

Progesterone and preterm birth prevention: translating clinical trials data into clinical practice



Society for Maternal-Fetal Medicine Publications Committee, with the assistance of Vincenzo Berghella, MD

OBJECTIVE: We sought to provide evidence-based guidelines for using progestogens for the prevention of preterm birth (PTB).

METHODS: Relevant documents, in particular randomized trials, were identified using PubMed (US National Library of Medicine, 1983 through February 2012) publications, written in English, which evaluate the effectiveness of progestogens for prevention of PTB. Progestogens evaluated were, in particular, vaginal progesterone and 17-alpha-hydroxy-progesterone caproate. Additionally, the Cochrane Library, organizational guidelines, and studies identified through review of the above were utilized to identify relevant articles. Data were evaluated according to population studied, with separate analyses for singleton vs multiple gestations, prior PTB, or short transvaginal ultrasound cervical length (CL), and combinations of these factors. Consistent with US Preventive Task Force suggestions, references were evaluated for quality based on the highest level of evidence, and recommendations were graded.

RESULTS AND RECOMMENDATIONS: Summary of randomized studies indicates that in women with singleton gestations, no prior PTB, and short CL ≤ 20 mm at ≤ 24 weeks, vaginal progesterone, either 90-mg gel or 200-mg suppository, is associated with reduction in PTB and perinatal morbidity and mortality, and can be offered in these cases. The issue of universal CL screening of singleton gestations without prior PTB for the prevention of PTB remains an object of debate. CL screening in singleton gestations without prior PTB cannot yet be universally mandated. Nonetheless, implementation of such a screening strategy can be viewed as reasonable, and can be considered by individual practitioners, following strict guidelines. In singleton gestations with prior PTB 20-36 6/7 weeks, 17-alpha-hydroxy-progesterone caproate 250 mg intramuscularly weekly, preferably starting at 16-20 weeks until 36 weeks, is recommended. In these women with prior PTB, if the transvaginal ultrasound CL shortens to < 25 mm at < 24 weeks, cervical cerclage may be offered. Progestogens have not been associated with prevention of PTB in women who have in the current pregnancy multiple gestations, preterm labor, or preterm premature rupture of membranes. There is insufficient evidence to recommend the use of progestogens in women with any of these risk factors, with or without a short CL.

Key words: 17-alpha-hydroxy-progesterone caproate, cervical length, preterm birth, prior preterm birth, progestogens, vaginal progesterone

Introduction

Progesterone was isolated and characterized in 1934, and its role in myometrial

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quiescence was first reported in 1954.^{1,2} From 2003 through 2011, several randomized trials evaluating the effect of either 17-alpha-hydroxy-progesterone caproate (17P) given intramuscularly (IM) or natural progesterone given vaginally or orally for prevention of preterm birth (PTB) have been published. The term “progestogens” includes both vaginal progesterone and 17P.

Given this large amount of new important information, the scope of this article is to review the level-1 evidence (randomized controlled trials [RCTs] and metaanalyses of RCTs) evaluating the role of progestogens in the preven-

tion of PTB, and to provide clinicians with current recommendations for their use in possible clinical scenarios. Other publications have not addressed the totality of this new information.³⁻⁵

As 17P and vaginal progesterone may vary in their effect,^{6,7} they will be addressed separately. The effects of interventions for reduction of PTB often vary by the population studied, and in particular by major risk factor categories for PTB. Major differences exist when analyzing effects of other interventions by number of fetuses (ie, singleton vs multiple gestations), prior PTB (vs not), and short cervical length (CL) on transvaginal ultrasound (TVU) (vs not).⁸ Therefore data will be analyzed according to these major categories of risk.

What are the mechanism of action and safety data of progestogens? (Levels II and III)

The mechanisms of action and safety of progestogens are not the purpose of this review, and are discussed only briefly. While the exact mechanism of action of progestogens in preventing PTB is unknown, several possibilities have been proposed (Table 1).⁹⁻¹⁷ In general, the evidence seems to favor 2 mechanisms: an antiinflammatory effect that counteracts the inflammatory process leading to PTB, and a local increase in progesterone in gestational tissues that counteracts the functional decrease in progesterone leading to PTB (Table 1).⁹⁻¹⁷

Regarding safety, several studies failed to detect any long-term effect from the intrauterine exposure of the fetus to pharmacologic progestogens, even when given in the first trimester.¹⁸ Follow-up, at a mean of 4 years, of 278 children randomized in the largest RCT evaluating 17P for prevention of recurrent PTB revealed no differences in physical examination, health status, or performance (motor, problem solving, personal-social) compared to placebo.¹⁹

What is the evidence and recommendation for use of progestogens for prevention of PTB in singleton gestations with no prior PTB, with unknown CL? (Levels I and III)

17P

In 168 women in active military duty with only a 3% rate of prior PTB and unknown CL, 17P 1000 mg IM weekly starting at 16-20 weeks was not associated with any effect on the incidence of PTB or perinatal outcomes compared to placebo.²⁰

Vaginal progesterone

No RCT has evaluated the effect of vaginal progesterone in this population.

In summary, there is insufficient evidence to determine the impact on PTB of progestogens in singleton gestations with no history of PTB, and with unknown or normal CL.

What is the evidence and recommendation for use of progestogens for prevention of PTB in singleton gestations with no prior PTB, but short CL? (Levels I, II, and III)

17P

It is particularly important to assess the effectiveness of progesterone in women without prior PTB, as most PTBs occur in this population. In 657 nulliparous women with singleton gestations with TVU CL ≤ 30 mm at 16-22 3/7 weeks, 17P 250 mg IM weekly through 36 weeks was associated with similar incidences of PTB < 35 weeks (13.5% vs 16.1%; $P = .35$) and < 37 weeks (25.1% vs 24.2%; $P = .80$) compared to placebo.²¹ This RCT was stopped due to a planned interim analysis that revealed further enrollment was statistically very unlikely to demonstrate a significant difference between the groups.

In 79 women with singleton pregnancies (66% of whom had no prior PTB) with TVU CL < 25 mm between 16-24 weeks, 17P was associated with similar rates of PTB and neonatal morbidity and mortality compared to cerclage.²² Cerclage was significantly more effective than 17P at reducing the incidences of PTB < 35 weeks and < 37 weeks in the

TABLE 1
Proposed mechanisms of action reported for progestogens to prevent preterm birth⁹⁻¹⁷

Stimulate transcription of ZEB1 and ZEB2, which inhibit connexin 43 (gap-junction protein that helps synchronize contractile activity) and oxytocin-receptor gene
Decrease prostaglandin synthesis, infection-mediated cytokine production (antiinflammatory effects) by fetal membranes/placenta
Changes in PR-A and PR-B expression (decreased PR-A/PR-B ratio keeps uterus quiescent)
Membrane-bound PR in myometrium
PRs, when stimulated by progesterone, help selected gene promotion, or prevent binding of other factors
Interfere with cortisol-mediated regulation of placental gene expression
Nongenomic pathways
Reduce cervical stromal degradation in cervix
Alter barrier to ascending inflammation/infection in cervix
Reduce contraction frequency in myometrium
Attenuate response to hemorrhage/inflammation in decidua
Alter estrogen synthesis in fetal membranes/placenta
Alter fetal endocrine-mediated effects

PR, progesterone receptor; ZEB1, zinc finger E-box binding homeobox protein 1; ZEB2, zinc finger E-box binding homeobox protein 2.

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subgroup with TVU CL ≤ 15 mm.²² This RCT was stopped before planned recruitment was completed as the authors stated that "it had become impractical, unethical, and unreasonable to withhold progesterone from one study group."²²

Vaginal progesterone

In 250 women from the United Kingdom, Chile, Brazil, and Greece, with mostly (90%) singleton gestations and TVU CL ≤ 15 mm at 20-25 weeks, of whom about 85% had no prior PTB, vaginal progesterone 200 mg nightly started at 24 weeks until 34 weeks was associated with a 44% significant decrease in spontaneous PTB (SPTB) < 34 weeks (19% vs 34%; relative risk [RR], 0.56; 95% confidence interval [CI], 0.36-0.86), but no significant effect on neonatal morbidities (composite neonatal adverse outcome: RR, 0.57; 95% CI, 0.23-1.31).²³ A subgroup analysis of only women without prior PTB confirmed significant benefit of progesterone in preventing PTB < 34 weeks (RR, 0.54; 95% CI, 0.34-0.88).²³ The prevalence of TVU CL ≤ 15 mm in the population screened for

the study was 1.7%. Based on the frequency of short TVU CL and effectiveness for prevention of SPTB < 34 weeks from the work of Fonseca et al,²³ the number of women needed to be screened with CL to prevent 1 SPTB < 34 weeks is approximately 387, if all women with a CL ≤ 15 mm receive vaginal progesterone. Once a TVU CL ≤ 15 mm is identified, the number needed to treat to prevent 1 PTB < 34 weeks is about 7.

In 458 women with singleton gestations and TVU CL 10-20 mm at 19-23 6/7 weeks, of whom about 84% had no prior PTB, vaginal progesterone 90-mg gel daily started at 20-23 6/7 weeks until 36 6/7 weeks was associated with a 45% significant reduction in PTB < 33 weeks (9% vs 16%; RR, 0.55; 95% CI, 0.33-0.92), and a 43% significant reduction in composite neonatal morbidity and mortality (8% vs 14%; RR, 0.57; 95% CI, 0.33-0.99).²⁴ The incidences of PTB < 28 and < 35 weeks, and respiratory distress syndrome (RDS), were also significantly decreased. Analysis of only women without prior PTB confirmed significant benefit of progesterone in

preventing PTB <33 weeks (8% vs 15%; RR, 0.50; 95% CI, 0.27–0.90).²⁴ The prevalence of CL 10–20 mm was 2.3% in the population screened. The study enrolled patients in 44 centers in 10 countries (largest enrollment from United States, 46% of total), and the ethnic distribution of those included was about a third Caucasian, a third African American, and a third Asian. Protocol violations may have influenced the outcomes, and the study was both industry- and National Institutes of Health-sponsored. After evaluating data from this trial only, the Food and Drug Administration (FDA) concluded that the study did not meet the statistical significance generally expected to support the approval of the product in the US market from a single trial. The FDA raised the issue of robustness in efficacy in the US subgroup as compared to overall efficacy in the trial, and stated that additional clinical work would be required to support the approval.²⁵ Based on the frequency of short CL and effectiveness for prevention of PTB <33 weeks from this study,²⁴ the number of women needed to be screened with CL to prevent 1 PTB <33 weeks is approximately 604, if all women with a CL 10–20 mm receive vaginal progesterone. Once a TVU CL 10–20 mm is identified, the number needed to treat to prevent 1 PTB <33 weeks is about 14. The study did not address the management of women with a CL <10 mm.

In a metaanalysis, including 554 singleton gestations, with no prior PTB, and TVU CL ≤ 25 mm mostly <25 weeks, vaginal progesterone was associated with a significant reduction in PTB <33 weeks (RR, 0.60; 95% CI, 0.39–0.92) and a nonsignificant reduction in composite neonatal morbidity and mortality (RR, 0.70; 95% CI, 0.42–1.16).²⁶

Two cost-effectiveness analyses evaluating universal CL screening in singleton gestations, to identify those with short CL eligible for vaginal progesterone, have been published so far.^{27,28} Both reported that such a strategy would be cost-effective. In one study, compared to other managements, including no screening, universal sonographic screening of CL in singletons was predicted to

result in a reduction of 95,920 PTBs <37 weeks annually in the United States, and was actually cost-saving (almost \$13 billion saved).²⁷ Even varying the assumptions (eg, the cost of vaginal progesterone or of TVU screening), universal screening was the preferred strategy 99% of the time.²⁷

The other cost-effectiveness analysis targeted women with singleton gestation without prior PTB. A strategy of universal screening with a single TVU CL at 18–24 weeks and treatment with vaginal progesterone if the CL was ≤ 1.5 cm resulted in >\$12 million saved, 424 quality-adjusted life-years gained, and 22 neonatal deaths or long-term neurologic deficits prevented for every 100,000 women screened compared with no screening. Even varying the assumptions over a wide range of possible values (eg, the cost of vaginal progesterone or of TVU screening), universal screening was cost-effective >99% of the time.²⁸ This cost-effectiveness analysis initially addressed only women with a TVU CL ≤ 1.5 mm. In an addendum, the authors mention that a reanalysis adding progesterone treatment for women with TVU CL between 1.6–2.5 mm did not change their conclusions, with the details of the reanalysis not provided.

In summary, in women with singleton gestations, no prior SPTB, and short TVU CL, vaginal progesterone is associated with reduction in PTB and composite perinatal morbidity and mortality. Based on these results,^{23,24} if a TVU CL ≤ 20 mm is identified at ≤ 24 weeks, vaginal progesterone can be offered for prevention of PTB. The 2 studies used different progesterone preparations and dosages. Vaginal progesterone 200-mg suppository was used in the trial for CL ≤ 15 mm,²³ and 90-mg gel for the trial for CL 10–20 mm.²⁴ There is insufficient evidence that any of the vaginal preparations or doses are superior, as they have not been compared. CL, cost, availability, and other factors may influence preferred dosing.^{27,28}

A decision of whether to institute a *policy of universal screening* for short cervix with TVU in women with singleton gestations without prior PTB requires several careful considerations:

- The available trials have addressed efficacy of progesterone for women identified with a TVU short cervix. There are no data regarding effectiveness of universal TVU screening for short cervix followed by vaginal progesterone for those with a short cervix, compared to no screening. The only evidence in favor of such an approach is based on cost-effectiveness analyses.
- It is possible that a proportion of women with a short cervix may be identified without a specific universal TVU screening. This may result in a lower than estimated added benefit of universal screening over current practice of visualization of the lower uterine segment on all transabdominal ultrasound performed in the second trimester. Data are currently insufficient to suggest benefit, or harm, of transabdominal screening of CL for prevention of PTB using progesterone or any other intervention as therapy if a short CL is identified. Transabdominal ultrasound may not detect 57% of women with a short TVU CL.²⁹ The randomized data on benefit from vaginal progesterone for women with short CL screened women utilizing TVU.^{23,24}
- Universal screening approach may not produce the same results in practice as those in a controlled trial. This may be due to differences in population, logistical differences in screening methods, stretching of the eligibility and management criteria (scope creep), and unintended consequences of universal screening. Performing multiple follow-up scans, doing them outside of the studied gestational age (18–24 weeks), applying the treatment to women outside the studied CL range, or using other interventions for a short CL, such as bed rest or cerclage, may potentially result in adverse unintended consequences. The eligibility criteria were different between the 2 RCTs, and neither included all the women who had a CL below what is traditionally considered as short in the United States (<25 mm). The Fonseca et al²³ trial did not include women with a CL between 15–25 mm, and the Hassan et al²⁴ trial did not include

TABLE 2
Cervical length as screening test in singleton gestations

TVU CL screening test criteria

Characteristic of screening test	Comments	TVU fulfills criteria
Disease		
Disease is clinically important	PTB: no. 1 cause of perinatal mortality and morbidity in developed countries; associated with 1 million deaths annually worldwide	Yes
Disease is clearly defined	Birth <37 wk	Yes
Disease prevalence is well known	12% in United States, about 10% worldwide	Yes
Disease natural history is known/recognizable early asymptomatic phase	First cervical changes associated with later PTB occur at internal os, and can only be detected early by ultrasound	Yes
Screening		
Screening technique well described	Described in several articles ³⁰⁻³²	Yes
Screening is safe and acceptable	TVU is safe even in women with PPRM ³² ; 99% of women would have TVU again; <2% have severe pain ³³	Yes
Screening has reasonable cutoff identified	20 mm is 5th percentile, 25 mm is 10th percentile in general US population ³⁰	Yes
Results are reproducible (reliable)	<10% intraobserver and interobserver variability	Yes; extremely important to control quality of TVU CL
Results are accurate (valid)	Better than manual examination; predictive in all populations studied	Yes
Intervention, cost-effectiveness, and feasibility		
“Early” intervention is effective	Two positive randomized trials both reported that using vaginal progesterone for short TVU CL is effective in preventing PTB ^{23,24,26}	Yes
Screening and treating abnormal is cost-effective	Two cost-effectiveness articles published ^{27,28}	Yes, in fact cost-saving
Facilities for screening are readily available	All pregnancies are offered ultrasound for fetal anatomy screening at around 18-24 wk	Yes, but must be properly organized
Facilities for treatment are readily available	Vaginal progesterone is easily administered as outpatient	Yes

CL, cervical length; PPRM, preterm premature rupture of membranes; PTB, preterm birth; TVU, transvaginal ultrasound.

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women with a CL <10 mm or between 20–25 mm. Neither trial included women with CL >20 mm, and therefore there is very limited evidence that vaginal progesterone is beneficial in these women.^{23,24,26} It should be noted that only 1.7–2.3% of women were identified to have short CL in the 2 large trials published,^{23,24} but that the incidence of CL ≤20 mm at 22–24 weeks in the largest blinded US study was 5%.³⁰ The use of different progesterone formulations (90-mg gel and 200-mg suppository) between the 2 trials should also be taken into account. There is no evidence that the 2 preparations are interchangeable in

that the one that was efficacious in the 10–20 mm range would also be efficacious in those with a CL <10 mm. In a metaanalysis, both of these 2 preparations had similar significant efficacy.²⁶

- If an approach of universal screening is to be adopted, then TVU CL screening needs to be done with proper technique and with quality assurance to be effective.
- There may be lack of availability of this screening test in some geographic areas.

All of the above need to be taken into consideration when deciding on whether to change prenatal care for million of women by instituting universal screening with a single TVU assessment of CL

at around 18–24 weeks in women with a singleton gestation without prior SPTB. On the other hand, TVU CL screening of singleton gestations does fulfill many criteria for an effective screening test (Table 2).³⁰⁻³³ A number of experts have recommended TVU CL universal screening.³⁴⁻³⁶ This is based mostly, in addition to what is listed on Table 2, on the following facts:

- There is level-1 evidence of prevention of PTB and neonatal benefits based on treating with vaginal progesterone low-risk singleton gestations identified with TVU screening to have a short CL.
- This strategy is not only beneficial in terms of improvement in health in a

condition (PTB) of utmost importance to society, but also cost-effective, and in fact cost-saving.

- TVU CL is a safe, acceptable, reproducible, and accurate screening test, with potentially widespread availability.

Therefore, both proponents and opponents of universal screening raise valid issues. CL screening in singleton gestations without prior PTB cannot yet be mandated universally. Nonetheless, implementation of such a screening strategy should be viewed as reasonable, and can be considered by individual practitioners. Third-party payers should not deny reimbursements for this screening. Practitioners who decide to implement universal CL screening should follow strict guidelines:

- TVU CL needs to be performed with proper technique to yield accurate results, with quality control and monitoring. To ensure quality, the Perinatal Quality Foundation is setting up a program on the proper training for clinical use of TVU CL measurement.
- Randomized trials and cost-effectiveness studies were mostly based on performing a single TVU CL at 18-24 weeks on singleton gestations, and on using vaginal progesterone, either 90-mg gel or 200-mg suppository, as intervention when the TVU CL was ≤ 20 mm at < 24 weeks. Clinicians should refrain from screening different populations, screening at different gestational ages, and stretching the definition of short CL to include measurements > 20 mm. There is also no evidence that other preparations (eg, IM 17P) or doses would be efficacious, even within the specified CL range.

What is the evidence and recommendation for use of progestogens for prevention of PTB in singleton gestations with prior PTB, and unknown or normal CL? (Levels I, II, and III)

17P

In 43 women with mostly singleton gestation ($> 90\%$) and either prior PTB or > 1 prior spontaneous abortion, 17P 250 mg IM weekly started as soon as prenatal care began was associated with significant reduction in PTB < 37 weeks

and perinatal mortality compared to placebo.³⁷

In 463 women with singleton gestation and prior SPTB at 20-36 6/7 weeks of a singleton gestation, compounded 17P 250 mg IM weekly started at 16-20 6/7 weeks was associated with reduction in the incidences of PTB < 35 (RR, 0.66; 95% CI, 0.54–0.81), PTB < 37 and < 32 weeks, and supplemental oxygen and intraventricular hemorrhage (IVH) compared to placebo.⁶ Based mostly on this clinical trial, 17P has been recommended for all women with prior SPTB 20-36 6/7 weeks.^{3,5} The estimated number of prevented PTBs < 37 weeks in the United States by this policy is about 9870 annually.³⁸

While the best evidence for efficacy is for 17P to be started < 21 weeks, beneficial effects have been reported when 17P is started by ≤ 27 weeks.^{39,40} 17P should not be stopped early (eg < 32 weeks), as this is associated with increased incidence of PTB.⁴¹

Vaginal progesterone

In 142 women with singleton gestations and mostly prior PTB ($> 90\%$), vaginal progesterone 100 mg nightly from 24-34 weeks was associated with significant reduction in the incidences of PTB < 37 weeks (RR, 0.48; 95% CI, 0.25–0.96) and < 34 weeks, as well as reduction in contraction frequency compared to placebo.⁴²

In 659 women with singleton gestation and prior SPTB 20-35 0/7 weeks, vaginal progesterone 90-mg gel every morning starting at 18-22 6/7 weeks and continued until 37 0/7 weeks was not associated with significantly different rates of PTB < 37 , 36, 33, or 29 weeks, or neonatal morbidity and mortality.⁷ Several women screened for this trial were excluded because of short CL.⁷

Effect of progesterone on CL

In singleton gestations with prior PTB, 17P has not been associated with an effect on the development of short CL.⁴³ On the other hand, vaginal progesterone was associated with significant reduction in the incidence of short CL in women with singleton gestations and prior PTB.¹⁶

Oral progesterone

In 148 women with singleton gestation and prior SPTB 20-36 6/7 weeks, oral progesterone 100 mg twice a day was associated with significantly reduced rates of PTB < 37 weeks and neonatal intensive care unit admission compared to placebo.⁴⁴ In 33 women with singleton gestation and prior PTB 20-36 6/7 weeks, oral progesterone 400 mg daily was associated with trend (but no significant differences) for reduced rates of PTB < 37 weeks (26% vs 57%; $P = .15$) and ventilator use (0% vs 21%; $P = .07$) compared to placebo.⁴⁵

In summary, in singleton gestation with prior SPTB, in which CL is unknown, progestogen administration is beneficial in preventing PTB. Although we have limited data comparing the different preparations of progestogens, there is at present stronger evidence of effectiveness for 17P than for vaginal progesterone, based on the 2 largest trials.^{6,7} Therefore, 17P 250 mg IM weekly starting at 16-20 weeks until 36 weeks should be recommended to women with singleton gestations and prior SPTB 20-36 6/7 weeks. In cases in which 17P is unavailable, other progesterone preparations may be considered.⁴²

What is the evidence and recommendation for use of progestogens for prevention of PTB in singleton gestations with prior PTB, and short CL? (Levels I, II, and III)

17P

There are no RCTs evaluating the effectiveness of 17P compared to placebo in women with singleton gestations, prior PTB, and short CL. In this population, 17P has only been evaluated as an adjunct or an alternative to cervical cerclage.

In singleton gestations with prior SPTB and a short TVU CL < 25 mm at < 23 weeks, 17P was associated with statistically significant decrease in PTB < 24 weeks and perinatal death in women not receiving cerclage in a secondary analysis of a cerclage trial.⁴⁶ Beneficial effects of 17P were noted primarily for women with CL 15-24.9 mm, while they were nonsignificant for women with CL < 15 mm. Overall, women with a CL < 25 mm

had a 34% risk of PTB <32 weeks if they received neither 17P nor cerclage, 25% if they received cerclage, 21% if they received 17P, and 17% if they received both.⁴⁶ While these results were not statistically significant, they suggest that further research is needed to evaluate the relationship and possible cumulative beneficial effect of progesterone and cerclage.

In a randomized trial that did not recruit the planned sample size, 17P had similar effects compared to cerclage in preventing PTB in women with a TVU CL <25 mm, but cerclage was more beneficial in women with CL <15 mm.²² While cerclage seems to be more efficacious (lower RRs) for CL on the lower end of the range,^{47,48} progesterone seems to be most efficacious for moderately short CL.^{23,24,26}

Vaginal progesterone

In a secondary analysis of an RCT⁷ evaluating just the 46 singleton gestations with prior SPTB <35 weeks and short TVU CL <28 mm at 18-22 6/7 weeks, vaginal progesterone 90-mg gel daily started at 18-23 6/7 weeks until 37 weeks was associated with significant decreases in the rates of both PTB <32 weeks and neonatal intensive care unit admission compared to placebo.⁴⁹

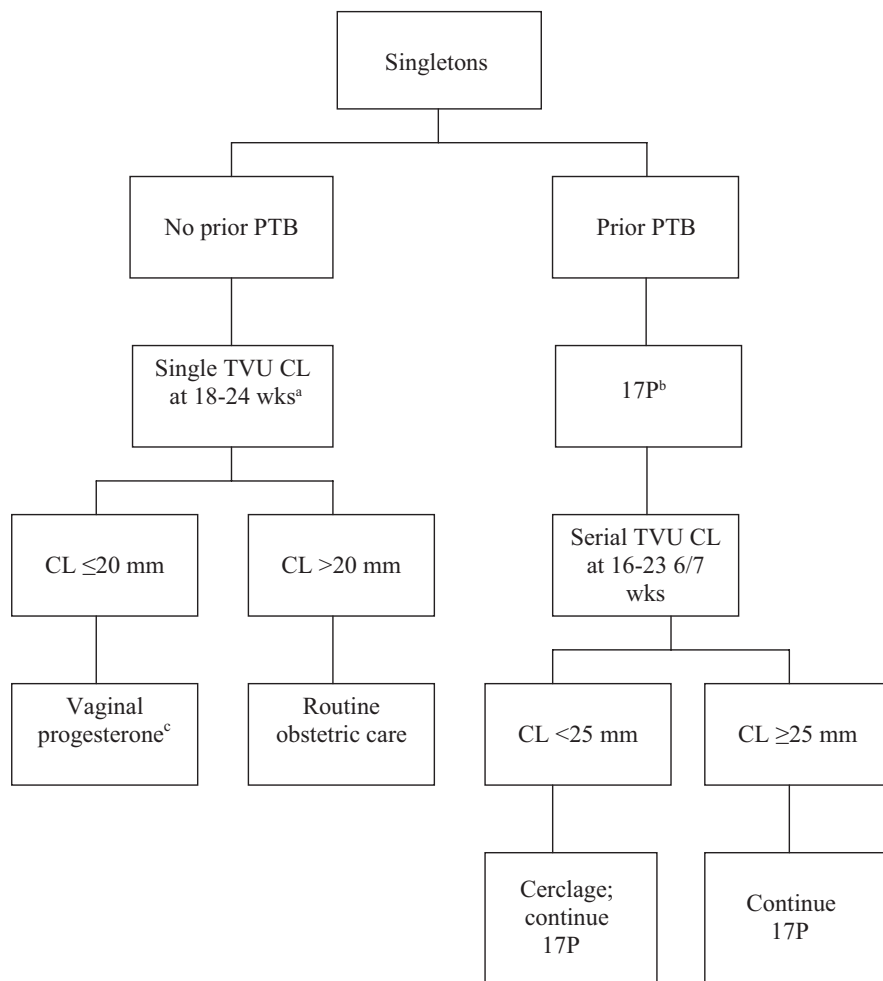
In 71 singleton gestations with prior PTB, vaginal progesterone 100-mg suppositories daily between 24-34 weeks was associated with significant reduction in incidences of PTB <37 weeks (24% vs 50%; odds ratio [OR], 3.11; 95% CI, 1.13-8.53) and <34 weeks (5.4% vs 26.5%; OR, 6.30; 95% CI, 1.25-31.70) compared to placebo.⁵⁰

In a metaanalysis, including 169 singleton gestations with prior PTB and TVU CL \leq 25 mm mostly <25 weeks, vaginal progesterone was associated with a significant reduction in PTB <33 weeks (RR, 0.54; 95% CI, 0.30-0.98) and in composite neonatal morbidity and mortality (RR, 0.41; 95% CI, 0.17-0.98).²⁶

Based on the pooled results of 5 clinical trials, in 504 singleton pregnancies with prior SPTB at <34 weeks and TVU CL <25 mm at <24 weeks' gestation, cerclage was associated with a significant

FIGURE

Algorithm for use of progestogens in prevention of PTB in clinical care



^aIf TVU CL screening is performed; ^b17P 250 mg intramuscularly every week from 16-20 weeks to 36 weeks; ^ceg, daily 200-mg suppository or 90-mg gel from time of diagnosis of short CL to 36 weeks.

CL, cervical length; PTB, preterm birth; 17P, 17-alpha-hydroxyprogesterone caproate; TVU, transvaginal ultrasound.

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30% reduction in the risk of PTB <35 weeks (28% vs 41%; RR, 0.70; 95% CI, 0.55-0.89) and a 36% reduction in composite perinatal mortality and morbidity (16% vs 25%; RR, 0.64; 95% CI, 0.45-0.91).⁸ Therefore screening women with singleton gestations with prior SPTB with TVU CL starting usually at 16 weeks and every 2 weeks until 23 weeks is suggested, so that cerclage can be offered for those who develop a TVU CL <25 mm. As the vast majority of women in this metaanalysis and its included randomized trials did not receive 17P, there is insufficient evidence to determine if the concurrent use of progesterone and cer-

clage offers an additive effect in reducing the risk of PTB in this group of women with prior PTB.⁴⁶ Therefore, the optimal management of the patient with progressive cervical shortening despite progesterone therapy remains uncertain.

In summary, 17P should be recommended to women with prior SPTB starting at 16 weeks, as described above. If the cervix shortens <25 mm by TVU <24 weeks in such a woman with singleton gestation and prior SPTB, there is insufficient evidence to assess efficacy of a different progesterone therapy, and therefore it is reasonable to continue 17P

TABLE 3

Current Society for Maternal-Fetal Medicine recommendations regarding use of progestogens for prevention of preterm birth

Population	Recommendation regarding use of progestogens
Asymptomatic	
Singletons without prior SPTB and unknown or normal TVU CL	No evidence of effectiveness
Singletons with prior SPTB	17P 250 mg IM weekly from 16-20 wk until 36 wk
Singletons without prior SPTB but CL \leq 20 mm at \leq 24 wk	Vaginal progesterone 90-mg gel or 200-mg suppository daily from diagnosis of short CL until 36 wk
Multiple gestations	No evidence of effectiveness
Symptomatic	
PTL	No evidence of effectiveness
PPROM	No evidence of effectiveness

17P, 17-alpha-hydroxy-progesterone caproate; CL, cervical length; IM, intramuscularly; PPRM, preterm premature rupture of membranes; PTL, preterm labor; SPTB, spontaneous preterm birth; TVU, transvaginal ultrasound.

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until 36 weeks, and to offer cervical cerclage (Figure).

What is the evidence and recommendation for use of progestogens for prevention of PTB in multiple gestations, and unknown or normal CL? (Levels I and III)

17P

In 77 women with twin gestation, 17P 250 mg IM weekly from 28-33 weeks was not associated with any effect on PTB rates or perinatal morbidity and mortality compared to placebo.⁵¹

In 655 women with dichorionic (DC) twin gestation, of whom <10% had prior PTB, 17P 250 mg IM weekly starting at 16-20 weeks and ending at 35 weeks was not associated with any effect on PTB rates or perinatal morbidity and mortality in a National Institute of Child Health and Human Development-sponsored RCT compared to placebo.⁵²

In 30 women with twin gestation, of whom 27% had a prior PTB, 17P 250 mg IM weekly starting at 20-30 weeks and ending at 34 weeks was associated with similar incidences of PTB <35 weeks and <30 weeks, as well as similar rates of neonatal morbidity and mortality compared to placebo. CL was not reported.¹⁰

In 240 women with DC twin gestation, 17P 250 mg IM weekly starting at 16-24 weeks until 34 weeks was associated with similar incidences of PTB and neonatal morbidity compared to placebo.⁵³

Two RCTs have evaluated the effect of 17P in triplet gestations. In a total of about 190 triplet gestations, 17P 250 mg IM weekly started at around 16-20/22 weeks' gestation until 34/35 weeks was not associated with effects on incidence of PTB or perinatal morbidity and mortality compared to placebo.^{54,55}

Vaginal progesterone

In 500 women with twin gestation, vaginal progesterone 90 mg daily starting at 24 weeks and continued for at least 10 weeks was not associated with significant effects in incidences of PTB or perinatal morbidity and mortality compared to placebo.⁵⁶

In 677 women with diamniotic twin gestation, vaginal progesterone 200-mg pessaries starting at 20-24 weeks until 34 weeks were not associated with significant effects on incidences of PTB or perinatal complications compared to placebo.⁵⁷

In 67 twin gestations, vaginal progesterone 100-mg suppositories daily between 24-34 weeks were associated with significant reduction in incidences of PTB <37 weeks (51% vs 79%; OR, 3.48; 95% CI, 1.16-10.46) but not <34 weeks (10% vs 25%; OR, 2.90; 95% CI, 0.76-11.20) compared to placebo.⁴⁹

No RCT has yet been reported on the effect of vaginal progesterone on triplet gestations.

In summary, the evidence does not support the use of any type of progestogen for prevention of PTB in multiple gestations with unknown CL. In women with prior SPTB, and a current multiple gestation, some experts have suggested the use of 17P starting at 16 weeks based on the historic risk factor,⁵⁸ but there is insufficient evidence to make this a recommendation.

What is the evidence and recommendation for use of progestogens for prevention of PTB in multiple gestations, and short CL? (Levels I and III)

17P

In a secondary analysis of a trial involving women with DC twin gestation, 52 women, of whom 18.5% had prior PTB, were identified to have a TVU CL of \leq 35 mm (25th percentile) between 16-20 weeks. 17P 250 mg IM weekly starting at 16-20 weeks and ending at 35 weeks was associated with similar incidences of PTB <35 weeks (64% vs 46%; $P = .18$) compared to placebo.⁵⁹

Vaginal progesterone

In a secondary analysis of a trial involving women with diamniotic twin gestation, 47 women, of whom 9% had prior PTB, were identified to have TVU CL \leq 30 mm between 20-24 weeks. Vaginal progesterone 200-mg pessaries starting at 20-24 weeks until 34 weeks were not associated with an effect on PTB <34 weeks (29% vs 40%; RR, 0.63; 95% CI, 0.18-2.23) compared to placebo.⁶⁰

In a metaanalysis, including 52 twin gestations found to have a TVU CL <25 mm at \leq 24 weeks, vaginal progesterone was associated with similar incidence of PTB <33 weeks (30% vs 45%; RR, 0.70; 95% CI, 0.34-1.44) and <35 weeks (52% vs 62%; RR, 0.91; 95% CI, 0.57-1.46), but a significant reduction in composite neonatal morbidity and mortality (24% vs 40%; RR, 0.56; 95% CI, 0.30-0.97) compared to placebo.²⁶

In summary, there is insufficient evidence to assess the effect of progestogens in women with both multiple gestation and short CL.

What is the evidence and recommendation for use of progestogens for prevention of PTB in preterm labor? (Levels I, II, and III)

Primary tocolysis

In 57 women admitted between 13–36 weeks with contractions, progesterone 400 mg orally once was associated with a significant decrease in the frequency of contractions, but no PTB or neonatal outcomes were reported compared to placebo.⁶¹

Adjunctive tocolysis

In 44 women with mostly singleton gestations (>90%) and threatened preterm labor (PTL) at <35 weeks treated with ritodrine, natural progesterone 400 mg orally every 6 hours × 24 hours (then 400 mg every 8 hours for next 24 hours, and then 300 mg every 8 hours onward) was associated with similar rates of PTB, but with lower total dose of ritodrine administered and shorter maternal hospital stay compared to placebo.⁶²

Maintenance tocolysis

17P. In 60 women with singleton gestation still pregnant after successful tocolysis for PTL, 17P 341 mg twice weekly started at 25–33 6/7 weeks until 36 weeks was associated with significant reduction in the incidence of PTB <37 weeks (but not 35 weeks) and of risk of cervical shortening compared to no such treatment.⁶³

In 188 women with singleton gestations still pregnant after successful tocolysis for PTL, 17P 500 mg IM twice weekly started at 24–31 6/7 weeks until 36 weeks was associated with similar incidences of PTB <37, <34, and <32 weeks, and of perinatal morbidity and mortality compared to no such treatment.⁶⁴

Vaginal progesterone. In 70 women with singleton gestation still pregnant after successful tocolysis for PTL, vaginal progesterone 400 mg daily until delivery was associated with longer latency until delivery, later gestational age at delivery (PTB was not reported), and RDS compared to no such treatment.⁶⁵

In summary, there is currently insufficient evidence to recommend progestogens for primary, adjunctive, or maintenance tocolysis.

What is the evidence and recommendation for use of progestogens for prevention of PTB in preterm premature rupture of membranes? (Levels I and III)

17P

In 69 women with singleton gestations and preterm premature rupture of membranes (PPROM) at 24–30 weeks, 17P 250 mg IM is associated with no effect on interval to delivery, gestational age at delivery, or neonatal mortality and morbidity compared to placebo.¹¹

Vaginal progesterone

No RCT has evaluated the effect of vaginal progesterone in this population.

In summary, there is insufficient evidence to assess effect of progesterone in women with PPROM. In a woman who has been receiving 17P for prior SPTB, in the absence of evidence to the contrary, it is reasonable to continue 17P once membranes have ruptured.

Conclusions

Assessment of efficacy of progestogens for prevention of PTB should be done separately for each type of progestogens, with vaginal and IM routes of administration the most studied types (Table 3). Efficacy probably varies also depending on each different risk factor. In addition, dose, gestational age at initiation and termination, compliance, and other issues are factors that influence efficacy of progestogens for prevention of PTB. Therefore, singleton vs multiple gestation, history (eg, prior PTB), short TVU CL (and degree of) or not, asymptomatic vs PTL and PPROM, etc, are all factors that should be considered, as progestogens have different effects in populations with any one (or combination of) risk factor. Several metaanalyses have been published,^{4,66–68} but they either do not evaluate these studies according to the different populations just mentioned, or soon become out of date because of publications of new RCTs.

RECOMMENDATIONS

Level I and level III evidence, level A recommendation

1. There is insufficient evidence to recommend the use of progestogens in singleton gestations with no prior PTB, and unknown CL.

Level I evidence, level A recommendation

2. In women with singleton gestations, no prior SPTB, and short TVU CL ≤20 mm at ≤24 weeks, vaginal progesterone, either 90-mg gel or 200-mg suppository, is associated with reduction in PTB and perinatal morbidity and mortality, and can be offered in these cases.

Level I and level III evidence, level B recommendation

3. The issue of universal TVU CL screening of singleton gestations without prior PTB for the prevention of PTB remains an object of debate. CL screening in singleton gestations without prior PTB cannot yet be universally mandated. Nonetheless, implementation of such a screening strategy can be viewed as reasonable, and can be considered by individual practitioners. Given the impact on prenatal care and potential misuse of universal screening, stretching the criteria and management beyond those tested in RCTs should be prevented. Practitioners who decide to implement universal TVU CL screening should follow strict guidelines. Practitioners who choose to screen low-risk singleton gestations may consider offering vaginal progesterone, either 90-mg gel or 200-mg suppositories, for short TVU CL ≤20 mm at ≤24 weeks.

Level I and level III evidence, level A and B recommendations

4. In singleton gestations with prior SPTB 20–36 6/7 weeks, 17P 250 mg IM weekly preferably starting at 16–20 weeks until 36 weeks is recommended. In these women, if the TVU CL shortens to <25 mm at <24 weeks, cervical cerclage may be offered.

Level I, level II, and level III evidence, level B recommendation

5. Progestogens have not been associated with prevention of PTB in multiple gestations, PTL, or PPROM. There is insufficient evidence to recommend the use of progestogens in women with any of these risk factors, with or without a short CL. Some experts offer 17P to women with a prior SPTB and a current multiple gestation, but there are insufficient data to evaluate the risks and benefits of this intervention in this population.

Quality of evidence

The quality of evidence for each article was evaluated according to the method outlined by the US Preventative Services Task Force:

- I** Properly powered and conducted randomized controlled trial (RCT); well-conducted systematic review or metaanalysis of homogeneous RCTs.
- II-1** Well-designed controlled trial without randomization.
- II-2** Well-designed cohort or case-control analytic study.
- II-3** Multiple time series with or without the intervention; dramatic results from uncontrolled experiment.
- III** Opinions of respected authorities, based on clinical experience; descriptive studies or case reports; reports of expert committees.

Recommendations were graded in the following categories:

Level A

The recommendation is based on good and consistent scientific evidence.

Level B

The recommendation is based on limited or inconsistent scientific evidence.

Level C

The recommendation is based on expert opinion or consensus.

This opinion was developed by the Publications Committee of the Society for Maternal–Fetal Medicine with the assistance of Vincenzo Berghella, MD, and was approved by the executive committee of the society on March 11, 2012. Dr Berghella and each member of the publications committee (Vincenzo Berghella, MD [chair], Sean Blackwell, MD [vice-chair], Brenna Anderson, MD, Suneet P. Chauhan, MD, Joshua Copel, MD, Cynthia Gyamfi, MD, Donna Johnson, MD, George Saade, MD, Hyagriv Simhan, MD, Lynn Simpson, MD, Joanne Stone, MD, Alan Tita, MD, Michael Varner, MD, Ms Deborah Gardner) have submitted a conflict of interest disclosure delineating personal, professional, and/or business interests that might be perceived as a real or potential conflict of interest in relation to this publication. ■

REFERENCES

1. Csapo A, Goodall M. Excitability, length tension relation and kinetics of uterine muscle contraction in relation to hormonal status. *J Physiol* 1954;126:384-95. Level II-2.
2. Keirse MJNC. Progestogen administration in pregnancy may prevent preterm delivery. *Br J Obstet Gynaecol* 1990;97:149-54. Level I.
3. American College of Obstetricians and Gynecologists. Use of progesterone to reduce preterm birth: ACOG committee opinion no. 419. *Obstet Gynecol* 2008;112:963-5. Level III.
4. Dodd JM, Flenady V, Cincotta R, Crowther CA. Prenatal administration of progesterone for preventing preterm birth in women considered to be at risk of preterm birth. *Cochrane Database Syst Rev* 2006;1:CD004947. Level I.
5. Kilpatrick SJ, for the Society for Maternal-Fetal Medicine. Progesterone for the prevention of preterm birth. *Contemp Obstet Gynecol* 2009;6:32-3. Level III.
6. Meis PJ, Klebanoff M, Thom E, et al. Prevention of recurrent preterm delivery by 17 alpha-hydroxyprogesterone caproate. *N Engl J Med* 2003;348:2379-85. Level I.
7. O'Brien JM, Adair CD, Lewis DF, et al. Progesterone vaginal gel for the reduction of recurrent preterm birth: primary results from a randomized, double-blind, placebo-controlled trial. *Ultrasound Obstet Gynecol* 2007;30:687-96. Level I.
8. Berghella V, Rafael TJ, Szychowski JM, Rust OA, Owen J. Cerclage for short cervix on ultrasonography in women with singleton gestations and previous preterm birth: a meta-analysis. *Obstet Gynecol* 2011;117:663-71. Level I.
9. Renthall NE, Chen NN, Williams KC, et al. miR-200 family and targets, ZEB1 and ZEB2, modulate uterine quiescence and contractility during pregnancy and labor. *Proc Natl Acad Sci U S A* 2010;107:20828-33. Level II-2.
10. Briery CM, Veillon EW, Klauser CK, et al. Progesterone does not prevent preterm births in women with twins. *South Med J* 2009;102:900-4. Level I.
11. Briery CM, Veillon EW, Klauser CK, et al. Women with preterm premature rupture of the membranes do not benefit from weekly progesterone. *Am J Obstet Gynecol* 2011;204:54.e1-5. Level I.
12. Zakar T, Mesiano S. How does progesterone relax the uterus in pregnancy? *N Engl J Med* 2011;364:972-3. Level II-2.
13. Peltier MR, Tee SC, Smulian JC. Effect of progesterone on proinflammatory cytokine production by monocytes stimulated with pathogens associated with preterm birth. *Am J Reprod Immunol* 2008;60:346-53. Level II-2.
14. Xu H, Gonzalez JM, Ofori E, Elovitz MA. Preventing cervical ripening: the primary mechanism by which pregestational agents prevent preterm birth? *Am J Obstet Gynecol* 2008;198:314.e1-8. Level II-2.
15. Sfakianaki AK, Norwitz ER. Mechanisms of progesterone action in inhibiting prematurity. *J Matern Fetal Neonatal Med* 2006;19:763-72. Level II-2.
16. O'Brien JM, DeFranco EA, Adair CD, et al. Effect of progesterone on cervical shortening in women at risk for preterm birth: secondary analysis from a multinational, randomized, double-blind, placebo-controlled trial. *Ultrasound Obstet Gynecol* 2009;34:653-9. Level I.
17. Zakar T, Hertelendy F. Progesterone withdrawal: key to parturition. *Am J Obstet Gynecol* 2007;196:289-96. Level II-2.
18. Resseguie LJ, Hick JF, Bruen JA, Noller KL, O'Fallon WM, Kurland LT. Congenital malformations among offspring exposed in utero to progestins, Olmsted County, Minnesota, 1936-1974. *Fertil Steril* 1985;43:514-9. Level II-2.
19. Northen AT, Norman GS, Anderson K, et al, for the National Institute of Child Health and Human Development (NICHD) Maternal-Fetal Medicine Units (MFMU) Network. Follow-up of children exposed in utero to 17 a-hydroxyprogesterone caproate compared with placebo. *Obstet Gynecol* 2007;110:865-72. Level I.
20. Hauth JC, Gilstrap LC III, Brekken AL, Hauth JM. The effect of 17 alpha-hydroxyprogesterone caproate on pregnancy outcome in an active-duty military population. *Am J Obstet Gynecol* 1983;146:187-90. Level I.
21. Grobman WA; for the Eunice Kennedy Shriver National Institute of Health and Human Development. Randomized controlled trial of progesterone treatment for preterm birth prevention in nulliparous women with cervical length less than 30mm. *Am J Obstet Gynecol* 2012;206:s367. Level I.
22. Keeler SM, Kiefer D, Rochon M, Quinones JN, Novetsky AP, Rust O. A randomized trial of cerclage vs 17 α -hydroxyprogesterone caproate for treatment of short cervix. *J Perinat Med* 2009;37:473-9. Level I.
23. Fonseca EB, Celik E, Parra M, Singh M, Nicolaides KH. Progesterone and the risk of preterm birth among women with a short cervix. *N Engl J Med* 2007;357:462-9. Level I.
24. Hassan SS, Romero R, Vidyadhari D, et al, for the PREGNANT Trial. Vaginal progesterone reduces the rate of preterm birth in women with a sonographic short cervix: a multicenter, randomized, double-blind, placebo-controlled trial. *Ultrasound Obstet Gynecol* 2011;38:18-31. Level I.
25. US Food and Drug Administration. Advisory committees. Available at: www.fda.gov/AdvisoryCommittees/Calendar/ucm279859.htm. Accessed March 5, 2012. Level III.
26. Romero R, Nicolaides K, Conde-Agudelo A, et al. Vaginal progesterone in women with an asymptomatic sonographic short cervix in the midtrimester decreases preterm delivery and neonatal morbidity: a systematic review

- and meta-analysis of individual patient data. *Am J Obstet Gynecol* 2012;206:124.e1-19. Level I.
- 27.** Cahill AG, Odibo AO, Caughey AB, et al. Universal cervical length screening and treatment with vaginal progesterone to prevent preterm birth: a decision and economic analysis. *Am J Obstet Gynecol* 2010;202:548.e1-8. Level III.
- 28.** Werner EF, Han CS, Pettker CM, et al. Universal cervical-length screening to prevent preterm birth: a cost-effectiveness analysis. *Ultrasound Obstet Gynecol* 2011;38:32-7. Level III.
- 29.** Hernandez-Andrade E, Romero R, Ahn H, et al. Transabdominal evaluation of uterine cervical length during pregnancy fails to identify a substantial number of women with a short cervix. *J Mat Fetal Neo Med* 2012 Mar 16 [Epub ahead of print]. Level II-1.
- 30.** Iams JD, Goldenberg RL, Meis PJ, et al. The length of the cervix and the risk of spontaneous premature delivery. *N Engl J Med* 1996;334:567-72. Level II-1.
- 31.** Rafael TJ. Short cervical length. In: Berghella V, ed. *Preterm birth: prevention and management*. New York: Wiley-Blackwell; 2010. Level III.
- 32.** Carlan SJ, Richmond LB, O'Brien WF. Randomized trial of endovaginal ultrasound in preterm premature rupture of membranes. *Obstet Gynecol* 1997;89:458. Level I.
- 33.** Dutta RL, Economides DL. Patient acceptance of transvaginal sonography in the early pregnancy unit setting. *Ultrasound Obstet Gynecol* 2003;22:503-7. Level II-2.
- 34.** Lockwood CJ. The real progesterone story. *Contemp Obstet Gynecol* 2011;5:10-5. Level III.
- 35.** Campbell S. Universal cervical-length screening and vaginal progesterone prevents early preterm births, reduces neonatal morbidity and is cost saving: doing nothing is no longer an option. *Ultrasound Obstet Gynecol* 2011;38:1-9. Level III.
- 36.** Combs CA. Vaginal progesterone for asymptomatic cervical shortening and the case for universal screening of cervical length. *Am J Obstet Gynecol* 2012;206:101-3. Level III.
- 37.** Johnson JW, Austin KL, Jones GS, Davis GH, King TM. Efficacy of 17 α -hydroxyprogesterone caproate in the prevention of premature labor. *N Engl J Med* 1975;293:675-80. Level I.
- 38.** Petrini JR, Callaghan WM, Klebanoff M, et al. Estimated effect of 17 α -hydroxyprogesterone caproate on preterm birth in the United States. *Obstet Gynecol* 2005;105:267-72. Level III.
- 39.** González-Quintero VH, Istwan NB, Rhea DJ, Smarkusky L, Hoffman MC, Stanziano GJ. Gestational age at initiation of 17-hydroxyprogesterone caproate (17P) and recurrent preterm delivery. *J Matern Fetal Neonatal Med* 2007;20:249-52. Level II-2.
- 40.** How HY, Barton JR, Istwan NB, Rhea DJ, Stanziano GJ. Prophylaxis with 17 α -hydroxyprogesterone caproate for prevention of recurrent preterm delivery: does gestational age at initiation of treatment matter? *Am J Obstet Gynecol* 2007;197:260.e1-4. Level II-2.
- 41.** Rebarber A, Ferrara LA, Harley ML, et al. Increased recurrence of preterm delivery with early cessation of 17- α -hydroxyprogesterone caproate. *Am J Obstet Gynecol* 2007;196:224.e1-4. Level II-2.
- 42.** da Fonseca EB, Bittar RE, Carvalho MH, Sugaib M. Prophylactic administration of progesterone by vaginal suppository to reduce the incidence of spontaneous preterm birth in women at increased risk: a randomized placebo-controlled double-blind study. *Am J Obstet Gynecol* 2003;188:419-24. Level I.
- 43.** Durnwald CP, Lynch CD, Walker H, Iams JD. The effect of treatment with 17 α -hydroxyprogesterone caproate on changes in cervical length over time. *Am J Obstet Gynecol* 2009;201:410.e1-5. Level II-2.
- 44.** Rai P, Rajaram S, Goel N, Ayalur Gopalakrishnan R, Agarwal R, Mehta S. Oral micronized progesterone for prevention of preterm birth. *Int J Gynaecol Obstet* 2009;104:40-3. Level I.
- 45.** Glover MM, McKenna DS, Downing CM, et al. A randomized trial of micronized progesterone for the prevention of recurrent preterm birth. *Am J Perinatol* 2011;28:377-81. Level I.
- 46.** Berghella V, Figueroa D, Szychowski JM, et al, for the Vaginal Ultrasound Trial Consortium. 17- α -hydroxyprogesterone caproate for the prevention of preterm birth in women with prior preterm birth and a short cervical length. *Am J Obstet Gynecol* 2010;202:351.e1-6. Level II-1.
- 47.** Owen J, Szychowski J. Can the optimal cervical length for placing ultrasound-indicated cerclage be identified? *Am J Obstet Gynecol* 2011;204:s198-9. Level II-1.
- 48.** Owen J, Hankins G, Iams JD, et al. Multicenter randomized trial of cerclage for preterm birth prevention in high-risk women with shortened midtrimester cervical length. *Am J Obstet Gynecol* 2009;201:375.e1-8. Level I.
- 49.** DeFranco EA, O'Brien JM, Adair CD, et al. Vaginal progesterone is associated with a decrease in risk for early preterm birth and improved neonatal outcome in women with a short cervix: a secondary analysis from a randomized, double-blind, placebo-controlled trial. *Obstet Gynecol* 2007;30:697-705. Level II-1.
- 50.** Cetingoz E, Cam C, Sakalli M, et al. Progesterone effects on preterm birth in high-risk pregnancies: a randomized placebo-controlled trial. *Arch Gynecol Obstet* 2011;283:423-9. Level I.
- 51.** Hartikainen-Sorri AL, Kauppila A, Tuimala R. Inefficacy of 17 α -hydroxyprogesterone caproate in the prevention of prematurity in twin pregnancy. *Obstet Gynecol* 1980;56:692-5. Level I.
- 52.** Rouse DJ, Caritis SN, Peaceman AM, et al; National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. A trial of 17 α -hydroxyprogesterone caproate to prevent prematurity in twins. *N Engl J Med* 2007;357:454-61. Level I.
- 53.** Combs CA, Garite T, Maurel K, Das A, Porto M; for the Obstetrix Collaborative Research Network. 17-hydroxyprogesterone caproate for twin pregnancy: a double-blind, randomized clinical trial. *Am J Obstet Gynecol* 2011;204:221.e1-8. Level I.
- 54.** Caritis SN, Rouse DJ, Peaceman AM, et al, for the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD), Maternal-Fetal Medicine Units Network (MFMU). Prevention of preterm birth in triplets using 17 α -hydroxyprogesterone caproate: a randomized controlled trial. *Obstet Gynecol* 2009;113:285-92. Level I.
- 55.** Combs CA, Garite T, Maurel K, et al, for the Obstetrix Collaborative Research Network. Failure of 17-hydroxyprogesterone to reduce neonatal morbidity or prolong triplet pregnancy: a double-blind, randomized clinical trial. *Am J Obstet Gynecol* 2010;203:248.e1-9. Level I.
- 56.** Norman JE, Mackenzie F, Owen P, et al. Progesterone for the prevention of preterm birth in twin pregnancy (STOPPIT): a randomized, double-blind, placebo-controlled study and meta-analysis. *Lancet* 2009;373:2034-40. Level I.
- 57.** Rode L, Klein K, Nicolaides KH, Krampfl-Bettelheim E, Tabor A; PREDICT Group. Prevention of preterm delivery in twin gestations (PREDICT): a multicenter, randomized, placebo-controlled trial on the effect of vaginal micronized progesterone. *Ultrasound Obstet Gynecol* 2011;38:272-80. Level I.
- 58.** Iams JD, Berghella V. Care for women with prior preterm birth. *Am J Obstet Gynecol* 2010;203:89-100. Level III.
- 59.** Durnwald CP, Momirova V, Rouse DJ, et al, for the Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Second-trimester cervical length and risk of preterm birth in women with twin gestations treated with 17- α hydroxyprogesterone caproate. *J Matern Fetal Neonatal Med* 2010;23:1360-4. Level II-1.
- 60.** Klein K, Rode L, Nicolaides KH, Krampfl-Bettelheim E, Tabor A; PREDICT Group. Vaginal micronized progesterone and risk of preterm delivery in high-risk twin pregnancies: secondary analysis of a placebo-controlled randomized trial and meta-analysis. *Ultrasound Obstet Gynecol* 2011;38:281-7. Level II-1.
- 61.** Erny R, Pigne A, Prouvost C, et al. The effects of oral administration of progesterone for premature labor. *Am J Obstet Gynecol* 1986;154:525-9. Level I.
- 62.** Noblot G, Audra P, Dargent D, Faguer B, Mellier G. The use of micronized progesterone in the treatment of menace of preterm delivery. *Eur J Obstet Gynecol Reprod Biol* 1991;40:203-9. Level I.
- 63.** Facchinetti F, Paganelli S, Comitini G, Dante G, Volpe A. Cervical length changes during preterm cervical ripening: effects of 17- α -hydroxyprogesterone caproate. *Am J Obstet Gynecol* 2007;196:453.e1-4. Level I.

- 64.** Rozenberg P, Chauveaud A, Deruelle P, et al. Prevention of preterm delivery after successful tocolysis in preterm labor by 17 alpha-hydroxyprogesterone caproate: a randomized controlled trial. *Am J Obstet Gynecol* 2012; 206:206.e1-9. Level I.
- 65.** Borna S, Sahabi N. Progesterone for maintenance tocolytic therapy after threatened preterm labor: a randomized controlled trial. *Aust N Z J Obstet Gynaecol* 2008;48:58-63. Level I.
- 66.** Su LL, Samuel M, Chong YS. Progestational agents for treating threatened or established preterm labor. *Cochrane Database Syst Rev* 2010;1:CD006770. Level I.
- 67.** MacKenzie R, Walker M, Armson A, Hannah ME. Progesterone for the prevention of preterm birth among women at increased risk: a systematic review and meta-analysis of randomized controlled trials. *Am J Obstet Gynecol* 2006;194:1234-42. Level I.
- 68.** Sanchez-Ramos L, Kaunitz AM, Delke I. Progestational agents to prevent preterm birth: a meta-analysis of randomized controlled trials. *Obstet Gynecol* 2005;105:273-9. Level I.

The practice of medicine continues to evolve, and individual circumstances will vary. This opinion reflects information available at the time of its submission for publication and is neither designed nor intended to establish an exclusive standard of perinatal care. This publication is not expected to reflect the opinions of all members of the Society for Maternal–Fetal Medicine.