PAPER

Abductor sign: a reliable new sign to detect unilateral non-organic paresis of the lower limb

M Sonoo

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Correspondence to:
Dr Masahiro Sonoo,
Department of Neurology,
Teikyo University School of Medicine, Kaga 2-11-1,
Itabashi-ku, Tokyo
1738605, Japan;
sonoom@
med.teikyo-u.ac.jp

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Objectives: To test a new neurological sign, the ''abductor sign,'' which can distinguish between organic and non-organic leg paresis using synergic movements of the bilateral hip abductors.
Methods: The subjects were 33 patients presenting with paresis of one leg, 17 of organic origin and 16 of non-organic origin (hysteria). To test the abductor sign, the examiner told the patient to abduct each leg, and opposed this movement with his hands placed on the lateral surfaces of the patient's legs. The leg contralateral to the abducted one showed opposite actions for organic paresis and non-organic paresis: for example, when the paretic leg was abducted, the sound leg stayed fixed in organic paresis, but moved in the hyperadducting direction in non-organic paresis. Hoover's sign was used for comparison in the same patients.
Results: The abductor sign gave the correct classification for all 33 cases. Hoover's sign was reliable if the results were carefully interpreted, but it was non-diagnostic for 16 patients because of strong hip extensors and in two because of strong hip flexors. Two patients with non-organic paresis succeeded in tricking the examiner by pretending full effort to lift the paretic leg.
Conclusions: The abductor sign is a useful test to detect non-organic paresis, because (1) it is difficult for a hysterical patient to deceive the examiner, (2) the hip abductor is one of the most commonly involved muscles in pyramidal weakness, and (3) the results are easily visible as movement or non-movement of the unabducted leg.

The detection of non-organic paresis associated with conversion disorder (hysteria) or malingering has been an important theme of neurology for over a century.[1] Previous investigators have pointed out the danger of overinvestigating hysterical patients,[2–4] and also of an erroneous diagnosis of hysteria made on a patient with true organic disease.[3 5–7] Thus the need for a reliable clinical sign which can confirm the non-organic nature of the paresis has not lessened, even in this era of sophisticated diagnostic methods including imaging studies.

Hoover's sign is a famous classical sign which discriminates between organic and non-organic paresis of the lower limb.[8] However, several clinicians have stated that this test may give variable or equivocal results.[2 7 9–12] I have developed a new neurological test named the ''abductor sign,'' which resembles Hoover's sign in using a contralateral synergic movement, but provides a clearer distinction between organic and non-organic paresis of the lower limb.

Preliminary results of this study have been reported.[13]

METHODS

The subjects were 33 patients presenting with paresis of one leg, or of both legs but dominant in one. Of these patients, 16 were of non-organic origin (three men and 14 women, aged 16 to 75 years) and 17 were of organic origin (12 men and five women, aged 25 to 87). The non-organic patients were collected consecutively from patients referred to me (both inpatients and outpatients) during a 22 month period up to May 2001. The organic patients were selected from the same population.

Non-organic paresis was diagnosed by a negative Babinski's sign, symmetrical tendon reflexes, typical give way weakness,[2 14] or non-selective involvement of the flexor and extensor muscles. The paretic side was the left in 11 patients, and the right in five. In four patients, the psychogenic weakness overlaid some organic disease that was unlikely to cause unilateral leg weakness (Bell's palsy, trigeminal neuralgia, rotatory vertigo, or painful diabetic neuropathy). In four other patients, the symptoms followed an identifiable event including medical interventions (three general or local anaesthesia; one traffic accident). In the remaining eight patients, no definite cause was identified. The distinction between conversion disorder (hysteria) and malingering was not pursued, because this differentiation is often difficult and requires a detailed psychological interview.[14 15] However, most patients were suspected to have hysteria, because they were generally cooperative with the examinations.

The causative level of the organic paresis was corticospinal in 14 patients (eight cerebrovascular disease, one cerebral injury, two multiple sclerosis, two cervical spondylosis, one amyotrophic lateral sclerosis (ALS) with predominant upper motor neurone involvement), neurogenic in two patients (both with ALS), and myopathic in one (inclusion body myositis). The organic paresis of corticospinal origin was diagnosed by a unilateral positive Babinski's sign, hyperreflexia, or relative sparing of the extensors of the legs.[14 16] Neurogenic or myopathic weakness was diagnosed by the appropriate findings on needle electromyography.

For testing the abductor sign, the examiner stood at the feet of the patient, who was lying supine. He placed his hands on the lateral sides of both legs, and opposed the abducting motion of the legs during the following manoeuvres, while ensuring that he exerted equal pressure with both hands; this was easily achieved because applying equal adducting strength with both arms is a natural synergic action of the examiner.

Abductor sign—preparatory test

First, as a preparatory test, the examiner told the patient to abduct both legs simultaneously as hard as possible. Weak abduction of the paretic leg was evident for both organic and

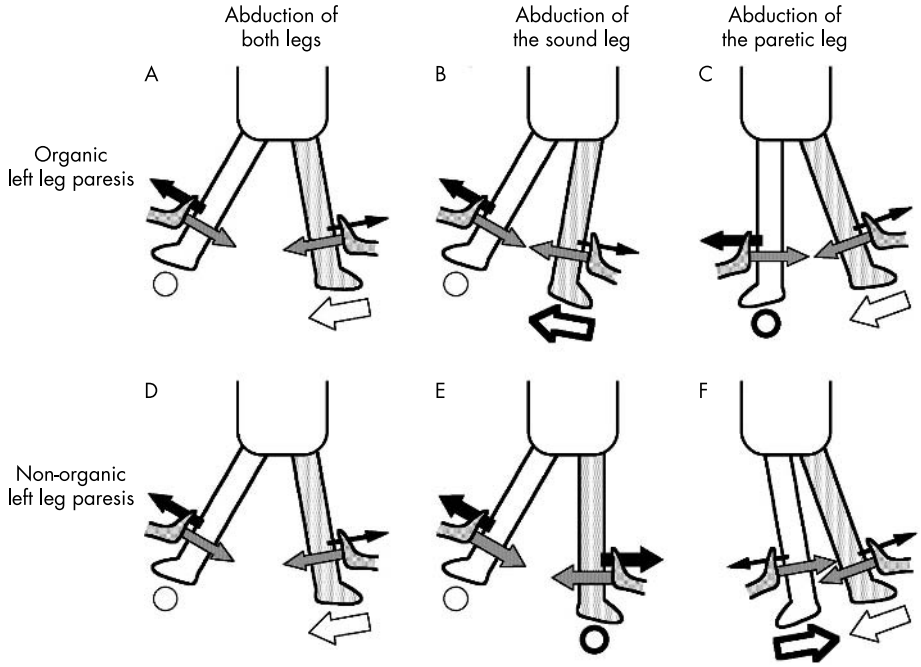

Figure 1 Schematic explanation of the abductor sign. (A) and (D): abduction of both legs; (B) and (E): abduction of the sound leg; (C) and (F): abduction of the paretic leg, for organic and non-organic left leg paresis (the paretic left leg is shadowed). Black arrow, abducting power exerted by the patient's leg; grey hand mark, examiner's hand; grey arrow, adducting power exerted by the examiner's hand opposing the patient's leg; white arrow, direction of movement of the leg; white circle, a leg that does not move; bold white arrow, movement of the unabducted leg used for diagnosis; bold white circle, non-movement of the unabducted leg used for diagnosis.

non-organic pareses: the sound leg was fixed in an abducted position fully opposing the examiner's hand, whereas the paretic leg moved towards the adducting direction because of the stronger opposing force imposed by the examiner (fig 1A and 1D).

Abductor sign—main test

Next, as the main test, the examiner told the patient to abduct each leg in turn, as strongly as possible. The examiner observed the behaviour of the unabducted leg, which was initially placed in an adducted position along the midline. The examiner directed the patient's attention solely to the abducted leg, away from the unabducted leg.

In organic paresis, when the patient was told to abduct the sound leg, the sound leg remained fixed in an abducted position, whereas the paretic leg, which must normally exert a synergic abducting force to oppose the examiner's hand, was overpowered and moved in the hyperadducting direction (fig 1B and 2A). When he was told to abduct the paretic leg, it was overpowered by the examiner's hand, whereas the sound leg exerted a strong synergic force and remained fixed in its original position (fig 1C and 2B)

In non-organic paresis, however, different phenomena are observed. When the patient is told to abduct the sound leg, the entire movement set to ''abduct the sound leg'' is normally strong. Thus not only is abduction of the sound leg strong, but the synergic opposition of the ''paretic leg'' is also strong, and the latter remains fixed in its original position (fig 1E and 2C). When the patient is told to abduct the paretic leg, the entire movement set becomes weak. Therefore, not only the abducting paretic leg, but also the opposing ''sound leg'' becomes weak, and the latter moves towards the hyperadducting direction overpowered by the examiner's hand (fig 1F and 2D).

The above opposite sets of reactions of the unabducted leg were termed ''organic'' and ''non-organic'' patterns of the abductor sign, respectively.

Hoover's sign

Hoover's sign was also tested in every subject. In the supine position, the patient is told to lift one extended leg, and the examiner exerts an opposing downward pressure on the lifted leg. At the same time, the examiner places his other hand under the heel of the unlifted leg, and evaluates the synergic downward pressure by exerting an opposing upward force.

Hoover's original description indicated that the sign is composed of two separate tests.[8] The first, here named Hoover's test 1, examines the complementary opposition of the paretic leg when the sound leg is lifted. This downward pressure is compared against the strength of the hip extensor manually tested beforehand. The paresis was judged to be non-organic if the paretic leg exerted full downward opposition, stronger than the manually tested strength. The paresis was judged to be organic if the downward pressure was equally weak to the manually tested strength. When the manually tested strength of the hip extensor was full, this test was not diagnostic.

Hoover's test 2 examines the complementary opposition of the sound leg when the patient lifts or attempts to lift the paretic leg. When the sound leg exerts only weak downward pressure and is passively lifted by the examiner's hand, the paresis is judged to be non-organic. A normally strong downward opposition of the sound leg suggests organic paresis. When the manually tested strength of the hip flexor is full, this test is not diagnostic.

We judged that Hoover's sign as a whole indicated non-organic paresis if at least one of the two tests suggested non-organic paresis, because both phenomena indicating non-organic paresis were unlikely to occur in organic paresis.

RESULTS

Every patient in the series had some weakness of the hip abductor, and the abductor sign was diagnostic. The abductor sign showed a non-organic pattern for all 16 patients with

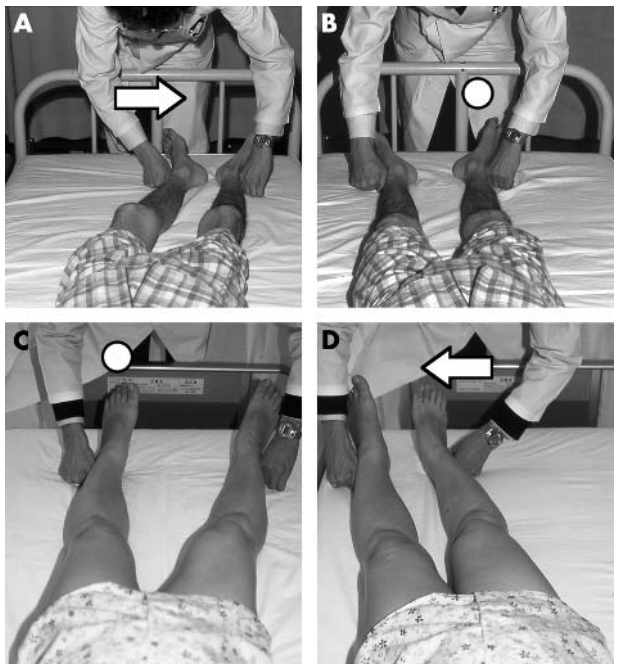

Figure 2 Abductor sign in a patient with organic paresis and a patient with non-organic paresis. White arrow, movement; white circle, non-movement of the unabducted leg. (A), (B): a 49 year old man with multiple sclerosis presenting with left leg paresis (organic). (A) The patient abducts the sound right leg; the unabducted paretic leg moves in the hyperadducting direction. (B) The patient abducts the paretic left leg; the unabducted sound leg remains in its original position. (C), (D): a 45 year old woman with hysterical paresis overlaying radicular injury presenting with left leg paresis (non-organic). (C) The patient abducts the sound right leg; the unabducted ''paretic'' leg remains in its original position. (D) The patient abducts the paretic left leg; the unabducted ''sound'' leg moves in the hyperadducting direction.

non-organic paresis, and an organic pattern for all 17 patients with organic paresis (table 1).

Hoover's test 1 correctly indicated non-organic paresis in all 12 patients with non-organic paresis who had weak hip extensors. It was not diagnostic for the remaining four patients with normal hip extensors. Hoover's test 2 indicated an organic pattern in two of the 15 non-organic patients with hip flexor weakness: thus the downward opposition of the sound leg was at full strength despite the weak elevation of the paretic leg. In one of these two patients, Hoover's test 1 indicated non-organic paresis, and Hoover's sign as a whole was judged to be non-organic. In the other patient, Hoover's test 1 was non-diagnostic because of the normal hip extensor, and he was diagnosed as organic even by the combination of the two tests comprising Hoover's sign. In one patient, both the hip flexor and extensor were normal, and Hoover's sign was not diagnostic at all.

Among the 17 patients with organic paresis, the hip extensors were normal in 12, and the hip flexors were normal in one, reflecting the lesser involvement of the extensors in pyramidal weakness[14 16]; Hoover's test 1 was non-diagnostic in the patients with normal hip extensors, and test 2 was non-diagnostic in the patient with normal hip flexors. Hoover's tests 1 and 2 correctly indicated organic paresis when diagnostic.

DISCUSSION

The abductor sign is a new neurological test using contralateral synergic movements, similar to Hoover's sign. Voluntary abduction of one leg inevitably accompanies the synergic contraction of the gluteus medius on the other side.

Table 1 Summary of results

Test	Non-organic pattern	Organic pattern	Non-diagnostic
Non-organic paresis (n = 16)			
Hoover's test 1	12 (100%)	0	4
Hoover's test 2	13 (87%)	2	1
Hoover's sign (combined)	14 (93%)	1	1
Abductor sign	16 (100%)	0	0
Organic paresis (n = 17)			
Hoover's test 1	0	5 (100%)	12
Hoover's test 2	0	16 (100%)	1
Hoover's sign (combined)	0	16 (100%)	1
Abductor sign	0	17 (100%)	0

Hoover's test 1 is judged as non-organic when the paretic limb exerts a full downward opposition that is stronger than the manually tested strength of the hip extensor, and as organic when it exerts weak opposition comparable to the manually tested strength. Hoover's test 2 is judged as non-organic when the sound limb exerts only weak downward opposition, and as organic when it exerts full downward opposition. The abductor sign is judged non-organic or organic according to the definition in the text.
Each test is judged non-diagnostic when the strength of the relevant muscles is full: hip extensors for Hoover's test 1, hip flexors for Hoover's test 2, and hip abductors for the abductor sign.
Hoover's sign (combined) is judged non-organic when at least one of the two tests suggests non-organic paresis.
Figures in parenthesis for non-organic pattern in non-organic paresis indicate sensitivity to detect the non-organic nature, those for organic pattern in organic paresis indicate specificity. Non-diagnostic cases were excluded from both calculations.

Otherwise the pelvis would be rotated towards the abducted leg owing to the action of the gluteus medius—the contraction of the gluteus medius on the unabducted side stabilises the pelvis and gives a firm base for the action of the other gluteus medius to abduct the leg.

In organic paresis, all the observed phenomena simply correspond to the weakness of the gluteus medius on the paretic side. In contrast, as Babinski pointed out, hysterical paresis affects the whole ''system'' of voluntary movements which the patient is called on to perform.[1 14 17 18] Thus the entire set of movements to abduct the sound leg is strong, whereas the entire set of movements to abduct the paretic leg is weak.

The difference between the above two situations becomes evident when the examiner tells the patient to abduct each leg ''separately,'' and exerts an adducting pressure using his hands to oppose both legs. Here the test also uses the synergic action of both arms of the examiner, which should produce almost symmetrical adducting force. For example, when the patient abducts the sound leg in organic paresis, the abducting strength of the sound leg is balanced by the opposing pressure of the examiner's hand, whereas the equally strong adducting pressure of the other hand of the examiner overpowers the weak synergic contraction of the gluteus medius on the paretic leg, which thus moves in the hyperadducting direction. As described in the methods section in detail, the different modes of action between organic and non-organic paresis result in diametrically opposite behaviour of the unabducted leg—that is, movement or non-movement. The only necessary technique is to urge the patient to concentrate on the abducted leg and pay no attention to the unabducted leg. This is common to Hoover's sign, where the examiner must take care to keep the patient from being aware that the leg actually examined is the unlifted one.

A few phenomena related to leg abduction or adduction have been described. Raimiste reported the abnormal contralateral associated movement of abduction or adduction of the paretic leg observed in hemiplegic patients,[19] which is

now known as ''Raimiste's leg sign.''[14] He also stated that this associated movement was not observed in hysterical patients. However, both the manoeuvre and the results of this sign are different from the present abductor sign. In Raimiste's sign, the examiner resists only the abduction of the sound leg, and observes unresisted free movement of the paretic leg. The paretic leg moves in an abducting direction only in the organic paresis because of the abnormal associated movement. The direction of the movement of the paretic leg is in the opposite direction in Raimiste's sign from the present abductor sign: with the abductor sign it should move in a hyperadducting direction overpowered by the examiner. This clearly shows that the two signs are completely different.

Weintaub[17] mentioned a sign to detect non-organic weakness using the contralateral synergic contraction of the thigh adductors. He stated that in a patient complaining of unilateral thigh adductor weakness, the physician can feel this muscle contract when he tests the opposite thigh against resistance. However, there was no mention of the thigh abductors in that paper. DeMyer[20] gave a brief description of a test that is close to my abductor sign, stating that the same principle as in Hoover's sign—of causing inadvertent bracing of the putatively paralysed part—operates in testing adduction and abduction of the legs. He then wrote ''When the examiner squeezes both knees together or tries to pull them both apart, the (hysterical) patient often automatically braces the putatively paralysed limb against the action of the intact limb.'' This description may correspond to a part of the present abductor sign—abduction of the sound limb in non-organic paresis—although DeMyer did not explicitly mention the important aspect of the sign that the examiner must ask the patient to abduct one leg separately; concurrent abduction of both legs only reveals the weakness of the paretic leg, even in non-organic paresis (fig 1A and 1D). There was no further mention of, for instance, the abduction of the paretic limb in non-organic paresis or the findings in organic paresis.

Hence, I believe that the abductor sign described here is a novel sign that has never been reported, except for the brief and incomplete mention by DeMyer.[20]

Several investigators have stated that Hoover's sign may give variable or equivocal results.[2 7 9–12] I am afraid that this may partly reflect an insufficient or incorrect understanding of this complicated test, as follows.

First, although Hoover's sign is obviously composed of two separate tests, many articles or textbooks mentioned only one—either test 1[20–23] or test 2.[10 16 24]

Second, neither test of Hoover's sign is diagnostic when the relevant muscle has normal strength: hip extensors for test 1 and hip flexors for test 2. However, such limitations of the application of Hoover's sign have not been explicitly mentioned in previous articles. Hoover himself mentioned the comparison between voluntary strength and the involuntary pressure, stating ''If the hemiparetic patient is asked to lift the normal leg ... he will exhibit an opposition with the paretic leg which is directly proportional to the voluntary muscular strength...''[8] Normal strength of the hip extensors occurred in as many as 12 of 17 patients with organic paresis in my present series. Hoover's test 1 is not diagnostic in such patients. If the examiner is not aware of this, he might misdiagnose many organic patients as non-organic because the downward pressure exerted by the paretic leg is strong.

Third, a modified Hoover's sign manoeuvre has been proposed by Adams and Victor.[25] They first tell the patient to press both legs toward the bed and feel the downward pressure by both hands under the heels, and then ask the patient to raise the sound leg against resistance. They stated that no added pressure is felt in organic paresis, but the pressure will increase in hysterical paresis. However, the downward pressure when both legs are pressed down does not usually reach maximum voluntary strength because this action is difficult to perform, as one can easily see if one attempts to replicate this movement oneself. In contrast, when the examiner applies resistance to the elevated leg, this resistance more easily counterbalances the downward pressure of the other leg, which can now reach maximal strength. Accordingly, the increased downward pressure can occur not only in non-organic paresis, but also in normal persons and in a mildly paretic leg of organic origin. I am afraid that the modified Hoover manoeuvre of Adams and Victor is misleading, and that it may even have increased the impression that Hoover's sign is unreliable.

Lastly, there have been a few previous attempts to quantify Hoover's sign, with little success.[10 26] The latest study by Ziv *et al* clearly discriminated between organic and non-organic paresis using a quantitative simulation of Hoover's sign.[22] However, they could not verify Hoover's test 2, because the involuntary downward pressure when the paretic limb was raised was similarly weak in both organic and non-organic pareses. I suspect that this might be due to the stabilised pelvis in their experiments, which would tend to undermine the synergic relation and, for instance, would reduce the need for complementary opposition when one leg is lifted. Their experiments are thus not a faithful copy of Hoover's sign, nor of the modified manoeuvre of Adams and Victor,[25] which they described as the sole clinical manoeuvre to elicit Hoover's sign in their introduction.[22] Quantification of a neurological sign is not simple, because the manoeuvres used for quantification may themselves cause modification of the original sign and may lead to different conclusions.

My present study revealed adequate reliability in the clinical application of Hoover's sign. Specificity in detecting hysteria was 100% for both test 1 and test 2 (table 1). The sensitivity was 100% for test 1 and 87% (13/15) for test 2, when non-diagnostic cases were excluded.

Two non-organic patients showed an organic pattern in test 2—that is, strong downward pressure of the sound leg despite weak elevation of the paretic leg. This was predicted by Hoover,[8] who stated ''Whether this lack of complemental opposition will always be found or not in malingerers and hysterical subjects remains for further observation to determine.'' These exceptional patients successfully disintegrated the synergic movements and ''pretended'' a full effort to lift the paretic leg. One can show that this is just possible by voluntarily pressing one leg (not both legs) down forcefully without lifting the other leg. In contrast, no hysterical patient in the present series succeeded in deceiving the examiner in either Hoover's test 1 or the abductor sign. These two manoeuvres must be more difficult to get round than Hoover's test 2. One can recognise this by attempting to raise one leg forcefully without exerting an equal downward pressure of the other leg, or to abduct one leg forcefully without exerting an equal abducting force of the other leg, both of which are very difficult and unnatural.

I will summarise the comparison between the abductor sign and Hoover's sign as follows. First, both tests show excellent specificity and sensitivity, but it is probably harder to deceive the examiner with the abductor sign and Hoover's test 1 than with Hoover's test 2. Second, because the gluteus medius and hip flexor are among the most frequently involved muscles in pyramidal weakness, the abductor sign and Hoover's test 2 are more often diagnostic than Hoover's test 1, requiring hip extensor weakness, especially in organic paresis (table 1). The third and the most important advantage of the abductor sign is that it gives a simple, visible result in terms of movement or non-movement of the unabducted leg. This contrasts with Hoover's sign, which depends on the

subjective assessment of the downward pressure using the examiner's hands.

My study has a few limitations. First, it was not blinded for the examiner: I personally undertook both the examinations and the diagnostic evaluations of the patients. It would be ideal to verify the present results using a blinded investigation. Second, my series did not include patients with weakness caused by pain, or those with cortical lesions producing neglect or other higher cortical dysfunction. Such patients may respond differently in these tests. Lastly, there was no non-organic patient in the series who was able to deceive the examiner over the abductor sign, but we cannot deny the possibility that further investigation may reveal such a ''clever'' patient, although I suspect that this must be quite exceptional.

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