Screening Criteria and Idiopathic Adolescent Scoliosis

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Screening for idiopathic adolescent scoliosis is examined by applying currently recommended criteria to the disease and the available screening tests. The epidemiology, natural history, and current screening strategies are briefly reviewed. The most significant problems discussed are uncertainties in the characteristics of brace candidates; gaps in the knowledge of the natural history of the disease; questions over the availability and accessibility of facilities to diagnose and treat individuals with positive screening tests; and a very high rate of false positives in the initial screening tests.

Although much of value has been written recently about screening for idiopathic adolescent scoliosis (IAS),[1-11] several difficult and controversial questions have been addressed only superficially and some have not been raised. Most previous articles have been written from the point of view of orthopedic surgeons and have concentrated on school screening. This paper is from the primary care physician's perspective, and is not bound to any particular screening setting. As in most of the literature on this topic, no new objective data are presented.

The purpose of this paper is to apply carefully worked out screening criteria to IAS. The information generated from this systematic discussion should provide primary care physicians with a solid foundation for designing appropriate screening programs. No ideal program is recommended because each setting has its own special needs. The principles of screening have been stressed leaving the details of particular programs for primary care physicians to select.

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Background

Classification

Idiopathic adolescent scoliosis curves are grouped into five classes: cervicothoracic, thoracic, thoracolumbar, combined thoracic and lumbar, and lumbar. Previous articles on screening have not specified the classes of curves which should be diagnosed early. Cervicothoracic curves are not the principal targets of screening programs since they are very rare and are not amenable to brace treatment. There are also problems with lumbar curves which should temper the zeal for early diagnosis. Lumbar curves have the best prognosis of any of the five classes, do not pro-

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duce cardiopulmonary problems, and are generally less cosmetically significant. Lumbar curves are thought to be associated with low back pain, but there is sufficient controversy on the amount of curvature which will cause pain and the proper management of these curves that looking for subtle ones may not be wise. In addition, the lumbar curves are the most difficult to detect with current initial screening tests. In view of these considerations, this paper deals primarily with thoracic, thoracolumbar, and the thoracic portion of combined curves.

Another important consideration is whether the curve is balanced or unbalanced. This is significant for screening since balanced curves are better tolerated, less cosmetically deforming, and have a lesser tendency for progression. Because of this, they can be observed safely over a longer period, especially in patients in whom the prerequisites for early treatment are not clearly met.

Natural History

Idiopathic adolescent scoliosis begins with the adolescent growth spurt which occurs roughly between the 10th and 13th chronologic year. A small degree (5 to 15 degrees) of curvature is quite common, being present in up to 10 to 15 percent of the adolescent population.[1,3] Some of the small curves progress, some stay the same, and others disappear.[1] Unfortunately, present data do not allow a more precise definition of the prognosis. The small curves are evenly distributed between the sexes[1,3] and social classes.[1] For some unknown reason, the curves progress more, and more often, in females.[12] One to two per thousand adolescents will progress to a curve of greater than 20 degrees, the point at which brace treatment is usually first considered.[1,3] In these curves, the sex ratio ranges from three to five females to one male.[2,12,13]

What happens to untreated curves after 20 degrees? Prospective studies without treatment of these patients are unavailable. Shands reviewed TB screening x-rays from 50,000 people over age 14 years and found that in this untreated population, 1.9 percent had curves of more than ten degrees. Of these, 72 percent had curves between 10 and 19 degrees, 16 percent were between 20 and 29 degrees, and 12 percent were 30 degrees or greater. Two thirds of those with curves above 30 degrees had curves below 60 degrees, which is the point at which the need for surgery is almost universally accepted. Very severe IAS (greater than 60 degree curves) were found very rarely in this untreated population, only in about .06 percent of the total.[13]

IAS curves progress most rapidly during growth. Their progression after growth is approximately proportional to their severity. The best data on an untreated population are from Collis, who found that after an average of 24 years, 60 to 80 degree thoracic curves increased an average of 28 degrees. Above and below the 60 to 80 degree range, progression was less.[14] The progression of small and moderate untreated curves is very poorly understood.

Cardiopulmonary disability is the only type of morbidity in IAS which can be described objectively. It has been shown to be associated with the severe thoracic curves. A decreased vital capacity can be demonstrated in patients with curves of approximately 50 degrees or more.[15] Cardiopulmonary disability significant enough to impair exercise tolerance is probably associated with curves greater than 75 degrees.[15,16]

The subjective problems of deformity and pain are more difficult to assign to a point in the spectrum of IAS. The perception of curves as being cosmetically significant is quite variable.[14,17,18] Some authors feel that most patients with IAS feel ugly and that this results in psychological hardship and failure to find spouses.[17,18] Others have found that "some patients with very small curves felt emotional about their barely perceptable deformity and others with curves greater than 100 degrees accepted their deformity with equanimity."[14] Pain is also variably perceived. While Nachemson and Nilsonne both found this to be common in IAS of an unspecified degree, Collis found the incidence of back pain complaints the same as in the general population.[14]

Ideal Screening Program

The elements of the "ideal" program emerge from numerous recent screening articles. It begins in the school where physical education teachers and school nurses examine all students between 10 and 13 years of age and refer those with any degree of "rib hump" to a primary care physician. The physician should then confirm the abnormal finding, obtain a single standing AP spine film, and measure the curve by the Cobb technique. If a curve is found, referral is recommended if it is

greater than 15 degrees, and follow-up x-rays every three to six months are indicated for curves from 5 to 15 degrees.[3,7,11]

Screening Criteria

Idiopathic adolescent scoliosis can now be considered from the point of view of screening criteria. The list of criteria comes from Frankenburg and Kamp's text *Pediatric Screening Tests*.[19] The criteria are divided into those that apply to the disease and those that apply to the diagnostic tests which can be used to discover the disease.

Criteria for Disease

Criterion 1: *Must be serious or potentially so.* Clearly, IAS meets this criterion.

Criterion 2: *Through diagnostic tests and procedures, it should be possible to differentiate diseased from borderline individuals.* This is the criterion which is most tenuously met. In IAS, this criterion is better understood if "patients needing treatment" is substituted for "diseased." Treatment for IAS falls into two types: brace/exercise and surgical. The indications for either type of treatment are quite controversial. While there is general agreement at the extremes of the spectrum, the gray area is very broad. The most important variables in defining who needs treatment include the patient's curve class and degree of curvature, rate of progression, bone age, sex, psychological make-up, family stability, economic situation, philosophic approach to illness, and the accessibility and philosophy of local scoliosis treatment centers. To evaluate Criterion 2 each of these variables must be discussed.

Since it takes about three years to get the maximum benefit from the brace[20-22] and since the patient must be growing for this entire interval, the bone age at first diagnosis should be around 10 to 13 years for females, and 11 to 14 years for males. If patients are screened after these age ranges, the amount of agreement on the indications for brace treatment decreases markedly. In general, the older the patient, the larger a curve can get before treatment is recommended.

The psychological make-up of the individual with IAS will influence the point at which treatment is recommended. This is especially true with brace candidates. A study by Myers and his colleagues showed that brace treatment is very stressful and that there is a significant failure rate because of noncompliance on a psychological basis. They also found that significant psychological problems in the adolescent patient or in one or both of his parents jeopardized brace treatment.[23] Moe and Blount observe that "emotionally stable, private patients do well; service patients with poor home conditions usually fail to get acceptable results."[24] Thus, the more psychologically unstable the patient and/or his parents, the greater the degree of curvature before treatment is likely to be effective.

Another factor which influences the point at which treatment is recommended is the family's economic situation. This is especially true of brace candidates. From experience at a local scoliosis clinic, it was estimated that a full three-year course of brace treatment would cost around $2,000. In this clinic, less than one half of the patients have insurance which covers any part of brace treatment other than x-rays. The brace itself is the major expense (each around $700 and most patients needing two over a three-year period); this cost is rarely covered. For very poor families, help can usually be found from state and philanthropic organizations, but poor and lower middle income families often have significant difficulties. Thus, of necessity, treatment may be recommended a little later in these circumstances.

Given the nature of IAS and the major gaps in knowledge of its natural history and response to treatment, the patient's philosophy must also influence the point at which treatment is recommended. This is especially true with brace treatment and especially for smaller curves. That this is important is emphasized by a study which showed that the incidence of noncompliance in brace wearing was strongly related to the patient and family's acceptance that treatment was, in fact, necessary.[23]

The last of the major factors influencing the decision to treat IAS is the philosophy and accessibility of local orthopedic surgeons. A screening program which turns up curves which local orthopedic surgeons think are insignificant cannot be considered successful. The approach of these consultants is critical in the definition of what kind of a patient constitutes a treatment candidate. The accessibility of orthopedists is especially important in brace candidates, and especially in rural areas, since the distance involved significantly influences cost and difficulty of maintaining the

close contact necessary for successful brace treatment.

The indications for brace and surgical treatment will probably continue to have large gray areas in the future. For example, the referral point for brace consideration in a poor, culturally deprived, rural community might be as high as 30 degrees and in order to cut down on cost, the criteria for obtaining an x-ray might be quite strict. Given this same population, another planner might focus on identification of surgical candidates while another might favor an aggressive program with a 15 degree referral point. Many options are open in screening any particular population. But to screen effectively for this disorder, careful consideration of each of the major factors discussed under this criterion must begin at the design stage of the program and continue through every phase of its development.

Criterion 3: *Prognosis should be improved if the disease is detected and treated prior to the usual time of diagnosis.*

3a: *Known natural history.*

3b: *Proven effective treatment whose effectiveness improves with early diagnosis.*

Only the rough outlines of the natural history of IAS are known. Curves above 40 degrees are better understood than smaller curves.[14,17,18,25] More knowledge of the natural history of untreated small curves would improve the design of screening programs. The experience of screening programs is helpful in this respect.

There is little debate that early (brace) treatment can be effective and can probably prevent some patients from needing surgery. The exact characteristics of the brace candidate and the point at which this intervention must occur have not been precisely documented. It is known that most patients with curves above 40 degrees at the beginning of brace treatment will eventually need surgery.[20-22]

Parents noticing difficulty in fitting clothing or seeing a curvature in an unclothed child appears to be the most common form of diagnosis without screening. It is felt that this method of diagnosis does not bring patients to the attention of orthopedic surgeons sufficiently early, but this has not been documented empirically.

IAS almost certainly meets this criterion in patients who are good brace candidates. Documentation of the natural history of small curves and some empiric data on nonscreening diagnostic times would help IAS meet this criterion.

Criterion 4: *Adequate lead and screening times.*

4a: *Lead time: the time between early diagnosis by screening and the usual diagnosis.*

4b: *Screening time: time between earliest diagnosis by screening tests and point of optimal treatability.*

The time of usual diagnosis is not well known, but it is thought to be quite late in the natural history of the disease. The lead time almost certainly is adequate for IAS since the screening tests can pick up very subtle curves. The screening time also is almost certainly adequate since the screening tests can discover curves less than 10 degrees and the optimal initial treatment time is thought to be around 20 degrees.

Criterion 5: *Treatable disease.* IAS meets this criterion.

Criterion 6: *Relatively prevalent.* There is general agreement that the prevalence of IAS is adequate to justify screening.

Criterion 7: *Low risk to screening.* Screening for IAS is a very low risk to the patient in the sense of physical harm. The only test which carries risk is the x-ray. The discreet use of this modality would almost certainly constitute a negligible risk. Though previous articles have not noted it, there would seem to be significant psychological risk. Because of present problems with the screening tests, many well patients must be either referred for orthopedic evaluation, or further follow-up examinations.[1,3,4] The stress resulting from this threat to the patient's and his family's sense of well-being should not be ignored as a potential risk factor in screening.

Criterion 8: *Facilities available to diagnose and treat the individuals found to have positive screening tests.* The availability and accessibility of professionals with the experience, knowledge, and wisdom necessary to decide which patients should undergo brace and surgical treatment should be a prerequisite to beginning a screening program. To ensure that every one of the patients with a positive test gets a proper evaluation and complete explanation may be quite difficult. Present screening programs generate very large numbers of positive tests in comparison to the number of patients who are ultimately treated, with typical ratios of about 75:1.[1,3,12] There is considerable difference of opinion as to how the 74 patients with "false" positive

screening tests should be managed in terms of explanation and recommended follow-up.

Criterion 9: *Reasonable cost.* No studies of the cost of screening are available. Previous articles have focused on the very low cost of the most frequently used initial screening test—the "bend test." Although it is said that this test can be performed by physical education teachers and school nurses at 100 candidates per hour,[12] one wonders what the false positive and false negative rates would be at this speed. The cost of follow-up examinations on the positive tests has not been thoroughly investigated. Since the ratio of positive tests to treated patients presently runs about 75:1, this cost may significantly increase the total cost of screening. It should also be considered that some authors are currently recommending that patients with a positive screening test on one occasion be followed every 3 to 6 months with follow-up examinations and x-rays, and this cost may also be significant. Recognizing these deficiencies in knowledge, IAS screening can probably be done at a reasonable cost. The very serious potential of the illness and the probable impossibility of diagnosing it in any other way suggest that society would probably be willing to pay for good quality screening.

Criterion 10: *Public acceptance.* The numerous articles attesting to a good public acceptance of screening programs for IAS clearly show that the disease meets this criterion.[1,3,4]

Criteria for Screening Tests for Idiopathic Adolescent Scoliosis

The screening tests can be divided into three stages. Stage 1 includes the initial physical test or tests applied to the whole target population, probably by non-MD examiners. Stage 2 includes the tests applied to the people with positive findings in Stage 1. These are done by primary care physicians, and generally include x-rays. Stage 3 tests are done on patients who are considered to need treatment at that point or in the near future; they are usually performed by orthopedic surgeons. Due to the lack of data, application of screening criteria is only appropriate for the Stage 1 tests.

Stage 1 Tests

Tests recommended for this stage include the "bend test"[1,3,4]; spinous process alignment; differences in shoulder height, scapular height and/or prominence, hip height or prominence; presence of "lateral triangle"[9]; abnormal plumbline alignment[9]; observation for excessive kyphosis; and observation for excessive lordosis. By far the most important of these is the "bend test." In addition to indicating a structural curve, it is claimed to be the most sensitive test.

In applying the criteria, these tests may be grouped into two sets. One set is the bend test alone, the other set is the remainder of the general back examination items.

Criterion 1: *Acceptable to the target population.* The numerous articles describing the good public acceptance of screening programs make this a matter of record.

Criterion 2: *Simplicity.* The bend test is reasonably simple and probably would meet this criterion if more empiric data were available. There are subtleties to interpretation of the bend test and a tendency to interobserver differences of a considerable degree.

It is somewhat difficult to specify what constitutes normal and abnormal findings among the general back examination items, which are unlikely to meet the criterion for simplicity.

Criterion 3: *Reliability—consistency or repeatability of results.* This criterion refers to the reliability of interobserver, intertest, and test/retest observations. There have not been studies which would shed light on these aspects of either the bend test or the general back examination items. Therefore, whether this criterion is met is purely conjectural.

Criterion 4: *Validity—frequency with which the result of a test is confirmed by the diagnosis.* While this has not been studied explicitly for either the bend test or the general back examination items, some observations pertinent to this question can be extrapolated from available data. The false positive and false negative rates as well as the sensitivity and specificity of the screening tests are considered within this criterion. The number of positive tests which do not result in treatment is very high. Brooks and his colleagues found more than 13.5 percent of their target population to have a positive initial screening test, but only 0.15 percent were treated.[1] Lonstein's results were similar with 7 percent with positive physical findings and 0.10 percent treated.[3] This degree of false-positive testing would suggest that present screening tests probably do not meet this criterion.

Criterion 5: *Appropriate for the population.*

Since the incidence of IAS seems to be relatively high in all populations which have been studied, it is likely that this criterion will be easily satisfied if the other test problems can be reduced.

Criterion 6: *Reasonable cost.* There are no empiric data on this problem.

Stage 2 Tests

Patients found to have a positive initial screening test will need to be seen by their primary care physician. A careful physical examination is required, and assessment of the more subtle and difficult psychological and economic considerations must be carried out.

Stage 3 Tests

Assuming that both the initial and second stages have been executed properly, the orthopedic surgeon will be receiving a population of potential brace or surgical candidates with relatively few needing no treatment. This stage in the screening process will entail subtle physical diagnosis and evaluation of psychological and social parameters.

Summary and Conclusions

The existing literature has been explored and some of the data extracted which shed light on the issues involved in screening for idiopathic adolescent scoliosis. The necessity of screening for IAS is virtually certain. While the screening programs which have been studied to date provide a good foundation, many difficulties remain. These include uncertainties in the characteristics of brace and surgical candidates, gaps in the knowledge of the natural history of the disease (especially small and moderate-sized curves), uncertainty about where in the natural history various therapies are best introduced, questions over the availability and accessibility of facilities to diagnose and treat individuals with positive screening tests, a near absence of reliable cost data, a very high false-positive rate with the initial screening tests, and numerous unanswered questions on the simplicity, reliability, validity, and cost of many of the recommended screening tests. There is also a problem with accessibility of information on screening for IAS. Many of the journal articles which were most helpful in preparing this paper have only appeared in state medical society journals. The primary care texts are almost devoid of relevant information. To date, orthopedic surgeons have led the field in research and application of research findings in this sphere. It is hoped that the future will see contributions from pediatrics and family practice.

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