Diagnostic Categories of Incontinence and the Role of Urodynamic Testing

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Urinary incontinence is the result of an imbalance between the maximum intravesical pressure and the maximum urethral pressure at any given time except during normal voiding. Any combination that brings about an excess of intravesical pressure over the maximum urethral pressure will result in urine loss. Such combinations are outlined in Table 1. This simplified table does not necessarily indicate that a rise in intravesical pressure or a drop in urethral pressure equates to urinary incontinence. In many cases, specifically in the elderly, multiple factors may be involved and may together produce an imbalance that may lead to urinary incontinence.

The uninhibited detrusor contraction (UDC) regardless of etiology must be of sufficient force to break through the urethral lumen to produce urinary incontinence. Urine loss, therefore, in patients with UDC will depend on the status of the urethral sphincters at the time of the occurrence of the UDC.

Passive increase of bladder pressure may be observed in patients with overdistended bladders. Bladder wall compliance may be normal or even increased, such that overflow incontinence occurs at very large bladder volumes. This is in contrast to bladders with reduced compliance where urine loss may occur at low volumes.

In cases of unstable urethra, the urethral pressure drop is considered an inappropriate response (relaxation) of the urethral sphincter to either a detrusor contraction or detrusor stretching without measurable detrusor contraction. An appropriate normal response to bladder wall stretching or to an involuntary detrusor contraction is contraction of the periurethral striated muscle. The exact etiology of this entity is still poorly understood.

The loss or reduction of urethral compliance may lead to urinary incontinence because the rigid wall may not be able to collapse totally and occlude the lumen of the urethra. Conversely, during voiding, because the rigid bladder neck may not allow adequate urethral funneling, voiding (emptying) dysfunction may be observed as well.

When urinary incontinence is manifest, it may present in various forms. Urge urinary incontinence is involuntary loss of urine that is preceded by an urge to void. Included in this category is the sudden, uncontrollable voiding with little warning; if no warning is present, this type of incontinence is termed "unconscious" or "reflex." Stress urinary incontinence is defined as loss of urine at the time of physical exertion. Mixed urge and stress incontinence is urine loss of both the urge and stress types. Overflow urinary incontinence is urine loss associated with a distended bladder.

COMPENSATORY MECHANISMS TO PREVENT URINARY INCONTINENCE

There are many individuals who may have an anatomic failure or physiologic dysfunction mentioned above, yet are able to maintain continence. Continence is maintained by developing compensatory strategies that prevent the bladder pressure from overcoming the maximum urethral closure pressure. Such mechanisms may include: (1) Increased frequency of voiding. Such a mechanism may prevent a reflex detrusor contraction or prevent bladder overdistension. (2) Reduction of fluid intake. This reduces urine output, which in turn prolongs bladder filling time for those with small functional bladder capacity or those with high postvoid residual (PVR) urine volume. (3) Provision of easy access to toilet and toilet supplements. This reduces bladder holding time from the time of urgency to voiding.

PRECIPITANTS OF URINARY INCONTINENCE

Any condition that disturbs or alters the compensatory or defensive mechanisms may precipitate urinary incontinence. Examples of such precipitants are: (1) use of medications such as diuretics in patients with preexisting uninhibited detrusor contractions and alpha-adrenergic blockers in patients with conditions that pre-

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TABLE 1. COMBINATIONS OF URETHRAL AND INTRAVESICAL PRESSURE THAT RESULT IN URINE LOSS

A. Increase of intravesical pressure over the maximum urethral pressure
  1. Active increase of bladder pressure as a result of uninhibited or involuntary detrusor contractions (UDC)
    a. unstable bladder (absence of neurologic lesion)
    b. detrusor hyperreflexia (presence of neurologic lesion)
  2. Passive increase of bladder pressure—acute or chronic bladder overdistension
    a. normal or increased bladder compliance with urinary retention secondary to neurogenic and nonneurogenic causes
    b. decreased bladder compliance secondary to radiation, chemotherapy, interstitial cystitis, etc.

B. Decrease of maximum urethral pressure below the maximum intravesical pressure
  1. Active decrease of urethral pressure secondary to uninhibited sphincter relaxation with or without detrusor contraction
  2. Passive decrease of maximum urethral closure pressure (MCP)
    a. loss of urethral support secondary to pelvic musculofascial relaxation
    b. intrinsic urethral abnormalities
      1) rigid noncompliant urethra as a result of fibrosis from previous multiple operations, infections, etc.
      2) defective urethra
        a) traumatic—pelvic trauma, obstetric trauma, etc.
        b) postsurgical—prostatectomy, diverticulectomy, etc.
    c. neurogenic sphincter—sacral and peripheral lesions

dispose them to stress urinary incontinence; and (2) reduction of mobility, increased hydration, or both in patients with small functional bladder capacity.

URODYNAMIC TESTS FOR URINARY INCONTINENCE

Any evaluation of urinary incontinence should start with a thorough history that should include urologic, gynecologic, neurologic, and pertinent medical history. The onset, frequency, severity, and clinical presentation of urinary incontinence should be investigated in detail. This should be followed by a physical examination, which should include a rectal, pelvic, and neurourologic examination. A urinalysis and a PVR urine measurement is helpful and should be part of the evaluation of urinary incontinence.

A simple provocative stress test with a full bladder is a method of documenting the presence of urine loss during the act of physical exertion. The most common technique is to ask a patient with a full bladder to cough or strain either in the standing or in the lithotomy position, or in both positions. The presence of urine loss at the time of exertion is an excellent objective documentation of stress urinary incontinence. However, as there are several causes of stress urinary incontinence, one should utilize all other findings to arrive at the specific cause of the stress urine loss.

Cystometry is a test that measures bladder capacity, volume of first sensation of fullness (proprioception), presence or absence of uninhibited detrusor contraction, intravesical pressures, and bladder compliance. Although there are many techniques of performing cystometry, the most commonly used technique is the retrograde filling of the bladder with sterile water (with or without contrast) or CO_2. Like any other test, the findings should be correlated with other clinical findings, as an abnormal cystometric finding may be of no clinical significance.

Urethral pressure profilometry (UPP) is a test that measures pressures along the entire length of the urethra. Passive, or static, UPP is performed by measuring urethral pressures when the bladder is not contracting and the patient is at rest. Stress, or dynamic, UPP is performed while the patient tries to provoke stress incontinence (coughing). A third use of UPP is to detect a pressure gradient suggestive of obstruction; this test (micturitional UPP) is performed during voiding. Except for the micturitional UPP, these tests may be performed using gas, fluid, or membrane transducers. In each test, the intravesical pressure is measured simultaneously with the urethral pressure measurements. The maximum urethral pressure (MUP), maximum urethral closure pressure (MUCP), and functional urethral length (FUL) are measured by the test.

The lateral stress cystogram is a radiographic study of the bladder and urethral location in relation to the symphysis pubis and the urogenital diaphragm. This is performed using a small feeding tube or catheter in the urethra with the bladder filled to capacity with contrast. Earlier versions of this test were known as the bead chain cystourethrogram. The radiographs are taken with the patient in a true lateral position, in the resting and then straining positions. The posterior urethrovesical angle (PUV) is created by the intersection of the line drawn along the urethra and that of the posterior wall of the bladder. The urethral axis is formed by the line drawn along the urethra and a vertical line crossing the urethral line at the urethral meatus. Cinefluoroscopy may be incorporated during this study to visualize directly the location, behavior, and competence of the bladder outlet at rest and during straining. Additional measurements such as simultaneous determination of bladder, urethral, and rectal pressures may be incorporated during the radiographic study of the bladder and urethra.

Uroflowmetry is a test that measures the flow of urine during voiding. An average flow rate can be determined by measuring the time it took to empty the bladder content. An electronic unit measures not only the average flow rate, but also the peak flow rate and the pattern of voiding.

A pressure flow study assesses the relationship between urine flow rate and simultaneous measurements of intrarectal and intravesical pressures during voiding. The test is reserved for cases of suspected outlet obstruction. Further details of urodynamic evaluation can be found in standard texts.

ANALYSIS AND EVALUATION OF THE RESULTS OF THE URODYNAMIC TEST IN NONINSTITUTIONALIZED ELDERLY

To assess the urodynamic characteristics of both continent and incontinent elderly and to determine the role of the urodynamic tests in urinary incontinence evaluation, a study was undertaken among continent and incontinent respondents to our Medical, Epidemiologic and Social Aspects of Aging (MESA) survey conducted in Washtenaw County, Michigan. The subjects were household respondents who were initially identified from a probability sample, invited to a free clinic evaluation, and then invited to undergo free urodynamic testing. Of the 1,955 household respondents, 456 women and 298 men attended the clinic. From this group, 169 women (94 incontinent and 75 continent) and 94 men (37 incontinent and 57 continent) accepted the urodynamic invitation. The specifics of the survey, clinical methods, urodynamic techniques, and biostatistical methods used may be obtained from our recent publications.[1-4]

The results to be presented here, unless otherwise noted, are analyses of our findings.

UROFLOWMETRY

The mean peak flow rate and average flow rate, when controlled for volume, were not significantly different between respondents with clinic diagnosis of continence and incontinence, between the four clinical types (urge, stress, mixed, or other) of urinary incontinence, or between the urodynamic diagnosis of competent and incompetent sphincters.[4] In addition, the continuity of the urinary stream was not associated with continence status or the clinical types of incontinence.

Thus, urine flow rates were not helpful in distinguishing between continent and incontinent subjects or between the clinical types of incontinence, confirming the previous observation of Fantl et al.[5] Uroflow measurements may be more helpful in predicting voiding or emptying symptoms following a bladder suspension operation or the use of bladder relaxants, but this will require further study.

POSTVOID RESIDUAL URINE VOLUME

Following voiding, a large amount of residual urine is always considered an important finding in the diagnosis of overflow urinary incontinence. However, there has been no definition as to when postvoid residual urine is significant in the diagnosis of urinary incontinence. Our MESA data showed that for both sexes no single value for PVR urine correlates with continence status.[3] Comparisons were made for PVR volumes of 0-50, 51-100, 101-150, and 151+ mL. The proportions of 69 continent female respondents among the four PVR groups were as follows: 78.1%, 9.7%, 2.4%, and 9.7%, respectively. Among 92 incontinent women, the proportions were 86.5%, 8.4%, 1.6%, and 3.5%, respectively. The proportions for men were quite similar to those for women. Since there are as many continent respondents as incontinent ones at any level of residual urine volume groups, it appears that elevated residual urine alone (using these cut-offs) does not cause urinary incontinence. It probably predisposes one to urinary incontinence in association with one or more of the precipitants or when there is superimposed detrusor overactivity and/or sphincteric failure. The PVR urine measurement, however, is helpful when evaluating incontinent or continent patients with symptoms suggestive of bladder emptying dysfunction. In addition, the knowledge of the PVR volume is also helpful before any pharmacologic or surgical therapy of urinary incontinence.

CYSTOMETRY

Our MESA data of noninstitutionalized elderly men and women 60 years and older revealed a significant difference ($Z = 4.25$, $P < .0001$) between the estimates of prevalence of UDC among men (35.2%) and women (7.9%). It also showed that there is no significant difference between the estimated prevalence among continent women (4.9%) and incontinent women (12.2%), as well as between continent men (32.3%) and incontinent men (50.0%).[3] Although, as anticipated, the differences are not statistically significant owing to large confidence limits, there is a tendency for the estimates of prevalence of UDC to be greater for incontinent than for continent subjects. When the data for both genders are combined, the comparison shows marginal significance ($Z = 2.02$, $P < .05$). Another significant finding is the discovery of UDC not only among continent subjects but also in subjects without any lower urinary tract symptoms of obstruction, irritation, or increased voiding frequency (nine times or more per day).

The 4.9% prevalence of UDC among our noninstitutionalized continent women is closer to Jones and Schoenberg's reported prevalence of 11.1% among hospitalized continent women.[6] However, our estimated prevalence of 12.2% among incontinent women is substantially lower than the reported prevalence by Brocklehurst and Dillane (53%),[7] Hilton and Stanton (39%),[8] Castleden et al (61%),[9] and Resnick et al.[10] The discrepancy appears to be related to health status, age, or both. Our community-dwelling subjects are both younger and healthier than the hospitalized patients (many with a prior stroke) in the Brocklehurst series, the institutionalized patients in the study by Resnick et al, and the highly selected cases in the other two series.

In men, UDC is a common finding regardless of continence status. Our estimated overall prevalence of 35.2% is compatible with the 43% prevalence among men with benign prostatic hypertrophy reported by Schoenberg et al,[11] but lower than the 53% prevalence among continent male volunteers reported by Andersen et al,[12] the 59% found in incontinent men by Resnick et al,[10] and the 88% prevalence among incontinent men obtained by Castleden et al.[9]

Our findings further showed that urologic symptoms of obstruction, irritation, and frequency of voiding do not correlate with the occurrence of UDC.[3] Among 166 women studied, the prevalences of UDC are 7% for asymptomatic respondents, 8% for women with irritative symptoms, and 7% for those with bladder emptying symptoms. Women who voided eight times or less per day had a prevalence of UDC of 6.2%, whereas those who voided nine times or more per day had a prevalence of UDC of 9.8%. Furthermore, men with objective urodynamic findings of outlet obstruction (high detrusor pressure and low urine flow) did not have an increased prevalence of detrusor overactivity[3]: of 23 such subjects, only four (17.4%) had UDC. Although this low prevalence may be due to small sample size, these findings raise more questions as to the origin of UDC in men.

These observations suggest that UDC discovered on cystometry may not necessarily be the specific factor causing the bladder symptom, as UDC is observed in symptomatic as well as asymptomatic respondents. Conversely there are times when symptoms are "classic" for the presence of UDC yet cystometric study fails to show UDC, presumably because the expected UDC is suppressed by the patient during the test period. In both cases, pharmacologic treatment may be needed to resolve the symptoms. Therefore, routine cystometry need not be a prerequisite for a pharmacologic trial in patients with symptoms of urinary frequency, urgency, and urge incontinence, as long as the urine is normal (no infection or hematuria) and the postvoid residual urine volume is low. Such trials not only evaluate, but also simultaneously manage these patients. Initial short-term pharmacologic trials of a bladder relaxant especially in an outpatient setting are also advantageous, considering that alternative treatments are limited and that cystometry is time-consuming, requires instrumentation and some expertise in performing and interpreting the data, and is potentially expensive. If the drug trial fails, then one can embark on specific urodynamic tests to search for the cause of voiding symptoms.

Future research incorporating the practice of initial pharmacologic therapy without cystometry on patients with urgency, frequency and urge incontinence with normal urine, and low PVR, compared to screening cystometry prior to pharmacologic therapy, will further clarify this issue.

URETHRAL PRESSURE PROFILOMETRY (FEMALES ONLY)

Henriksson et al[13] and Rud[14] have shown that the MUP and the MUCP decrease with age. Contrary to the observation of Henriksson that the drop in urethra pressure is maximized at the age of 60, our data showed progressive reduction of pressure as age increases.[4]

Urethral profilometry was performed using a laterally oriented, double-sensor microtransducer catheter and an automatic puller.[3] Dynamic profilometry was performed with the proximal transducer held stationary in the mid-urethra. In the standing position, but not in the supine, there were significant differences observed between the continent and incontinent groups with respect to the static UPP values of MUP ($t = 2.46$, $P = .015$), MUCP ($t = 2.63$, $P = .001$), and FUL ($t = 3.09$, $P = .0025$). Incontinent respondents had lower mean values than continents on all three variables. However, there were no significant differences in the mean values of these variables between the stress (including mixed stress/urge) and nonstress incontinents. Comparisons between continent subjects with urodynamic diagnoses of competent sphincters and incontinent subjects with incompetent sphincters showed that the pattern was generally repeated for standing MUCP ($t = 2.47$, $P = .015$) and standing FUL ($t = 3.62$, $P = .0005$), but not for standing MUP ($t = 3.18$, $P = .08$). In spite of the significance of these differences, the MUP, MUCP, and FUL values overlap a great deal between the different diagnostic groups with the result that the test is not diagnostic.

The result of this UPP study applies only to the elderly and cannot be generalized to younger women. The MUP and MUCP among continent young women are approximately double those of the elderly group, and, therefore, values of MUP and MUCP among stress incontinent young women may indeed show a distinctly different pattern when compared to older women.[13,14] Although significant differences exist between groups, overlap between younger and older women is extensive enough to reduce the diagnostic usefulness of the test.

The results of the stress UPP (simultaneous bladder and urethral pressure while coughing) showed that significant differences exist between continent and incontinent respondents in the standing but not in the supine position ($P = .017$). There is also a significant difference between the different types of incontinence ($X^2 = 13.405$, $P = .009$) where 61.4% of respondents with stress have a positive dynamic UPP result. However, it was also positive in 39.1% of the mixed group, 33.3% of the pure urge group, 20% of the other category, and 31.3% of the continent group. These overlaps make it difficult to use these tests alone in the diagnosis of urinary incontinence.

LATERAL STRESS CYSTOGRAM

Results of the lateral stress cystogram between continent and incontinent respondents show that PUV is significantly wider among incontinent subjects ($t = 3.26$, $P = .001$). However, between incontinent respondents, it does not distinguish between stress and nonstress type of incontinence (Figure 1). Neither urethral axis nor the position of the bladder with regard to the urogenital diaphragm (line drawn between the inferior edge of the symphysis pubis and the sacrococcygeal junction) was significantly different between continent and incontinent subjects nor between those with stress and nonstress types of incontinence. The same pattern was also observed between self-reported continent respondents with urodynamic diagnosis of a normal (competent) sphincter and those self-reported incontinent respondents with urodynamic diagnosis of an incompetent sphincter (Table 2).

This finding supports the view that PUV is significantly wider among incontinent women, a finding in support of observations by Jeffcoate and Roberts.[15] The problem with this test is that it does not distinguish between stress and nonstress types of urinary incontinence. In addition, significant overlap exists, which means that this test cannot be used alone in the diagnosis of urinary incontinence. It appears that the test is more valuable in the assessment of the type of repair to be used or in the evaluation of postbladder suspension voiding dysfunction.

Although small sample size may explain the absence of correlation between location of the bladder neck and either continence status or urethral competence, these findings raise doubts about the theory that descent of the bladder neck below the urogenital diaphragm is a major factor in the development of stress urinary incontinence.[16,17] This finding warrants further study.

PROVOCATIVE STRESS TEST

A positive provocative stress test (observed fluid loss via urethra while coughing with a full bladder) was significantly correlated with incontinence status and, specifically, with stress and mixed stress/urge incontinence ($P \leq .0005$). The test produced more positive results when incontinence was of a moderate to severe degree.[4]

The sensitivity and specificity of the provocative stress test were determined by comparing the actual result of the test to the self-reported continence status and type of incontinence (stress or nonstress). The estimated sensitivity of the test is 39.5% (probability of a positive test if the subject reports stress incontinence). The specificity of the test is 98.5% (likelihood that a

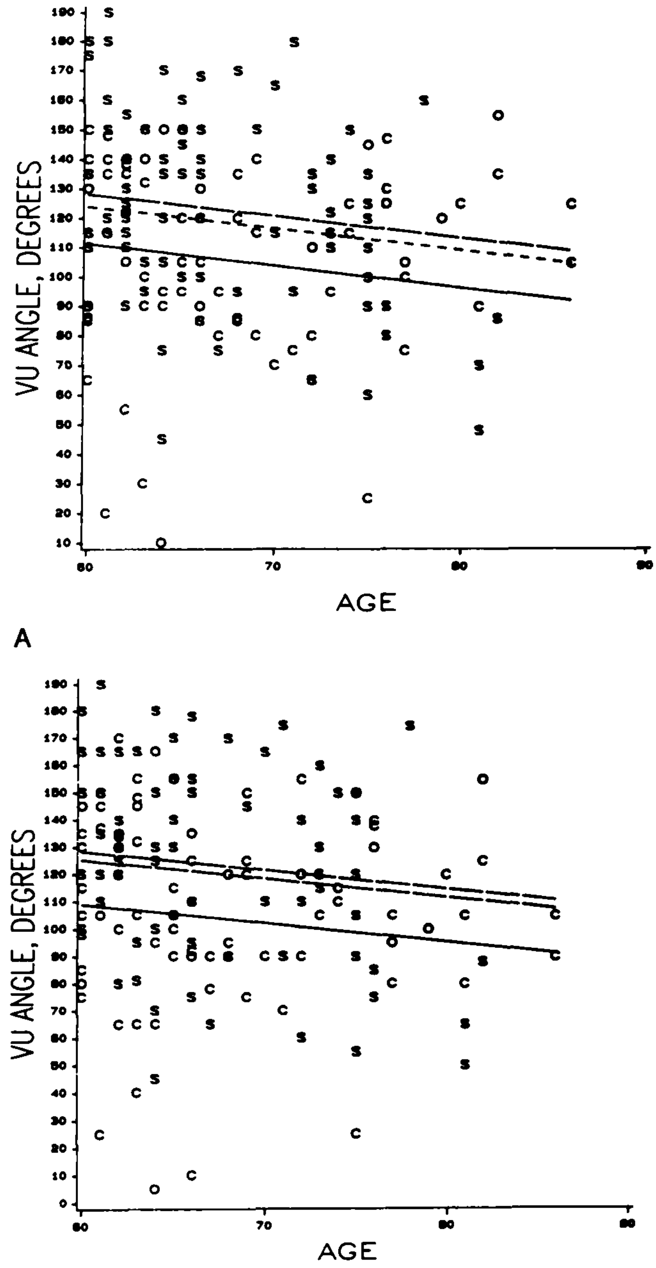

FIGURE 1. *The vesicourethral angles measured in the resting (A) and straining (B) positions are displayed against the ages of the respondents. The symbol "C" denotes a continent respondent, "S" a respondent displaying stress or mixed stress/urge symptoms, and "O" a nonstress respondent. The lines have been fit by the least squares criterion: the solid line for the continent respondents, the dashed line for the stress respondents, and the lightly dashed line for the nonstress respondents. The hypothesis that the PUV angle of the respondents decreases with age was not rejected ($t = 1.81$ and -1.543, and $P = .07$ and $.12$ for resting and straining positions, respectively). After adjusting for age, the resting PUV angle is not significantly different between the three groups ($F = 3.17$, $P = .08$). In the straining position, the difference is significant ($F = 5.26$, $P = .006$), but the difference between stress and nonstress incontinence is not ($F = 0.11$, $P = .75$).*

TABLE 2. RESULTS OF LATERAL STRESS CYSTOGRAMS

Continence Status of Sphincter	PUV		Axis		UGD	
	At Rest	Straining	At Rest	Straining	At Rest	Straining
C + C	107.6	104.4	27.0	30.2	0.11	−0.12
SD	28.7	28.7	18.0	17.6	0.50	0.80
n	40.0	40.0	40.0	40.0	38.0	37.0
I + I	125.7	127.9	31.0	35.2	−0.07	−0.52
SD	31.9	34.3	19.5	20.4	1.03	1.47
n	66.0	66.0	66.0	65.0	65.0	65.0
P: C + C vs I + I	<.01	<.01	0.29	0.20	0.33	0.13

PUV, posterior urethrovesical; Axis, axis of the urethra; UGD, urogenital diaphragm; C + C, self-reported continent and competent sphincter; SD, standard deviation; n, number of subjects; I + I, self-reported incontinence + incompetent sphincter.

person complaining of nonstress incontinence or no incontinence at all will have a negative stress test).

The provocative stress test is an extremely specific test, producing only one false-positive result out of 68 (1.5%) when tested against self-reported continence status. Of greater importance is that it was 100% specific for subjects who have nonstress incontinence symptoms (none of 13 nonstress subjects developed positive results). There were 30 of 79 subjects (38%) who had a positive stress test.

To determine the sensitivity and specificity of the respondent's report of incontinence, and specifically of responses suggesting stress incontinence (with and without urgency), self-reports were compared to the urodynamic assessment of urethral competence. Urethral incompetence was diagnosed when the provocative stress test, stress cystogram, or dynamic UPP was abnormal. The sensitivity of self-reported stress incontinence (with or without urgency) was 57.2%, and the specificity was 84.1%.

In the final analysis, the findings of this study among elderly ambulatory clinic respondents suggest that the symptom of stress urine loss either alone or in combination with other symptoms has a good correlation with the urodynamic diagnosis of an incompetent sphincter, whereas the symptom of urge with or without stress has a poor correlation with the cystometric finding of UDC. In addition, a simple full bladder provocative stress test is an extremely specific test and, although its sensitivity is low, when positive it indicates a moderate to severe degree of stress urinary incontinence. The rest of the battery of urodynamic testing—including uroflow study, static and stress urethral pressure profile, lateral cystography, and cystometry—should be individualized and used only in specific cases: eg, when the diagnosis cannot be established with the simple evaluation, when previous therapeutic trials have failed, in determining which approach to use, and in assessing or predicting the outcome of therapy.

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