

**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:**      **Acute Onset of Scrotal Pain — without Trauma, without Antecedent Mass**

**Variant 1:**                      **Adult or Child.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL</u>*</b>
US scrotum with Doppler	9	Excellent study that is generally available and has high sensitivity and specificity.	O
Tc-99m scrotal scintigraphy	4	Well-established study for adults. Interpretative experience and careful technique required.	☢☢☢
MRI pelvis (scrotum) without and with contrast	3	May be helpful if other tests inconclusive, but most often not practical in light of exigencies of the acute scrotum.	O
MRI pelvis (scrotum) without contrast	1		O
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

## ACUTE ONSET OF SCROTAL PAIN — WITHOUT TRAUMA, WITHOUT ANTECEDENT MASS

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### **Summary of Literature Review**

The ability to confidently establish a surgical versus a nonsurgical diagnosis for acute scrotal pain is important. The benefits of early surgery for testicular salvage in ischemic disease, primarily torsion of the spermatic cord, are well known [1,2] but must be balanced against the costs of operating unnecessarily on a large number of patients with nonsurgical disease, primarily acute epididymitis [2-5]. Although the acute scrotum is defined as acute scrotal swelling with or without pain, most patients present with pain as their primary complaint. The most common differential diagnoses of the acute scrotum include: 1) torsion of the spermatic cord, 2) torsion of the testicular appendages, and 3) acute epididymitis or epididymoorchitis. Less common diagnoses include: strangulated hernia, segmental testicular infarction trauma, testicular tumor, and idiopathic scrotal edema. This appropriateness discussion, however, will be limited to patients with acute pain who have no history of trauma and no history of a mass before the onset of pain.

Testicular torsion is rare in patients older than age 35 [1,3]. Acute epididymitis is commonly the cause of acute scrotal pain in patients younger than age 18, very common in patients age 19 to 25, and overwhelmingly the etiology in patients older than age 25. There are enough exceptions to these guidelines, particularly in patients younger than age 30, that they must be used with caution. Acute scrotal pain in prepubertal boys occurs most commonly from torsion of the testicular appendages, a process that may clinically mimic testicular torsion or epididymoorchitis [6]. A pathognomonic physical examination finding (“blue dot sign”) is infrequently encountered.

Patients with testicular torsion typically present with abrupt scrotal pain, while those with epididymitis have a more gradual onset of pain. Patients with torsion will have a normal urinalysis, while those adults (but not children) [7] with epididymitis will have an abnormal one. There is, however, overlap in the clinical presentation of the different causes of acute scrotal pain. Imaging in clinically equivocal cases may lead to an early diagnosis of testicular torsion and thus decrease the number of unnecessary surgeries. A study comparing primary scrotal exploration (294 patients) and initial ultrasound (US) examination (332 patients) with exploration for positive US results or a high clinical suspicion of torsion [5], showed that US obviated the need for exploration in many patients and thus shortened hospital stays.

### **Radionuclide Imaging**

Radionuclide scrotal imaging (RNSI) is an accurate examination in the differential diagnosis of ischemia versus infection [8]. The specificity in differentiating ischemia from other photon-deficient lesions is slightly lower [8]. Photon-deficient areas secondary to hydrocele, spermatocele, uncommonly an edematous appendix testis, and rarely an inguinal hernia can be mistaken for an avascular testis [8]. One study found that 20 of 27 photopenic scrotal lesions were false positives (not torsion), and the US examination prevented unnecessary surgery in 16 (59%) of these cases [9]. Many large series using RNSI to evaluate the acute scrotum have been reported [1,3,10-

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14]. The examination and the technique are well established [1,3,8] and reproducible, and most imaging specialists and nuclear medicine technologists have been trained in the performance and interpretation of these examinations. Problems in examination performance may arise in infants and very small children whose genitalia are small and therefore difficult to image. With increasing use of US, experience with RNSI, especially for more recently trained physicians, is decreasing, and this examination is seldom performed in most departments. The unavailability of RNSI equipment in many radiology practices and the time required for RNSI examinations may be also limiting factors [15].

Ga-67- or In-111-labeled white blood cell scans can be used to diagnose epididymo-orchitis, but is not useful in the acute setting where torsion of the spermatic cord is in the differential diagnosis since it takes at least 8 hours to perform.

## Ultrasound

Standard US of the scrotum should include both gray-scale and Doppler studies. Linear high-resolution transducers should be used. The studies should include both the scrotum and inguinal area. Gray-scale US alone can distinguish the cystic or solid nature of scrotal masses and often can identify an inflamed epididymitis or a necrotic testis, but it is much less sensitive to the earliest changes resulting from decreased or absent testicular perfusion. In patients with torsion, however, a normal homogenous echo pattern, is likely to indicate a viable testis, whereas a hypoechoic or inhomogeneous testis is likely to be nonviable [16]. Recent studies have shown a high sensitivity of gray-scale US to detect torsion of the spermatic cord [17-19].

A multicenter study of 919 patients 1 to 18 years of age studied for an acute scrotum found false negative color Doppler ultrasound (CDU) studies in 50 of 208 patients with torsion (sensitivity 76%) [20]. An abnormal spermatic cord “twist” was identified, however, in 199 of 208 patients (sensitivity 96%). Further, a normal linear cord was found in patients without torsion (705/711, 99% specificity). This finding has also been referred to as the “whirlpool sign” and can be found at the external inguinal ring, above the testis, and posterior to the testis and may be best seen in longitudinal, transverse, or oblique scans depending on the particular patient [21].

CDU is a valuable examination for evaluating testicular perfusion [4,12,22-31]. Settings optimized to detect slow flow include use of a small color-sampling box, lowest pulse repetition frequency, and lowest possible threshold [31]. Studies in the early 1990s showed a reasonable sensitivity and specificity for diagnosis of torsion [25,31] comparable to RNSI [28,32]. CDU equipment has improved, and experience has increased, with resultant sensitivity and specificity now ranging between 89%-100% [33-38]. Experience with CDU in evaluating the acute scrotum has increased, both by practicing physicians and by those in training. It is readily available and can be done quickly without any specific preparation. Power Doppler US can be used in place of, or as an adjunct to, CDU [39]. Power Doppler US has been shown to demonstrate flow where CDU does not and, in general, to demonstrate slower flow better than CDU [15,40,41]. Power Doppler US is especially useful to demonstrate intratesticular flow in prepubertal testes [42,43].

Doppler US is not without drawbacks. One area of concern has been its application in the young child and particularly the prepubertal child [44]. Studies in children have shown a sensitivity of 89% and specificity of 100%, but technically unsuccessful studies can occur, emphasizing the need for experience and proper equipment settings when examining the young child [45].

Blood flow can occasionally be preserved in patients with torsion [46,47]. Attention to spectral Doppler waveforms patterns (high-resistance arterial waveform, monophasic waveform) [47] and spermatic cord morphology (thick spermatic cord) [18-20,46] may help diminish false negative examinations.

The most common cause of acute scrotal pain in adolescent boys and adults is epididymo-orchitis. Grayscale US combined with color Doppler imaging is the prime imaging means to make this diagnosis. The epididymis is enlarged and may be increased or decreased in echogenicity. Scrotal wall thickening and hydrocele are common. The testis is involved in 20%-40% of cases (epididymo-orchitis). Increased color Doppler flow in the epididymis and, if involved, the testis is characteristic.

The most common cause of acute scrotal pain in the child is torsion of a testicular appendage (appendix epididymis or appendix testis). Reactive changes (hydrocele, epididymal head enlargement, increased color Doppler flow) from torsion of a testicular appendage may mimic epididymitis [6]. The torsed testicular appendage can be difficult to identify with US. It was seen in only nine of 29 patients (31%) in one study [6], but it is usually larger, rounder, and has more surrounding flow than normal appendages [48]. A size criterion of >5.6 mm alone

may discriminate torsion from normal testicular appendages with low sensitivity (67%) but high specificity (100%), obviating surgery in some cases [49].

Scrotal fat necrosis is an uncommon cause of mild to moderate scrotal pain typically in overweight prepubescent boys with recent cold exposure, usually from swimming. Typically diagnosed clinically, bilateral intrascrotal masses caudal to the testes are palpated. On US, the testes are normal, and the scrotal fat caudal to the testes is characteristically hyperechoic, with posterior shadowing [50].

An uncommon cause of acute scrotal pain in adult men (median age 37-38) is segmental testicular infarction [51,52]. While most cases are considered idiopathic, a number of associated conditions have been described, including epididymo-orchitis, trauma, or hematological disorders (sickle cell disease, polycythemia, and hypersensitivity angitis) and previous surgery. While a wedge-shaped avascular focal area on US is considered the classic appearance [52], round lesions were seen in 13/24 patients (54.2%) and color Doppler flow was seen in 4/24 patients (16.7%) in one series [51]. Magnetic resonance imaging (MRI) may be useful to identify patients with segmental testicular infarction when US is not conclusive. Segmental infarction is most often imperceptible on unenhanced T1-weighted MR images, but may show a central high-signal-intensity focus from hemorrhage. It is well-margined but has variable signal intensity on T2-weighted images. After administration of gadolinium chelate contrast medium, it is avascular but is most often circumscribed by an enhancing rim [52]. Because distinguishing between segmental testicular infarction and testicular tumor can be difficult, most authors in the past recommended surgery, but more recently a conservative approach with US follow-up has been recommended [53].

Acute idiopathic scrotal edema (AISE) is a rare, self-limiting condition that is characterized by sudden onset of edema and erythema of the scrotal wall. It is more commonly observed in children than in adults and is often diagnosed by exclusion. AISE is usually painless. The hallmarks of US findings are marked thickening of the scrotal wall with a heterogeneous striated and edematous appearance with increased vascularity [54]. Other findings include increased peritesticular blood flow, reactive hydrocele, and enlargement and increased vascularity of the inguinal lymph nodes [55]. The testes and epididymides are normal and do not show increased vascularity.

### **Magnetic Resonance Imaging**

MRI techniques are not typically used for the acute scrotum due to the limited availability of equipment and the long examination time involved. However, the use of MRI in scrotal diseases is increasing [56-58]. In one report, 11 patients with subacute signs and symptoms were evaluated, and a differential diagnosis between ischemia in six patients and infection in five patients could be made [59]. In a second study of 39 patients with an acute scrotum and an inconclusive US and physical examination, MRI had a sensitivity of 93% and a specificity of 100% for torsion [58]. The most sensitive finding in torsion is decreased or lack of perfusion on dynamic contrast-enhanced MRI [60]. Other characteristics include low or very low signal intensities with spotty or streaky patterns on fat-suppressed T2-weighted, heavily T2-weighted, or T2\*-weighted images [58,60]. The use of a combination of dynamic contrast-enhanced T1-weighted MRI imaging with T2- and T2\*-weighted sequences may help distinguish patients with torsion alone from those with torsion and hemorrhagic necrosis [60].

### **Summary**

- Patients in whom there is a strong clinical suspicion for testicular torsion can be promptly referred for scrotal exploration.
- CDU is the study of choice to evaluate patients with acute scrotal pain due to its widespread availability and its ability to diagnose testicular torsion with a high degree of sensitivity and specificity and to distinguish other causes of scrotal pain and swelling.
- RNSI is infrequently used due to longer examination times, less availability, use of radiation, and diminished diagnostic capability in young boys.
- If one performs CDU and results are equivocal for testicular torsion, scrotal exploration may ensue.
- Future studies are needed to evaluate the role of MRI in patients with acute scrotal pain who have equivocal CDU findings.

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.		

## Supporting Documents

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

## References

1. Chen DC, Holder LE, Melloul M. Radionuclide scrotal imaging: further experience with 210 new patients. Part 2: Results and discussion. *J Nucl Med*. 1983;24(9):841-853.
2. Joyce JM, Grossman SJ. Scrotal scintigraphy in testicular torsion. *Emerg Med Clin North Am*. 1992;10(1):93-102.
3. Holder LE, Martire JR, Holmes ER, Wagner HN, Jr. Testicular radionuclide angiography and static imaging: anatomy, scintigraphic interpretation, and clinical indications. *Radiology*. 1977;125(3):739-752.
4. Lerner RM, Mevorach RA, Hulbert WC, Rabinowitz R. Color Doppler US in the evaluation of acute scrotal disease. *Radiology*. 1990;176(2):355-358.
5. Lam WW, Yap TL, Jacobsen AS, Teo HJ. Colour Doppler ultrasonography replacing surgical exploration for acute scrotum: myth or reality? *Pediatr Radiol*. 2005;35(6):597-600.
6. Karmazyn B, Steinberg R, Livne P, et al. Duplex sonographic findings in children with torsion of the testicular appendages: overlap with epididymitis and epididymoorchitis. *J Pediatr Surg*. 2006;41(3):500-504.
7. Graumann LA, Dietz HG, Stehr M. Urinalysis in children with epididymitis. *Eur J Pediatr Surg*. 2010;20(4):247-249.
8. Lutzker LG, Zuckier LS. Testicular scanning and other applications of radionuclide imaging of the genital tract. *Semin Nucl Med*. 1990;20(2):159-188.

9. Hod N, Maizlin Z, Strauss S, Horne T. The relative merits of Doppler sonography in the evaluation of patients with clinically and scintigraphically suspected testicular torsion. *Isr Med Assoc J*. 2004;6(1):13-15.
10. Eshghi M, Silver L, Smith AD. Technetium 99m scan in acute scrotal lesions. *Urology*. 1987;30(6):586-593.
11. Golimbu M, Florio FE, Al-Askari S, Morales PA, Passalacqua A. Value of scrotal scanning. Report of 62 cases. *Urology*. 1985;25(1):89-92.
12. Lewis AG, Bukowski TP, Jarvis PD, Wacksman J, Sheldon CA. Evaluation of acute scrotum in the emergency department. *J Pediatr Surg*. 1995;30(2):277-281; discussion 281-272.
13. Melloul M, Paz A, Lask D, Manes A, Mukamel E. The value of radionuclide scrotal imaging in the diagnosis of acute testicular torsion. *Br J Urol*. 1995;76(5):628-631.
14. Nakielnny RA, Thomas WE, Jackson P, Jones M, Davies ER. Radionuclide evaluation of acute scrotal disease. *Clin Radiol*. 1984;35(2):125-129.
15. Sidhu PS. Clinical and imaging features of testicular torsion: role of ultrasound. *Clin Radiol*. 1999;54(6):343-352.
16. Middleton WD, Middleton MA, Dierks M, Keetch D, Dierks S. Sonographic prediction of viability in testicular torsion: preliminary observations. *J Ultrasound Med*. 1997;16(1):23-27; quiz 29-30.
17. Karmazyn B, Steinberg R, Kornreich L, et al. Clinical and sonographic criteria of acute scrotum in children: a retrospective study of 172 boys. *Pediatr Radiol*. 2005;35(3):302-310.
18. Arce JD, Cortes M, Vargas JC. Sonographic diagnosis of acute spermatic cord torsion. Rotation of the cord: a key to the diagnosis. *Pediatr Radiol*. 2002;32(7):485-491.
19. Baud C, Veyrac C, Couture A, Ferran JL. Spiral twist of the spermatic cord: a reliable sign of testicular torsion. *Pediatr Radiol*. 1998;28(12):950-954.
20. Kalfa N, Veyrac C, Lopez M, et al. Multicenter assessment of ultrasound of the spermatic cord in children with acute scrotum. *J Urol*. 2007;177(1):297-301; discussion 301.
21. Vijayaraghavan SB. Sonographic differential diagnosis of acute scrotum: real-time whirlpool sign, a key sign of torsion. *J Ultrasound Med*. 2006;25(5):563-574.
22. Atkinson GO, Jr., Patrick LE, Ball TI, Jr., Stephenson CA, Broecker BH, Woodard JR. The normal and abnormal scrotum in children: evaluation with color Doppler sonography. *AJR Am J Roentgenol*. 1992;158(3):613-617.
23. Burks DD, Markey BJ, Burkhard TK, Balsara ZN, Haluszka MM, Canning DA. Suspected testicular torsion and ischemia: evaluation with color Doppler sonography. *Radiology*. 1990;175(3):815-821.
24. Dewire DM, Begun FP, Lawson RK, Fitzgerald S, Foley WD. Color Doppler ultrasonography in the evaluation of the acute scrotum. *J Urol*. 1992;147(1):89-91.
25. Fitzgerald SW, Erickson S, DeWire DM, et al. Color Doppler sonography in the evaluation of the adult acute scrotum. *J Ultrasound Med*. 1992;11(10):543-548.
26. Horstman WG, Middleton WD, Melson GL. Scrotal inflammatory disease: color Doppler US findings. *Radiology*. 1991;179(1):55-59.
27. Middleton WD, Melson GL. Testicular ischemia: color Doppler sonographic findings in five patients. *AJR Am J Roentgenol*. 1989;152(6):1237-1239.
28. Middleton WD, Siegel BA, Melson GL, Yates CK, Andriole GL. Acute scrotal disorders: prospective comparison of color Doppler US and testicular scintigraphy. *Radiology*. 1990;177(1):177-181.
29. Ralls PW, Jensen MC, Lee KP, Mayekawa DS, Johnson MB, Halls JM. Color Doppler sonography in acute epididymitis and orchitis. *J Clin Ultrasound*. 1990;18(5):383-386.
30. Suzer O, Ozcan H, Kupeli S, Gheiler EL. Color Doppler imaging in the diagnosis of the acute scrotum. *Eur Urol*. 1997;32(4):457-461.
31. Wilbert DM, Schaerfe CW, Stern WD, Strohmaier WL, Bichler KH. Evaluation of the acute scrotum by color-coded Doppler ultrasonography. *J Urol*. 1993;149(6):1475-1477.
32. Paltiel HJ, Connolly LP, Atala A, Paltiel AD, Zurakowski D, Treves ST. Acute scrotal symptoms in boys with an indeterminate clinical presentation: comparison of color Doppler sonography and scintigraphy. *Radiology*. 1998;207(1):223-231.
33. al Mufti RA, Ogedegbe AK, Lafferty K. The use of Doppler ultrasound in the clinical management of acute testicular pain. *Br J Urol*. 1995;76(5):625-627.
34. Baker LA, Sigman D, Mathews RI, Benson J, Docimo SG. An analysis of clinical outcomes using color doppler testicular ultrasound for testicular torsion. *Pediatrics*. 2000;105(3 Pt 1):604-607.
35. Galejs LE, Kass EJ. Color Doppler ultrasound evaluation of the acute scrotum. *Tech Urol*. 1998;4(4):182-184.

36. Hendrikx AJ, Dang CL, Vroegindeweyj D, Korte JH. B-mode and colour-flow duplex ultrasonography: a useful adjunct in diagnosing scrotal diseases? *Br J Urol*. 1997;79(1):58-65.
37. Kadish HA, Bolte RG. A retrospective review of pediatric patients with epididymitis, testicular torsion, and torsion of testicular appendages. *Pediatrics*. 1998;102(1 Pt 1):73-76.
38. Yagil Y, Naroditsky I, Milhem J, et al. Role of Doppler ultrasonography in the triage of acute scrotum in the emergency department. *J Ultrasound Med*. 2010;29(1):11-21.
39. Hamper UM, DeJong MR, Caskey CI, Sheth S. Power Doppler imaging: clinical experience and correlation with color Doppler US and other imaging modalities. *Radiographics*. 1997;17(2):499-513.
40. Coley BD, Frush DP, Babcock DS, et al. Acute testicular torsion: comparison of unenhanced and contrast-enhanced power Doppler US, color Doppler US, and radionuclide imaging. *Radiology*. 1996;199(2):441-446.
41. Zinn HL, Cohen HL, Horowitz M. Testicular torsion in neonates: importance of power Doppler imaging. *J Ultrasound Med*. 1998;17(6):385-388.
42. Bader TR, Kammerhuber F, Herneth AM. Testicular blood flow in boys as assessed at color Doppler and power Doppler sonography. *Radiology*. 1997;202(2):559-564.
43. Luker GD, Siegel MJ. Scrotal US in pediatric patients: comparison of power and standard color Doppler US. *Radiology*. 1996;198(2):381-385.
44. Stehr M, Boehm R. Critical validation of colour Doppler ultrasound in diagnostics of acute scrotum in children. *Eur J Pediatr Surg*. 2003;13(6):386-392.
45. Yazbeck S, Patriquin HB. Accuracy of Doppler sonography in the evaluation of acute conditions of the scrotum in children. *J Pediatr Surg*. 1994;29(9):1270-1272.
46. Bentley DF, Ricchiuti DJ, Nasrallah PF, McMahon DR. Spermatocord torsion with preserved testis perfusion: initial anatomical observations. *J Urol*. 2004;172(6 Pt 1):2373-2376.
47. Dogra VS, Rubens DJ, Gottlieb RH, Bhatt S. Torsion and beyond: new twists in spectral Doppler evaluation of the scrotum. *J Ultrasound Med*. 2004;23(8):1077-1085.
48. Yang DM, Lim JW, Kim JE, Kim JH, Cho H. Torsed appendix testis: gray scale and color Doppler sonographic findings compared with normal appendix testis. *J Ultrasound Med*. 2005;24(1):87-91.
49. Baldisserotto M, de Souza JC, Pertence AP, Dora MD. Color Doppler sonography of normal and torsed testicular appendages in children. *AJR Am J Roentgenol*. 2005;184(4):1287-1292.
50. Harkness G, Meikle G, Craw S, Samalia K. Ultrasound appearance of scrotal fat necrosis in prepubertal boys. *Pediatr Radiol*. 2007;37(4):370-373.
51. Bilagi P, Sriprasad S, Clarke JL, Sellars ME, Muir GH, Sidhu PS. Clinical and ultrasound features of segmental testicular infarction: six-year experience from a single centre. *Eur Radiol*. 2007;17(11):2810-2818.
52. Fernandez-Perez GC, Tardaguila FM, Velasco M, et al. Radiologic findings of segmental testicular infarction. *AJR Am J Roentgenol*. 2005;184(5):1587-1593.
53. Madaan S, Joniau S, Klockaerts K, et al. Segmental testicular infarction: conservative management is feasible and safe. *Eur Urol*. 2008;53(2):441-445.
54. Klin B, Lotan G, Efrati Y, Zlotkevich L, Strauss S. Acute idiopathic scrotal edema in children--revisited. *J Pediatr Surg*. 2002;37(8):1200-1202.
55. Lee A, Park SJ, Lee HK, Hong HS, Lee BH, Kim DH. Acute idiopathic scrotal edema: ultrasonographic findings at an emergency unit. *Eur Radiol*. 2009;19(8):2075-2080.
56. Nagler-Reus M, Guhl L, Volz C, Wuerstlin S, Arlart IP. [Magnetic resonance tomography of the scrotum. Experiences with 129 patients]. *Radiologe*. 1995;35(8):494-503.
57. Terai A, Yoshimura K, Ichioka K, et al. Dynamic contrast-enhanced subtraction magnetic resonance imaging in diagnostics of testicular torsion. *Urology*. 2006;67(6):1278-1282.
58. Watanabe Y, Dohke M, Ohkubo K, et al. Scrotal disorders: evaluation of testicular enhancement patterns at dynamic contrast-enhanced subtraction MR imaging. *Radiology*. 2000;217(1):219-227.
59. Trambert MA, Mattrey RF, Levine D, Berthoty DP. Subacute scrotal pain: evaluation of torsion versus epididymitis with MR imaging. *Radiology*. 1990;175(1):53-56.
60. Watanabe Y, Nagayama M, Okumura A, et al. MR imaging of testicular torsion: features of testicular hemorrhagic necrosis and clinical outcomes. *J Magn Reson Imaging*. 2007;26(1):100-108.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.