Exacerbation of certain medical conditions at specific phases of the menstrual cycle is a well-recognized phenomenon. We review the effects of the menstrual cycle on medical conditions, including menstrual migraine, epilepsy, asthma, rheumatoid arthritis, irritable bowel syndrome, and diabetes. We discuss the role of medical suppression of ovulation using gonadotropin-releasing hormone agonists in the evaluation and treatment of these disorders. Peer-reviewed publications from English-language literature were located via MEDLINE or from bibliographies of relevant articles. We reviewed all review articles, case reports and series, and therapeutic trials. Emphasis was placed on diagnosis and therapy of menstrual cycle–related exacerbations of disease processes. Abrupt changes in the concentrations of circulating ovarian steroids at ovulation and premenstrually may account for menstrual cycle–related changes in these chronic conditions. Accurate documentation of symptoms on a menstrual calendar allows identification of women with cyclic alterations in disease activity. Medical suppression of ovulation using gonadotropin-releasing hormone agonists can be useful for both diagnosis and treatment of any severe, recurrent menstrual cycle–related disease exacerbations.

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The menstrual cycle, an event that punctuates the lives of most women, may be associated with diverse physical, psychological, and behavioral changes. Not surprisingly, it plays a significant role in women's health and disease. Conversely, menstrual cyclicity can be easily disrupted by disease, both physical and psychological.

Exacerbation of certain medical conditions at specific menstrual cycle phases is a well-recognized phenomenon. Accurate documentation of symptoms on a menstrual calendar allows identification of women with cyclic alterations in disease activity. The majority of these effects occur during the luteal and menstrual phases of the cycle. Diseases most often affected are those characterized by relapsing and remitting courses, and those that are easily triggered by external factors; for example, migraine, asthma, and epilepsy.

Several theories have been proposed to explain these menstrual cycle–related effects on existing disease processes, including fluctuations in levels of sex steroids, cyclic alterations in the immune system, and changing perceptions of disease severity brought about by premenstrual alterations in mood, as seen in premenstrual syndrome.

THE MENSTRUAL CYCLE

Normal menstrual cyclicity requires coordination of the hypothalamus, pituitary gland, and ovaries. Gonadotropin-releasing hormone is released in a pulsatile fashion from the hypothalamus. Its secretion is modulated by a variety of neurotransmitters, including norepinephrine, serotonin, and endogenous opioids. Gonadotropin-releasing hormone

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stimulates the release of follicle-stimu-
itating hormone and luteinizing hor-
mones from the anterior pituitary.3

The follicular phase, or the time
of oocyte development before ovu-
lation, is marked by progressive
growth of an ovarian follicle. This
phase is characterized by estrogen se-
cretion, at first gradual, and then ex-
ponential in the 5 to 6 days leading
up to ovulation. An abrupt transient
decline in estrogen level occurs co-
incident with ovulation. Recovery in
the luteal phase results from corpus
luteal production of estrogen and
progesterone.

The lifespan of the corpus lu-
teum is fixed at approximately 12
days. If fertilization of the ovum does
not occur, the corpus luteum invol-
utes, levels of estrogen and proges-
terone fall dramatically, and men-
struation occurs. Falling levels of
ovarian hormones remove the nega-
tive feedback from the pituitary gland and hypothalamus, and a new cycle of ovarian stimulation begins.1

GONADOTROPIN-RELEASING
HORMONE AGONISTS

Gonadotropin-releasing hormone agonists are analogues of gonado-
tropin-releasing hormone, the hy-
pothalamic hormone that binds to
specific receptors in the anterior pi-
tuitary gland, stimulating the re-
lease of gonadotropins. Gonadotro-
pin-releasing hormone agonists, by
binding to gonadotropin-releasing
hormone receptors, cause an initial
increase in follicle-stimulating hor-
mones and luteinizing hormone sec-
cretion, the so-called flare effect. Af-

fter about 1 week however, down-
regulation and desensitization of the
pituitary gland produces a hypogo-
nal state, sometimes likened to a
pituitary gland produces a hypogo-
regulation and desensitization of the
women increases considerably af-

after menarche.8-12 Sixty percent of
women with migraine link attacks
to menstruation. True menstrual mi-
gaine, however, occurs in the 8% to
14% of women who experience mi-
gaines exclusively at the time of
menstruation, and are virtually free
of migraine at other times of the
cycle, with the exception of the small
percentage of these women who ex-
perience a brief exacerbation asso-
ciated with ovulation.8,11

Seventy percent to 90% of
women with menstrual migraine ex-
perience improvement during preg-
nancy, especially during the sec-
and and third trimesters.9,10,12,13
These women may experience mi-
gaine attacks in the postpartum pe-
riod, associated with falling estro-
gen levels.14 Oral contraceptives have
a variable effect on migraine, caus-
ing headaches to worsen, improve,
or show no change.15 Analogous to
women with menstrual migraine,
some users of oral contraceptives
experience headaches only during
tablet-free or placebo days.16 Al-
though the prevalence of migraine
headaches decreases with advanc-
ing age, migraine can either regress
or worsen at menopause.17

Migraines are vascular head-
aches, associated with a vasocon-
strictive phase followed by vaso-
dilatation.18 Factors thought to trigger
these vascular changes include ab-
normal platelet aggregation, altered
platelet content of serotonin, aberr-
rant neurotransmitter activity, and
central opioid disregulation.19-22 In
menstrual migraine, estrogen with-
drawal is likely responsible for ini-
tiating some or all of these vascular
effects on intracranial vessels. Estro-
gen regulation of prostaglandin pro-
duction may also be directly or indi-
rectly involved with the pathogenesis
of menstrual migraine.11,23

Several investigators24-27 have
demonstrated an effect of estrogen
on the vasculature. It has been pro-
posed that in women with men-
strial migraine, estrogen may sen-
sitize intracranial vessels, making
these vessels more responsive to hor-
monal changes, leading to vasocon-
striction associated with estrogen
withdrawal.28 Estrogen administra-

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tion to women with menstrual migraine can preclude the expected migraine attack until the use of estrogen is discontinued.28 The response to estrogen withdrawal is triggered by the abrupt decline in estrogen levels, rather than by any absolute level.28 Progesterone administration, while delaying menstrual flow, does not prevent the occurrence of migraine at the expected time.28

Treatment of menstrual migraine may be symptomatic or prophylactic. Ergotamine tartrate, analgesics, and antiemetics will provide symptomatic relief in most women. Nonsteroidal anti-inflammatory agents are occasionally effective in women with menstrual migraine.29

Prophylactic therapy is indicated for women with menstrual migraine who do not experience adequate relief from symptomatic treatment. The occurrence of migraine headaches at predictable times each month permits tailored use of prophylactic medications such as ergotamine, β-blockers, calcium channel blockers, and antidepressants.29 Because estrogen withdrawal is implicated in the pathogenesis of menstrual migraine, it may be more physiologic to treat these women prophylactically with estrogen.35-38 Estrogen, which can be administered in either oral or percutaneous form, is started 48 hours before the anticipated onset of headache at midcycle or at menstruation, and is continued for 3 and 6 days, respectively. Estradiol (1 mg) taken sublingually immediately at the onset of aura may interrupt the usual progression to migraine headache.35

Tamoxifen citrate is reported to relieve menstrual migraine.15,36 Recent reports37 indicate that sumatriptan succinate, a 5-hydroxytryptamine1 receptor agonist, is also effective. There is no evidence to support the use of progesterone in the treatment of menstrual migraine.

Use of medications that suppress the hypothalamic-pituitary-ovarian axis have been successful for treatment of women whose menstrual migraines are refractory to the usual therapies, or in whom migraines are problematic at times other than at midcycle or at menstruation (usually luteal). Danazol, an androgen derivative, has shown variable effectiveness.15,38,39 A recent report40 demonstrated dramatic success in treating menstrual migraine with gonadotropin-releasing hormone agonists, combined with continuous low-dose estrogen replacement therapy. Women who respond to this treatment typically can expect to experience long-term relief following surgical oophorectomy with low-dose estrogen replacement therapy. Concomitant hysterectomy, while unnecessary for migraine prevention, simplifies subsequent hormone replacement therapy, allowing replacement with estrogen alone and avoiding the need for progestin, which at times triggers recrudescence of migraine. For the few women who experience exacerbation of migraine headaches while receiving estrogen replacement therapy, several strategies have been suggested including reduction of estrogen dose, continuous rather than cyclic estrogen administration, and changing the type or route of administration of estrogen.29

CATAMENIAL EPILEPSY

Catamenial epilepsy is observed in 10% to 70% of women with epilepsy.43,44 The wide range in reported incidence is because of the lack of a generally accepted definition of catamenial epilepsy.45 Up to 70% of women with epilepsy claim that most of their seizures are exacerbated by menstruation.42 Strictly defined, however, catamenial epilepsy is epilepsy that occurs at or worsens around menstruation, and can be objectively demonstrated in approximately 12% of women with epilepsy.42 A strict definition is important as it has implications for management of seizure. Menstrual exacerbations occur with all types of seizures.43 Catamenial epilepsy is believed to result from cyclic alterations in both ovarian hormone levels and drug metabolism.

The evidence that ovarian steroid fluctuations are involved is compelling. In women who develop catamenial epilepsy, seizures frequently start at or shortly after menarche.44 Patients with mixed seizure types show increased electroencephalographic activity during menstruation.45 Seizure threshold is increased by progesterone and decreased by estrogen, an effect presumably caused by alterations in brain excitability.46 A decrease in the progesterone level, or in the progesterone-estrogen ratio, correlates with increased seizure activity.47 Frequency of seizure has been shown to increase during 2 specific times in the menstrual cycle. The first corresponds to the rapid decrease in progesterone just before menses, and the second to the elevation of estrogen before ovulation.46,48 An increase in frequency of seizure has also been demonstrated during anovulatory cycles when progesterone levels are relatively low.49 Finally, menopause or oophorectomy may lead to significant improvement in epilepsy.50

Menstrual abnormalities and gynecologic syndromes such as polycystic ovaries, hypogonadotropic and hypergonadotropic hypogonadism, oligomenorrhea, and amenorrhea are more common in women with epilepsy.51-55 This could result directly from the effects of anticonvulsant medications on the hypothalamic-pituitary axis, or indirectly through alterations in the metabolism of sex steroids. Women with temporal lobe epilepsy are particularly prone to anovulation. Dysfunction of the limbic cortex, which is extensively interconnected with the hypothalamus, appears to alter the release of hypothalamic hormones and pituitary gonadotropins, resulting in anovulation.56

Altered metabolism of anticonvulsants at different times in the cycle is well established. Decreased serum levels of phenytoin demonstrated during menses in women with catamenial epilepsy correlate with increased seizure activity.51-57 The decrease in estrogen and progesterone at menstruation is believed to stimulate the release of hepatic monooxygenase enzymes, which accelerates anticonvulsant metabolism, and increases the risk for breakthrough seizures.58 Treatment of catamenial epilepsy requires measurement of serum levels of anticonvulsants during times of seizure exacerbation, with alterations in dosing as appropriate to improve seizure control.47

Many investigators47-49,50-62 have shown progesterone therapy to be
beneficial. Medroxyprogesterone acetate given orally (10-40 mg once daily) or intramuscularly (150 mg every 6-12 weeks) has been the most widely tested.\textsuperscript{47,48} In addition to its antiepileptic properties, progesterone given in this fashion may also reduce frequency of seizure by suppressing gonadotropin release which, in turn, lowers estrogen levels.\textsuperscript{38,61} The effects of combined oral contraceptives on frequency of seizure have been inconsistent, with seizure exacerbation occurring on the pill-free days according to some reports.\textsuperscript{47} Uninterrupted combined use of oral contraceptives or the progestin-only oral contraceptive may be preferable in women with epilepsy as they result in continuous progestin exposure.\textsuperscript{45} Since efficacy of oral contraceptives may be decreased in patients with epilepsy receiving anti-convulsant therapy because of accelerated metabolism of the contraceptive steroids, a higher dose (50 µg) of oral contraceptive pills are recommended. The use of ovarian suppressive agents such as danazol and gonadotropin-releasing hormone agonists with steroid add-back for control of seizure has not been described in the literature. It may be worthwhile to consider these medications in patients refractory to the anti-convulsant and hormonal therapies previously discussed.

**ASTHMA**

The observation that asthma is influenced by gonadal steroids is supported by the fact that asthma is more common in females after puberty.\textsuperscript{63,64} In many women there is an increased frequency and severity of attacks premenstrually or at menstruation.\textsuperscript{65} Gibbs et al\textsuperscript{66} objectively confirmed the worsening of asthmatic symptoms premenstrually by documenting significant decreases in peak expiratory flow rates. Women are also more likely to be hospitalized premenstrually for asthma complications, including respiratory failure.\textsuperscript{57,68}

The precise cause of premenstrual asthma remains elusive, but may be related to changing levels of progesterone or prostaglandins. Progesterone, increases steadily after ovulation, and falls abruptly in the days before menstruation. Its relaxant effect on smooth muscle contractility may contribute to cyclic changes in airway responsiveness in women with menstrual cycle-related exacerbations of asthma.\textsuperscript{61} Progesterone-stimulated hyperventilation may further influence asthma leading to symptomatic deterioration and dyspnea.\textsuperscript{69,70} Although a luteal increase in asthma symptoms and decrease in peak expiratory flow rates have been demonstrated, an associated deterioration in airway reactivity has not been shown.\textsuperscript{71} There is also no relationship between airway function and absolute levels of progesterone. Although some prostaglandins have bronchoconstrictive effects, endogenous prostaglandin synthesis has shown no correlation with premenstrual asthma.\textsuperscript{72} The lack of definitive evidence for either progesterone or prostaglandin mediation has led to the theories that premenstrual asthma may in part be due to altered perception, or heightened awareness of symptoms.\textsuperscript{66,73} Menstrual cycle-related alterations in immune mechanisms have also been suggested.\textsuperscript{74}

Treatment for premenstrual asthma includes the usual medications for asthma: β-adrenergic agonists, anticholinergics, and corticosteroids.\textsuperscript{41} Intramuscular progesterone was shown to be effective in 3 women with severe, refractory premenstrual asthma, eliminating the decrease in peak flow rate, as well as reducing total corticosteroid requirement.\textsuperscript{75} The use of danazol, intramuscular medroxyprogesterone acetate (Depo-Provera), or gonadotropin-releasing hormone agonists to suppress menstrual cyclicity remains a promising area for investigation.

**RHEUMATOID ARTHRITIS**

Symptoms of rheumatoid arthritis often improve in the luteal phase when gonadal steroid production is maximal. Similarly, improvement is seen during pregnancy, with exacerbation postpartum.\textsuperscript{76,78} A subjective increase in morning stiffness and arthritic pain during menstruation and the early follicular phase has been shown.\textsuperscript{79} Rudge et al\textsuperscript{80} objectively documented menstrual cycle-related variations in rheumatoid arthritis by demonstrating a significant decline in mean grip strength at the start of menstruation. Similarly, the size of finger joints peaked within 6 days of the start of menstruation, corresponding in many cases with increased body weight.\textsuperscript{80}

The abrupt decline of ovarian steroidogenesis resulting from involution of the corpus luteum is thought to be responsible for “menstrual arthritis,” a rare condition in which arthritis occurs exclusively at the time of menses.\textsuperscript{81} Cyclic alterations in rheumatoid arthritis may be attributable to menstrual cyclicity in the immune response. Cyclic changes in local antibody release\textsuperscript{82,83} and in white blood cell subpopulations\textsuperscript{84} have been described. Both estrogen and progesterone have anti-inflammatory properties that may ameliorate arthritic symptoms.\textsuperscript{85,86} Premenstrual exacerbation of symptoms has also been attributed to altered pain perception associated with premenstrual alterations in mood.\textsuperscript{80}

Estrogen, either alone\textsuperscript{87} or in the combination oral contraceptive pill\textsuperscript{88} has proved beneficial for some women with rheumatoid arthritis. Oral contraceptives may delay onset of disease, but do not prevent its occurrence.\textsuperscript{80-81} Although not as thoroughly studied, estrogen replacement therapy in postmenopausal women appears not to protect against the occurrence of rheumatoid arthritis.\textsuperscript{82,83}

**IRRITABLE BOWEL SYNDROME**

Irritable bowel syndrome is a common gastrointestinal disorder, diagnosed clinically by the triad of chronic or recurrent abdominal pain, altered bowel habits, and the absence of a structural or biochemical abnormality.\textsuperscript{94,95} Symptoms of irritable bowel syndrome appear in late adolescence and affect women 3 to 20 times more frequently than men.\textsuperscript{94,96} In women, symptoms tend to recur and become cyclic, with exacerbation during the postovulatory and premenstrual phases of the menstrual cycle, suggesting a hormonal influence.\textsuperscript{97,98} Women in the ovulatory phase frequently report constipation in the progesterone-dominant luteal phase, with loose stool or diarrhea at, or
immediately preceding, the onset of menstruation.

Progestosterone has well-documented effects on the gastrointestinal system, including a reduction in lower esophageal sphincter tone and delayed gastric emptying.99,100 Delayed gastrointestinal transit time in women, particularly during the luteal phase, has also been demonstrated.101-103 Progesterone may act as an endogenous antagonist of enteric nerve function.98 Abrupt progesterone withdrawal may trigger an increase in bowel activity.

Gastrointestinal symptoms such as abdominal pain, diarrhea, and constipation are consistently reported by women with irritable bowel syndrome, in association with the menstrual cycle.104-108 The most dramatic changes in bowel symptoms occur at the start of menstrual flow, a time when the levels of progesterone fall, and prostaglandin E2 and F2 alpha, powerful stimulants of colonic contractility, rise.104,105,109 Patients with irritable bowel syndrome, in whom the colon is hyperresponsive to a variety of stimuli, may have an exaggerated colonic response to prostaglandins released during menstruation.97

Treatment of irritable bowel syndrome is generally symptomatic, including antispasmodic and promotility agents, and bulk-forming laxatives. The theory of prostaglandin involvement in menstrual-related exacerbations of irritable bowel syndrome raises the possibility of treatment with prostaglandin synthesis inhibitors.

There have been several reports98 of successful treatment of irritable bowel syndrome with gonadotropin-releasing hormone agonists. With the menstrual cycle completely eliminated, these women experience significant and progressive improvement in bowel symptoms. Interestingly, many of these women experienced transient recurrence of their symptoms during the progestin phase of the estrogen and progesterin add-back therapy, given to minimize the long-term adverse effects associated with gonadotropin-releasing hormone agonists.98 It is likely that gonadotropin-releasing hormone agonists have direct effects on the enteric nervous system, in addition to their indirect effects on the gut, mediated through ovarian hormone suppression.114 This possibility is supported by limited evidence that gonadotropin-releasing hormone agonists provide relief from irritable bowel syndrome in men and in menopausal women.111 The expense and potential adverse effects of these medications will preclude prolonged use in most circumstances. Rarely, if dramatic relief results from a trial of ovarian suppression, ovariectomy and low-dose estrogen replacement may have a therapeutic role.

**DIABETES**

Menstrual cycle–related alterations in glycemic control during the luteal and premenstrual phases in some insulin-dependent individuals with diabetes have been reported.50,112-115 Most women describe a deterioration in glycemic control, although improvements have also been noted.113,114 Diabetic ketoacidosis, severe insulin reactions, and hypoglycemic episodes also occur more frequently around menstruation.111,114 In one exceptional case, insulin resistance and ketoacidosis recurred exclusively during menstruation.116

Altered insulin receptor binding and affinity at different times during the menstrual cycle have been reported in some,117-119 but not all120 studies. Attempts to identify the hormones responsible for menstrual cycle–related changes in carbohydrate metabolism have produced conflicting results. Impaired glucose tolerance during the luteal phase is reported in healthy women without diabetes.121,122 In studies123-125 on the effects of oral contraceptives, physiologic levels of estrogen were found to have minimal effects on carbohydrate metabolism in women without diabetes. Studies126-128 of gestational agents have also demonstrated variable effects. It is possible that even small effects of estrogen and progesterone on glucose homeostasis are exaggerated in women with diabetes, in whom the normal feedback regulation between plasma glucose levels and insulin secretion is lost.112 Loss of eating control, such as bingeing or increased intake of sweets, is described by many women in the luteal phase and premenstrually,120-122 and is another possible cause for loss of glycemic control in women with diabetes during this time.

The exact mechanism of menstrual cycle–related effects on glucose homeostasis in women with diabetes is enigmatic. In practical terms however, women with diabetes should be counseled regarding the possibility of altered control. They need to recognize changes in their eating patterns and adjust insulin dosages accordingly. Ovarian suppression with gonadotropin-releasing hormone agonists has been used in women with recurrent life-threatening complications, such as recurrent severe insulin reactions or ketoacidosis associated with specific phases of the menstrual cycle, with good effect.113

**MISCELLANEOUS DISORDERS**

The previous discussion describes the effects of the menstrual cycle on several relatively common disorders. Several rare conditions show menstrual variation in severity. There are numerous case reports of catamenial pneumothorax, the occurrence of recurrent spontaneous pneumothorax exclusively associated with menses, possibly the result of pleural or diaphragmatic endometriosis.133-139 This has been successfully treated with gonadotropin-releasing hormone agonists.140

There is some evidence that acute appendicitis presents more frequently in the luteal phase, although this could be because of the misdiagnosis of pain in the right lower quadrant resulting from corpus luteal cysts, leading to unnecessary appendectomy. Other disorders exacerbated by the postovulatory and premenstrual phases of the menstrual cycle include acne, endocrine allergy and anaphylaxis, hereditary angioedema, erythema multiforme, urticaria, aphthous ulcers, Behc¸et syndrome, acute intermittent porphyria, paroxysmal supraventricular tachycardia, glaucoma, and multiple sclerosis.41,144-149 Gonadotropin-releasing hormone agonists have been used for some of these conditions, in particular for recurrent anaphylaxis and acute intermittent porphyria, when symp-
toms are severe or disabling.\textsuperscript{150,152} In contrast to these disorders, myasthenia gravis generally improves premenstrually.\textsuperscript{150,159} Although one early report\textsuperscript{152} indicated better outcomes if breast surgery was performed in the luteal phase, but subsequent investigators\textsuperscript{156} have been unable to confirm this finding.

AN APPROACH TO MENSTRUAL CYCLE–RELATED EXACERBATION OF MEDICAL DISORDERS

Exacerbation of certain medical conditions at specific times during the menstrual cycle is a well-recognized phenomenon. If a woman’s history is suggestive of significant deterioration of the underlying condition, then accurate documentation should be obtained using a menstrual calendar. Where appropriate, cyclic modulation of therapy may overcome any deleterious menstrual cycle–related changes in the disease process. If such measures prove ineffectual, a trial of medical ovulation suppression may be warranted. If a dramatic benefit results, consideration should be given to ongoing therapy with a gonadotropin-releasing hormone agonist and steroid add-back, or to a cheaper alternative such as intramuscular medroxyprogesterone acetate or danazol. If these medical approaches are impractical because of cost or adverse effects, and the woman’s fertility aspirations have been met, consideration of hysterectomy and bilateral oophorectomy with ongoing estrogen replacement therapy is appropriate.

CONCLUSIONS

The recognition of recurrent menstrual cycle–related exacerbations of a medical disorder opens the door to innovative treatments that alter or suppress gonadal steroid production. Elimination of ovarian cyclicality may provide dramatic relief for some women in whom standard therapies prove less than ideal.

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