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# Color-flow and power Doppler imaging of the testes

**Abstract** The development of color-flow imaging has made ultrasound the primary imaging modality for the evaluation of testicular pathology. The ability to distinguish between epididymo-orchitis and torsion is of great clinical significance in those patients with acute onset of pain. Not only does the appropriate treatment depend on the correct diagnosis, but the outcome following that treatment is also dependent on establishment of the diagnosis. Although it is of less importance in the evaluation of testicular neoplasms, color-flow imaging does provide adjunctive information that can aid in establishment of the proper diagnosis in confusing clinical situations. The diagnosis of varicocele depends on color-flow imaging, and the prediction of testicular viability following trauma is essential for proper treatment. More studies concerning the use of power Doppler for imaging of scrotal disorders are necessary to determine what its role will be.

The development of color-flow and power Doppler has made ultrasound the imaging modality of choice for the evaluation of scrotal pathology. The ability to demonstrate normal vascular anatomy as well as the presence or absence of flow in various pathologic conditions has improved not only the diagnosis of various scrotal disorders but also the therapeutic outcome following treatment. Ultrasound has become particularly useful in the evaluation of acute scrotal disorders. The four major testicular pathologies diagnosed with ultrasound include epididymo-orchitis; torsion, including torsion of the testicular appendages; tumors; and varices. On rare occasions, testicular trauma may also be evaluated with ultrasound.

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## Normal findings

Prior to the development of color-flow imaging, radionuclide scintigraphy was the principle means for evaluating the scrotum. As early as 1990, reports began to appear in the literature describing the technique of color-flow testicular imaging as well as descriptions of early pathology (Fig. 1). It became clear that a distinction between adults and children being examined with color-flow ultrasound was necessary. Initially the flow sensitivity of the early ultrasound units was not as developed as it currently is, and it was difficult to see normal blood flow in children. Atkinson et al. [1] demonstrated in 32 patients aged from 7 day to 18 years that color flow correctly distinguished between 8 testicular torsions and the remaining patients, who had various pathologies, including epididymitis, epididymo-orchitis, tumors, and hydroceles. More recently, Paltiel et al. [10] demonstrated that the resistive indices obtained from color-flow duplex imaging spectrums performed in 33 asymptomatic healthy boys ranging in age from 3 days to 17.5 years diminished with increasing age. In particular, the larger the testicular volume, the lower the resistive index. They concluded that the mean testicular resistive index is lower in post-pubertal boys than in prepubertal boys. Despite these results, color-flow imaging in neonates and in young children remains problematic. It was hoped that the development of power Doppler imaging, which is approximately 15 dB more sensitive than color-flow imaging for the detection of flow, would prove helpful in this population. Although some improvement in the ability of power Doppler imaging to detect testicular flow has recently been reported, the accuracy of ultrasound imaging in

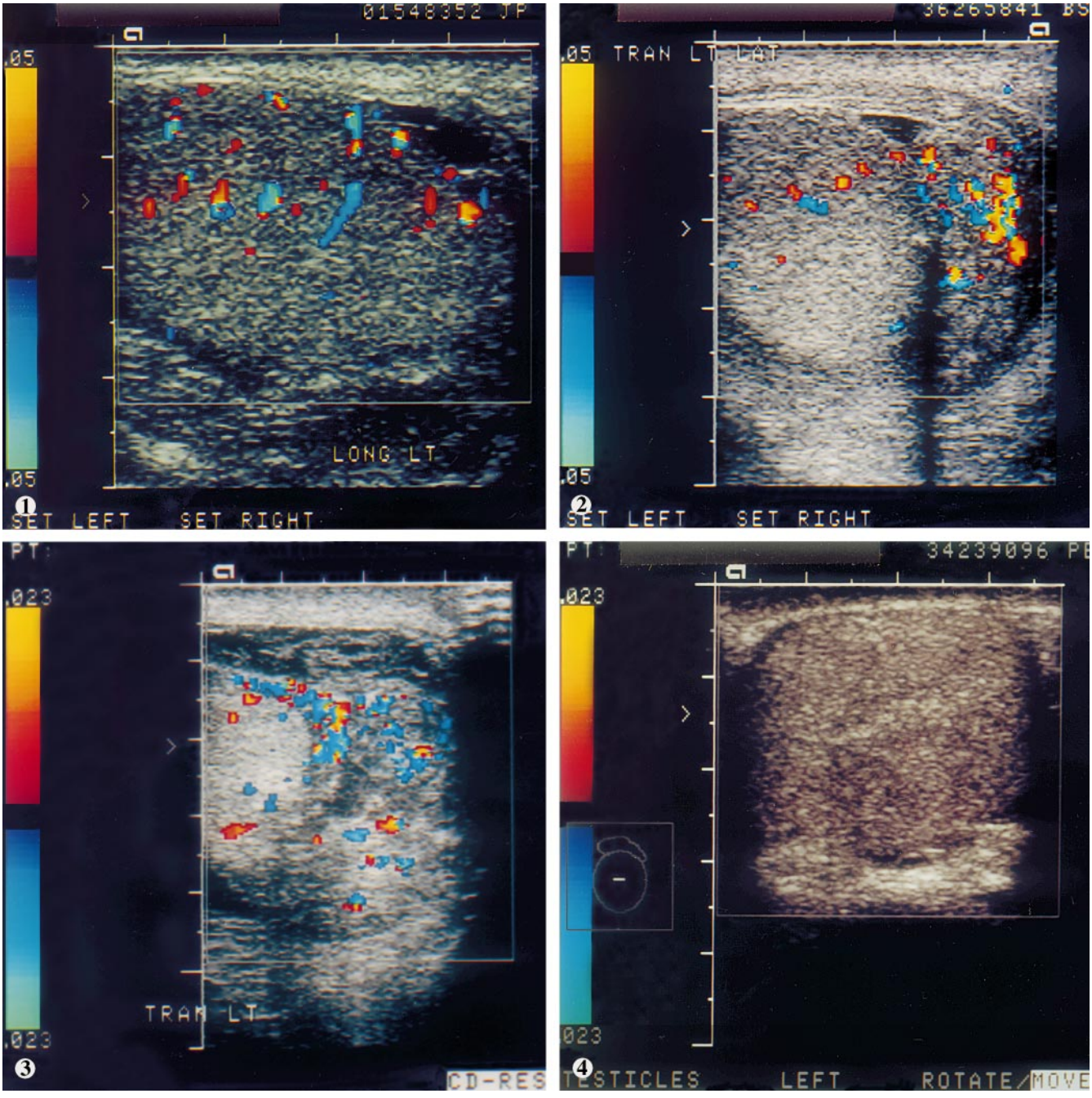



**Fig. 1** This color-flow image demonstrates normal testicular vascular anatomy. Centripetal vessels enter from the periphery of the testicle centrally. These vessels turn on themselves and are then known as recurrent rami, and this accounts for the *blue* and *red* appearance of some of the vessels shown

**Fig. 2** Color-flow image of epididymo-orchitis. The epididymis is enlarged relative to the testicle and, on color imaging, markedly increased flow can be seen within the epididymal head. The normal epididymis generally has low-velocity, high-resistance flow, and low-resistance arterial flow as well as venous flow are generally not seen. In this case a small amount of echogenic fluid is also visible within the left hemiscrotum, consistent with a small pyocele

**Fig. 3** Color-flow image of epididymo-orchitis. In this case as in the last, the epididymal head is enlarged and contains increased flow within it. In addition, the periphery of the testicle is markedly hyperemic, consistence with orchitis

**Fig. 4** Color-flow image obtained in a 20-year-old man presenting with acute onset of pain. No flow is present within the testicle, which otherwise appears normal in size and echogenicity. The other side was normal and at surgery a 720 torsion was found. There is some evidence to suggest that torsed testicles that are normal in echogenicity have increased rates of salvageability at surgery as compared with torsed testicles demonstrating testicular hypoechogenicity

detecting flow has not improved considerably in children.

The major indication for testicular ultrasound in the acute setting is differentiation between epididymo-orchitis and testicular torsion. Both can present as acute onset of pain, and the clinical differentiation between these entities is unreliable, with a nearly 50% false-positive rate being determined for cases explored surgically on the basis of clinical findings alone. Epididymo-orchitis is an inflammatory disease involving the epididymis, testes, or both, and it can be viral, bacterial, or traumatic in etiology. Gray-scale ultrasound findings include enlargement of the entire epididymis or of the head, body, or tail alone and, on occasion, enlargement and inhomogeneity of the testicle. Unfortunately, the gray-scale findings for testicular torsion vary, depending on the duration of the disorder. Early, the epididymis and the testicle may appear normal on gray-scale images. Malrotation of the testicle has been described as a finding in torsion, although this has proved to be an unreliable ultrasound finding. Some emphasis continues to be placed on malrotation as part of the clinical examination. Color-flow imaging is essential for distinguishing between torsion and epididymo-orchitis.

In acute epididymo-orchitis there is increased blood flow within the epididymis (Fig. 2). Normally, only high-resistance, low-velocity arterial flow can be demonstrated on duplex Doppler imaging: however, in the presence of inflammation, lower-resistance arterial flow as well as venous flow can be detected. In severe enough cases, hyperemia of the involved testicle can also be demonstrated (Fig. 3). In contrast to testicular torsion, there is diminished flow, if any, on the involved side (Fig. 4). With torsion, the epididymis can become enlarged primarily due to venous outflow obstruction, and the lack of flow in the enlarged epididymis is a key feature for distinguishing epididymo-orchitis from testicular torsion. Middelton et al. [9] reported the use of color Doppler ultrasound in acute scrotal disorders in 28 patients. Testicular torsion was correctly diagnosed in seven cases with Doppler ultrasound. This result was compared with to radionuclide scintigraphy, where one false-negative diagnosis of a 180° torsion occurred. Hence, Middelton concluded that color Doppler ultrasound is at least as accurate as testicular scintigraphy and that it could be used in the evaluation of acute testicular pathology. Burks et al. [3] evaluated 32 patients with a painful scrotum; 7 of these 32 patients were diagnosed as having testicular ischemia on the basis of color-flow imaging, but flow was increased in one patient with an acute torsion. Flow was normal on the contralateral testicle on all cases. The author concluded that color Doppler sonography was a useful means of evaluating testicular ischemia. Patriquin et al. [11] evaluated 65 boys with acute scrotal pain by color Doppler ultrasound, and all then had scintigraphy and/or surgery or follow-up. Of 19 cases of testicular torsion, 17 were confirmed at surgery. However, there were six technical failures in which a flow signal could not be seen in either testicle. It was concluded that although color Doppler sonography was more useful than scintigraphy for evaluating testicular torsion, false-negative findings could occur, particularly in infants and children. A case report by Sanders et al. [12] demonstrated a case of reversed diastolic flow within the testicle. This occurred in a patient with epididymo-orchitis complicated by testicular necrosis. This is a complication that occurs rarely, and the authors concluded that impending infarction might be heralded by reversed diastolic flow within the testicle.

As both gray-scale and color Doppler imaging have improved, the diagnosis of torsion of the testicular appendages has become possible. Strauss et al. [13] reported five cases of an echogenic mass located posterior or inferior to the head of the epididymis in men with acute onset of pain. All were surgically confirmed to be torsion of the testicular appendages rather than of the testicle itself. Most recently, testicular detorsion during real-time color-flow Doppler imaging was reported by Cannon et al. [4]. In this case report, color Doppler imaging proved to be the means by which successful detorsion could be evaluated. In our own experience at the University of Texas-Houston, from 1994 to January 1, 1997, 174 patients with acute scrotum were evaluated at LBJ General Hospital. Of these, 25 were correctly identified as having torsion. Two false-positive torsions occurred in patients with epididymo-orchitis complicated by necrosis, although in these cases the diagnosis was suspected due to the presence of flow within the epididymal heads.

The potential for testicular salvage diminishes considerably in direct correlation with the duration of the interval between the onset of symptoms and surgical treatment. A salvage rate of nearly 100% is possible if the testicle is detorsed within 4 h of the onset of symptoms. When this period lasts longer than 12 h the salvage rate falls to less than 50%, although in some patients, intermittent or partial torsion occurs and these cases will have potential salvageability despite the prolonged duration of symptoms (Fig. 5). Differentiation of epididymo-orchitis from testicular torsion is of extreme importance since in general, epididymo-orchitis is a medically treatable condition and torsion requires surgery immediately. Few reports have emerged regarding the utility of power Doppler imaging in making this distinction, although early indications are that power Doppler imaging will primarily be used to improve visualization of flow within normal testicles of neonates and prepubertal males. Further work will be necessary to determine whether power Doppler imaging will really be necessary and should become the standard of care for evaluation of the acute scrotum.

## Tumors

Testicular tumors are generally divided into seminoma (Fig. 6) and nonseminomatous groups. Nonseminomatous tumors include teratocarcinoma, choriocarcinoma,

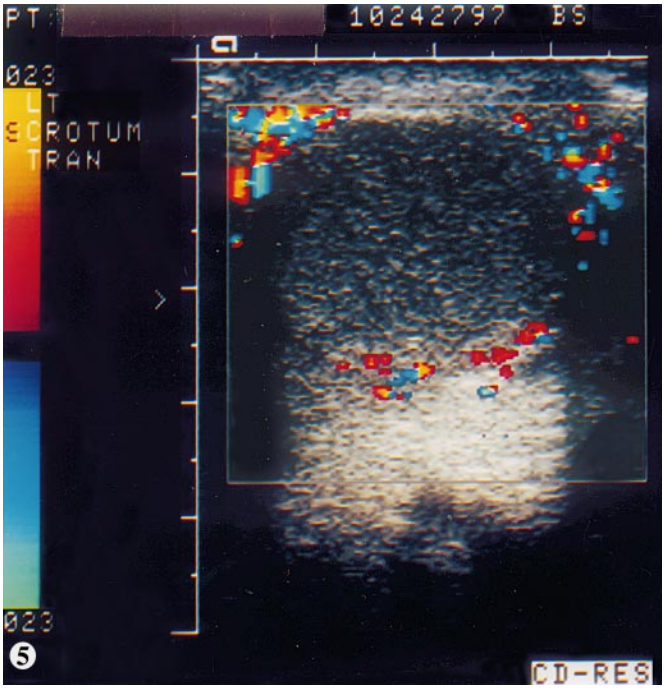
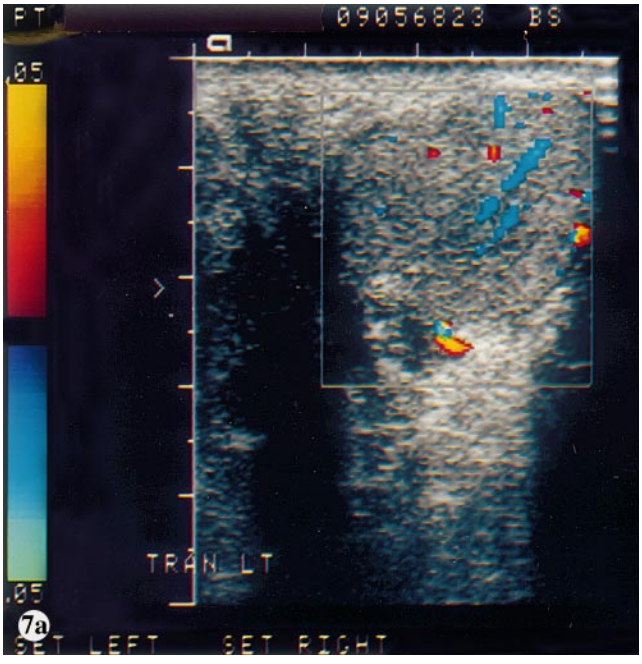




**Fig. 5** Color-flow image obtained in a 16-year-old boy with 2 days of testicular pain, demonstrating a markedly hypoechoic testicle with a hyporemic rim along the periphery. This finding is consistent with prolonged or delayed torsion. At surgery this testicle was infarcted

**Fig. 6** Color-flow image demonstrating no flow within the hypoechoic testicle. This was diagnosed as a torsion and the patient did present with acute onset of pain. At surgery a 360° torsion was indeed present; however, at pathology the entire testicle was replaced by seminoma. On occasion, testicular masses can present with acute onset of pain, and differentiation of torsion, epididymo-orchitis, and tumor can be difficult in this situation



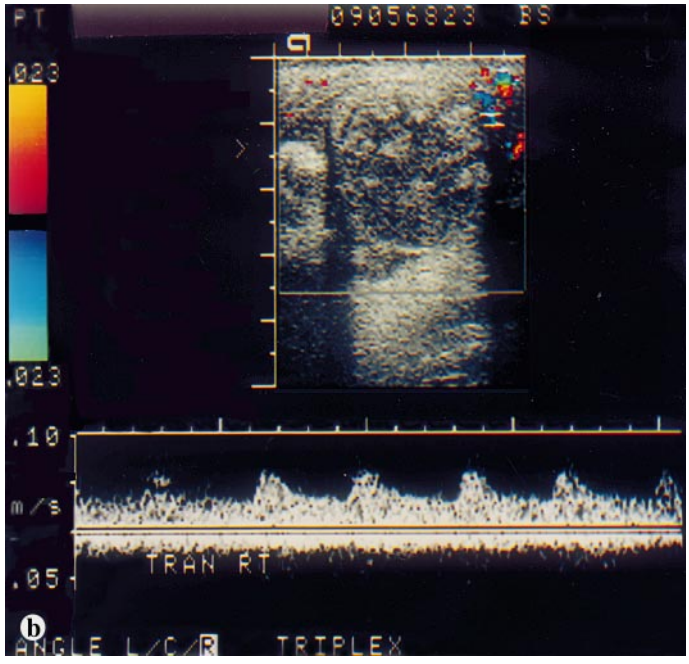




**Fig. 7** **a** Normal-sized testicle in a 32-year-old men with acute onset of right-sided pain. **b** The contralateral side has a complex bilobate mass with areas of increased echogenicity that do not cause posterior acoustic shadowing. The color-flow image demonstrates increased flow within the epididymis, consistent with the clinical presentation of acute epididymis. An ultrasound examination 1 month later demonstrated an unchanged appearance of the testicle, and at surgery a choriocarcinoma was found

and embryonal cell carcinoma (Fig. 7). Clinically, testicular masses can present as painless swelling and enlargement of the testicle. On occasion, however, these patients present with acute onset of pain, and differentiation of tumor from torsion and epididymo-orchitis with ischemia becomes difficult. On gray-scale imaging, seminomas are generally hypoechoic and fairly homogeneous in echogenicity. Teratocarcinomas tend to be cystic and may even contain calcifications. Embryonal

cell carcinomas may have diffusely hyperechogenic areas within them that do not cause posterior acoustic shadowing. Color-flow imaging generally demonstrates the presence of flow within the affected testicle, although on occasion, bizarre vascular anatomy will be seen due to distortion of the vessels by the neoplasm.

The degree of tumor vascularity is largely determined by the size of the lesion, with tumors measuring less than 1.5 cm in diameter generally having less flow than those with a diameter of greater than 1.5 cm. The presence of increased flow within an inhomogeneous testicle serves to exclude a diagnosis of torsion. Since in some cases, differentiation of tumor from epididymo-orchitis is not possible clinically, all patients with focal hypoechoic masses or diffuse inhomogeneity of the testicle must undergo follow-up examination to exclude neoplasm. The majority of testicular tumors occur in young to middle-aged men, particularly seminomas. Tumors of childhood can occur, and the prevalence of leukemia and lymphoma is much greater in these patients than in older individuals. In elderly male patients, lymphoma as well as metastases, is including those from melanoma, are more common. Luker and Siegel [7, 8] demonstrated increased blood flow in six of seven testicular neoplasms that had normal gray-scale testicular appearances. This article suggested that color-flow imaging was necessary in some instances to demonstrate testicular neoplasms. Backus et al. [2] described an association between testicular microlithiasis and primary testicular neoplasms. The primary means for making this differentiation was the presence of abnormal blood flow within the testicle. Horstman et al. [6] evaluated 21 neoplasms larger than 1.6 cm in diameter that were hypervascular and 6 of 7 lesions less than 1.6 cm in diameter that were hypovascular. They concluded that testicular size is associated with the amount of flow and, in particular, with the resistive indices of the flow signals obtained at duplex imaging.

Since testicular neoplasms are some of the neoplasms most responsive to chemotherapy, prompt diagnosis and staging is required for adequate outcome. Evaluation of the renal hila with both ultrasound and computer-assisted tomographic (CT) scanning once a testicular lesion is demonstrated is important. Controversy remains regarding the need for CT scanning versus chest radiography to evaluate pulmonary metastasis, particularly from seminoma. To date, very little has been written regarding the use of power Doppler imaging in the evaluation of testicular neoplasms, although recent presentations have suggested that the flow can be seen in smaller lesions with this modality than with color-flow imaging. The effect on treatment outcomes has yet to be demonstrated.

## Varicocele

Varicocele is a common entity that is frequently underreported but occurs in approximately 70% of normal adults. It represents dilatation of the veins of the spermatic cord and can be associated with pain, testicular atrophy, and a scrotal mass. In the majority of patients it is completely asymptomatic. The majority of varicoceles occur on the left side, i.e., nearly 80%, with 10% being bilateral and 10% occurring on the right. This is felt to be due to the differences in venous drainage from the right and left testicles into the inferior vena cava and left renal vein, respectively. On gray-scale imaging a varicocele can be suspected when a large number of tubular, anechoic structures measuring greater than 2 mm in diameter are present. For confirmation of a varicocele, however, color-flow imaging is necessary. Flow can be demonstrated within the dilated veins, but, more importantly, reflux during valsalva maneuvers or during standing confirms the diagnosis. Two cases of intratesticular varicocele, a rare anomaly, were reported by Weiss et al. [14]. Reflux into veins within the testicle were demonstrated on color-flow imaging and then confirmed surgically. Cvitanic et al. [5] evaluated varicocele recurrence following reparative surgery. In this series, following a varicocele repair, 64% of 28 patients had evidence of varicocele recurrence. Although varicocele is not a life-threatening condition, its effect on male fertility has been established, and the diagnosis is therefore important for this reason.

## Trauma

Color-flow and duplex imaging have also found utility in the evaluation of patients with testicular trauma. In these patients, rupture of the testicle would be an indication for surgical exploration. Determination as to whether part or all of the remaining testicle is viable is primarily reliant on the degree of vascularity that can be seen within the testicular fragments. This can be demonstrated with color-flow imaging. To date, little has been written regarding the utility of power Doppler imaging in this clinical situation. Ultrasound evaluation of testicular trauma is not uncommon, although actual rupture of a testicle that is well protected by several layers is far less uncommon than peritesticular hematocele.

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