This chapter reviews the current recommendations for imaging the following commonly encountered clinical indications: women with abnormal uterine bleeding (either pre- or postmenopausal), women with pelvic pain, women with a pelvic mass, men with scrotal pain, and men with a scrotal mass. The main points of the chapter are:

1. Pelvic ultrasound is the imaging study of choice for the evaluation of abnormal uterine bleeding.
2. Pelvic ultrasound is the imaging study of choice for the evaluation of female pelvic pain and masses.
3. Scrotal ultrasound is the study of choice for evaluation of scrotal pain and masses.

The remainder of the chapter discusses the clinical indications, the disease processes leading to the clinical indications, and the rationale behind ordering the studies. The chapter also illustrates several of the causative diseases.

Before proceeding, a few words about ultrasound technology. A detailed -or even a superficial- discussion of the physics of ultrasound is beyond the scope of this chapter. It is of interest, however, that the technology of ultrasound (like CT and MR) continues to advance, with developments allowing prettier, and, of course, more diagnostic scans. These developments include processing software such as harmonic imaging, and hardware such as the development of smaller and smaller probes allowing, for example, endoscopic ultrasound. A technical development which may have a large impact on the practical, day-to-day business in the radiology department is the sector probe with associated software. This technology captures a volume of data. With the current widely deployed technology, the technologist performing the ultrasound study tries to align the two dimensional plane of the ultrasound beam in the exact orientation to optimally demonstrate the target anatomy. With three dimensional scanning, the ultrasound machine acquires a volume of data which may be manipulated on a workstation. This technology, if widely implemented, has the potential to substantially reduce patient scan time and improve patient service.

Regardless of the technology of ultrasound, it makes sense that patients are (at least somewhat) mentally prepared for the ultrasound exam. Female patients should be advised that, for most women, pelvic ultrasound examination consists of two parts. The first part is a transabdominal scan, performed with the scan probe on the abdominal wall just above the symphysis pubis, which requires a full bladder. The pressure of the probe against a full bladder is not typically painful but may be mildly uncomfortable. If the patient arrives in the department without a full bladder, it is usually necessary to ask the patient to drink a large volume of water and to wait until the bladder is full before proceeding, so if you send a patient for an immediate pelvic ultrasound make sure the patient does not stop at the restroom on the way to the radiology department. The second part of the female pelvic ultrasound examination is the
endovaginal (also known as transvaginal) exam, which involves the use of a specially designed probe which is placed in the vagina. This technology, obviously not used in women who have never been sexually active nor in those who do not consent to the procedure, allows much better evaluation of the interior of the uterus (particularly the endometrial stripe) and the adnexae. It is best that women know about this aspect of the exam beforehand so that they can be mentally prepared at the time of the examination.

Another method of uterine evaluation using sonography is the sonohysterogram. In this study, the cervix is cannulated with a catheter and water is instilled into the uterine cavity. This has the effect of demonstrating the endometrial lining with much greater clarity than studies done without the instilled water, particularly with respect to differentiation of focal versus diffuse endometrial lesions. Sonohysterography may be helpful on occasion, but many gynecologists forego its use. These gynecologists reason that if a relatively interventional study is required anyway, hysteroscopy allows not only direct inspection of the endometrial canal, but biopsy of any abnormality to determine its histology. Histologic characterization is generally necessary for definitive treatment.

Finally, note that in addition to “gray-scale” images, ultrasound studies may incorporate color (color Doppler examination) or graphs (with spectral Doppler examination) to depict flow.

**PELVIC ULTRASOUND IS THE IMAGING STUDY OF CHOICE FOR THE EVALUATION OF ABNORMAL UTERINE BLEEDING**

Pelvic ultrasound is the study of choice for both abnormal premenopausal and postmenopausal uterine bleeding, but the causes of bleeding in these two scenarios differ and therefore they will be discussed separately.

**Postmenopausal bleeding**

Postmenopausal bleeding may have any one of many causes (Table 1), and, while most are benign and self limiting, endometrial cancer accounts for approximately 10% of such cases. Either endometrial biopsy or pelvic ultrasound may be used as the initial test for evaluation of the endometrium in women with postmenopausal bleeding, and often both tests will be used (see below). While the ultrasound examination will not provide an unequivocal histologic diagnosis, it is often helpful in directing further work-up. This section reviews the ultrasound results in the most common causes of uterine bleeding. Most of these processes will manifest with an abnormal, thickened endometrial stripe. The normal postmenopausal endometrial stripe measures less than 5 mm. Note that while the thickness of the endometrium is important, the stripe’s appearance is also critical: the endometrial stripe should demonstrate uniform thickness and should be uniformly hyperechoic relative to the adjacent uterus.

<table>
<thead>
<tr>
<th>Cause</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrophy</td>
<td>59%</td>
</tr>
<tr>
<td>Polyps</td>
<td>12%</td>
</tr>
<tr>
<td>Endometrial cancer</td>
<td>10%</td>
</tr>
<tr>
<td>Endometrial hyperplasia</td>
<td>10%</td>
</tr>
<tr>
<td>Hormonal effect</td>
<td>7%</td>
</tr>
<tr>
<td>Cervical cancer</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>


**Atrophy**

Postmenopausal lack of estrogen causes atrophy of both the endometrium and vagina. Endometrial atrophy and the associated lack of lubricating fluid erode the endometrial lining. Erosions of the atrophic endometrium may bleed. The ultrasound study in these patients may show either a normal or a thin endometrial stripe. The ultrasound study may also show blood (visualized as fluid) within the endometrial canal.

**Endometrial polyps**

Endometrial polyps are benign endometrial growths seen more frequently in women given
estrogen or the breast cancer drug tamoxifen. Polyps may cause either diffuse or focal thickening of the endometrial stripe, and in this regard the transvaginal study is more accurate not only in measuring the exact stripe thickness but also in differentiating whether the stripe is diffusely or focally abnormal. Note that endometrial polyps may also cause bleeding in premenopausal patients (see below, Figure 2).

**Endometrial hyperplasia**

Endometrial hyperplasia may produce a thick stripe on pelvic ultrasound. This thick stripe cannot be distinguished from the thick stripe caused by endometrial cancer, so these women will typically undergo biopsy. Note that since postmenopausal women should be estrogen deficient, endometrial hyperplasia is abnormal; causes include endogenous estrogen production from ovarian or adrenal tumors or exogenous estrogen therapy.

**Endometrial cancer**

While approximately 90% of patients with postmenopausal bleeding will eventually be found to have a benign cause, and while many patients with a thick endometrial stripe may have a benign cause (such as hypertrophy or an endometrial polyp) for this finding, the combination of postmenopausal bleeding and a thick endometrial stripe needs to be regarded with great suspicion. Almost all these patients require biopsy, and on occasion, re-biopsy, for evaluation (Figure 1).

![Figure 1](image1)

**Figure 1.** Endometrial cancer in a 60 year old woman with postmenopausal bleeding. This patient had a single episode of bright red blood followed by spotting. Endometrial biopsy resulted in a benign polyp and no malignancy. The ultrasound demonstrated a thick endometrial stripe, after which the patient had hysteroscopy and a D&C, with a diagnosis of endometrial cancer. This is an example of where the addition of an ultrasound study to endometrial biopsy resulted in improved patient management.

![Figure 2](image2)

**Figure 2.** Endometrial polyp in a 50 year old with premenopausal bleeding. A. Transabdominal pelvic ultrasound study shows a diffusely abnormal thick endometrial stripe (arrows). B. Transvaginal pelvic ultrasound study demonstrates that there is a focal lesion along the mid to inferior aspect of the endometrial stripe. Biopsy demonstrated an endometrial polyp.
Abnormal premenopausal bleeding

As one source notes, “a confusing, inconsistent, and overlapping array of terms has evolved to describe abnormal frequency, duration, or volume of uterine bleeding”. For this reason, the general term “abnormal uterine bleeding” is often used. Pelvic ultrasound may be used in these patients to evaluate endometrial stripe thickness, because polyps (Figure 2), hyperplasia, and malignancy may also occur in premenopausal patients. For further discussion of these disease entities, see above.

PELVIC ULTRASOUND IS THE IMAGING STUDY OF CHOICE FOR THE EVALUATION OF FEMALE PELVIC PAIN AND MASSES

Women may present with pelvic masses, or pain in the adnexa, or painful masses, or pain in the adnexa with a mass found on ultrasound which may not be the cause of the pain. When imaging is necessary, as with abnormal bleeding, ultrasound is the study of choice.

Acute pelvic pain

Many diseases produce pelvic pain in women. This section discusses and illustrates gynecologic causes. Chapter 1 discusses renal causes and Chapters 7 and 8 discuss gastrointestinal causes. History and physical examination results may point to which organ system and which disease causes pelvic pain (Table 2), but features of the various diseases overlap. Ultrasound is usually the best first examination to perform because of the relatively low cost, absence of ionizing radiation, and availability. CT or MR may be done for further evaluation if necessary (see page 101).

<table>
<thead>
<tr>
<th>Pain Feature</th>
<th>Suggests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missed period or positive pregnancy test</td>
<td>Ectopic pregnancy</td>
</tr>
<tr>
<td>New onset mid-cycle pain</td>
<td>Physiologic cyst</td>
</tr>
<tr>
<td>Pain following intercourse</td>
<td>Ruptured cyst</td>
</tr>
<tr>
<td>Dysmenorrhea and dyspareunia</td>
<td>Endometriosis</td>
</tr>
<tr>
<td>Acute onset pain with nausea and vomiting</td>
<td>Ovarian torsion</td>
</tr>
<tr>
<td>Pain with fever</td>
<td>Pelvic inflammatory disease</td>
</tr>
</tbody>
</table>

Table 2. Pelvic pain features which suggest a specific diagnosis.

Ectopic pregnancy

Any woman of child-bearing age with acute pelvic pain needs to have a pregnancy test done, and if the pregnancy test is positive it is imperative to exclude an ectopic pregnancy. If there is a live, normal appearing intrauterine pregnancy with compatible beta HCG measurements, then other sources of pelvic pain should be sought, unless the patient is on fertility drugs (which greatly increase the changes of otherwise extremely rare simultaneous intra- and extra-uterine pregnancy). If there is no obvious, appropriately sized intrauterine...
pregnancy, then ectopic pregnancy should be suspected. In some ectopic pregnancies, there is fluid in the endometrium which forms a so-called “pseudogestational sac” which may be impossible to distinguish from an early intrauterine pregnancy. Pelvic ultrasound studies may or may not show an adnexal mass, and will rarely demonstrate a genuine fetus (with heartbeat) outside the gestational sac.

**Ovarian cyst - simple**

A simple cyst is a cyst with no solid component. Cysts may cause pain because of expansion of the ovarian capsule, rupture (in which case there may be little remaining of the cyst but there may be free fluid in the pelvis) and hemorrhage (see below). Given the frequent appearance of cysts in asymptomatic patients, the causal connection between cysts and pelvic pain may be difficult to establish. For premenopausal patients, simple cysts smaller than 3 cm almost always represent dominant (Graafian) follicles, and some authors advocate the term “follicle” for such lesions rather than “cyst” (even though they are cysts), as a way to indicate that such small, simple cysts are probably best ignored, particularly if asymptomatic. Simple cysts larger than 10 cm typically undergo surgical exploration, while cysts between 3 and 10 cm are followed with sequential ultrasound studies to document stable or decreased size.

Recommendations regarding the timing of follow-up studies vary from a single study done following the next menstrual cycle to multiple studies done at 3 month intervals for up to two years. Most of these cysts decrease in size within 12 to 24 months. For postmenopausal patients, size criteria for intervention move downward, with follow-up typically recommended for all cysts (or at least cysts over 20 mm) and surgical exploration for cysts over 5 cm, although again recommendations vary. In most cases, correlation with CA-125 measurements is advised, with surgical exploration in those patients with elevated levels.

**Ovarian cyst - hemorrhagic**

Hemorrhage into a simple cyst typically causes pain. The ultrasound appearance of hemorrhagic ovarian cysts is typically highly characteristic, allowing a presumptive diagnosis; a follow-up study is usually performed to confirm resolution of the abnormality (Figure 4).

![Figure 4. Hemorrhagic cyst in a 44 year old with sudden onset pelvic pain. A. Pelvic US done when the patient was in acute pain shows an enlarged heterogeneous ovary (arrows). B. Follow-up ultrasound done 10 weeks later following resolution of symptoms demonstrates that the ovary has returned to normal (arrows).](image-url)
Figure 5. Endometriosis in a 32 year old with pelvic pain. A. Transabdominal ultrasound shows a large homogeneous pelvic mass. B. Transvaginal ultrasound also shows a large homogenous mass with somewhat better detail of the uniform coarse echotexture. Imaging features are characteristic of an endometrioma (as was found at surgery), but some hemorrhagic cysts have a similar appearance.

Endometriosis

While endometriosis typically causes chronic rather than acute pelvic pain, hemorrhage into an endometrioma may cause acute pelvic pain. The ultrasound study may occasionally demonstrate a typical appearance of a relatively homogenous, hypoechoic adnexal lesion (Figure 5), but the imaging features may also resemble those of a hemorrhagic cyst. Small endometrial implants may cause pain but be very difficult to identify on ultrasound. MR may be used to identify and characterize endometriomas.

Ovarian torsion

The ovary may twist on its pedicle, compromising blood flow and resulting in pelvic pain, nausea, and vomiting, clinical features shared by appendicitis. Ultrasound will typically demonstrate a swollen ovary, often accompanied by inflammatory free fluid in the pelvis. While color and spectral Doppler studies may be abnormal and characteristic with obvious diminished or absent flow within the ovary, these studies may show normal appearing flow either because of intermittent torsion or because arterial flow (demonstrated on the ultrasound study) is impeded only after venous flow (not demonstrated on the ultrasound study, but a source of symptoms when diminished).

Pelvic inflammatory disease

Pelvic inflammatory disease (PID) may cause pelvic pain secondary to inflammation of mucosal surfaces. Most cases of PID result from ascending infection from a sexually transmitted disease which causes cervicitis, endometritis, and then infection of the fallopian tubes with associated pyosalpinx. Sonography may be normal prior to development of pyosalpinx. See Figure 1 in Chapter 8, page 102.

Degenerating uterine fibroid

Degenerating uterine fibroids undergoing hemorrhage or infarction may cause pelvic pain. Ultrasound performs well in diagnosing uterine fibroids, although, as with ovarian cysts, fibroids are so commonly seen in asymptomatic patients that it may be difficult to establish the fibroid as a cause of pain. Sonographic features which may suggest degeneration include anechoic areas suggesting hemorrhage or color Doppler studies showing a lack of blood flow suggesting infarction. Magnetic resonance imaging may be helpful if differentiation between infarcted tissue and remaining vascularized tissue is necessary for surgical planning (Figure 6).
Female pelvic mass

Multiple diseases may produce pelvic masses. Many of these disease processes will also cause pain, and these processes are discussed above. Painless pelvic masses of the uterus typically represent fibroids (see above). Painless adnexal masses may represent simple cysts (again, see above) or a complex mass, often arising in the ovary. Such complex masses generally require gynecologic or even gynecologic oncologist referral, particularly in the postmenopausal patient. While researchers have made multiple attempts to define ultrasound criteria to separate benign and malignant adnexal and ovarian masses based on various imaging features (size, complexity, vascular flow indices), no imaging feature or set of features is entirely accurate and most of these patients either need close follow-up or surgical exploration.

Complex (combined cystic and solid) adnexal lesions

In premenopausal patients, dermoid cysts (Figure 7) and hemorrhagic cysts (Figure 1) will often demonstrate a characteristic appearance, with surgery typically performed on the former and sequential follow-up studies performed on the latter to prove resolution. Absent a typical appearance of one of these entities, or in postmenopausal

Figure 6. Degenerating (infarcting) fibroid in a 46 year old with pelvic pain. A. US shows hypoechoic areas within a fibroid (arrows) compatible with necrotic debris. B. T1 weighted MR done without contrast shows the exophytic fibroid (arrows). C. T2 weighted MR shows areas of T2 prolongation (bright signal, arrow) within the fibroid corresponding to the hypoechoic areas on the US study, representing fluid secondary to necrosis. D. Contrast-enhanced, fat-suppressed T1 weighted image demonstrates intense enhancement of the fibroid (arrows) except for the necrotic central portion.
Figure 7. Pelvic (ovarian) dermoid in a 17 year old with a painless pelvic mass. A. Transvaginal ultrasound shows a cystic component (white arrow) as well as an intensely echogenic region which casts a shadow (black arrow). B. CT scan shows both calcified (black arrow) and fatty (white arrow) components in a large predominantly hypodense (cystic) lesion. Surgical resection was performed, yielding an ovarian dermoid.

Figure 8. Uterine fibroids in a 40 year old with a painless pelvic mass. A. US study shows multiple fibroids within the uterus with typical “venetian blind” shadowing (white arrows). B. Sagittal T1 weighted MR (done for further characterization of multiple fibroids) demonstrates a huge exophytic fibroid (arrow) emanating from the superior margin of the uterus.
patients, referral to a gynecologic oncologist is usually appropriate because of the likelihood of malignancy.

**Uterine fibroids**

Fibroids make up the vast majority of uterine masses. US can demonstrate the size and location of uterine fibroids, which typically show a characteristic “venetian blind” type of shadowing (Figure 8).

**SCROTAL ULTRASOUND IS THE STUDY OF CHOICE FOR EVALUATION OF SCROTAL PAIN AND MASSES**

Scrotal symptoms may be divided by various methods, for example by how acute the symptoms are, whether the presentation is pain or a painless mass, or by the age of the patient. This chapter will address scrotal pathology in terms of how acute the symptoms are. Note that many of the acute patients may come to the emergency room rather than to a clinic. If imaging is required, regardless of how scrotal symptoms are divided, ultrasound is the imaging study of choice.

**Scrotal US is the study of choice to evaluate acute scrotal pain**

<table>
<thead>
<tr>
<th>Disease</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testicular torsion</td>
<td>16%</td>
</tr>
<tr>
<td>Torsion of the testicular appendix</td>
<td>46%</td>
</tr>
<tr>
<td>Epididymitis</td>
<td>35%</td>
</tr>
</tbody>
</table>


Ultrasound performs admirably in the evaluation of scrotal pain. Ultrasound should be able to diagnose or at least suggest one of the three most common diseases accounting for scrotal pain: testicular torsion, torsion of the testicular appendix, and epididymitis (see Table 3). Less frequent causes include infections of the scrotal wall and testicular rupture from trauma. Note that epididymitis and torsion may occur with or without associated trauma.

**Testicular torsion**

Patients with testicular torsion present with pain, usually acute in onset and sometimes after vigorous physical activity or minor trauma. Children may awake with pain in the scrotum. Torsion occurs when the testicle twists on its vascular pedicle, impeding blood flow both into and out of the testicle. Impaired blood flow causes testicular swelling and pain, and may progress to infarction relatively quickly, making prompt diagnosis imperative. The imaging features include swelling and abnormal color Doppler images (Figure 9), but because the torsion may be intermittent or not have progressed to the point where arterial flow has stopped, color Doppler imaging may still show flow and thus be misleading. Pulsed wave or spectral Doppler imaging is more sensitive and should be included in all scrotal examinations, but it, too, may be misleading, and the scan may show only testicular swelling or even be normal (especially in cases of intermittent torsion). Therefore, patients with severe intermittent or severe persistent pain should probably be referred to urology for evaluation regardless of the ultrasound results, unless the clinical features and ultrasound results are clearly those of epididimo-orchitis or torsion of a testicular appendix.

**Torsion of the testicular appendix**

The testicular appendix is a small, vestigial structure along the anterior, superior aspect of the testicle. These appendages may twist on their pedicles, impeding blood flow with subsequent testicle infarction and associated pain. The pain is usually less severe and of more gradual onset than testicular torsion, but the two processes may be quite difficult to distinguish clinically. Ultrasound generally demonstrates a normal appearance of the testicles and epididymis in torsion of the testicular appendix; occasionally, ultrasound demonstrates the twisted appendage as a small, avascular structure adjacent to the testicle at the location of maximum pain.
Figure 9. Testicular torsion with infarction in a 59 year old man with four days of scrotal pain. A. Scrotal ultrasound of the abnormal side shows a swollen testicle with no flow to the testicle but hyperemic tissue around the testicle, along with a reactive hydrocele. B. Ultrasound of the opposite testicle shows the normal, contralateral testicle with normal flow, as indicated by flow within the testicle.

Figure 10. Epididymitis in a 14 year old with three days of scrotal pain. A. Ultrasound with color Doppler of the asymptomatic side shows a normal sized epididymis with normal flow (arrow). B. Ultrasound with color Doppler of the symptomatic side shows swelling and hyperemia of the epididymis, with increased flow (arrow).
**Epididymitis**

The epididymis connects the testicle to the vas deferens, and is a coiled tubular structure along the posterior, superior margin of the testicle. Inflammation of the epididymis may occur secondary to trauma, severe straining (particularly young men participating in the weight lifting exercise known as “squats”), bicycle and motorcycle riding, or sexually transmitted diseases. The epididymis is swollen and painful on clinical examination. Ultrasound demonstrates an enlarged epididymis with increased flow compared to the contralateral side on color Doppler imaging (Figure 10).

**Other infections**

Infections of the scrotal wall and perineum (Fornier’s gangrene) may also be assessed with ultrasound, which will demonstrate extensive skin thickening and hyperemia with normal testicles deep to the abnormal superficial tissues (Figure 11). These infections require emergent referral and treatment.

**Scrotal US is the study of choice to evaluate chronic scrotal conditions**

Ultrasound is also the study of choice for the evaluation of chronic scrotal conditions, including an absent testicle (with suspected cryptorchidism) chronic scrotal pain (which may be caused by varicocele or chronic epididymitis), and a scrotal mass (which may be caused by a spermatocele, hydrocele, or testicular tumor).

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**Figure 11.** Fornier’s gangrene in a 48 year old with severe pain and swelling of the scrotum for several days. A. Normal testicle with normal flow on color Doppler, but with thick surrounding tissue (arrow). B. The testicle from a different angle, with a larger field of view, demonstrates the testicle swimming in a sea of inflammatory tissue.
Undescended testicle

Undescended testicles present with an absence of one or both testicles in the scrotum. Undescended testicles do not produce sperm as well as testicles in the scrotum, and are prone to malignant degeneration\(^\text{10}\). Undescended testicles are usually in the inguinal canal and may be seen with ultrasound (Figure 12). Intra-abdominal undescended testicles may be evaluated with CT.

Varicocele

Varicoceles may cause pain or present as a painless mass. The root problem is venous drainage: on the left side, the testicular vein runs from the testicle to the left renal vein, which it enters at an approximately perpendicular angle, making the left side prone to reflux and varicocele formation. Ultrasound will demonstrate a “bag of worms” appearance adjacent to the testicle, with color flow imaging showing abundant flow in the varicocele (Figure 13).
Epididymal cyst

With respect to palpable lesions of the scrotum, most of the extratesticular lesions will be benign cysts, and represent either epididymal cysts (less than 2 cm) or spermatoceles (greater than 2 cm). These lesions demonstrate the classic ultrasound appearance of a cyst, showing an anechoic appearance with no internal echoes, a sharply defined wall, and posterior enhancement (because more of the ultrasound beam travels through the cyst than the adjacent soft tissues) (Figure 14). Typically, these lesions require no treatment and the course of action consists of reassuring the patient that all is well.

Testicular tumor

Intratesticular palpable lesions, unlike extratesticular lesions, are more frequently solid and such lesions are always worrisome (Figure 15). While there are some generalities regarding the appearance of the lesion and the ultimate pathologic diagnosis, distinguishing between the various cell types by ultrasound is not possible and basically a moot point anyway, since virtually all of these lesions result in orchiectomy and pathologic evaluation.
SUMMARY

Ultrasound examination is the study of choice for evaluation of female pelvic pain, abnormal uterine bleeding (both pre- and postmenopausal), and pelvic masses. Ultrasound allows evaluation of the endometrial stripe, which is helpful in the work-up of patients with possible endometrial cancer. It also allows differentiation of fibroids within the uterus from adnexal cysts and masses. Ultrasound examination is also the study of choice for scrotal pain and masses. It can usually identify and distinguish torsion of the testicular appendage and testicle. Ultrasound can also differentiate benign, extratesticular causes of masses (e.g., varicoceles and spermatoceles) from malignant, intratesticular lesions.

REFERENCES

5. Hoffman MS. Overview of the evaluation and management of adnexal masses. UpToDate, accessed 12/17/08.