (3, 5)	5 (3, 7)	5 (3, 5)	0.326
Menopausal status				0.966
Premenopausal	27 (73.0)	28 (71.8)	27 (69.2)	
Postmenopausal	10 (27.0)	11 (28.2)	12 (30.8)	
Gravidity				0.166
Nulliparous	10 (27.0)	4 (10.3)	6 (15.4)	
Multiparous	27 (73.0)	35 (89.7)	33 (84.6)	
Previous vaginal birth				0.017
Yes	22 (59.5)	31 (79.5)	19 (48.7)	
No	15 (4.5)	8 (20.5)	20 (51.3)	
Marital status				0.656
Single	4 (10.8)	1 (2.6)	4 (10.3)	
Marriage	30 (81.1)	34 (87.2)	31 (79.5)	
Divorced	3 (8.1)	4 (10.3)	4 (10.3)	
Underlying Medical condition				0.601
Yes	17 (46.0)	22 (56.4)	18 (46.2)	
No	20 (54.1)	17 (43.6)	21 (53.9)	
History of drug allergy				0.765
Yes	3 (8.1)	2 (5.1)	4 (10.3)	
No	34 (91.9)	37 (94.9)	35 (89.7)	
Difficulty of procedure				0.185
Easy	27 (73.0)	25 (64.1)	19 (48.7)	
Moderate	5 (13.5)	10 (25.6)	14 (35.9)	
Difficult	5 (13.5)	4 (10.3)	6 (15.4)	
Operator				0.926
Internist	4 (10.8)	3 (7.7)	4 (10.3)	
Gynecologist	33 (89.2)	36 (92.3)	35 (89.7)	
Indication of procedure				0.412
Menorrhagia	21 (56.8)	27 (69.2)	25 (64.1)	
Postmenopausal bleeding	9 (24.3)	10 (25.6)	11 (28.2)	
Other	7 (18.9)	2 (5.1)	3 (7.7)	

Data are presented as mean ± standard deviation, median (interquartile range; min-max), or n (%)

After adjusting for history of vaginal delivery, procedure duration, procedural difficulty, and operator, neither 2% lidocaine gel nor 10% lidocaine spray showed a significant association with pain reduction compared with placebo. The adjusted β coefficient for lidocaine gel was –0.27 (95% CI 0.95, 0.42, p = 0.447), and for lidocaine spray was 0.18 (95% CI 0.22, 0.88, p = 0.617) (Table 2).

These results indicated that topical lidocaine provided no significant benefit in pain control during endometrial sampling.

Pain intensity was evaluated using the visual analog scale (VAS) at five procedural points (P1 – P5). The median (interquartile range) pain scores for each group are shown in Table 3 and Fig.2.

Table 2. Adjusted β co-efficient controlled by history of vaginal birth, time of procedure, difficulty of procedure and operator.

Analgesia	Pain score	95% CI	p value
Placebo	Reference		
Lidocaine gel	-0.27	-0.95, 0.42	0.447
Lidocaine spray	0.18	-0.22, 0.88	0.617

CI: confidence interval

Table 3. Pain score and overall pain score between groups.

Pain score median (IQR, min-max)	Lidocaine gel (n = 37)	Lidocaine spray (n = 39)	Placebo (n = 39)	p value
P1	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.215
P2	0 (0, 2)	2 (0, 3)	1 (0, 3)	0.388
P3	4 (2, 5)	5 (3, 5)	3 (2, 5)	0.412
P4	6 (3, 8)	6 (4, 8)	6 (4, 9)	0.735
P5	1 (0, 3)	2 (0, 3)	1 (0, 4)	0.529
Overall pain (P3-P5)	12 (5, 15)	13 (10, 17)	11 (7, 17)	0.611

IQR: interquartile range

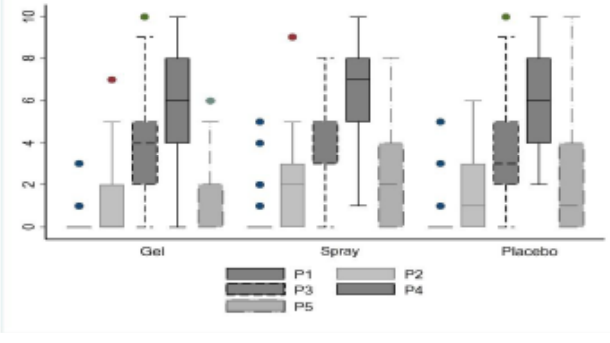


Fig. 2. Box plots of procedure pain scores by group.

There were no statistically significant differences in pain scores among the three groups: 2% lidocaine gel, 10% lidocaine spray, and placebo—at any procedural step (P1 – P5) (p > 0.05 for all comparisons).

Median pain scores were low during the initial steps (P1 – P2) across all groups, increased notably during endometrial aspiration (P4), and declined there after (P5). The highest pain scores

were consistently observed at P4, corresponding to the insertion and aspiration phases of the procedure.

The overall pain score, calculated as the sum of P3 – P5, also showed no significant difference among the three groups (p = 0.611).

Participants and operators' satisfaction (5-point Likert scale) are detailed in Table 4.

Table 4. Satisfactory of participants and operators between groups.

Satisfactory scale mean ± SD	Lidocaine gel (n = 37)	Lidocaine spray (n = 39)	Placebo (n = 39)	p value
Patient	4.29 ± 0.85	4.41 ± 0.82	4.18 ± 1.00	0.537
Operator	4.27 ± 0.87	4.26 ± 0.85	4.18 ± 0.94	0.890

SD: standard deviation

The mean (± standard deviation) satisfaction scores were high across all groups, indicating a generally positive experience with the procedure. Among participants, mean satisfaction scores were 4.29 ± 0.85 in the 2% lidocaine gel group, 4.41 ± 0.82 in the 10% lidocaine spray group, and 4.18 ± 1.00 in the placebo group, with no statistically significant difference observed among groups (p = 0.537).

Similarly, operators' satisfaction scores were 4.27 ± 0.87, 4.26 ± 0.85, and 4.18 ± 0.94 in the 2% lidocaine gel, 10% lidocaine spray, and placebo groups, respectively, with no significant difference (p = 0.890). These results suggested that both participants and operators were generally satisfied with the procedure, and the use of topical lidocaine, either gel or spray, did not significantly.

When stratified by age, a statistically significant difference in overall pain scores was identified among women aged 35 – 50 years (p = 0.027), whereas no significant difference was observed among those aged > 50 years (p = 0.138). Within the younger subgroup, participants who received 2% lidocaine gel reported significantly lower overall pain scores compared with those who received 10% lidocaine spray (p = 0.004), suggesting a possible age-related variation in analgesic response.

No statistically significant differences in pain scores were found when stratified by procedural difficulty, menopausal status or history of vaginal delivery (Table 5).

Table 5. Overall pain score divided by subgroup of characteristics data.

Factors median (IQR, min-max)	Lidocaine gel (n = 37)	Lidocaine spray (n = 39)	Placebo (n = 39)	p value
Age				
35 - 50	11 (4, 12; 1-15) **	14.5 (10, 18; 1-24) **	10.5 (6.5, 15.5; 2-28)	0.027
> 50	16.5 (13, 20; 2-26)	10 (10, 14; 5-23)	15.0 (7, 17;3-25)	0.138
Difficulty of procedure				
Easy	11 (3, 15; 1-26)	13 (10, 17; 1-21)	11 (6, 15; 2-24)	0.438
Moderate	12 (11, 17; 5-25)	12.5 (10, 17; 5-24)	10.5(7, 17; 3-28)	0.764
Difficult	13 (13, 14; 12-20)	13 (9, 16.5; 8-17)	16 (7, 17; 6-20)	0.944
Menopausal status				
Premenopausal	11 (3, 13; 1-26)	14 (9, 17.5; 1-24)	11 (6, 16; 2-28)	0.111
Postmenopausal	16.5 (13, 20; 5-25)	10 (10, 15; 8-23)	14.5 (8.5, 18.5; 2-25)	0.147
History of vaginal birth				
Yes	12.5 (8, 17; 1-25)	13 (10, 17;1-24)	11 (4, 15; 2-24)	0.346
No	12 (3, 13; 2-26)	12 (6.5, 16.5; 4-18)	13.5 (8.5, 17; 4-28)	0.291

** In the post-hoc subgroup analysis of women aged 35 – 50 years, pain scores differed among the three groups (overall p = 0.027). Scores were lower with lidocaine gel than with lidocaine spray (p = 0.004), but neither differed significantly from placebo (p = 0.405 and 0.176, respectively).
IQR: interquartile range

Fig. 3. Overall pain scores (sum of P3 – P5) stratified by age and treatment group. The analysis among women aged 35 – 50 years was post-hoc and exploratory.

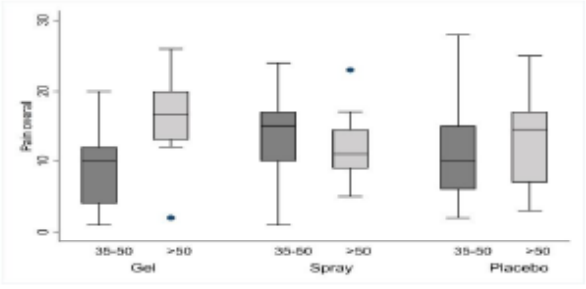


Fig. 3. Box plots of overall pain scores by age group.

Discussion

This study found that topical lidocaine gel or spray offered no significant analgesic advantage over placebo for the general population. However, subgroup analysis revealed a significant, age-dependent benefit, with 2% lidocaine gel providing superior pain relief in women aged 35 – 50, but not in those over 50.

These results reinforce the consensus that surface anesthesia cannot adequately penetrate the deep uterine and cervical nerve pathways involved in the procedure. Consequently, topical lidocaine is insufficient for pain management. Optimal pain control likely requires a multimodal strategy incorporating systemic or paracervical interventions.

Consistent with existing literature[7, 12], 2% lidocaine gel failed to provide significant pain alleviation during endometrial sampling. This lack of efficacy is likely attributable to the physiological nature of the procedure; pain is primarily driven by uterine cramping and endometrial manipulation. These represent visceral nociceptive stimuli that topical anesthetics cannot effectively penetrate or block[7, 8]. Similarly, 10% lidocaine spray demonstrated limited analgesic utility[4, 12–14], potentially due to its superficial tissue penetration and brief contact time, both of which are insufficient to suppress deeper pain signals associated with uterine contractions[7, 8]. Notably, our findings are supported by Tueman and Wongluecha (2026), who demonstrated that multimodal analgesia, specifically combining lidocaine gel with oral NSAIDs, offers superior pain management compared to monotherapy[17]. Significant age-related variations in analgesic response were observed[18], suggesting that participant age is a key determinant of topical anesthetic efficacy. These findings underscore the necessity of considering age-specific profiles when selecting anesthetic formulations to optimize pain management outcomes during endometrial sampling. While both topical interventions proved safe and well-tolerated, they offer minimal clinical benefit when used in isolation. Consequently, future research should focus on multimodal pain control strategies to optimize patient comfort during office-based gynecological procedures.

This study has several strengths, including its randomized, single-blind, placebo-controlled design, which minimized potential bias, and the assessment of pain at five distinct procedural stages. The inclusion of satisfaction ratings from both participants and operators, together with the absence of observed adverse events, allowed a broader evaluation of the clinical acceptability of the interventions.

Several limitations should be acknowledged. This single-center study may have limited generalizability and may have been underpowered to detect small between-group differences. As it was not designed as an equivalence or non-inferiority trial, the nonsignificant findings should not be interpreted as evidence of equivalence. The post-hoc, non-

prespecified finding among women aged 35 – 50 years is exploratory and requires confirmation in a larger study. Finally, catheter-insertion depth, tissue quantity, and histopathological adequacy were not prospectively assessed and should be included in future studies.

Conclusion

In the present study, no statistically significant reduction in pain was detected with topical 2% lidocaine gel or 10% lidocaine spray compared with placebo during endometrial sampling. These findings should not be interpreted as demonstrating equivalence, as the study was not designed as an equivalence or non-inferiority trial. In a post-hoc subgroup analysis of women aged 35 – 50 years, lidocaine gel was associated with lower pain scores than lidocaine spray; however, neither intervention differed significantly from placebo. This exploratory finding requires confirmation in an adequately powered study.

Acknowledgement

The author gratefully acknowledges all study participants and the staff of the Gynecologic Outpatient Department at Nakornping Hospital for their cooperation and assistance. The author also thanks the Nakornping Hospital Ethics Committee and the Department of Obstetrics and Gynecology for facilitating this research.

Potential conflicts of interest

The author declares no competing interests.

References

1. Novak E. Endometrial sampling. In: Berek JS, editor. Berek & Novak's Gynecology. 14th ed. Philadelphia: Lippincott Williams & Wilkins 2007;465.
2. Vitale SG, Buzzaccarini G, Riemma G, Pacheco LA, Sardo ADS, Carugno J. Endometrial biopsy: indications, techniques and recommendations—an evidence-based guideline for clinical practice. J Gynecol Obstet Hum Reprod 2023;52:102588.
3. Kulaksiz D, Erin R. Direct hysteroscopic endometrial sampling and Pipelle sampling in perimenopausal women. Minerva Obstet Gynecol 2020;74:343–7.
4. Piotto M, Focchi G, Marques R, Teixeira A, Gonçalves W, Nicolau S. Assessment of preoperative endometrial histopathological sampling as a predictor of final surgical pathology in endometrial cancer. Rev Bras Ginecol Obstet 2020;42:6428.
5. Aksoy H, Aksoy U, Ozyurt S, Acmaz G, Bayyigit MA, Yucel B. Effect of lidocaine spray in pain management during office-based endometrial sampling: a randomized placebo-controlled trial. J Obstet Gynaecol 2016;36:246–50.
6. Kunavikitikul K, Suprasert P, Khunamornpong S, Settakorn J, Natprathan A. Accuracy of the Wallach Endocell endometrial cell sampler in diagnosing endometrial carcinoma and hyperplasia. J Obstet Gynaecol Res 2011;37:483–6.
7. Karaca I, Yapca O, Adiyeke M, Toz E, Karaca S. Effect of cervical lidocaine gel for pain relief in Pipelle endometrial sampling. Eurasian J Med 2016;48: 189–91.
8. Lambert B, Gonthier M, Dery JP, Lepage Y. Comparison of pain factors and randomized roles of Vabra and Wallach Endocell in endometrial evaluation. Gynecol Obstet Invest 1998;45:258–61.
9. Charoenkwan K, Nanthasupha C. Methods of pain control during endometrial biopsy: a systematic review and meta-analysis of randomized controlled trials. J Obstet Gynaecol Res 2020;46:9–30.
10. Ahmed A, Ahmed S, Abd A, Mustafa K, Mohammed A, Mahmoud R, et al. Medications for pain relief in outpatient endometrial sampling or biopsy: a systematic review and network meta-analysis. Fertil Steril 2019;112:140–8.
11. Somchit W, Lertkhachonsuk A, Vallipakorn S. Naproxen for pain relief during endometrial biopsy: a randomized controlled trial. J Med Assoc Thai 2015;98:631–5.
12. Likkasitipan N, Wariyasirivaj B. Effect of lidocaine gel for pain relief during endometrial sampling: a double-blinded randomized controlled trial. Thai J Obstet Gynaecol 2021;29:273–80.
13. Piyawetchakarn R, Charoenkwan K. Effects of lidocaine spray for reducing pain during endometrial aspiration biopsy: a randomized controlled trial. J Obstet Gynaecol Res 2019;45:987–93.
14. Kornsuwan P, Wiriyasirivaj B. Lidocaine spray for pain control during office-based endometrial biopsy: a randomized placebo-controlled trial. Thai J Obstet Gynaecol 2018;26:262–9.
15. Sripha M, Charakorn C, Lekskul N, Lertkhachonsuk A. Analgesic effect of lidocaine spray during endometrial biopsy: a randomized controlled trial. Thai

J Obstet Gynaecol 2018;26:190–7.
16. Abbas A, Ellah N, Hosmy M, Abdellah S, Ali M. Self-administered vaginal 2% lidocaine in-situ gel for pain relief during copper intrauterine device insertion in women with previous cesarean delivery only: a double-blind randomized placebo-controlled trial. Eur J Contracept Reprod Health Care 2021;26: 132–8.
17. Tueman K., Wongleucha T. Lidocaine gel combined with ibuprofen versus ibuprofen alone for pain relief during an endometrial biopsy: a randomized controlled trial. Thai J Obstet Gynaecol 2026;34:30-41.
18. González-Roldán AM, Terrasa JL, Sitges C, van der Meulen M, Anton F, Montoya P. Age-related changes in pain perception are associated with altered functional connectivity during resting state. Front Aging Neurosci 2020;12:116.

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 459-469.

OBSTETRICS

Performance of the FullPIERS Model for the Determination of Maternal and Perinatal Complications in Patients with Severe Preeclampsia in Cartagena, Colombia

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ABSTRACT

Objectives: To evaluate the prognostic performance of the FullPIERS (full Pre-eclampsia Integrated Estimate of RiSk) model in predicting severe maternal and perinatal complications using diagnostic performance measures such as sensitivity, specificity, and area under the receiver operating characteristic (ROC) curve in patients with severe preeclampsia treated at Clínica Maternidad Rafael Calvo of Cartagena, Colombia, between 2022 and 2023.

Materials and Methods: A retrospective cohort study was conducted using medical records of women diagnosed with severe preeclampsia between January 2022 and December 2023. The study population consisted of pregnant women with a gestational age ≥ 20 weeks who were treated at a public second-level healthcare institution. The independent variable was the score obtained from the FullPIERS model, while the dependent variables corresponded to the occurrence of two composite outcomes. A severe maternal complication was defined as the occurrence of at least one of the following: placental abruption, eclampsia, hemolysis, elevated liver enzymes and low platelets (HELLP) syndrome, stillbirth, admission to the intensive care unit, or maternal death. A perinatal complication was defined as the occurrence of at least one of the following: intrauterine growth restriction, admission to the neonatal intensive care unit, or neonatal death. The follow-up period for outcome identification was up to 48 hours after hospital admission, according to the original definition of the model.

Results: A total of 151 women with severe preeclampsia were included, of whom 47.8% developed maternal and/or perinatal complications. A severe maternal complication occurred in 20 women (13.2%) — intensive care unit admission in 11 (7.3%), HELLP syndrome in 9 (6.0%), stillbirth in 3 (2.0%), placental abruption in 2 (1.3%) and eclampsia in 2 (1.3%), with no maternal deaths — and a perinatal complication occurred in 64 neonates (42.4%), mainly admission to the neonatal intensive care unit (35.8%) and intrauterine growth restriction (13.9%). A FullPIERS-estimated probability ≥ 1% was associated with an 11-fold higher risk of severe maternal complications [odds ratio 11.09, 95% confidence interval 3.87, 31.72]

(sensitivity 55%, specificity 90.08%, PPV 45.83%, NPV 92.91%). The ROC curve showed an area under the curve of 0.781 for the prediction of severe maternal complications, whereas perinatal complications did not show statistically significant differences.

Conclusion: The FullPIERS model is useful for predicting severe maternal complications in women with severe preeclampsia. However, it was not designed to predict perinatal outcomes; therefore, related results should be interpreted as exploratory analyses rather than as evidence of the model's predictive capacity.

Keywords: preeclampsia, complications, fullPIERS, morbidity, obstetrics.

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Received: 6 March 2026, **Revised:** 2 September 2026, **Accepted:** 21 September 2026

Introduction

Preeclampsia is a progressive multisystem disorder that affects between 2% and 8% of pregnancies and represents one of the leading causes of maternal and fetal morbidity and mortality, with rates approaching 100 cases per 100,000 live births in developing countries[1]. According to the World Health Organization (WHO), 25% of cases occur in Latin America and the Caribbean, and nearly 95% of maternal deaths occur in low- and middle-income countries, most of which are potentially preventable[2]. In Colombia, it ranks as the leading cause of maternal mortality, with a ratio of 42 per 100,000 live births[3]. In Cartagena (Bolívar), hypertensive disorders account for 70.9% of these events[4].

Severe complications include hemolysis, elevated liver enzymes and low platelets (HELLP) syndrome, stroke, eclampsia, and renal dysfunction, and may also result in fetal death, preterm birth, and cerebral palsy[5-7]. In order to optimize risk stratification, the full preeclampsia Integrated Estimate of Risk (FullPIERS) model was developed to predict severe maternal complications within 48 hours after hospital admission using clinical variables such as gestational age, chest pain or dyspnea, oxygen saturation, platelet count, creatinine, and transaminases. Therefore, its use is not appropriate for predicting adverse fetal or neonatal outcomes[8,9].

This model was developed and validated by Von Dadelszen et al in 2011[10] with the aim of predicting severe maternal complications[11]. The model was derived from a prospective, multicenter cohort of 2,023 women with preeclampsia admitted to tertiary obstetric centers in Canada, New Zealand, Australia and the United Kingdom, and estimates the probability of a composite adverse maternal outcome — maternal death or serious central nervous system, cardiorespiratory, hematological, hepatic or renal morbidity — occurring within 48 hours of admission. The final logistic equation includes six variables that are routinely available at the bedside: gestational age at eligibility, chest pain or dyspnea, oxygen saturation, platelet count, serum creatinine and aspartate aminotransferase. In the derivation cohort the model showed an area under the receiver operating characteristic curve of 0.88 (95% confidence interval 0.84, 0.92), and subsequent temporal and external validations have reproduced areas under the curve of between 0.70 and 0.83, including cohorts from low- and middle-income countries[9,15]. It is currently used in internationally recognized referral hospitals, such as Hospital Clínic of Barcelona, where it forms part of the hypertension and pregnancy protocol to

assess the risk of maternal complications in patients with severe preeclampsia[12]. Studies such as that of Cázarez-Ávalos et al have evaluated the predictive performance for the occurrence of severe maternal complications using a 5% cut-off point of the FullPIERS score[13].

However, although the model has undergone external validation, it has not been specifically evaluated in the local population. In this context, the high prevalence of hypertensive disorders of pregnancy in the Colombian Caribbean, where these disorders account for 70.9% of all cases of extreme maternal morbidity reported in Cartagena[3,4], makes it relevant to assess its prognostic performance in this specific clinical setting, given the potential influence of population and healthcare variations on its performance. Therefore, the aim of this study was to evaluate the prognostic performance of the FullPIERS model as a predictor of severe maternal complications in women with severe preeclampsia treated at Clínica Maternidad Rafael Calvo in Cartagena, Colombia, during the period 2022–2023, with the main outcome being the occurrence of a severe maternal complication within 48 hours of hospital admission, as defined below.

Materials and Methods

A single-center retrospective cohort study was conducted at E.S.E. Clínica Maternidad Rafael Calvo (CMRC) in Cartagena between January 2022 and December 2023. CMRC is a public second-level referral maternity hospital that cares mainly for women affiliated with the subsidized regime of the Colombian health system in the department of Bolívar. Women with ≥ 20 weeks of gestation diagnosed with severe preeclampsia according to the criteria of the American College of Obstetricians and Gynecologists (ACOG) were included[14]. Severe preeclampsia was defined as a systolic blood pressure ≥ 160 mmHg and/or a diastolic blood pressure ≥ 110 mmHg, or a systolic blood pressure ≥ 140 mmHg and/or a diastolic blood pressure ≥ 90 mmHg on two occasions at least 4 hours apart, accompanied by at least one feature suggestive of end-organ damage: thrombocytopenia (platelet count < 100,000 × 10^9/L), impaired liver function (transaminase levels more than twice the upper limit of normal), severe persistent right upper quadrant or epigastric pain with no alternative explanation, renal insufficiency (serum creatinine > 1.1 mg/dL or doubling of the serum creatinine concentration in the absence of other renal disease), pulmonary edema, new-onset headache unresponsive to treatment, or visual symptoms.

A total of 165 women admitted with a diagnosis of severe preeclampsia (ICD-10 code O14.1) during the study period were identified as the source population. The sample size required was calculated with Episet software v1.2.02 for the estimation of a single proportion in a finite population of 165 women, assuming an expected proportion of adverse maternal outcome of 50% (the most conservative scenario), a 95% confidence level and an absolute precision of 0.02, which yielded a required sample of 151 women. The clinical records of all 165 women were then reviewed against the eligibility criteria and 14 were excluded: 5 because the diagnosis of preeclampsia had been made in the postpartum period, 3 because the record did not contain the data needed to compute the FullPIERS score or to ascertain the outcomes, 3 because delivery had taken place outside the institution, and 3 because of pre-existing chronic hypertension. The remaining 151 women, representing 91.5% of the source population and matching the calculated sample size, constituted the study sample (Fig. 1). Women aged 14–45 years with pregnancies between 21 and 42 weeks of gestation and complete medical records allowing calculation of the FullPIERS score were included. Patients with multiple pregnancies, chronic hypertension, or a history of hepatic, renal, pulmonary, or autoimmune diseases were excluded, as were women in whom preeclampsia was diagnosed in the postpartum period and women who delivered outside the institution.

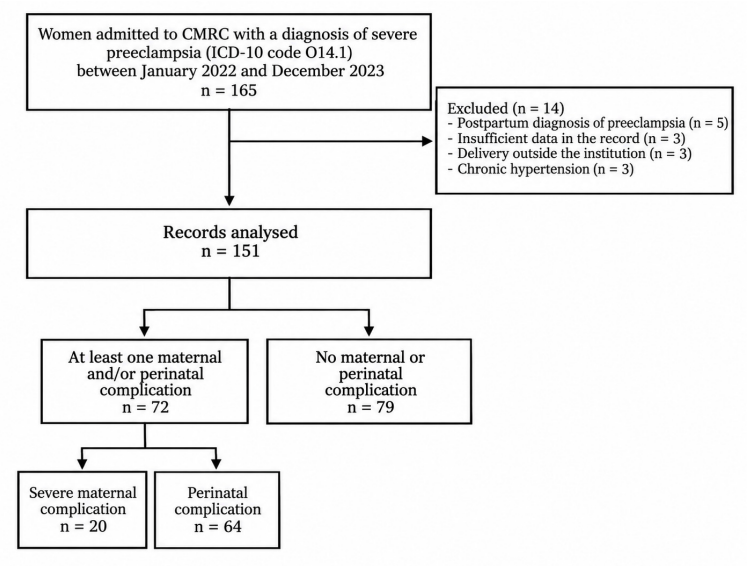


Fig. 1. Flow chart of the selection of the study population.

Sociodemographic variables such as age and nationality were collected, as well as maternal variables including gestational age, determined by first-trimester ultrasound or by the recorded last menstrual period. Obstetric history variables included number of previous pregnancies, parity, previous cesarean sections, body mass index (BMI), systolic and diastolic blood pressure, and oxygen saturation.

Paraclinical variables included platelet count, serum creatinine, and transaminases obtained from laboratory tests performed at hospital admission or within the first 24 hours of hospitalization. The following maternal variables were also recorded: mode of delivery, placental abruption, eclampsia, HELLP syndrome, stillbirth, intensive care unit (ICU) admission, and maternal death within 48 hours of admission. Perinatal variables recorded were intrauterine growth restriction, admission to the neonatal intensive care unit (NICU), and neonatal death within the first 48 hours of life.

The primary outcome was the occurrence of a severe maternal complication within 48 hours of hospital admission, defined as a composite of at least one of the following: placental abruption, eclampsia, HELLP syndrome, stillbirth, admission to the ICU, or maternal death. The secondary outcome was the occurrence of a perinatal complication, defined as a composite of at least one of the following: intrauterine growth restriction, admission to the NICU, or neonatal death within the first 48 hours of life. Throughout the manuscript, the term "severe maternal complication" refers exclusively to this composite maternal outcome and is not used interchangeably with individual maternal variables such as mode of delivery. Stillbirth was included in the maternal composite as pre-specified in the study protocol; this differs from the composite used in the original FullPIERS derivation study and is addressed in the limitations section.

Maternal risk was estimated using the FullPIERS model through the calculator available at the University of British Columbia[15]. The calculation was performed using the clinical and paraclinical information recorded at admission or within the first 24 hours of hospitalization. Treating physicians did not have access to the model score. The estimated probability was first analyzed as a continuous variable; the optimal cut-off point (≥ 1%) was subsequently identified from the receiver operating characteristic (ROC) curve using the Youden index.

Data were obtained from medical records coded as ICD-10 O14.1, consolidated in Microsoft Excel, and cleaned to exclude incomplete records. Only patients who strictly met the previously defined inclusion and

exclusion criteria were included. Qualitative variables were presented as absolute and relative frequencies, and quantitative variables according to their distribution. The distribution of continuous variables was assessed with the Kolmogorov–Smirnov test; normally distributed variables were summarized as mean and standard deviation, and non-normally distributed variables as median and interquartile range (IQR). Bivariate analysis was performed using Chi-square, Fisher's exact test, and the Mann–Whitney U test. The association between the probability of complications estimated by the FullPIERS model and outcomes was evaluated using multiple logistic regression as a prognostic prediction approach to obtain adjusted odds ratios (OR) and 95% confidence intervals (CI) ($p < 0.05$) [16]. Model performance was assessed using ROC curve analysis, area under the curve (AUC), sensitivity, specificity, and optimal cut-off point determined by the Youden index. All analyses were performed with R version 4.3.2.

The study was approved by the Research Ethics Committee of the University of Cartagena (Act No. 008 of 09/06/2024) and by the Ethics and Research Committee of Clínica Maternidad Rafael Calvo (Act CIMA-06092024), in accordance with the ethical principles established in the Declaration of Helsinki of the World Medical Association (current version, 2024). The study was classified as minimal risk according to Resolution 008430 of 1993 of the Colombian Ministry of Health, as it used existing clinical records and ensured the confidentiality of information.

Results

A total of 151 women with severe preeclampsia aged between 14 and 43 years were included between 2022 and 2023. Most patients were Colombian (134/151; 88.7%), while 17 (11.3%) were Venezuelan. Overall, 64.2% were multiparous and 35.8% nulliparous. Among multiparous women, 71.5% had no history of hypertensive disorders of pregnancy, and 32.5% had a previous cesarean section.

The mean gestational age at diagnosis was 36.4 weeks (range 25.2–41.1). The median systolic blood pressure was 160 mmHg (range 120–220) and the median diastolic blood pressure was 79 mmHg (range 61–140); the median peripheral oxygen saturation was 99% (range 96–100) and the median body mass index was 30.6 kg/m² (range 19.7–64). Dyspnea was reported by 0.7% of the women and chest pain by 1.3%. Cesarean section was the route of delivery in 82.8% of the cases and vaginal delivery in 17.2%.

A severe maternal complication occurred in 20 of the 151 women (13.2%) and a perinatal complication in 64 neonates (42.4%); overall, 72 women (47.8%) presented at least one maternal and/or perinatal complication. No maternal or neonatal deaths were recorded within the first 48 hours. The components of both composite outcomes are shown in Table 1.

Table 1. Frequency of the components of the composite maternal and perinatal outcomes (n = 151).

Outcome	n (%)
Severe maternal complication (composite)	20 (13.2)
Intensive care unit admission	11 (7.3)
HELLP syndrome	9 (6.0)
Stillbirth	3 (2.0)
Placental abruption	2 (1.3)
Eclampsia	2 (1.3)
Maternal death	0 (0.0)
Perinatal complication (composite)	64 (42.4)
Neonatal intensive care unit admission	54 (35.8)
Intrauterine growth restriction	21 (13.9)
Neonatal death	0 (0.0)

Percentages were calculated over the 151 women included. The components of each composite are not mutually exclusive, so their sum exceeds the number of women with the composite outcome.
HELLP: hemolysis, elevated liver enzymes and low platelet count.

When comparing the groups with and without severe maternal complications, significant differences were observed. Women who developed a severe maternal complication had a lower platelet count [median 166 × 10^3/μL (IQR 142, 236) vs 249 × 10^3/μL (IQR 199, 299), p < 0.001], a higher AST level [40.5 U/L (IQR 27.3, 155) vs 22 U/L (IQR 17.5, 30), p = 0.01], a higher ALT level [39 U/L (IQR 15.8, 120) vs 15 U/L (IQR 12, 24.5), p = 0.02] and a higher serum creatinine level [0.90 mg/dL (IQR 0.71, 0.95) vs 0.67 mg/dL (IQR 0.56, 0.80), p < 0.001] than women without a severe maternal complication. No significant differences were found for age, nationality, gestational age, oxygen saturation, body mass index, history of hypertensive disorders of pregnancy, nulliparity, dyspnea or chest pain (Table 2).

Table 2. Association between sociodemographic and clinical factors and severe maternal complications.

Independent variables	Maternal complication – No	Maternal complication – Yes	p value
Age*	26 (21.5, 32)	28.5 (22.8, 33.3)	0.379
Nationality			0.84
Colombian	116 (88.5%)	18 (90%)	
Venezuelan	15 (11.5%)	2 (10%)	
Gestational age*	36.5 (35.1, 38.5)	36.2 (31.8, 38.1)	0.09
O_2 saturation*	99 (98, 99)	99 (98, 99)	0.96
BMI*	29.7 (26.4, 33.5)	30.9 (26.1, 33.1)	0.64
Platelet count (×10^3)*	249 (199, 299)	166 (142, 236)	< 0.001
AST*	22 (17.5, 30)	40.5 (27.3, 155)	0.01
ALT*	15 (12, 24.5)	39 (15.8, 120)	0.02
Creatinine*	0.67 (0.56, 0.80)	0.90 (0.71, 0.95)	< 0.001
Previous HDP history			0.48
Yes	36 (27.5%)	7 (35%)	
No	95 (72.5%)	13 (65%)	
Nulliparity			0.56
Yes	48 (36.6%)	6 (30%)	
No	83 (63.4%)	14 (70%)	
Dyspnea			1.00
Yes	1 (0.8%)	0 (0%)	
No	130 (99.2%)	20 (100%)	
Chest pain			1.00
Yes	2 (1.5%)	0 (0%)	
No	129 (98.5%)	20 (100%)	

Values are expressed as median (interquartile range).
BMI: body mass index, AST: aspartate aminotransferase, ALT: alanine aminotransferase, HDP: hypertensive disorders of pregnancy.

Regarding perinatal outcomes, no significant differences were found in clinical and sociodemographic characteristics, except for gestational age, which was lower in the group with complications [34.5 weeks (IQR 32, 35.5) vs 38 weeks (IQR 36.4, 39), p < 0.001], and peripheral oxygen saturation (p = 0.03), although the median value of the latter was identical in both groups (Table 3). The probability of a severe maternal complication estimated by the FullPIERS model was significantly higher among women who developed a severe maternal complication, but did not differ significantly according to the occurrence of perinatal complications (Table 4).

In the logistic regression model, an estimated probability ≥1% was associated with an eleven-fold increase in the odds of a severe maternal complication compared with a probability <1% [OR 11.09 (95% CI 3.87–31.72), p < 0.001] (Table 5).

Table 3. Association between sociodemographic and clinical factors and perinatal complications.

Independent variables	Perinatal complication – No	Perinatal complication – Yes	p value
Age*	25 (21, 31)	27.5 (22, 33.3)	0.22
Nationality			0.25
Colombian	75 (86.2%)	59 (92.2%)	
Venezuelan	12 (13.8%)	5 (7.8%)	
Gestational age*	38 (36.4, 39)	34.5 (32, 35.5)	< 0.001
O_2 saturation*	99 (98, 99)	99 (98, 99)	0.03
BMI*	29.7 (26.4, 33.5)	30.1 (26.2, 33.5)	0.72
Platelet count ($\times 10^3$)*	241 (189, 287)	244 (189, 304)	0.68
AST*	22 (17.5, 30.5)	25 (18, 34.5)	0.29
ALT*	17 (12, 25)	17 (12, 26.3)	0.68
Creatinine*	0.70 (0.57, 0.82)	0.69 (0.59, 0.80)	0.73
Previous HDP history			0.77
Yes	24 (27.6%)	19 (29.7%)	
No	63 (72.4%)	45 (70.3%)	
Nulliparity			0.09
Yes	36 (41.4%)	18 (28.1%)	
No	51 (58.6%)	46 (71.9%)	
Dyspnea			0.42
Yes	0 (0%)	1 (1.6%)	
No	87 (100%)	63 (98.4%)	
Chest pain			0.17
Yes	0 (0%)	2 (3.1%)	
No	87 (100%)	62 (96.9%)	

Values are expressed as median (interquartile range).
BMI: body mass index, AST: aspartate aminotransferase, ALT: alanine aminotransferase, HDP: hypertensive disorders of pregnancy.

Table 4. FullPIERS-estimated probability of an adverse maternal outcome (%) according to the occurrence of severe maternal and perinatal complications.

Outcome	FullPIERS probability (%) – Without complication	FullPIERS probability (%) – With complication	p value
Severe maternal complication (n = 131 vs 20)	0.30 (0.10, 0.55)	1.00 (0.37, 1.78)	0.02
Perinatal complication (n = 87 vs 64)	0.30 (0.15, 0.60)	0.40 (0.20, 0.70)	0.06

Values are the probability of an adverse maternal outcome within 48 hours of admission estimated by the FullPIERS model, expressed as a percentage and reported as median (interquartile range). Groups were compared with the Mann–Whitney U test.

Table 5. Logistic regression model for the association between a FullPIERS-estimated probability ≥ 1% and severe maternal complications.

Predictor	β	SE	Z	OR (95% CI)	p value
FullPIERS ≥ 1% vs < 1%	2.41	0.567	4.24	11.09 (3.87, 31.72)	< 0.001

β: regression coefficient, SE: standard error, OR: odds ratio, CI: confidence interval.
Dependent variable: occurrence of a severe maternal complication within 48 hours of hospital admission.

The ROC curve of the FullPIERS model for the prediction of severe maternal complications (Fig. 2) showed an area under the curve (AUC) of 0.781 with an optimal cut-off value ≥1% (sensitivity 55%, specificity 90.08%, positive predictive value (PPV) 45.83%, negative predictive value (NPV) 92.91%) and a Youden index of 0.45.

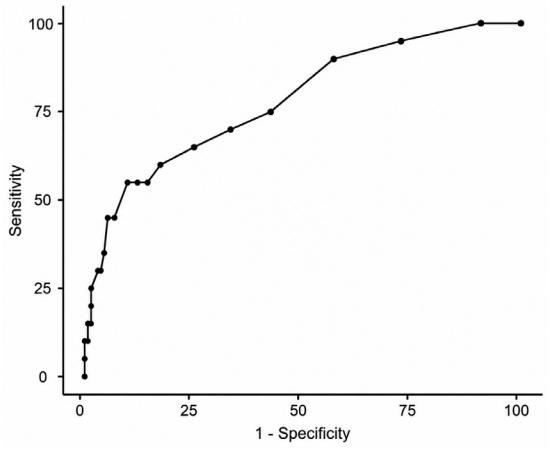


Fig. 2. ROC curve of the FullPIERS model for the prediction of severe maternal complications.
ROC: receiver operating characteristic

Discussion

The present study found that severe preeclampsia occurred more frequently in young women, multigravidas, and those with overweight, a profile that may reflect potential selection bias and could limit the generalizability of the findings to the broader population. Although nulliparity is often described as a risk factor, the higher proportion of multigravidas in this cohort is consistent, albeit heterogeneously, with findings from studies conducted in Latin American populations, suggesting epidemiological variability depending on the healthcare context.

A substantial proportion of pregnancies ended at gestational ages below term, reflecting obstetric decisions aimed at protecting maternal health in the context of severe preeclampsia. The median gestational age observed among patients with perinatal complications was comparable to that reported by Boutot et al[17]. In this context, adverse perinatal outcomes identified in this population, such as intrauterine growth restriction and neonatal intensive care unit admission, occurred in the setting of lower gestational age at birth.

Laboratory parameters showed consistent associations with maternal complications, including thrombocytopenia, elevated transaminases, and increased creatinine levels, markers that reflect endothelial damage and progressive organ dysfunction and reinforce the clinical importance of their monitoring. These findings are consistent with the pathophysiological basis of the FullPIERS model described by Von Dadelszen et al[10], as well as with the findings of Almeida et al, who reported predictive capacity for the early identification of severe maternal complications in patients with preeclampsia[18]. The frequency of HELLP syndrome observed in this study is comparable to that reported in other Latin American studies, where progression to eclampsia or hemolysis has been documented[19].

Regarding the analysis of the FullPIERS model, an estimated probability ≥ 1%, identified as the optimal cut-off through ROC analysis, was associated with a higher likelihood of severe maternal complications, with an adjusted odds ratio of approximately 11. The model demonstrated adequate discriminatory

performance (AUC 0.781), consistent with the original validation study[10].

External studies, such as that by Payne et al, have reported comparable performance in early-onset preeclampsia, supporting the reproducibility of the model[20]. In line with the existing literature, the model showed limited ability to predict perinatal outcomes, likely influenced by gestational age at delivery and clinical decisions regarding pregnancy termination, which may introduce an intervention bias.

Our findings are also consistent with reports from other settings with a high burden of hypertensive disorders of pregnancy. In a Thai cohort of 200 women with severe preeclampsia, Kampruan et al reported acute renal failure in 4.0%, pulmonary edema in 2.0%, neurological complications in 5.0% and a cesarean section rate of 57.5%, together with preterm birth in 45.0%, low birth weight in 47.0% and neonatal resuscitation in 19.0%[21]. The frequencies of maternal complications observed in our cohort were of a comparable order of magnitude, whereas our caesarean section rate (82.8%) was considerably higher, cesarean which probably reflects local obstetric practice and the referral profile of our institution rather than a difference in disease severity. Phianpiset et al, in turn, showed that severe preeclampsia diagnosed before 34 weeks of gestation accounted for 15.9% of severe preeclamptic women and was associated with a markedly higher rate of admission to the neonatal intensive care unit (37.1% vs 1.1%) and with a lower mean birth weight[22]. This observation is directly relevant to our results, since the perinatal complications identified in our cohort were concentrated in pregnancies delivered at earlier gestational ages, and it supports our interpretation that gestational age at delivery, rather than the FullPIERS probability, is the main determinant of adverse perinatal outcomes in severe preeclampsia.

This study has limitations. First, its retrospective, single-center design means that the analysis depended on the completeness and accuracy of routinely collected clinical records, so that only associations, and not causal relationships, can be established. Second, the sample size was small, and the number of events was low (20 severe maternal complications), which limited the precision of the estimates, as reflected in the width of the confidence interval of the odds ratio, and precluded a more extensive multivariable adjustment. Third, the optimal cut-off point (≥ 1%) was derived from the same dataset using the Youden index, so the reported sensitivity and specificity are likely to be optimistic and require confirmation in an independent sample; thresholds of 5% and 30% have been used in other validation studies. Fourth, stillbirth was included in the composite maternal outcome as pre-specified in the study protocol, whereas the original FullPIERS composite comprises only maternal death and serious maternal morbidity, which may have attenuated the observed performance of the model. Finally, our results come from a single public second-level maternity hospital in the Colombian Caribbean and should not be extrapolated to other populations without further validation. The main strength of the study is that, to our knowledge, this is the first evaluation of the FullPIERS model in the Colombian Caribbean and one of the few carried out in a second-level public hospital of a middle-income country — precisely the setting in which the model would be most useful for triage and timely referral, and in which external validation data remain scarce[9].

Conclusion

The FullPIERS model demonstrated adequate ability to discriminate and detect severe maternal complications in cases of severe preeclampsia. A cut-off point ≥ 1% was associated with a significant increase in risk (OR 11.09, 95% CI 3.87, 31.72). In addition, laboratory markers such as a decreased platelet count, elevated AST/ALT levels, and increased creatinine were associated with a higher frequency of complications, supporting their clinical relevance.

However, the model did not demonstrate utility in predicting perinatal outcomes, likely due to the influence of factors such as gestational age and obstetric decision-making. Therefore, its application

should primarily focus on maternal risk assessment and be complemented with clinical criteria in decision-making related to perinatal management.

Acknowledgement

The authors would like to express their sincere gratitude to the women and their newborns who were part of this study. We also thank the healthcare professionals and support staff of Clínica Maternidad Rafael Calvo for their dedication to maternal and neonatal care and for their assistance during the data collection process. Their commitment and daily work made this research possible.

Author contributions

CGA: protocol/project development, data collection or management, data analysis, manuscript writing.
MFTL: protocol/project development, data collection or management, data analysis, manuscript writing.
JPSC: protocol/project development, data collection or management, data analysis, manuscript writing and editing.
KMM: protocol/project development, data analysis, manuscript editing.
ERP: protocol/project development, data analysis, manuscript editing

Potential conflicts of interest

The authors declare no competing interests.

References

1. Ortiz EI, Herrera E, De La Torre A. Extreme maternal morbidity: a tracer event to improve the quality of obstetric care in Latin America. Colomb Med (Cali) 2019;50:286-92.
2. Velumani V, Durán CC, Hernández LS. Preeclampsia: una mirada a una enfermedad mortal. Rev Fac Med Univ Nac Auton Mex 2021;64:7-18.
3. Buelvas VM, Jaraba CR. Asociación entre los niveles de déficit de base y la aparición de disfunción orgánica múltiple en pacientes con preeclampsia severa admitidas en la clínica Gestión Salud S.A.S (Cartagena) entre el 1 de enero de 2014 hasta 31 diciembre 2016. Biociencias 2017;12:59-70.
4. Departamento Administrativo Distrital de Salud (DADIS) de Cartagena. Boletín epidemiológico morbilidad materna extrema (MME) 2024;52:1-7.
5. Chávez DG, Tejada CA, Suárez AD, Gómez CF, Cabrera FJ, Figueroa C. Preeclampsia: nuevas etiologías. Univ Salud 2010;1:146-55.
6. Agrawal S, Maitra N. Prediction of adverse maternal outcomes in preeclampsia using a risk prediction model. J Obstet Gynaecol India 2016;66:104-11.
7. El-Sayed AAF. Preeclampsia: A review of the pathogenesis and possible management strategies based on its pathophysiological derangements. Taiwan J Obstet Gynecol 2017;56:593-8.
8. Garcés-Burbano YL, Bastidas-Sánchez BE, Ijají-Piamba JE, Rodríguez-Gamboa MA, Cajas-Santana DR, Ordoñez-Mosquera OE. Predicción de complicaciones maternas en trastornos hipertensivos del embarazo. Ginecol Obstet Mex 2021;89:583-94.
9. Ukah UV, Payne B, Lee T, Magee LA, Von Dadelszen P. External validation of the FullPIERS model for predicting adverse maternal outcomes in pregnancy hypertension in low- and middle-income countries. Hypertension 2017;69:705-11.
10. Von Dadelszen P, Payne B, Li J, Ansermino JM, Pipkin FB, Côté A-M, et al. Prediction of adverse maternal outcomes in pre-eclampsia: development and validation of the FullPIERS model. Lancet 2011;377:219-27.
11. Sharma A, Suri J, Khanam Z, Pandey D, Bachani S, Sharma A. Prediction of complications of pre-eclampsia using the FullPIERS high risk predictive model. Int J Gynaecol Obstet 2023;163:983-8.
12. Universitat de Barcelona, Hospital Clínic, Hospital Sant Joan de Déu. Protocolo: Hipertensión y Gestación In: Patología Materna y Obstétrica. Fetal Medicine Barcelona, Barcelona: Centro de Medicina Maternofetal y Neonatal de Barcelona (BCNatal), 2025:1-39.
13. Cázarez-Ávalos I, García-Benavente D, Toledo-Lorenzo C, Valle-Leal J, López-Valenzuela D. Desempeño diagnóstico del modelo FullPIERS como predictor de complicaciones perinatales en pacientes con preeclampsia. Ginecol Obstet Méx 2020; 88:1-7.
14. American College of Obstetricians and Gynecologists. Gestational hypertension and preeclampsia: ACOG Practice Bulletin, Number 222. Obstet Gynecol 2020;135:e237-e260.
15. Ukah UV, Payne B, Karjalainen H, Kortelainen E, Seed PT, Conti-Ramsden FI, et al. Temporal and external validation of the FullPIERS model for the

prediction of adverse maternal outcomes in women with pre-eclampsia. Pregnancy Hypertens 2019;15: 42-50.
16. Hosmer DW, Lemeshow S. Multiple logistic regression. In: Applied logistic regression. New York: Wiley, 2000:31-46.
17. Boutot M, Margueritte F, Boukeffa N, Coste Mazeau P, Aubard Y, Gauthier T. Validation externe du modèle FullPIERS dans la pré-éclampsie à partir d'une série française de 4 ans [External validation of FullPIERS model for prediction of adverse outcomes among women with pre-eclampsia in French maternity of 2014 to 2018]. Gynecol Obstet Fertil Senol 2020;48:167-173.
18. Almeida ST, Katz L, Coutinho I, Amorim MMR. Validation of FullPIERS model for prediction of adverse outcomes among women with severe pre-eclampsia. Int J Gynaecol Obstet 2017;138:142-7.
19. Vargas HV, Acosta AG, Moreno EM. La preeclampsia: un problema de salud pública mundial. Rev Chil Obstet Ginecol 2012;77:471-6.
20. Ukah UV, Payne B, Hutcheon JA, Ansermino JM, Ganzevoort W, Thangaratinam S, et al. Assessment of the FullPIERS risk prediction model in women with early-onset preeclampsia. Hypertension 2018;71: 659-65
21. Kampruan R, Sukonpan K, Wasinghon P. Pregnancy outcomes amongst normotensive and severe preeclampsia with or without underlying chronic hypertension pregnancy. Thai J Obstet Gynaecol 2016;24:202-8.
22. Phianpiset R, Phattanachindakun B, Boriboonhirunsarn D. Prevalence, risk factors, and pregnancy outcomes of early-onset severe preeclampsia among severe preeclamptic women in Siriraj Hospital. Thai J Obstet Gynaecol 2017;25: 26-34.

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 470-479.

GYNAECOLOGY

The Efficacy of Curcumin for Preventing Postoperative Bowel ileus after Total Abdominal Hysterectomy for Benign Gynecologic Surgery: A randomized controlled trial

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ABSTRACT

Objectives: To study the efficacy of curcumin for preventing postoperative bowel ileus after total abdominal hysterectomy for benign gynecologic surgery.

Materials and Methods: A double-blind, randomized, placebo-controlled trial was conducted in women who underwent benign gynecologic abdominal hysterectomy. Randomization was carried out to two groups post-surgery. The intervention group received one capsule of curcumin 500 mg, and the control group received one capsule of an identical placebo four times a day (6.00 am. 12.00 am. 5.00 pm. 10.00 pm.) until 72 hours after the operation. The primary outcome was ileus symptoms measured by the I-FEED score, while the secondary outcomes were time to first flatus, time to first defecation, additional antiemetic drugs, stomach pain, and diarrhea.

Results: From November 2025 to July 2026, 56 participants were enrolled. The incidence of ileus symptoms in the intervention group was shown to be significantly lower when compared to the control group (4 (14.3%) vs 14 (50%), relative risk 0.29, 95% confidence interval 0.11, 0.74, p = 0.01). Time to first flatus, time to first defecation, additional antiemetic drug, stomach pain, and diarrhea showed no significant differences between groups, and there were no serious adverse effects reported.

Conclusion: Curcumin intake following benign gynecologic abdominal hysterectomy significantly reduced postoperative bowel ileus.

Keywords: curcumin, total abdominal hysterectomy, postoperative ileus, ileus symptoms, I-FEED score.

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Received: 29 September 2026, **Revised:** 24 October 2026, **Accepted:** 30 October 2026

การศึกษาประสิทธิภาพของขมิ้นชันในการป้องกันภาวะลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัดมดลูกทางหน้าท้องในผู้ป่วยนรีเวชที่ไม่ใช่มะเร็ง: การทดลองแบบสุ่มที่มีกลุ่มควบคุม

ศิรภัสสร พลธรรม, ทุมวดี ตั้งศิริวัฒนา

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาประสิทธิภาพของขมิ้นชันในการป้องกันภาวะลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัดมดลูกทางหน้าท้องในผู้ป่วยนรีเวชที่ไม่ใช่มะเร็ง*

วัสดุและวิธีการ: *การศึกษานี้เป็นการทดลองแบบสุ่มที่มีกลุ่มควบคุม โดยมีประชากรตัวอย่างเป็นผู้ป่วยหญิงที่เข้ารับการผ่าตัดมดลูกทางหน้าท้องเนื่องจากโรคทางนรีเวชที่ไม่ใช่มะเร็ง โดยผู้เข้าร่วมวิจัยได้ถูกแบ่งเป็น 2 กลุ่ม โดยใช้การสุ่ม กลุ่มทดลองได้รับประทานขมิ้นชันแคปซูล 500 มิลลิกรัม ในวันถัดไปหลังการผ่าตัด เวลา 6.00 น., 12.00 น., 17.00 น. และ 22.00 น. จากนั้นเริ่มใหม่ในวันต่อไป ดำเนินต่อเนื่องไปจนกว่าจะครบ 72 ชั่วโมงหลังผ่าตัด และในกลุ่มควบคุมได้รับประทานยาหลอกในช่วงเวลาเช่นเดียวกัน ผลลัพธ์หลัก คือ ภาวะลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัด ผลลัพธ์รอง ได้แก่ ระยะเวลาหลังผ่าตัดจนถึงการผายลมครั้งแรก ระยะเวลาหลังผ่าตัดจนถึงการถ่ายอุจจาระครั้งแรก การขอยาแก้คลื่นไส้อาเจียนเพิ่ม อาการปวดท้องบริเวณลิ้นปี่ และอาการถ่ายเหลว*

ผลการศึกษา: *จากเดือนพฤศจิกายน 2568 ถึงกรกฎาคม 2569 จำนวนผู้เข้าร่วมวิจัยมีทั้งหมด 56 คน โดยพบว่า ประชากรกลุ่มทดลองที่ได้รับประทานขมิ้นชันมีอุบัติการณ์ของอาการลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัดต่ำกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ (4 (14.3%) vs 14 (50%), relative risk 0.29, 95% confidence interval 0.11, 0.74, p = 0.01) อย่างไรก็ตาม ผลลัพธ์รอง ได้แก่ ระยะเวลาหลังผ่าตัดจนถึงการผายลมครั้งแรก ระยะเวลาหลังผ่าตัดจนถึงการถ่ายอุจจาระครั้งแรก การขอยาแก้คลื่นไส้อาเจียนเพิ่ม อาการปวดท้องบริเวณลิ้นปี่ และอาการถ่ายเหลว ไม่พบความแตกต่างอย่างมีนัยสำคัญ ไม่พบผลข้างเคียงที่สัมพันธ์กับการรับประทานขมิ้นชันในการศึกษานี้*

สรุป: *ขมิ้นชันสามารถลดภาวะลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัดมดลูกทางนรีเวชที่ไม่ใช่มะเร็งอย่างมีนัยสำคัญทางสถิติ*

คำสำคัญ: *ขมิ้นชัน, การผ่าตัดมดลูกทางหน้าท้อง, ภาวะลำไส้ไม่เคลื่อนไหวภายหลังการผ่าตัด, อาการลำไส้ไม่เคลื่อนไหว, I-FEED score*

Introduction

Globally, hysterectomy for benign diseases is the most common gynecological surgery. The rate of hysterectomy in Thailand ranges between 6.1 and 8.6 per 1,000 women of all ages, based on data from Siriraj Hospital in Bangkok[1]. The most common complications of hysterectomy include infection, venous thromboembolic disease, injury to the genitourinary and gastrointestinal tracts, urinary incontinence, and intestinal ileus[2].

Postoperative bowel ileus refers to a disruption in normal gastrointestinal motility that occurs following surgery. Clinically, it presents as an inability to tolerate oral intake accompanied by abdominal bloating, resulting from impaired intestinal propulsion without signs of mechanical obstruction[3]. The characteristics of postoperative ileus include nausea, vomiting, abdominal bloating, difficulty resuming oral intake, and delayed return of bowel function such as passage of gas and stool. This condition has been associated with slower postoperative recovery, higher rates of complications, and extended hospitalization[4]. However, the cause and mechanism of postoperative ileus are incompletely understood. The autonomic nervous system significantly influences bowel movement. While parasympathetic activity enhances gut motility, sympathetic activity suppresses it. Following surgery, sympathetic nervous activity can contribute to reduced gastrointestinal movement. Additionally, certain hormones and neurotransmitters such as nitric oxide, calcitonin gene-related peptide, and corticotropin-releasing factors are believed to play a role in its onset[5].

Curcumin ($C_{21}H_{20}O_6$) is a yellow crystalline polyphenol derived from the rhizome of turmeric (Curcuma longa L.). It offers neuroprotective benefits by influencing the gut-brain axis, partly through stimulating the vagus nerve, especially under conditions of inflammation or oxidative stress, which leads to the release of acetylcholine (ACh) that activates muscarinic receptors on smooth muscle cells in the gut[6]. This action helps to coordinate the contraction and relaxation of the muscles, facilitating the movement of food through the digestive tract, and results in the stimulation of gut motility. Furthermore, curcumin can modulate gut motility via inflammation reduction, such as decreased serum levels of serotonin (5-HT), vasoactive intestinal peptide (VIP), and substance P (SP), neurotransmitters involved in gut motility regulation[7]. Some studies have demonstrated that curcumin can increase beneficial gut bacteria such as Bifidobacterium, Lactobacillus, and Akkermansia muciniphila, contributing to improved gut motility[8, 9]. Some studies show that curcumin can decrease the activation of p38 mitogen-activated protein kinase (MAPK) and myosin light chain kinase (MLCK), enzymes involved in inflammation and gut motility regulation[10].

Based on the aforementioned, curcumin is considered a simple and cost-effective alternative treatment for promoting the recovery of bowel function after surgery. Previous clinical studies have demonstrated its potential benefits in participants with gastrointestinal disorders. Wozniak et al[11] reported that oral curcumin reduced the Irritable Bowel Syndrome Symptom Severity Score (IBS-SSS) in participants with irritable bowel syndrome. Similarly, Lopresti et al[12] found that curcumin supplementation was associated with a significantly greater reduction in the total Gastrointestinal Symptom Rating Scale (GSRS) score among adults with self-reported digestive complaints.

However, evidence supporting the use of curcumin in the perioperative setting remains limited. Agarwal et al[13] conducted a randomized controlled trial (RCT) and found that curcumin significantly reduced postoperative pain and fatigue in participants undergoing laparoscopic cholecystectomy. Similarly, Phoolcharoen et al[14] reported significantly lower median visual analog scale (VAS) pain scores in participants receiving curcuminoids than in the control group following laparoscopic gynecologic surgery. Although these studies suggest potential benefits of curcumin in postoperative recovery, evidence regarding its effects on postoperative gastrointestinal symptoms and bowel function remains limited.

Therefore, this study aimed to investigate whether curcumin can reduce bowel ileus in patients undergoing total abdominal hysterectomy for benign gynecologic conditions.

Materials and Methods

The double-blind, randomized, placebo-controlled trial was conducted at the Department of Obstetrics and Gynecology, Khon Kaen Hospital. Data were collected from November 2025 to July 2026. Before the commencement of the research, it was reviewed and approved by the Khon Kaen Hospital Institute Review Board in Human Research.

This study included participants who were aged 18 years or older who underwent hysterectomy for benign gynecologic surgery (total abdominal hysterectomy, TAH, with or without adnexal surgery) and could communicate in the Thai language. Participants were excluded if they had a history of curcumin allergy, gastrointestinal diseases such as gastroesophageal reflux diseases, carminative drugs used within 48 hours before surgery, diabetes mellitus, anticoagulant use such as aspirin, clopidogrel, or warfarin, intraoperative visceral organ injury, or had an indication to restrict food intake within 24 hours after surgery.

Sample size determination in this study was based on a comparison of two independent proportions. The sample size calculation was based on a pilot study (15 participants per group) with a 10% dropout rate; the power of the test was 80%, α level of 0.05. Thus, 56 participants (28 in each group) were required.

The curcumin capsules used in this study were obtained commercially, with a strength of 500 mg per capsule. The capsules administered to the intervention group contained yellow turmeric powder and were enclosed in opaque white capsules. Participants in the control group received placebo capsules containing 500 mg of cornstarch, which were prepared by a pharmacist using aseptic techniques and enclosed in opaque white capsules. The placebo capsules were identical to the curcumin capsules in color and size, making them visually indistinguishable from the outside.

On the day of admission, the participants were informed about the study and were asked to provide written consent. After benign gynecologic surgery, randomization was carried out in sequence using a computer-generated program. Group A was designated as the intervention group (curcumin), while group B was assigned as the control group (placebo). Allocation concealment was conducted by using sealed opaque envelopes. The opaque envelopes were sequentially labeled and contained 12 capsules of curcumin or placebo (identical in size, shape, and color). The participants and investigators were blinded to the randomization process. The participants received the same preoperative evaluation and management, including routine hematological, biochemical, and other diagnostic investigations such as complete blood count (CBC), blood urea nitrogen (BUN), creatinine (Cr), electrolytes, urinalysis (UA), Chest X-ray (CXR), electrocardiogram (EKG) 12 leads, ultrasound, shortening pubic hair, vaginal douche, and Foley catheter before undergoing surgery. Participants were not allowed to consume any food after midnight the day before surgery and received intravenous hydration with Ringer's lactate solution at a rate of 100–120 mL/hr. Prophylaxis embolization was allowed a Caprini score (low molecular weight heparin or intermittent pneumatic compression). All participants underwent the same anesthetic technique, consisting of standard general anesthesia administered by an anesthesiologist. The participants received prophylactic intravenous antibiotics at the time of induction of anesthesia, consisting of cefazolin 2 g or clindamycin 900 mg in participants with a penicillin allergy. The surgery was performed by gynecologists at Khon Kaen Hospital using the same standard surgical procedure and standard equipment in a single operating room. The types of incisions used were low midline, Pfannenstiel, and Maylard incisions, depending on the participant's condition. Following the operation, treatment allocation was determined in consecutive order by the attending physicians. The envelopes containing curcumin capsules or placebo were opened by an uninformed

nurse at the ward. The participants in the intervention group (group A) received 500 mg curcumin capsules 4 times/day, at 6.00 am, 12.00 am, 5.00 pm, and 10.00 pm on the next day when the step diet started and continued for 72 hours after the operation. The control group (group B) received placebo at the same time. The time was counted by the central digital clock in the gynecologic ward. All participants received the same postoperative protocol, including standard pain management with an opioid agent (intravenous morphine 2 mg for participants weighing less than 50 kg or 3 mg for those weighing 50 kg or more) every 4 hours for the first 24 hours after surgery, followed by as-needed administration every 4 hours on the following day, with a maximum dose of 18 mg/day. Other standard analgesic medications included paracetamol (500 mg), one tablet orally every 6 hours around the clock, which was administered on postoperative days 1 and 2. Nonsteroidal anti-inflammatory drugs (NSAIDs), specifically ibuprofen (400 mg), one tablet orally after meals, were administered on postoperative days 1 and 2, except in participants with severe dyspepsia, chronic kidney disease, or NSAID allergy. Antiemetic medication, specifically metoclopramide (10 mg intravenously), was administered as needed every 8 hours on postoperative day 1, with a maximum dose of 30 mg/day. Additional antiemetic medications requested by participants on postoperative day 2 and 3 were recorded as additional antiemetic medication use, which was included as a secondary outcome. The postoperative protocol was prepared for all participants using the same physician's standardized postoperative orders. Intravenous fluids were administered during the first 24 hours after surgery at the maintenance rate calculated using the Holliday–Segar formula. Early ambulation on the day after surgery was performed. The urinary catheter was removed on the first postoperative morning. The postoperative feeding regimen (30–60 mL of water, clear liquids, and a soft diet) was allowed on the first postoperative day or as tolerated by the participants, and a regular diet was started on the second postoperative day. After participants regained consciousness, their outcomes were collected, and symptoms were reported to the ward staff (doctors or nurses), and then recorded in the medical records. The primary outcome was the presence of ileus symptoms, defined as a moderate-to-severe score on the I-FEED scoring system, which was calculated at 72 hours after surgery by doctors or nurses at the ward. The secondary outcomes included the time to first flatus after surgery, time to first defecation after surgery, use of additional antiemetic drugs, epigastric pain, and diarrhea. These outcomes were recorded in the morning on postoperative days 1, 2, and 3. If a participant did not pass stool before hospital discharge, a follow-up phone call was made within 3 days after discharge to assess defecation. The standard time was set by the central digital clock in the gynecologic ward. Adverse effects of curcumin, including epigastric discomfort, bloating, skin rash, or diarrhea, were observed by doctors or nurses. If an adverse effect occurred, the doctor assessed the symptoms and provided appropriate treatment, and the symptoms were closely observed until they improved. The participants could be discharged when they had stable vital signs without fever for at least 24 hours, could tolerate a solid diet, had normal urination and passage of flatus, had no vaginal bleeding or abdominal pain, experienced no surgical complications, and were able to walk independently.

Data were analyzed using the R statistical software, version 4.6.0. For comparisons of the differences in continuous variables between the two groups, the normality of data distribution was assessed using the Shapiro–Wilk test. Based on the distribution of the data, either student's t-test or the Wilcoxon rank-sum test was used, as appropriate, and data were presented as mean with standard deviation or median with interquartile range. Categorical variables were analyzed via the Pearson's chi-square test or Fisher's exact test and presented as percentages. The Kaplan-Meier curve illustrated the difference in time to first flatus and time to first defecation between the curcumin group and the

control group, as determined by the Peto & Peto test. A p value < 0.05 was considered statistically significant.

Based on the ethical principles of research aimed at protecting human rights, security, and human dignity, this proposal was approved by the Khon Kaen Hospital Institute Review Board in Human Research (KEF68032), and the study was registered at the Thai Clinical Trials Registry (TCTR20260220002).

Results

From November 2025 to July 2026, 56 participants who underwent hysterectomy via benign gynecologic surgery were enrolled and randomly assigned to one of two groups at a ratio of 1:1. There were no dropouts in this study. Twenty-eight participants each from the two groups were analyzed (Fig.1). Baseline characteristics showed no statistically significant difference between the two groups in terms of age, body mass index, previous abdominal surgery, preoperative bowel preparation, type of operation, skin incision, abdominal adhesion, duration of operation, and estimated blood loss (Table 1).

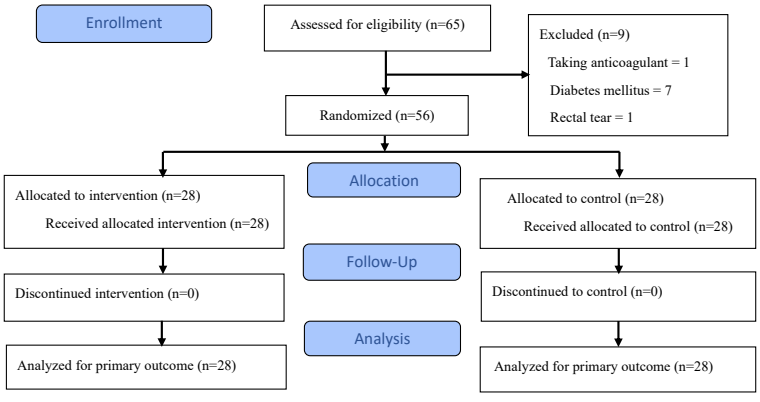


Fig. 1. Consort flow diagram

Table 1. Demographic characteristics.

	Intervention group (n = 28)	Control group (n = 28)	p value
Age (years), mean ± SD	46.9 ±7.6	47.2 ± 9.5	0.906
BMI (kg/m^2), mean ± SD	24.4 ± 3.9	24.4 ± 4.2	0.976
Previous abdominal surgery, n (%)	24.4 (4.2)	22 (78.6)	0.153
Preoperative bowel preparation, n (%)	7 (25)	14 (50)	0.098
Operation, n (%)			0.775
TAH with salpingectomy	10 (35.7)	8 (28.6)	
TAH with salpingo-oophorectomy	18 (64.3)	20 (71.4)	
Skin incision, n (%)			0.106
Low midline	9 (32.1)	16 (57.1)	
Pfannenstiel	18 (64.3)	12 (42.9)	
Maylard	1 (3.6)	0 (0)	
Abdominal adhesion, n (%)	6 (21.4)	9 (32.1)	0.546
Operative time (min), mean ± SD	103.9 ± 38.5	118.5 ± 36.8	0.151
EBL (ml), median (IQR)	100 (50,200)	175 (95,225)	0.105
Time from surgery close to start of intervention (hours), mean ± SD	17.2 ± 1.8	16.5 ± 2.2	0.2

SD: standard deviation, IQR: interquartile range, BMI: body mass index, EBL: estimated blood loss, TAH: total abdominal hysterectomy BMI: body mass index

The ileus symptoms were categorized by the I-FEED scoring system. Moderate symptoms (score 3-5) and severe symptoms (score > 6) were defined as postoperative ileus, and those in the intervention group were revealed to be significantly lower when compared to the control group. The incidence of ileus symptoms in the intervention group was 4 (14.3%), and in the control group was 14 (50%) (relative risk (RR) 0.29, 95% confidence interval (CI) 0.11, 0.74, p = 0.01) (Table 2). In addition, time to first flatus was 36 ± 12.6 hours and 35.7 ± 12.5 hours in the curcumin group and the control group, respectively. The mean difference was 0.39 hours (95%CI -6.39, 7.10). Time to first defecation was 66.3 ± 27.8 hours and 68.8 ± 16.6 hours in the curcumin group and the control group, respectively. The mean difference was -2.53 hours (95%CI -14.87, 9.82). No significant difference was observed in time to first flatus and time to first defecation; Kaplan-Meier curves of time to first flatus and time to first defecation were analyzed as time-to-event (Figs. 2 and 3). Furthermore, additional antiemetic drugs, stomach pain, and diarrhea were not significantly different between groups (Table 2). There were no serious adverse effects reported.

Table 2. Outcomes.

	Intervention group	Control group	RR	mean difference	95% CI	p value
Primary outcome						
Ileus symptoms, n (%)	4 (14.3)	14 (50)	0.29		0.11, 0.74	0.01
Secondary outcomes						
Time to first flatus (min), mean ± SD	36 ± 12.6	35.7 ± 12.5		0.36	-6.39, 7.10	0.916
Time to first defecation (min), mean ± SD	66.3 ± 27.8	68.8 ± 16.6		-2.53	-14.87, 9.82	0.682
Additional antiemetic drugs, n (%)	9 (32.1)	10 (35.7)				1.000
Stomach pain, n (%)	1 (3.6)	3 (10.7)				0.611

SD: standard deviation, CI: confidence interval

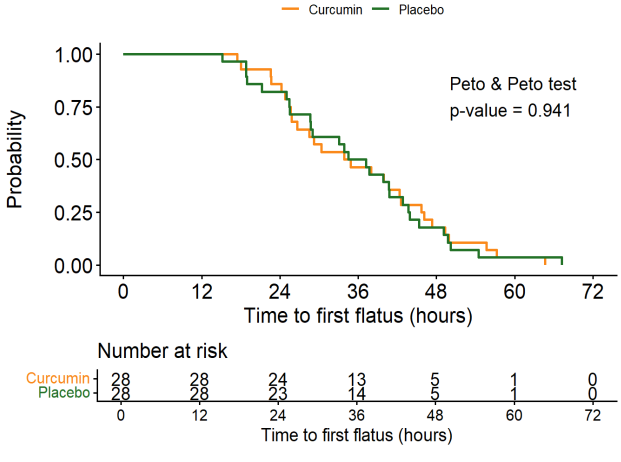


Fig. 2. Time to first flatus (hours)

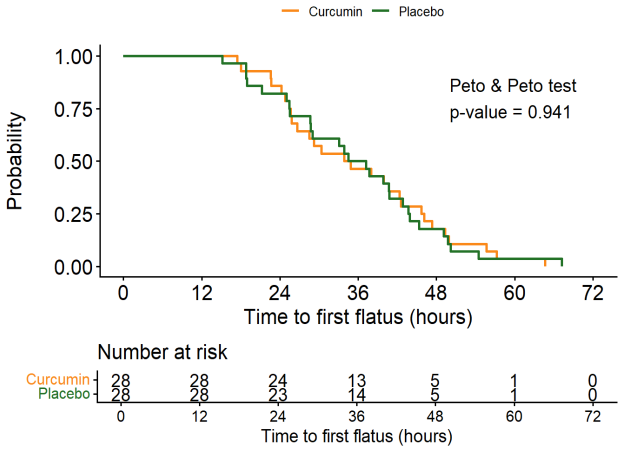


Fig. 3. Time to first defecation (hours)

Discussion

This double-blind, randomized, placebo-controlled trial aimed to evaluate the efficacy of curcumin for reducing postoperative bowel ileus after benign gynecologic surgery. The study revealed that the incidence of ileus symptoms in the intervention group was significantly lower when compared to the control group (4 (14.3%) vs. 14 (50%), RR 0.29, 95%CI 0.11, 0.74, p = 0.01). This supported the theory that curcumin could promote the recovery of bowel function after surgery and reduce postoperative ileus. The findings in this study were consistent with several previous studies. Woźniak et al[11] conducted a randomized trial in participants who were diagnosed with irritable bowel syndrome. They found that, in the intervention group, taking curcumin orally at a dose of 600 mg once daily during a meal for a 12-week period showed a statistically and significantly lower score for irritable bowel syndrome symptom severity (IBS-SSS) compared to the control group. Correspondingly, Lopresti et al[12] studied adults with self-reported digestive complaints. The intervention group received 500 mg of curcumin extract, and the control group received placebo. They found that curcumin was associated with a significantly greater reduction in the gastrointestinal symptom rating scale (GSRS) total score compared to the placebo. In both previous studies, as in the present study, curcumin was a simple intervention with minimal risk and potential clinical benefits in improving gastrointestinal symptoms. In this study, oral curcumin was administered at a dose of 500 mg four times daily, corresponding to a total daily dose of 2,000 mg. Postoperative bowel ileus was assessed at 72 hours after surgery, and the incidence of postoperative bowel ileus was significantly reduced in the curcumin group compared with the control group. These findings are consistent with those of Agarwal et al[13], who administered curcumin at a dose of 500 mg every 6 hours, also corresponding to a total daily dose of 2,000 mg. In their study, participants receiving curcumin demonstrated significantly lower pain scores and reduced postoperative fatigue on postoperative day 3 compared with the control group. Taken together, these findings suggest that a total curcumin dose of 2,000 mg/day may have beneficial effects on postoperative

recovery, including gastrointestinal function, pain, and postoperative fatigue.

In addition, oral curcumin was administered at a dose of 2,000 mg/day in this study, and no adverse events were observed, including pruritus, bloating, epigastric discomfort, or diarrhea. These findings support the favorable safety profile of curcumin at the dose used in this study. However, previous evidence has reported adverse effects at higher or varying doses. A systematic review by Hewlings and Kalman et al[15] found that some negative side effects have been reported. Seven subjects receiving 500–12,000 mg in a dose-response study and followed for 72 hours experienced diarrhea, headache, rash, and yellow stool. Therefore, the absence of adverse events in the current study may be related, at least in part, to the dose and duration of curcumin administration. Nevertheless, differences in study design, sample size, dosing regimen, and duration of follow-up should be considered when comparing safety outcomes across studies.

In addition, this study found that the number of participants requiring additional antiemetic medication was lower in the curcumin group than in the placebo group (9 (32.1%) vs 10 (35.7%), p = 1.000). Similarly, the incidence of stomach pain was lower in the curcumin group than in the placebo group (1 (3.6%) vs 3 (10.7%), p = 0.611). Although these differences did not reach statistical significance, the observed trends may suggest a potential benefit of postoperative curcumin in alleviating mild gastrointestinal discomfort or symptoms that may not be severe enough to warrant a specific diagnosis but could still affect postoperative recovery. However, the relatively low incidence of these outcomes may have limited the ability of the study to detect clinically meaningful differences.

No statistically significant differences were observed between the two groups in terms of time to first flatus, time to first defecation after surgery, or diarrhea. Time to first flatus and time to first defecation are subjective clinical outcomes because they rely on participants' observation and reporting to determine the recovery of gastrointestinal function. Therefore, these measures may be subject to reporting variability and may have limited the ability to detect differences between the groups. Furthermore, no cases of diarrhea were observed in either group. This finding may be explained by the relatively low incidence of postoperative diarrhea, particularly in participants who undergo preoperative fasting and have limited oral intake during the perioperative period.

The strengths of this study included its randomized controlled design and the absence of dropouts. The limitations of this study included the time to first flatus and time to first defecation being based on participant reports, which may have introduced some subjectivity in assessing bowel function recovery, as well as participants receiving meals according to the hospital's routine schedule rather than according to the time elapsed after surgery. This may have affected the assessment of time to first flatus and time to first defecation.

Conclusion

In summary, curcumin intake following total abdominal hysterectomy in benign gynecologic conditions showed significantly lower incidences of ileus symptoms. There were no serious adverse effects reported, supporting the safe and effective use of curcumin in postoperative care.

Acknowledgement

The authors would like to sincerely thank all the physicians and nurses in the gynecologic ward for their assistance, and the Department of Obstetrics and Gynecology at Khon Kaen Hospital for their support. The authors also extend their gratitude to the participants for their cooperation.

Potential conflicts of interest

The authors declare no competing interests.

References

1. Chalermchockcharoenkit A, Tanmahasamut P. The trend shifts in hysterectomy technique in Siriraj Hospital. J Siriraj Med 2007;59:325-7.
2. Clarke-Pearson DL, Geller EJ. Complications of hysterectomy. Obstet Gynecol 2013;121:654-73.
3. Venara A, Neunlist M, Slim K, Barbieux J, Colas PA, Hamy A, et al. Postoperative ileus: pathophysiology, incidence, and prevention. J Visc Surg 2016;153: 439-46.
4. Vather R, Trivedi S, Bissett I. Defining postoperative ileus: results of a systematic review and global survey. J Gastrointest Surg 2013;17:962-72.
5. Luckey A, Livingston E, Taché Y. Mechanisms and treatment of postoperative ileus. Arch Surg 2003;138:206-14.
6. Dou Y, Luo J, Wu X, Wei Z, Tong B, Yu J, et al. Curcumin attenuates collagen-induced inflammatory response through the "gut-brain axis". J Neuroinflammation 2018;15:6.
7. Tu X, Ren H, Bu S. Therapeutic effects of curcumin on constipation-predominant irritable bowel syndrome is associated with modulating gut microbiota and neurotransmitters. Front Microbiol 2023;14:1274559.
8. Peterson CT, Vaughn AR, Sharma V, Chopra D, Mills PJ, Peterson SN, et al. Effects of turmeric and curcumin dietary supplementation on human gut microbiota: a double-blind, randomized, placebo-controlled pilot study. J Evid Based Integr Med 2018;23:2515690X18790725.
9. Shen L, Liu L, Ji HF. Regulative effects of curcumin spice administration on gut microbiota and its pharmacological implications. Food Nutr Res 2017;61:1361780.
10. Wang J, Ghosh SS, Ghosh S. Curcumin improves intestinal barrier function: modulation of intracellular signaling and organization of tight junctions. Am J Physiol Cell Physiol 2017;312:C438-45.
11. Woźniak M, Fabisiak A, Talar-Wojnarowska R, Małecka-Wojciesko E. The effect of curcumin on symptoms and quality of life in patients with irritable bowel syndrome. Adv Hyg Exp Med 2022;76: 345-50.
12. Lopresti AL, Smith SJ, Rea A, Michel S. Efficacy of a curcumin extract (Curcugen™) on gastrointestinal symptoms and intestinal microbiota in adults with self-reported digestive complaints: a randomised, double-blind, placebo-controlled study. BMC Complement Med Ther 2021;21:40.
13. Agarwal KA, Tripathi CD, Agarwal BB, Saluja S. Efficacy of turmeric (curcumin) in pain and postoperative fatigue after laparoscopic cholecystectomy: a double-blind, randomized placebo-controlled study. Surg Endosc. 2011;25: 3805-10.
14. Phoolcharoen N, Oranratanaphan S, Ariyasriwatana C, Worasethsin P. Efficacy of curcuminoids for reducing postoperative pain after laparoscopic gynecologic surgery: a pilot randomized trial. J Complement Integr Med 2019;16.
15. Hewlings SJ, Kalman DS. Curcumin: a review of its effects on human health. Foods 2017;6:92.

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 480-490.

GYNAECOLOGY

The New Scoring System for Predicting Positive Surgical Margins of High-grade Cervical Intraepithelial Neoplasia after Loop Electrosurgical Excision Procedure

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ABSTRACT

Objectives: To develop prediction score for positive surgical margins after loop electrosurgical excision procedure (LEEP) in women with high-grade cervical intraepithelial neoplasia.

Materials and Methods: A diagnostic predictive model study was conducted during January 2025 to December 2026. Medical records of women with histologically confirmed cervical intraepithelial neoplasia 2/3 who underwent primary LEEP at HRH Princess Maha Chakri Sirindhorn Medical Center were reviewed between January 2017 and December 2023. Independent predictors identified by multivariable logistic regression were converted into a risk score based on regression coefficients. Model performance was assessed using area under the curve (AUC), calibration belt, and bootstrap internal validation.

Results: A total of 207 women were included. Four independent predictors were incorporated into the final model: endocervical gland involvement, transformation zone type, high-grade cytology, and cone depth. The total score ranged from 0 to 7. At a cutoff score of ≥ 4, the model yielded a sensitivity of 83.18%, specificity of 58%, positive predictive value of 67.9%, and negative predictive value of 76.3%. The model showed acceptable discrimination with AUC of 0.739 (95% confidence interval 0.672-0.807), with satisfactory calibration and good internal validity following bootstrap validation.

Conclusion: The prediction model can assist clinicians in estimating positive margin risk and optimizing surgical planning.

Keywords: cervical intraepithelial neoplasia, loop electrosurgical excision procedure, positive surgical margin, prediction model.

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Received: 6 September 2026, **Revised:** 28 September 2026, **Accepted:** 2 October 2026

ดัชนีใหม่ทำนายความเสี่ยงในการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้า

ณัฏฐา แสงสีทอง, นพพร โรจน์เพ็ญเพียร

บทคัดย่อ

วัตถุประสงค์: *เพื่อสร้างดัชนีใหม่ทำนายความเสี่ยงในการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้าในสตรีที่พบรอยโรคของปากมดลูกก่อนเป็นมะเร็งขั้นสูง*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาเพื่อพัฒนาดัชนีการทำนาย โดยการศึกษาทบทวนเวชระเบียนของสตรีที่พบรอยโรคของปากมดลูกก่อนเป็นมะเร็งขั้นสูง (cervical intraepithelial neoplasia 2/3) และได้รับการรักษาด้วย loop electrosurgical excision procedure เป็นครั้งแรก ณ ศูนย์การแพทย์สมเด็จพระเทพรัตนราชสุดาฯ สยามบรมราชกุมารี ระหว่างเดือนมกราคม 2560 ถึงเดือนธันวาคม 2566 ตัวแปรทำนายที่ได้จากการวิเคราะห์การถดถอยโลจิสติกพหุตัวแปร (multivariable logistic regression) ถูกนำมาพัฒนาเป็นคะแนนความเสี่ยงตามค่าสัมประสิทธิ์ ประเมินประสิทธิภาพของแบบจำลองด้วยพื้นที่ใต้โค้ง (area under the curve; AUC) และประเมินการสอบเทียบของดัชนีด้วย calibration belt และการตรวจสอบความเที่ยงตรงภายในด้วยวิธี bootstrap*

ผลการศึกษา: *มีสตรีเข้าร่วมการศึกษาทั้งหมด 207 ราย พบตัวแปรทำนาย 4 ตัวแปรที่นำมาใช้ในดัชนีทำนาย ได้แก่ การตรวจพยาธิวิทยาพบ endocervical gland involvement ชนิดของ transformation zone ผลตรวจเซลล์วิทยาปากมดลูกระดับ high-grade และระดับความลึกของการตัดปากมดลูก คะแนนรวมอยู่ในช่วง 0-7 คะแนน เมื่อใช้จุดตัดที่มากกว่าเท่ากับ 4 คะแนน ดัชนีทำนายมีความไวร้อยละ 83.18 ความจำเพาะร้อยละ 58 ค่าทำนายผลบวกร้อยละ 67.9 และค่าทำนายผลลบร้อยละ 76.3 ดัชนีทำนายมีความสามารถในการจำแนกอยู่ในระดับที่ยอมรับได้ โดยมีพื้นที่ใต้โค้งเท่ากับ 0.739 (95% CI 0.672-0.807) มีการประเมินการสอบเทียบที่ดีและความเที่ยงตรงภายในที่ดีหลังการตรวจสอบด้วยวิธี bootstrap*

สรุป: *ดัชนีทำนายนี้สามารถช่วยแพทย์ในการประเมินความเสี่ยงของการพบรอยโรคบริเวณขอบชิ้นเนื้อหลังการตัดปากมดลูกด้วยห่วงลวดไฟฟ้าและเป็นประโยชน์ในการวางแผนผ่าตัดต่อไป*

คำสำคัญ: *รอยโรคก่อนมะเร็งปากมดลูก, การตัดปากมดลูกด้วยห่วงลวดไฟฟ้า, การพบรอยโรคบริเวณขอบชิ้นเนื้อ, ดัชนีการทำนาย*

Introduction

Cervical cancer remains the fourth most common cancer among women worldwide[1], with an estimated 661,021 new cases and 348,189 deaths reported in 2022. Despite substantial reductions in disease burden following the implementation of cervical cancer screening programs, cervical cancer continues to represent a major public health problem, particularly in low- and middle-income countries[2]. In Thailand, cervical cancer remains one of the leading malignancies among women[3], highlighting the importance of effective screening and timely treatment of cervical precancerous lesions[4].

High-grade cervical intraepithelial neoplasia grades 2 and 3 (CIN2/3) are well-established precursor lesions with significant malignant potential if left untreated. American Society for Colposcopy and Cervical Pathology recommend excisional treatment for most women with histologically confirmed high-grade squamous intraepithelial lesion, particularly when the transformation zone is not fully visualized, endocervical involvement is suspected, or invasive disease cannot be excluded[5]. Loop electrosurgical excision procedure (LEEP) has become the most widely used excisional treatment because it is effective, minimally invasive, cost-effective, and can be performed safely in an outpatient setting[6]. In addition to providing definitive treatment, LEEP allows histopathological evaluation of the excised specimen, including assessment of surgical margin status, which is an important predictor of treatment success.

Positive surgical margins after LEEP have consistently been associated with an increased risk of residual or recurrent cervical intraepithelial neoplasia, persistent high-risk human papillomavirus infection, repeat excisional procedures, and subsequent hysterectomy in selected patients[7]. A previous Thai study evaluating hysterectomy specimens after LEEP or cold-knife conization demonstrated that residual disease remained an important finding following excisional treatment, highlighting the importance of adequate lesion removal and subsequent surveillance[8]. Although not all women with positive margins develop recurrent disease, margin status remains one of the strongest pathological predictors guiding postoperative surveillance and further management[9, 10]. Several clinical and pathological factors associated with positive surgical margins have been reported, including advanced age, menopausal status, abnormal cervical cytology, extensive lesion involvement, transformation zone type, endocervical gland involvement, lesion extension into the endocervical canal, and inadequate cone depth[11-14]. Based on these predictors, Zhu et al developed a clinical scoring system to estimate the risk of positive margins after cervical excision[15]. However, their model incorporated endocervical curettage (ECC) findings, a procedure not routinely performed in all women undergoing LEEP, thereby limiting its applicability in routine clinical practice. Furthermore, the model has not been externally validated in Thai women, whose clinical characteristics and treatment practices may differ from those of the original study population.

To date, no clinical prediction model has been developed specifically for the Thai population to estimate the risk of positive surgical margins following LEEP. Therefore, this study aimed to develop and internally validate a simple clinical prediction score, using routinely available variables, to predict positive surgical margins after LEEP in women with high-grade cervical intraepithelial neoplasia (CIN2/3). Additionally, we evaluated its diagnostic performance.

Materials and Methods

This diagnostic predictive model study was conducted at Her Royal Highness Princess Maha Chakri Sirindhorn Medical Center, Faculty of Medicine, Srinakharinwirot University, Thailand. Medical records of women who underwent LEEP between January 2017 and December 2023 were reviewed. The study protocol was approved by the Institutional Ethics Committee of Srinakharinwirot University (Approval No. SWUEC-673062) and was registered on the Thai Clinical Trials Registry (TCTR20250801001).

Women aged 18 years or older with histologically confirmed cervical intraepithelial neoplasia grade 2 or grade 3 (CIN2/3) who underwent their first LEEP and had all required data in medical record were eligible for inclusion. Patients were excluded if they had a previous diagnosis of invasive cervical cancer or other malignancies, invasive carcinoma identified on the final LEEP specimen, pregnancy at the time of treatment, or incomplete pathological reports that precluded evaluation of surgical margin status.

Demographic and clinical data were retrieved from medical records. The collected variables included age, parity, menopausal status, preoperative cervical cytology, transformation zone (TZ) type, satisfactory colposcopy, lesion quadrant involvement, cone depth, pathological margin status and endocervical gland involvement. Cervical cytology was categorized as low-grade group (atypical squamous cells of undetermined significance (ASC-US), low-grade squamous intraepithelial lesion (LSIL), atypical glandular cells, not otherwise specified (AGC-NOS)) or high-grade group (atypical squamous cells, cannot exclude HSIL (ASC-H), high-grade squamous intraepithelial lesion (HSIL), atypical glandular cells, favor neoplasia (AGC-FN)), adenocarcinoma, squamous cell carcinoma) according to the Bethesda System[16]. The transformation zone was classified as type 1, type 2, or type 3 according to the International Federation for Cervical Pathology and Colposcopy (IFCPC) nomenclature[17]. Endocervical gland involvement was determined from histopathological examination of pre-LEEP cervical biopsy. Cone depth was obtained from the final pathology report. Because the pathological measurement was performed after formalin fixation, the reported cone depth was adjusted for potential tissue shrinkage by adding 15% to the measured value. The adjusted cone depth was used in the statistical analysis and prediction model[18].

The primary outcome was the presence of a positive surgical margin after LEEP. A positive margin was defined as the presence of CIN involving either the ectocervical or endocervical or deep resection margin on the final histopathological report. A negative margin was defined as the absence of dysplastic epithelium at all surgical margins.

The sample size calculation was based on the area under the receiver operating characteristic curve (AUC) from a previous predictive index. The study by Zhu et al reported an AUC of 0.769 for predicting margin positivity. We hypothesized that our newly developed index would demonstrate superior predictive performance, with an anticipated AUC of 0.88. Given the observed ratio of positive to negative surgical margins (1:3) at Her Royal Highness Princess Maha Chakri Sirindhorn Medical Center, the sample size was calculated using the MedCalc online tool for ROC curve analysis(19). With a two-sided alpha error of 5% ($\alpha = 0.05$) and a statistical power of 80%, the minimum required sample size was determined to be 196 participants. Accounting for an estimated 5% rate of incomplete data, the total required sample size was adjusted to 207 participants, comprising 155 patients in the negative margin group and 52 patients in the positive margin group. Continuous variables were summarized as mean ± standard deviation (SD) and compared using the independent student's t-test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate. Variables with $p < 0.20$ in the univariable analysis were included in the multivariable logistic regression model to identify independent predictors of positive surgical margins. Adjusted odds ratio (aOR) with 95% confidence intervals (CIs) were reported.

A clinical prediction score was subsequently developed based on the final multivariable logistic regression model. The regression coefficient of each independent predictor was divided by the smallest coefficient in the model and rounded to the nearest integer to generate an assigned score for practical clinical use (final model). The total score was calculated by summing the assigned scores of all predictors. The predictive performances of the original regression model (original model) and the simplified prediction score model (final model) were then compared using the area under the receiver operating

characteristic curve (AUC). As there were no missing data among the variables included in the analysis, no imputation was required.

The discriminative ability of the prediction model was assessed using the AUC with a 95% CI. The cutoff score was selected by examining the receiver operating characteristic (ROC) curve and identifying the threshold that provided an appropriate balance between sensitivity and specificity. Calibration was evaluated using the calibration belt, and internal validation was performed using 1,000 bootstrap resampling. The diagnostic performance of different cutoff values was assessed by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). All statistical analyses were performed using Stata version 14 (StataCorp LP, College Station, TX, USA). A two-sided p value of < 0.05 was considered statistically significant.

Results

A total of 237 women with histologically confirmed CIN 2/3 who underwent LEEP between January 2017 and December 2023 were initially identified. After applying the exclusion criteria, 30 women were excluded: 27 with invasive cervical cancer identified on final histopathology and 3 with a history of prior malignancy. The remaining 207 women were included in the final analysis (Fig. 1). Among the 207 eligible women, 107 (51.7%) had positive surgical margins, whereas 100 (48.3%) had negative surgical margins following LEEP.

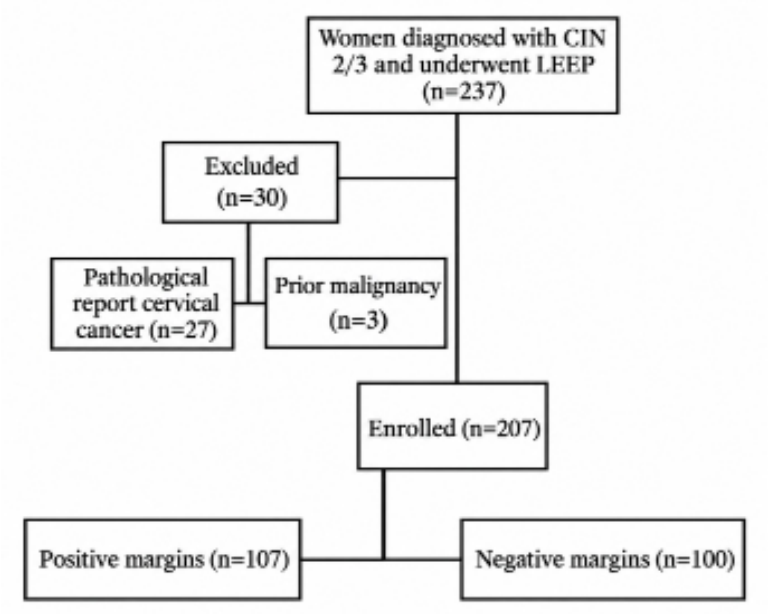


Fig. 1. Consort flow diagram.

CIN: cervical intraepithelial neoplasia, LEEP: loop electrosurgical excision procedure

The baseline demographic and clinicopathological characteristics of the study population are summarized in Table 1. Compared with women with negative surgical margins, those with positive surgical margins were older (40.47 ± 9.92 vs 37.42 ± 8.66 years, $p = 0.019$), had a lower mean cone depth (7.08 ± 2.67 vs 8.79 ± 3.49 mm, $p < 0.001$), and were more likely to have high-grade cytology, endocervical gland involvement, and a non-type 1 (type 2 or 3) transformation zone. Conversely, parity, menopausal status, satisfactory colposcopy, and lesion quadrant involvement were not significantly different between the two groups.

Table 1. Demographic characteristics of the patients.

Clinical characteristics	Positive margin (n = 107)	Negative margin	p value
Age (years), mean ± SD	40.47 ± 9.92	37.42 ± 8.66	0.019
Parity, n (%)			0.155
0	22 (48.89)	23 (51.11)	
1	30 (42.25)	41 (57.75)	
2	39 (62.9)	23 (37.1)	
3	13 (59.09)	9 (40.91)	
4	2 (33.33)	4 (66.67)	
5	1 (100)	0 (0)	
Menopausal status, n (%)			0.147
Pre-menopause	93 (50)	93 (50)	
Post-menopause	14 (66.67)	7 (33.33)	
Cone depth (mm), mean ± SD	7.08 ± 2.67	8.79 ± 3.49	
Cytology, n (%)			< 0.001
Low grade	16 (30.19)	37 (69.81)	
High grade	91 (59.09)	63 (40.91)	
Endocervical gland involvement, n (%)			< 0.001
Yes	88 (61.11)	56 (38.89)	
No	19 (30.16)	44 (69.84)	
Satisfactory colposcopy, n (%)			0.085
Yes	93 (49.73)	94 (50.27)	
No	14 (70)	6 (30)	
Type of transformation zone, n (%)			0.001
Type 1	70 (44.59)	87 (55.41)	
Type 2	24 (77.42)	7 (22.58)	
Type 3	13 (68.42)	6 (31.58)	
Quadrant of lesion, n (%)			0.182
No lesson	11 (45.83)	13 (54.17)	
1	38 (44.19)	48 (55.81)	
2	32 (55.17)	26 (44.83)	
3	14 (70)	6 (30)	
4	12 (63.16)	7 (36.84)	

SD: standard deviation

Multivariable logistic regression analysis identified four factors independently associated with positive surgical margins after LEEP: endocervical gland involvement on pre-LEEP biopsy (aOR 2.98, 95% CI 1.504, 5.914), non-type 1(type 2 or 3) versus type 1 transformation zone (aOR 3.13, 95% CI 1.484, 6.609), high-grade versus low-grade cytology (aOR 2.402, 95% CI 1.166, 4.945), and cone depth < 7.21 versus ≥ 7.21 mm (aOR 2.06, 95% CI 1.124, 3.784). Based on the regression coefficients, assigned scores were 2, 2, 2, and 1 point, respectively, yielding a total score ranging from 0 to 7 points (Table 2). The optimal cone depth cutoff of 7.21 mm was based on the study by Srijarusith and Rodpenper, which recommended this depth to achieve a higher likelihood of negative surgical margins[13]. The original model demonstrated an AUC of 0.747 (95% CI 0.681, 0.814), while the final simplified model achieved an AUC of 0.739 (95% CI 0.672, 0.807), with no statistically significant difference between the two (p = 0.114). Thus, the predictive performance of the final model was comparable to that of the original model (Fig. 2).

Table 2. Multivariable analysis and assigned score.

Predictive variable	Adjusted odds ratio	95%CI	p value	Coefficient	Assigned score
Endocervical gland involvement on pre-LEEP biopsy: Yes vs No	2.98	1.504-5.914	0.002	1.092832	2
Type of transformation zone: non-Type 1 vs type 1	3.13	1.484-6.609	0.003	1.14184	2
Cytology: high grade vs low grade	2.402	1.166-4.945	0.017	0.8761978	2
Cone depth < 7.21 vs ≥7.21 mm*	2.06	1.124-3.784	0.019	0.7239634	1

*Appropriate cone depth was at least 7.21 mm. to achieve negative margin
CI: confidence intervals, LEEP: loop electrosurgical excision procedure

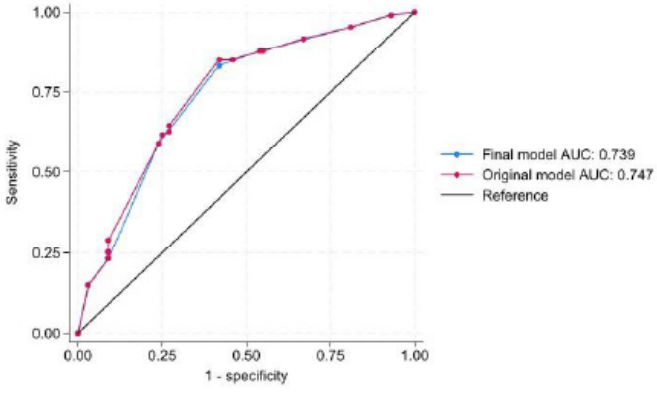


Fig. 2. Compare performance between original model and final model.
AUC: area under the curve

The diagnostic performance of the prediction score at different cutoff values is shown in Table 3. An optimal cutoff score of 4 yielded a sensitivity of 83.18%, specificity of 58.0%, positive predictive value of 67.9%, and negative predictive value of 76.3%. This cutoff was selected based on the optimal balance between sensitivity and specificity on the ROC curve, as well as the overall diagnostic accuracy of the model. The prediction model demonstrated acceptable discrimination, with an apparent AUC of 0.739 (95% CI 0.672, 0.807) (Fig. 3). After internal validation using 1,000 bootstrap resamples, the corrected AUC was 0.732 (95% CI 0.669, 0.803). The calibration belt showed no significant evidence of model miscalibration (p = 0.535), no observed data deviating above or below the bisector, and maintaining a narrow and consistent width across the entire predicted risk spectrum (Fig. 4).

Table 3. The diagnostic performance of the prediction score.

Cut-off point	Sensitivity	Specificity	Positive predictive value	Negative predictive value
≥ 0	100.00%	0.00%	51.6%	-
≥ 1	99.07%	7.00%	53.3%	87.5%
≥ 2	95.33%	19.00%	55.7%	79.2%
≥ 3	87.85%	46.00%	63.5%	78.0%
≥ 4*	83.18%	58.00%	67.9%	76.3%
≥ 5	58.88%	76.00%	72.4%	63.3%
≥ 6	23.36%	91.00%	73.5%	52.6%
≥ 7	14.95%	97.00%	84.2%	51.6%

* Optimal cut-off point

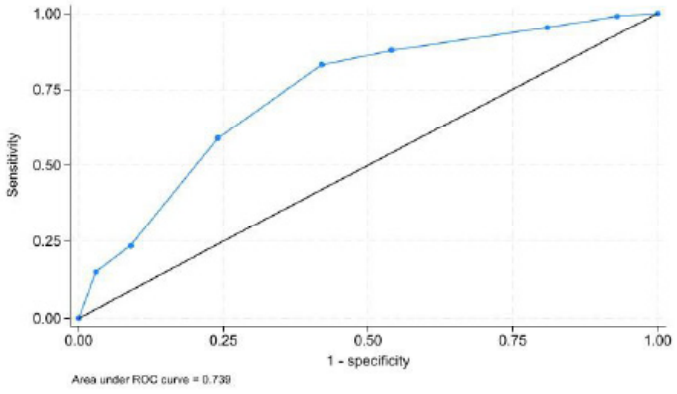


Fig. 3. The ROC curve of prediction model.
ROC: receiver operating characteristic

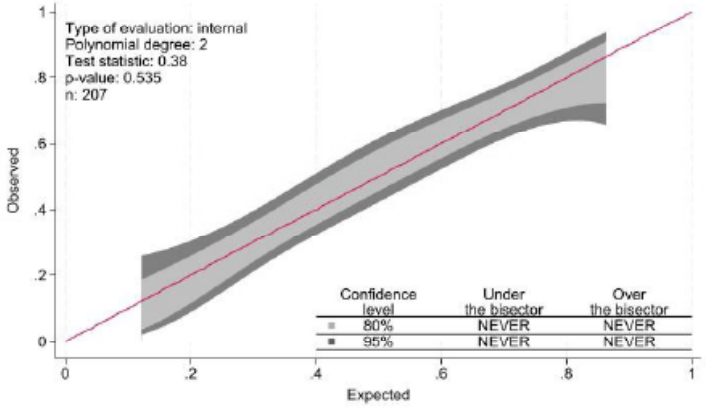


Fig. 4. The calibration belt.

Discussion

This study identified a combination of clinical, cervical cytology, cervical pathology, and procedural factors associated with positive surgical margins after LEEP. The resulting prediction model demonstrated acceptable discriminatory performance, suggesting that combining these routinely available factors may help identify women at increased risk of margin involvement. Achieving negative surgical margins remains clinically important because positive margins have consistently been associated with an increased risk of residual and recurrent cervical intraepithelial neoplasia[7]. Although not all women with positive margins develop recurrent disease, identifying factors associated with margin positivity may improve understanding of incomplete excision and inform future development of prediction tools that can be applied before or during the procedure[15].

Several prediction models for positive surgical margins have previously been proposed. Compared with the previously proposed model by Zhu et al[15], our model does not require routine endocervical curettage (ECC). This may facilitate its application in settings where ECC is not routinely performed before LEEP, as the prediction score can be calculated without requiring additional ECC findings. This feature may improve the practical applicability of the model within our clinical setting. Notably, all predictors in our proposed model can be determined prior to or during the LEEP procedure.

The positive margin rate in our study was higher than that reported in previous Thai studies. Champawong et al[20] reported a positive margin rate of 24.8% after LEEP, whereas Tanompongchat et al[21] reported margin involvement in 35.3% of women undergoing LEEP, which was consistent with prior institutional records. This elevated rate may partly reflect differences in temporal and geographical settings, as well as our institution's role as a tertiary care center receiving complex referral cases from diverse regions. Despite the difference in margin positivity, the factors identified in our model were broadly consistent with previous reports[13, 14, 22]. Endocervical gland involvement, transformation zone characteristics, high-grade cytology, and inadequate excision depth have all been associated with positive margin after excision. In our cohort, a type 2 transformation zone was significantly associated with margin positivity when compared with a type 1 transformation zone (aOR 3.59, 95% CI 1.35, 9.57, p = 0.011), whereas a type 3 transformation zone showed no significant association (aOR 1.95, 95% CI 0.66, 5.80, p = 0.228). This finding contrasts with previous studies that identified type 3 transformation zones as a primary risk factor[22], which may be attributed to the small number of participants with a type 3 transformation zone in our study. Consequently, the final model categorized transformation zones as type 1 versus non-type 1 (types 2 or 3).

An important potential application of the model relates to cone depth. Although actual cone depth was measured from the final pathological specimen in this study, the 7.21-mm threshold may serve as a practical reference for procedural planning. Surgeons could consider this threshold when selecting an appropriate loop size before LEEP and could measure the excised specimen immediately after the procedure. If the achieved depth is < 7.21 mm, particularly in women with a higher predicted risk based on the other model components, additional excision may be considered intraoperatively. This approach allows the scoring system to guide real-time decision-making during the pre- and intraoperative phases, rather than relying solely on postoperative pathological evaluation. The strengths of this study included, to our knowledge, the development of the first clinical prediction score for positive surgical margins after LEEP derived from a Thai population, the use of routinely available variables, and assessment of both discrimination and calibration. Internal validation using bootstrap resamples yielded a corrected AUC of 0.732, close to the apparent AUC of 0.739. Several limitations should be acknowledged. First, the retrospective, single-center design may limit the generalizability of our findings and introduced selection bias. Second, external validation was not performed, and long-term clinical outcomes, such as residual or recurrent disease, were unavailable. Third, the model is unable to predict site-specific margin positivity, namely ectocervical, endocervical, or deep surgical margins. Furthermore, this model is not applicable to the 'see-and-treat' approach, as pre-procedure histopathological confirmation of CIN 2/3 is required. Future prospective multicenter studies should externally validate the model. Incorporating additional predictors, such as high-risk human papillomavirus genotype or persistence, should be considered in future research. Furthermore, site-specific margin prediction would necessitate three distinct models requiring a significantly larger study population.

Conclusion

The prediction model comprising endocervical gland involvement, transformation zone type, cervical cytology, and cone depth can assist clinicians in estimating positive margin risk and optimizing surgical planning. It is user-friendly for routine clinical practice and demonstrates acceptable predictive performance and calibration.

Acknowledgement

This study was based on a dataset from HRH Princess Maha Chakri Sirindhorn Medical Center provided and produced by the Obstetric and Gynecological Department, Srinakharinwirot University.

Author contributions

Data curation, Formal analysis, Investigation, Methodology, Writing – first draft, **NS**, Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Methodology Funding acquisition, Writing – review and editing, **NR**.

Potential conflicts of interest

The authors declare no competing interests.

References

1. Bhatla N, Aoki D, Sharma DN, Sankaranarayanan R. Cancer of the cervix uteri: 2021 update. Int J Gynaecol Obstet 2021;155:28-44.
2. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2024;74:229-63.
3. Wongpratate M, Bumrungthai S. Cervical cancer in Thailand: 2023 update. Obstet Gynecol Sci 2024;67:261-9.
4. Ploysawang P, Rojanamatin J, Prapakorn S, Jamsri P, Pangmuang P, Seeda K, et al. national cervical cancer screening in Thailand. Asian Pac J Cancer Prev 2021;22:25-30.
5. Perkins RB, Guido RS, Castle PE, Chelmow D, Einstein MH, Garcia F, et al. 2019 ASCCP risk-based management consensus guidelines for abnormal cervical cancer screening tests and cancer precursors. J Low Genit Tract Dis 2020;24:102-31.
6. Tillmanns TD, Falkner CA, Engle DB, Wan JY, Mannel RS, Walker JL, et al. Preoperative predictors of positive margins after loop electrosurgical excisional procedure-Cone. Gynecol Oncol 2006;100:379-84.
7. Oh SH, Lee KB, Shin JW, Lee SH. Risk factors for recurrence of cervical intraepithelial neoplasia after loop electrosurgical excisional procedure in patients with positive margins. J Obstet Gynaecol Res 2023;49:2102-8.
8. Kumpasano T, Triratanachat S. Residual disease in hysterectomy specimens after loop electrosurgical excision or cold knife conization in high grade squamous intraepithelium lesion and microinvasive cervical carcinoma. Thai J Obstet Gynaecol 2017;19:67-73.
9. Ding T, Li L, Duan R, Chen Y, Yang B, Xi M. Risk factors analysis of recurrent disease after treatment with a loop electrosurgical excision procedure for high-grade cervical intraepithelial neoplasia. Int J Gynaecol Obstet 2023;160:538-47.
10. Suprasert P, Panyaroj W, Kietpeerakool C. Recurrent rates with cervical intraepithelial neoplasia having a negative surgical margin after the loop electrosurgical excision procedure in Thailand. Asian Pac J Cancer Prev 2009;10:587-90.
11. Ikeda M, Mikami M, Yasaka M, Enomoto T, Kobayashi Y, Nagase S, et al. Association of menopause, aging and treatment procedures with positive margins after therapeutic cervical conization for CIN 3: a retrospective study of 8,856 patients by the Japan Society of Obstetrics and Gynecology. J Gynecol Oncol 2021;32:e68.
12. Kanjanasirirut P, Pataradool K, Manusirivithaya S, Phaloprakarn C, Chavanisakun C. Prevalence and risk factors for positive surgical margin after loop electrosurgical excision procedure (LEEP) in patients with high grade squamous intraepithelial lesion. Thai J Obstet Gynaecol 2015;23:240-5.
13. Srijarusith N, Rodpenpear N. The appropriate of cone depth in loop electrical excision procedure (LEEP) for negative pathological margin from high grade precancerous lesion of cervix, retrospective study. Asian Pac J Cancer Prev 2022;23:659-64.
14. Cong Q, Yu Y, Xie Y, Li Y, Sui L. Risk factors of LEEP margin positivity and optimal length of cervical conization in cervical intraepithelial neoplasia. Front Oncol 2023;13:1209811.
15. Zhu M, Yu M, Chen Z, Zhao W. Construction and evaluation of a clinical prediction scoring system for positive cervical margins under colposcopy. Front Med (Lausanne) 2022;9:807849.
16. The Bethesda System for reporting cervical cytology. Definitions, criteria, and explanatory notes. Third dition. Anticancer Research 2015;35:5708.
17. Bornstein J BJ, Bosze P, Girardi F, Haefner H, Menton M, Perrotta M, et al. IFCPC colposcopic nomenclature. 2011.
18. Boonstra H, Oosterhuis JW, Oosterhuis AM, Fleuren GJ. Cervical tissue shrinkage by formaldehyde fixation, paraffin wax embedding, section cutting and mounting. Virchows Arch A Pathol Anat Histopathol 1983;402:195-201.
19. MedCalc Software Ltd. Sample size for area under ROC curve. https://www.medcalc.org/en/calc/sample-size-area-under-roc-curve.php (Version 23.7.1; accessed 30 November 2024)
20. Champawong R, Tangmanowuthikul S, Saenpoch S, Songthamwat S, Songthamwat M. Prevalence

and associated factors of positive margins of cervical tissue from loop electrosurgical excision procedure. Thai J Obstet Gynaecol 2019;27:187-94.
21. Tanompongchat R, Sangkarat S, Padungsutt P. Prevalence and risk factors of LEEP margin involvement. Thai J Obstet Gynaecol 2017;15:153-9.
22. Chen Y, Zhou JD. Application value of different transformation zone types and its genetic relationship with high-risk HPV type in diagnosis and therapy of cervical disease. Int J Clin Exp Med 2015;8:2447-52.

Thai Journal of Obstetrics and Gynaecology
November 2026, Vol. 34, No. 6, pp. 491-501.

OBSTETRICS

Three-Layer Anatomical Uterine Closure versus Conventional Two-Layer Closure for Early Cesarean Scar Sonographic Morphology: A randomized controlled trial

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ABSTRACT

Objectives: To compare early cesarean scar morphology between three-layer anatomical uterine closure and conventional two-layer closure, using the residual-to-adjacent myometrial thickness ratio (RMT/AMT) at 6 weeks postpartum as the primary outcome.

Materials and Methods: In this randomized controlled trial, 60 women undergoing primary cesarean delivery were assigned 1:1 to either a conventional two-layer group or a three-layer anatomical closure group, with randomization stratified by elective or emergency cesarean delivery. Transvaginal ultrasound was performed at 6 weeks postpartum by a blinded examiner. The primary outcome was the RMT/AMT ratio. Secondary outcomes included residual myometrial thickness, adjacent myometrial thickness, niche depth, niche length, niche depth/AMT ratio, niche presence, operative time, and estimated blood loss.

Results: All 60 participants received the allocated intervention, and sonographic outcomes were available for 56 participants (28 per group). The median RMT/AMT ratio was higher with three-layer anatomical closure than with conventional two-layer closure (0.800 [interquartile range, IQR 0.716, 1.000] vs 0.708 [IQR 0.604, 0.783], p = 0.007). Median niche depth was lower (2.4 [IQR 0, 3.1] vs 3.2 [IQR 2.55, 4.4] mm, p = 0.017), as was the median niche depth/AMT ratio (0.173 [IQR 0, 0.227] vs 0.234 [IQR 0.142, 0.318], p = 0.045). Median operative time was longer in the three-layer group (37 [IQR 33, 43] vs 33 [IQR 30, 36] minutes, p = 0.035), whereas estimated blood loss did not differ significantly between groups.

Conclusion: Three-layer anatomical uterine closure was associated with a higher RMT/AMT ratio and lower niche depth and niche depth/AMT ratio at 6 weeks postpartum than conventional two-layer closure. Operative time was slightly longer with the three-layer technique, whereas estimated blood loss did not differ significantly between groups. Longer-term studies are needed to determine the clinical significance of these early sonographic differences.

Keywords: cesarean delivery, uterine closure, three-layer closure, cesarean scar niche, residual myometrial thickness.

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Received: 22 August 2026, **Revised:** 14 October 2026, **Accepted:** 15 October 2026

การเย็บปิดมดลูกแบบ 3 ชั้นเชิงกายวิภาคเทียบกับการเย็บปิดแบบ 2 ชั้นตามวิธีปกติต่อลักษณะทางอัลตราซาวด์ของแผลเป็นจากการผ่าตัดคลอดระยะแรก: การทดลองแบบสุ่มมีกลุ่มควบคุม

อังคาร ตรีนิติ, เพียงฤทัย ริรัตนพงษ์

บทคัดย่อ

วัตถุประสงค์: *เพื่อเปรียบเทียบลักษณะทางอัลตราซาวด์ของแผลเป็นจากการผ่าตัดคลอดระยะแรก ระหว่างการเย็บปิดมดลูกแบบ 3 ชั้นเชิงกายวิภาคกับการเย็บปิดแบบ 2 ชั้นตามวิธีปกติ โดยใช้อัตราส่วนความหนาของกล้ามเนื้อมดลูกคงเหลือบริเวณแผลต่อความหนาของกล้ามเนื้อมดลูกข้างเคียง (RMT/AMT) ที่ 6 สัปดาห์หลังคลอดเป็นผลลัพธ์หลัก*

วัสดุและวิธีการ: *การทดลองแบบสุ่มมีกลุ่มควบคุมนี้ศึกษาในสตรีที่ได้รับการผ่าตัดคลอดครั้งแรกจำนวน 60 ราย สุ่มในอัตรา 1:1 ให้ได้รับการเย็บปิดมดลูกแบบ 2 ชั้นตามวิธีปกติหรือแบบ 3 ชั้นเชิงกายวิภาค โดยแบ่งชั้นการสุ่มตามการผ่าตัดคลอดแบบนัดหมายหรือฉุกเฉิน ประเมินด้วยอัลตราซาวด์ทางช่องคลอดที่ 6 สัปดาห์หลังคลอดโดยผู้ตรวจที่ไม่ทราบกลุ่มการรักษา ผลลัพธ์หลักคืออัตราส่วน RMT/AMT ส่วนผลลัพธ์รอง ได้แก่ ความหนาของกล้ามเนื้อมดลูกคงเหลือ ความหนาของกล้ามเนื้อมดลูกข้างเคียง ความลึกและความยาวของ niche อัตราส่วนความลึกของ niche ต่อ AMT การพบ niche ระยะเวลาผ่าตัด และปริมาณการเสียเลือดโดยประมาณ*

ผลการศึกษา: *ผู้เข้าร่วมทั้ง 60 ราย ได้รับการเย็บตามกลุ่มที่สุ่มไว้ และมีข้อมูลอัลตราซาวด์ที่ 6 สัปดาห์จำนวน 56 ราย กลุ่มละ 28 ราย ค่ามัธยฐาน RMT/AMT สูงกว่าในกลุ่มเย็บ 3 ชั้นเชิงกายวิภาค เมื่อเทียบกับกลุ่มเย็บ 2 ชั้น (0.800, IQR 0.716, 1.000] เทียบกับ 0.708 [IQR 0.604, 0.783], p = 0.007) ค่ามัธยฐานความลึกของ niche ต่ำกว่า (2.4 [IQR 0, 3.1] เทียบกับ 3.2 [IQR 2.55, 4.4] มม., p = 0.017) เช่นเดียวกับค่ามัธยฐานอัตราส่วนความลึกของ niche ต่อ AMT (0.173 [IQR 0, 0.227] เทียบกับ 0.234 [IQR 0.142, 0.318], p = 0.045) ค่ามัธยฐานระยะเวลาผ่าตัดนานกว่าในกลุ่มเย็บ 3 ชั้น (37 [IQR 33, 43] เทียบกับ 33 [IQR 30, 36] นาที, p = 0.035) ส่วนปริมาณการเสียเลือดโดยประมาณไม่แตกต่างกันอย่างมีนัยสำคัญระหว่างกลุ่ม*

สรุป: *การเย็บปิดมดลูกแบบ 3 ชั้นเชิงกายวิภาคสัมพันธ์กับค่า RMT/AMT ที่สูงกว่า และมีความลึกของ niche รวมทั้งอัตราส่วนความลึกของ niche ต่อ AMT ต่ำกว่าการเย็บปิดแบบ 2 ชั้นตามวิธีปกติที่ 6 สัปดาห์หลังคลอด ระยะเวลาผ่าตัดนานขึ้นเล็กน้อยในกลุ่มเย็บ 3 ชั้น ขณะที่ปริมาณการเสียเลือดโดยประมาณไม่แตกต่างกันระหว่างกลุ่ม ควรมีการศึกษาติดตามระยะยาวเพื่อประเมินความสำคัญทางคลินิกของความแตกต่างทางอัลตราซาวด์ในระยะแรกดังกล่าว*

คำสำคัญ: *การผ่าตัดคลอด, การเย็บปิดมดลูก, การเย็บปิดมดลูกแบบ 3 ชั้น, แผลเป็นจากการผ่าตัดคลอด, ความหนาของกล้ามเนื้อมดลูกคงเหลือ*

Introduction

As cesarean delivery rates continue to rise worldwide[1], increasing attention has been directed toward the potential long-term reproductive and obstetric consequences of cesarean delivery[2]. The uterine closure technique is a modifiable surgical factor that may influence subsequent cesarean scar healing. Previous randomized evidence summarized in a meta-analysis has shown that different closure techniques, particularly single- versus double-layer closure, may result in differences in residual myometrial thickness[3].

Histological studies have shown that cesarean scar healing may result in incomplete restoration of normal myometrial architecture and fibrotic remodeling[4]. Molecular and ultrastructural studies have further demonstrated increased collagen content and disruption of normal myometrial ultrastructure in cesarean scar tissue[5]. Postoperative scar morphology can be assessed noninvasively by transvaginal ultrasonography. Standardized sonographic evaluation includes measurement of residual myometrial thickness (RMT) at the scar site and adjacent myometrial thickness (AMT), together with other scar dimensions[6]. The RMT/AMT ratio provides a relative measure of myometrial restoration and has been used as an index of cesarean scar healing[7, 8].

Previous studies have evaluated several technical aspects of uterine closure, including layer number, locking versus non-locking sutures, and endometrial inclusion or exclusion[3, 8-10]. These findings suggest that scar morphology may be influenced by multiple aspects of the closure technique rather than layer number alone. Bujold and Romero incorporated these principles into a three-layer anatomical closure strategy that combines endometrial exclusion, non-locking parallel sutures for deep and bulk myometrial approximation, and restoration of the superficial myometrial and serosal contour[11]. Importantly, this approach represents an integrated anatomical closure strategy rather than simply the addition of a third suture layer to conventional two-layer closure.

Randomized evidence evaluating this three-layer anatomical closure strategy with standardized early postpartum sonographic assessment remains limited. Therefore, this study compared three-layer anatomical uterine closure with conventional two-layer closure. The 6-week assessment was selected because it corresponds to routine postpartum follow-up and follows substantial uterine involution, allowing for the evaluation of early scar morphology. The primary objective was to compare the RMT/AMT ratio at 6 weeks postpartum, while secondary objectives included the assessment of other sonographic and surgical outcomes.

Materials and Methods

Study design and setting

This prospective randomized controlled trial was conducted at Surin Hospital, Thailand. Participants were recruited between January and April 2026, and follow-up was completed in May 2026. The study compared three-layer anatomical uterine closure with conventional two-layer closure in women undergoing primary cesarean delivery. The study protocol was approved by the Institutional Ethics Committee of Surin Hospital (approval no. 122/2568). Written informed consent was obtained from all participants before enrollment. This study was registered with the Thai Clinical Trials Registry (TCTR20260629004).

Participants

Inclusion criteria comprised maternal age of at least 18 years, singleton pregnancy at 37 weeks or later, and primary cesarean delivery through a low transverse uterine incision. Both elective and emergency cesarean deliveries were included.

Women were excluded if they had a previous

cesarean delivery or other uterine surgery, a known uterine anomaly, placenta previa, placenta accreta spectrum, chorioamnionitis, or intraoperative findings identified before opening the allocation envelope that precluded standardized performance of either study closure technique, such as severe hemorrhage or extension of the uterine incision.

Randomization and allocation concealment

Participants were randomly assigned in a 1:1 ratio to either a conventional two-layer closure group or a three-layer anatomical closure group. Cesarean delivery was classified as elective or emergency before randomization according to the clinical indication and timing of surgery. Randomization was stratified by this classification using separate computer-generated permuted-block sequences with a block size of four within each stratum.

The allocation sequence was prepared by an independent investigator who was not involved in participant recruitment, surgery, or outcome assessment. Group assignments were placed in sequentially numbered, opaque, sealed envelopes. Each envelope was opened intraoperatively after delivery of the fetus and placenta, and immediately before uterine closure.

Surgical techniques

All cesarean deliveries were performed through a low transverse uterine incision. Polyglactin 910 (Vicryl®) sutures were used for uterine closure in all cases. Uterine closures were performed by three staff obstetrician-gynecologists with 18, 11, and 5 years of surgical experience in cesarean delivery, respectively. Before initiation of the study, all surgeons were trained and standardized in both closure techniques according to the study protocol and were required to perform the allocated technique as specified.

Conventional two-layer closure

In the conventional group, the uterine incision was closed using the routine two-layer technique at our institution. The first layer consisted of a continuous locking suture incorporating the endometrium and a large proportion of the myometrium, followed by a continuous non-locking imbricating second layer incorporating the remaining myometrium and serosa. Double-layer uterine closure has been evaluated extensively in randomized trials and systematic reviews[3, 8]. A locked first layer followed by an imbricating second layer has been reported as a commonly preferred two-layer technique in clinical practice[12].

Three-layer anatomical closure

In the three-layer anatomical closure group, hysterotomy was closed according to the anatomical principles described by Bujold and Romero[11]. The first layer approximated the deep myometrial edges immediately adjacent to the decidual–myometrial junction while excluding the endometrial surface from the suture line. A continuous non-locking 1-0 polyglactin 910 suture was placed parallel to the uterine incision using closely spaced bites to achieve accurate tissue approximation without excessive tension.

The second layer reapproximated the bulk of the myometrium using a second continuous non-locking 1-0 polyglactin 910 suture placed parallel to the incision.

The third layer reapproximated the remaining superficial myometrium and overlying serosa using a continuous 2-0 polyglactin 910 suture, restoring the seromuscular contour of the uterine incision without a separate closure of the visceral peritoneum (Fig. 1).

Based on the aforementioned, the three-layer anatomical closure differed from the conventional two-layer technique not only in the number of layers, but also in endometrial inclusion/exclusion, first-layer locking, suture orientation, and layer-specific reconstruction of the uterine wall.

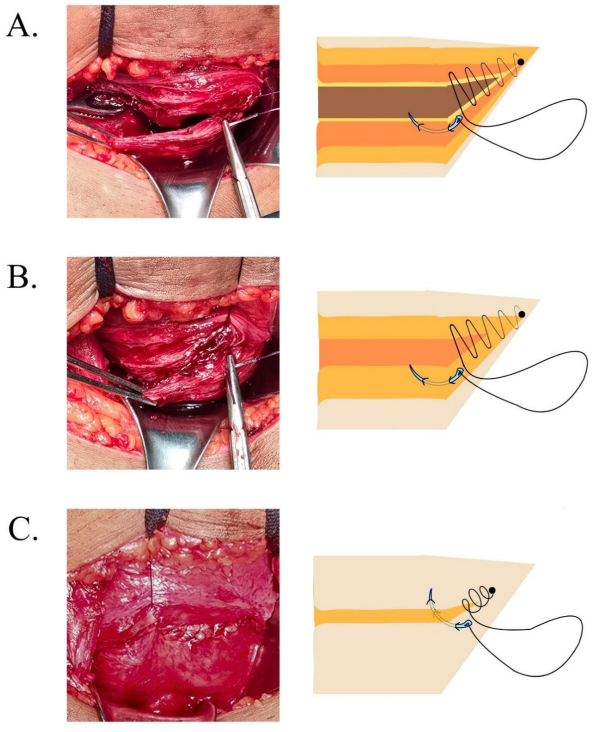


Fig. 1. Three-layer anatomical uterine closure technique. Representative intraoperative photograph and schematic diagrams illustrating the sequential steps of the three-layer anatomical closure. (A) Approximation of the deep myometrial edges immediately adjacent to the decidual–myometrial junction, with exclusion of the endometrial surface from the suture line, using a continuous non-locking suture placed parallel to the uterine incision. (B) Reapproximation of the bulk of the myometrium using a second continuous non-locking parallel suture. (C) Approximation of the remaining superficial myometrium and serosa using a continuous 2-0 suture to restore the seromuscular contour of the uterine incision without a separate closure of the visceral peritoneum.

Outcome assessment

Participants were scheduled for a postpartum follow-up visit at 6 weeks, during which cesarean scar morphology was assessed by transvaginal ultrasound.

Sonographic assessment

Transvaginal ultrasonography was performed using a Voluson S8 ultrasound system (GE HealthCare) with an E8C-RS micro-convex transvaginal probe (4.2–10.0 MHz), without contrast enhancement. The cesarean scar was initially identified in the sagittal plane, after which the probe was swept laterally across the scar to identify the sagittal section showing the largest visible niche, on which standardized scar measurements were subsequently obtained in accordance with previously described criteria[6].

Niche depth was defined as the vertical distance from the endometrial surface to the deepest point of the scar indentation. Residual myometrial thickness (RMT) was measured from the deepest point of the indentation to the uterine serosal surface at the same location. Adjacent myometrial thickness (AMT) was measured in the adjacent myometrium. Niche length was measured as the maximum

longitudinal length of the indentation in the selected sagittal section. The residual-to-adjacent myometrial thickness ratio (RMT/AMT) and the niche depth-to-adjacent myometrial thickness ratio (niche depth/AMT) were calculated from these measurements (Fig. 2).

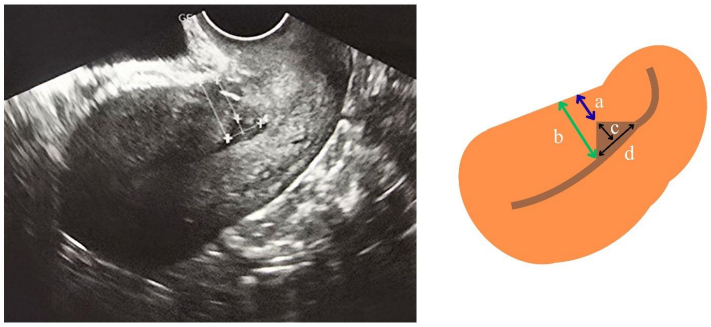


Fig. 2. Sonographic assessment of cesarean scar morphology. Representative transvaginal ultrasound image and corresponding schematic illustration in a sagittal plane through the cesarean scar. The measurements shown are residual myometrial thickness (a), adjacent myometrial thickness (b), niche depth (c), and niche length (d).

A niche was defined as an indentation at the cesarean scar site with a depth of at least 2 mm. For continuous analyses, niche depth was recorded as the measured indentation depth, including values below 2 mm, and was recorded as 0 mm when no indentation was visible. The niche depth/AMT ratio was calculated using the corresponding measured niche depth and AMT for all participants with evaluable ultrasound measurements.

When no visible scar indentation was identified, niche depth and length were recorded as 0 mm, and RMT was measured at the thinnest myometrial point corresponding to the cesarean scar site. When more than one indentation was present, measurements were obtained from the largest defect identified during systematic lateral sweeping of the scar.

All ultrasound assessments were performed by a single examiner who was blinded to treatment allocation. The examiner did not have access to the randomization list, allocation envelopes, operative notes, or details of the uterine closure technique at the time of assessment.

Primary and secondary outcomes

The primary outcome was the RMT/AMT ratio at 6 weeks postpartum. Secondary outcomes included the other sonographic measurements described above, as well as surgical outcomes comprising operative time and estimated blood loss. Operative time was defined as the interval from skin incision to completion of skin closure.

Sample size calculation

The sample size was calculated based on the primary outcome, the RMT/AMT ratio at 6 weeks postpartum. Based on preliminary data from 20 participants at our study center, which were not included in the final analysis, the mean RMT/AMT ratio was 0.78 ± 0.17 in the conventional two-layer group and 0.90 ± 0.11 in the three-layer anatomical closure group. These observed values corresponded to a mean difference of 0.12 and were used for the sample size calculation. With a two-sided alpha of 0.05 and 80% power, 23 evaluable participants were required per group. Allowing for an anticipated 20% loss to follow-up, the target sample size was increased to 30 participants per group, for a total of 60 participants.

Statistical analysis

Continuous variables were assessed for normality using histograms, Q–Q plots, and the Shapiro–Wilk test. Normally distributed variables were presented as means with standard deviations and compared using Welch's independent samples t-test. Non-normally distributed variables were presented as medians with interquartile ranges (IQR) and compared using the Mann–Whitney U test. Categorical variables were presented as numbers and percentages, and compared using Fisher's exact test, as appropriate. Niche presence was reported as a risk ratio with a 95% confidence interval.

Analyses were performed according to the intention-to-treat principle. Baseline characteristics and surgical outcomes were analyzed according to the randomized groups using all available data. Sonographic outcomes were analyzed using an available-case approach among participants with evaluable 6-week ultrasound measurements, with no imputation for missing data.

A p value of less than 0.05 was considered statistically significant. Statistical analyses were performed using Stata software, version 16.1 (StataCorp, College Station, TX, USA).

Results

A total of 60 women were randomized, with 30 assigned to the conventional two-layer uterine closure group and 30 to the three-layer anatomical closure group. All participants received the allocated intervention, with no crossover or protocol deviations after randomization. At the 6-week postpartum follow-up, two participants in each group did not undergo transvaginal ultrasound assessment. Consequently, sonographic outcomes were available for 56 participants and were analyzed using an available case approach, with 28 participants included in each group. Participant enrollment, allocation, follow-up, and analysis are summarized in the CONSORT flow diagram (Fig. 3).

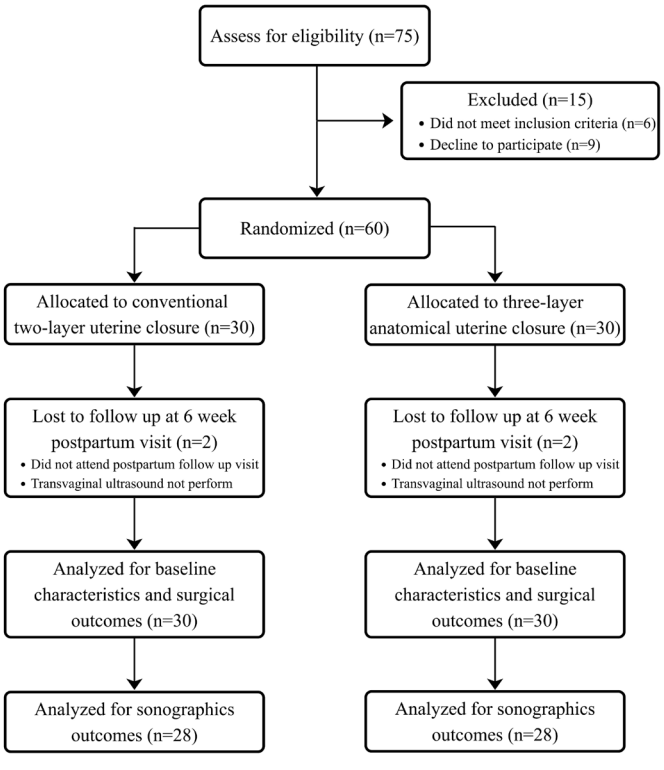


Fig. 3. CONSORT flow diagram.

Baseline characteristics are presented in Table 1. Maternal age, body mass index, parity, gestational age at delivery, cesarean urgency, indications for cesarean delivery, and birth weight were generally comparable between groups.

The sonographic and surgical outcomes are summarized in Table 2. Sonographic outcomes were available for 56 participants, with 28 women in each group. The median RMT/AMT ratio was higher in the three-layer anatomical closure group than in the conventional two-layer group (0.800 [IQR 0.716, 1.000] vs 0.708 [IQR 0.604, 0.783], p = 0.007).

Median niche depth was lower in the three-layer anatomical closure group (2.4 [IQR 0, 3.1] vs 3.2 [IQR 2.55, 4.4] mm, p = 0.017). A niche was identified in 22 of 28 women (78.6%) in the conventional two-layer group and 17 of 28 women (60.7%) in the three-layer anatomical closure group (risk ratio 0.77, 95% CI 0.54, 1.10, p = 0.245). The median niche depth/AMT ratio was also lower in the three-layer anatomical closure group (0.173 [IQR 0, 0.227] vs 0.234 [IQR 0.142, 0.318], p = 0.045). RMT, AMT, and niche length did not differ significantly between groups.

Surgical outcomes were available for all 60 randomized participants. The median operative time was 37 minutes (IQR 33, 43) in the three-layer anatomical closure group and 33 minutes (IQR 30, 36) in the conventional two-layer group (p = 0.035). Estimated blood loss did not differ significantly between groups (p = 0.248).

Table 1. Baseline characteristics.

Characteristic	Conventional two-layer (n = 30)	Three-layer anatomical (n = 30)	p value
Maternal age (years)	30.97 ± 5.21	31.30 ± 4.07	0.783
Maternal BMI (kg/m²)	29.59 (25.64, 34.58)	29.44 (24.46, 31.24)	0.506
Nulliparous, n (%)	22 (73.3)	23 (76.7)	1.000
Gestational age at delivery (weeks)	38.21 (37.71, 39.00)	38.21 (37.86, 38.86)	0.755
Cesarean delivery urgency, n (%)			1.000
Elective	14 (46.7)	15 (50.0)	
Emergency	16 (53.3)	15 (50.0)	
Indication for cesarean delivery, n (%)			0.426
Cephalopelvic disproportion	16 (53.3)	12 (40.0)	
Cesarean delivery on maternal request	7 (23.3)	12 (40.0)	
Premature rupture of membranes	1 (3.3)	3 (10.0)	
Breech presentation	3 (10.0)	2 (6.7)	
Non-reassuring fetal status	3 (10.0)	1 (3.3)	
Birth weight (grams)	3,177 ± 498	3,073 ± 357	0.358

Data are presented as mean ± standard deviation, median (interquartile range), or number (percentage).
Normally distributed continuous variables were compared using Welch's independent-samples t-test, non-normally distributed continuous variables using the Mann–Whitney U test, and categorical variables using Fisher's exact test.
BMI: body mass index

Table 2. Sonographic and surgical outcomes.

Outcome	Conventional	Three-layer anatomical (n = 30)	p value
Sonographic outcomes, n = 28 per group			
RMT (mm)	9.95 ± 2.57	10.91 ± 2.42	0.158
AMT (mm)	13.76 ± 2.46	13.33 ± 2.96	0.558
RMT/AMT ratio	0.708 (0.604, 0.783)	0.800 (0.716, 1.000)	0.007
Niche depth (mm)	3.2 (2.55, 4.4)	2.4 (0, 3.1)	0.017
Niche length (mm)	4.75 (3.55, 6.05)	3.7 (0, 5.75)	0.351
Niche depth/AMT ratio	0.234 (0.142, 0.318)	0.173 (0, 0.227)	0.045
Niche present, n (%)	22 (78.6)	17 (60.7)	0.245
Surgical outcomes, n = 30 per group			
Operative time (min)	33 (30, 36)	37 (33, 43)	0.035
Estimated blood loss (mL)	400 (300, 400)	400 (300, 500)	0.248

Data are presented as mean ± standard deviation, median (interquartile range), or number (percentage).
Normally distributed continuous outcomes were compared using Welch's independent-samples t-test, and non-normally distributed continuous outcomes were compared using the Mann–Whitney U test.
Niche presence was compared using Fisher's exact test.
RMT: residual myometrial thickness, AMT: adjacent myometrial thickness, IQR: interquartile range

Discussion

In this randomized controlled trial, three-layer anatomical uterine closure was associated with a higher RMT/AMT ratio at 6 weeks postpartum compared with conventional two-layer closure. This finding suggests more favorable myometrial restoration at the cesarean scar site. The lower niche depth and niche depth/AMT ratio in the three-layer group further support this interpretation. However, the clinical significance of these early sonographic differences remains uncertain. Regarding surgical outcomes, operative time was modestly longer with the three-layer technique, whereas estimated blood loss did not differ significantly between groups.

Much of the previous research on uterine closure focused on comparisons between single- and double-layer techniques, with inconsistent findings regarding cesarean scar morphology[3,13,14]. Subsequent studies increasingly examined specific technical aspects of uterine closure. A randomized trial reported greater residual myometrial thickness and a higher healing ratio with unlocked double-layer closure excluding the decidua compared with locked single-layer closure, whereas similar benefits were not demonstrated with locked double-layer closure including the decidua[8]. More recent studies have explored endometrium-free closure[10] and parallel-layer suturing[15], further suggesting that scar morphology may be influenced by specific technical aspects of uterine closure rather than layer number alone.

The three-layer anatomical closure technique described by Bujold and Romero integrates endometrial exclusion, non-locking parallel sutures for deep and bulk myometrial approximation, and restoration of the superficial seromuscular contour[11].

However, randomized evidence concerning the evaluation of this specific technique remains limited. Although a previous randomized trial reported similarly favorable sonographic scar outcomes, it evaluated a different layer-specific uterine closure technique[16]. To the best of the authors' knowledge, the present study is the first randomized controlled trial to directly compare this three-layer anatomical technique with conventional two-layer closure. Because multiple technical components differed between groups, the observed findings should be interpreted as the effect of the overall closure strategy rather than any individual component.

This study has several strengths. The randomized design and concealed allocation reduced the risk of selection bias, while standardized surgical techniques promoted consistency across procedures. Sonographic assessments were performed by a single examiner blinded to treatment allocation. Restricting enrollment to women undergoing primary cesarean delivery also reduced heterogeneity related to previous uterine surgery.

In addition to its strengths, several limitations should be considered. First, sonographic assessment at 6 weeks postpartum reflects early rather than mature scar morphology. Although previous studies have shown correlations between measurements at 6 weeks and 6 months, scar characteristics may continue to change during postpartum remodeling[17, 18]. Therefore, the observed differences may not necessarily persist over time, and longer-term follow-up is needed. Second, labor stage and cervical dilatation at cesarean delivery were not recorded separately. These factors may influence lower uterine segment anatomy and the location of the uterine incision, potentially affecting subsequent scar morphology[19, 20]. Although randomization was stratified by elective or emergency cesarean delivery, this classification may not fully capture differences in labor progression between participants. Third, additional focal repair or hemostatic sutures were not recorded systematically. These additional sutures may have influenced local tissue approximation and subsequent scar morphology, independently of the allocated closure technique. Furthermore, potential surgeon-specific effects were not formally evaluated. Although all surgeons underwent technique standardization and performed both procedures, variations in surgical execution could not be excluded as potential influences on scar morphology.

Conclusion

Three-layer anatomical uterine closure was associated with a higher RMT/AMT ratio and lower niche depth and niche depth/AMT ratio at 6 weeks postpartum compared with conventional two-layer closure. Operative time was slightly longer with the three-layer technique, whereas estimated blood loss did not differ significantly between groups. Longer-term studies are needed to determine whether these early sonographic differences persist and translate into clinically meaningful outcomes.

Acknowledgement

The authors would like to thank all the participants who took part in this study, and the obstetric, nursing, and ultrasound staff of Surin Hospital for their assistance with participant care, study coordination, and follow-up.

Potential conflicts of interest

The authors declare no competing interests.

References

1. 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.
2. Keag OE, Norman JE, Stock SJ. Long-term risks and benefits associated with cesarean delivery for mother, baby, and subsequent pregnancies: systematic review and meta-analysis. PLoS Med 2018;15:e1002494.
3. Qayum K, Kar I, Sofi J, Panneerselvam H. Single- versus double-layer uterine closure after cesarean section delivery: a systematic review and meta-analysis. Cureus 2021;13:e18405.
4. Debras E, Capmas P, Maudot C, Chavatte-Palmer P. Uterine wound healing after caesarean section: a

systematic review. Eur J Obstet Gynecol Reprod Biol 2024;296:83-90.
5. Paping A, Basler C, Ehrlich L, Fasting C, Melchior K, Ziska T, et al. Uterine scars after caesarean delivery: from histology to the molecular and ultrastructural level. Wound Repair Regen 2023;31:752-63.
6. Jordans IPM, de Leeuw RA, Stegwee SI, Amso NN, Barri-Soldevila PN, van den Bosch T, et al. Sonographic examination of uterine niche in non-pregnant women: a modified Delphi procedure. Ultrasound Obstet Gynecol 2019;53:107-15.
7. Ivan M, Banerjee A, Colley C, Tetteh A, Greenwold N, Casagrandi D, et al. Postnatal healing of cesarean scar: an ultrasound study. Am J Obstet Gynecol 2026;234:195-209.
8. Roberge S, Demers S, Girard M, Vikhareva O, Markey S, Chaillet N, et al. Impact of uterine closure on residual myometrial thickness after cesarean: a randomized controlled trial. Am J Obstet Gynecol 2016;214: 507.e1-6.
9. Dominoni M, Torella M, Molitierno R, Fordellone M, Saccone G, Colacurci D, et al. Single-versus double-layer uterine closure at the time of cesarean delivery and risk of uterine scar niche: a systematic review and meta-analysis of randomized trials. Arch Gynecol Obstet 2025;312:1095-106.
10. Antoine C, Meyer JA, Silverstein J, Buldo-Licciardi J, Lyu C, Timor-Tritsch IE. Endometrium-free closure technique during cesarean delivery for reducing the risk of niche formation and placenta accreta spectrum disorders. Obstet Gynecol 2025;145:674-82.
11. Bujold E, Romero R. Uterine closure after cesarean delivery: surgical technique, biological rationale, and clinical implications. Am J Obstet Gynecol 2026;233(6 Suppl):S82-102.
12. Demers S, Roberge S, Afiuni YA, Chaillet N, Girard I, Bujold E. Survey on uterine closure and other techniques for Caesarean section among Quebec's obstetrician-gynaecologists. J Obstet Gynaecol Can 2013;35:329-33.
13. Stegwee SI, van der Voet LF, Ben AJ, de Leeuw RA, van de Ven PM, Duijnhoven RG, et al. Effect of single- versus double-layer uterine closure during caesarean section on postmenstrual spotting (2Close): multicentre, double-blind, randomized controlled superiority trial. BJOG 2021;128:866-78.
14. Bamberg C, Hinkson L, Dudenhausen JW, Bujak V, Kalache KD, Henrich W. Longitudinal transvaginal ultrasound evaluation of cesarean scar niche incidence and depth in the first two years after single- or double-layer uterotomy closure: a randomized controlled trial. Acta Obstet Gynecol Scand 2017;96:1484-9.
15. Alper E, Aksakal E, Usta I, Urman B. The novel parallel closure technique compared to single-layer closure of the uterus after primary cesarean section decreases the incidence of isthmocele formation and increases residual myometrial thickness. Cureus 2024;16:e60932.
16. Zhao M, Yang X, An P, Hu W, Wang X, Xing H, et al. Layered precision suturing vs. traditional double-layer closure at cesarean: a randomized trial of uterine scar healing and maternal outcomes. Front Surg 2026;13:1749613.
17. Post BL, Verberkt C, Hup RJ, Jordans IPM, Stegwee SI, Twisk JWR, et al. Niche presence and changes of the uterine scar in the first year after caesarean section: a prospective longitudinal study. Eur J Obstet Gynecol Reprod Biol 2026;321:115051.
18. Dosedla E, Calda P. Can the final sonographic assessment of the cesarean section scar be predicted 6 weeks after the operation? Taiwan J Obstet Gynecol 2016;55:718-20.
19. Kamel R, Eissa T, Sharaf M, Negm S, Thilaganathan B. Position and integrity of uterine scar are determined by degree of cervical dilatation at time of Cesarean section. Ultrasound Obstet Gynecol 2021;57:466-70.
20. Elnajar AG, Arm R, AbdelRahman RM, Riad AAM, Hozain J, Helal MMO. Effect of cervical changes on the cesarean scar topography after primary cesarean sections: an observational study. BMC Pregnancy Childbirth 2025;25:1306.