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The Phenomenon of Multiple Stretch Reflexes

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Multiple stretch reflexes occur in muscles adjacent to or remote from the tap. The response may be ipsilateral or bilateral. These reflexes are encountered not only in normal subjects with brisk stretch reflexes but particularly in patients with lesions of the upper motor neuron.

The concussion obtained by the blow is conducted along bone to muscle. Muscle spindles are stimulated, and in this manner, independent stretch reflexes are produced in these muscles. This mechanism is responsible for the phenomenon of multiple stretch reflexes. The thorax and pelvis play important roles in the contralateral responses by transmitting these mechanical events across the midline. (Henry Ford Hosp Med J 1986;34:31-6)

Contraction of muscles remote from the site of percussion is encountered in patients with brisk stretch reflexes. These responses usually remain ipsilateral to the tap but may spread to the contralateral side. Various terms have been used to describe this phenomenon. In 1893, Sternberg (1) used the term multimuscular to describe these responses. Guillain and Alajouanine (2) mentioned diffused reflexes, whereas synreflexia was used by Austregesilo (3). Wartenberg (4) employed the words multiple, synchronous, or concomitant. Irradiation and spread of reflexes have been used by Lance (5). The term multiple stretch reflexes, which is descriptive of the phenomenon, will be used throughout this presentation. Lance and DeGail (6) also used the direct reflex to denote the contraction of muscle whose tendon has been tapped and the indirect reflex to denote the contraction of muscles remote from the tap.

Although the direct response is clearly a stretch response, the mechanism responsible for the indirect response has been controversial. Some clinicians, notably Strümpell (7), Valobra and Bertolotti (8), and Rasdolsky (9), postulated that the indirect responses resulted from spread through an intraspinal pathway, whereas Lance and DeGail (6), Teasdall and Magladery (10), and Teasdall and van den Ende (11) supported the observations of Wartenberg (4) that the responses were due to independent stretch reflexes.

No recent comprehensive review of multiple stretch reflexes has been found. Wartenberg mentioned the phenomenon in his series of articles on "Studies in Reflexes," which appeared in 1944, and referred to articles in the European literature (4,12,13). In this presentation, clinical examples of multiple stretch reflexes are given, the pertinent literature is reviewed, and the nature of the phenomenon is discussed.

Clinical Examples of Multiple Stretch Reflexes and Review of the Literature

Multiple stretch reflexes are elicited from several locations that can be grouped in four categories: the head and neck, the trunk, the upper limbs, and the lower limbs.

Head and neck

Since stretch reflexes are poorly developed in muscles innervated by the cranial nerves, the phenomenon is rarely encountered. However, the following multiple stretch reflexes have been described.

Jaw jerk—The jaw jerk is elicited by a tap directed downward to the chin. The mandible is depressed, and stretch of the mastication muscles occurs. The direct response consists of an elevation of the jaw. The jaw jerk is enhanced in patients with pseudobulbar palsy, and contraction of other muscles, especially facial muscles, may occur. The snout reflex also may occur with these blows. This primitive reflex consists of a puckering or pursing of the lips (14).

Orbicularis oculi reflex—Taps to the forehead to elicit the orbicularis oculi reflex are accompanied by bilateral lid closure (15). The indirect reflexes consist of participation of the lower facial muscles, and sometimes contractions of other muscles distant from the blow may occur (2,12). The orbicularis oculi reflex is also elicited following taps to the glabella. This glabellar reflex, also called Myerson's reflex, is enhanced in patients with cerebral lesions, especially Parkinson's disease.

Head retraction reflex—Although the head retraction reflex is seldom used by the clinician, the reflex is elicited by a tap to the maxillary bone beneath the nose. The response is an abrupt retraction of the head due to contraction of the neck's extensor muscles (16). Although the response is absent in normal subjects, it occurs in patients with bilateral upper motor neuron lesions above the spinal cord. Other muscles may also participate in this reflex. More often these blows elicit a puckering of the lips, which is called a snout reflex. This primitive reflex is encountered in patients with diffuse hemispheral disease (14).

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Trunk

Pectoral reflex—The pectoral reflex is a stretch response elicited by tapping either the origin, the insertion, or the belly of the pectoral muscle. The direct reflex consists of contraction of the pectoral muscle, which adducts and slightly internally rotates the arm. Sometimes the deltoid and the biceps muscles participate in the indirect response. Although the reflex may be found in normal subjects, in patients with upper motor neuron lesions, the pectoral jerk is exaggerated, and other muscles of the shoulder girdle and upper limb may contract as well as the contralateral pectoral muscle. Bilateral contractions of the pectoral muscles when the clavicle (17) or sternum (18) is tapped have also been reported.

Deep abdominal reflex—Deep abdominal reflexes may be elicited in normal subjects with brisk stretch reflexes but usually are encountered in patients with lesions of the upper motor neuron above the sixth thoracic segment. The blow of the reflex hammer is directed to the examiner's fingers, which are placed over the insertion of either a rectus abdominis muscle or external oblique muscle at the rib cage or the pubis. The response is a bilateral contraction of the abdominal muscles, but on occasion a unilateral contraction may occur.

In some patients with lesions of the upper motor neuron, a dissociation of the abdominal reflexes has been observed. This consists of an absence of the superficial abdominal reflexes and an exaggeration of the deep abdominal reflexes. Wartenberg (4) described a triple response when the deep abdominal reflexes were elicited, which consists of contractions of the abdominal muscles, the adductor muscles of the thighs, and the pectoral muscles.

Blows to the upper vertebrae and area of the scapula have been accompanied by a contraction of the shoulder girdle muscles and muscles of the upper limbs (4). In general, taps to the vertebrae were associated with bilateral responses while those to the scapula had unilateral responses.

Upper limb

Biceps reflex—Occasionally, when the biceps reflex is elicited by a tap to the biceps tendon, other muscles in the upper limb may participate in the indirect response. More frequently the biceps muscle contracts when other reflexes are tested, especially the brachioradialis and finger flexor. Contraction of the biceps may also occur from blows to the sternum, clavicle, and scapula (4,17).

Triceps reflex—The triceps reflex is elicited by a blow to the triceps tendon, and on occasion, other muscles in the upper limb may contract. Similarly, blows to more remote areas may be accompanied by contraction of the triceps (4).

The paradoxic triceps reflex is an unusual phenomenon. The response is elicited by a tap to the triceps tendon with the arm abducted 90° at the shoulder and the forearm hanging in a dependent attitude. The response is usually present in patients with an absent triceps reflex and consists of flexion of the forearm due to contraction of the biceps muscle. The paradoxic triceps reflex is encountered in patients with lesions at the seventh and eighth cervical cord segments, a condition that abolishes the triceps reflex. The biceps reflex remains since it is subserved by the intact fifth and sixth segments. Sometimes the paradoxic triceps reflex is encountered in patients with tabes dorsalis (19) and in those with hemiplegia (4). Paradoxic patellar and Achilles reflexes have also been observed in patients with appropriate peripheral lesions.

Brachioradialis reflex—A tap to the styloid process of the radius produces contraction of the brachioradialis muscle, and the forearm is flexed. If this brachioradialis reflex is brisk, even in normal subjects, other muscles may contract in the indirect response, such as the flexors of the hand and fingers, the supinator, and the biceps. The deltoid, latissimus dorsi, and pectoral muscles may also participate. These indirect responses may be obtained following blows to other areas of the forearm and hand.

In some patients, contraction of the brachioradialis muscle is absent following these blows, but flexion of the hand and fingers occurs as well as contraction of other muscles in the upper limb. This "inversion of the radial reflex" was first described by Babinski in 1910 (20) and indicates a lesion affecting the fifth and sixth cervical segments of the spinal cord (21). The participation of the flexor muscles is enhanced if the lesion at C5 and C6 also involves the upper motor neuron (4).

Wartenberg (4) mentioned that inversion of the brachioradialis reflex may be encountered in normal subjects. In my opinion, Wartenberg is probably incorrect since even discrete lesions in the cervical region may be detected with current diagnostic techniques.

Other reflexes elicited by blows to the radius and ulna may be associated with contractions of several muscles in the upper limb. These responses are dependent on the intensity and direction of the blows as well as the position of the forearm (12,22). They are of limited clinical significance.

Finger flexor reflex—A blow directed to partially flexed fingers produces a stretch of the forearm flexor muscles, and flexion of the fingers occurs. The finger flexor reflex also may be elicited following blows to the forearm or hand. Hoffmann's sign is a variant of this reflex (12). The finger flexor reflex and Hoffmann's sign may be present in normal subjects, provided that the stretch reflexes are brisk. These reflexes are also found in patients with lesions of the upper motor neuron. Other muscles in the upper limb may participate in the finger flexor reflex.

Lower limb

Knee jerk—In 1889, Lombard (23) reported that occasional contraction of flexor muscles of the thigh occurred when the knee jerk was elicited. In patients with hyperreflexia, Tschlenow (24) observed that the quadriceps along with other muscles in the lower limb may contract following taps to any point in the ipsilateral lower extremity. In these patients with brisk reflexes, Wartenberg (13) observed that tapping the patellar tendon not only produces contraction of the quadriceps muscle but also the adductor and flexor muscles of the thigh. The tibialis anterior, gastrocnemius, and even the abdominal muscles may participate in the indirect response following blows to the patellar tendon.

Adductor reflex—The adductor reflex is usually elicited with the patient supine, thighs abducted, knees flexed, and heels to-

gether. The patient can also sit at the edge of the examining table with the legs dependent. The stimulus is a blow to the medial epicondyle of the femur which stretches the adductor muscle. Contraction of the ipsilateral adductor muscle occurs. Occasionally, the contralateral adductor muscle participates in this reflex, provided that the stretch reflexes are sufficiently brisk.

With the patient seated, the crossed adductor reflex may be elicited following taps to the patella that are directed in the long axis of the femur. The discovery of this reflex was attributed to Marie in 1894 (25). Wartenberg (13) mentioned that the crossed adductor reflex may be more pronounced than the ipsilateral adductor reflex when the taps are applied to the heel of the foot with the patient supine and the leg extended. This later observation conflicts with Pflügers law, which states that the homolateral response is more active than the contralateral response in normal subjects.

Although the crossed adductor reflex has been associated with an upper motor neuron lesion by some clinicians (26-28), several other neurologists have maintained that the reflex may be encountered in normal subjects (13, 25,29,30). The crossed adductor reflexes are symmetrical in normal subjects, while in the patients, the crossed response is enhanced along with other stretch reflexes on the side of the upper motor neuron lesion.

Marie (25), Yawger (31), Wartenberg (13), and others have described an interesting phenomenon. This is an exaggerated adductor response either on the ipsilateral or contralateral side following taps to the patellar tendon in patients with absent knee jerks. Wartenberg assumed that these adductor reflexes were enhanced when adjacent reflex arcs were damaged and attributed this to an isolation phenomenon.

Taps to other areas, such as the symphysis pubis or superior ramus of the pubis (32), the lower lumbar spinous processes (33), and the crest and spine of the ilium (13), may evoke the adductor reflex in one or both limbs in patients with brisk stretch reflexes. In 1924, Guillain, Strohl, and Alajouanine (34) described the mediopubien reflex which consists of contraction of the abdominal muscles and the adductors of the thighs on tapping the symphysis pubis. This reflex is present in patients with brisk stretch reflexes. A dissociation of this reflex implies that either the deep abdominal reflex is absent and the adductor reflex present or vice versa.

Hamstring reflex—The hamstring reflex is elicited by tapping the tendon of the respective muscle. When exaggerated, other muscles of the lower limb may participate in the indirect response. The hamstring reflex may be obtained by tapping remote points such as the greater trochanter, lumbar vertebrae, and distal parts of the lower limb (13,35,36).

Ankle jerk—When brisk, the ankle jerk may be obtained by taps to areas other than the Achilles tendon. These blows may be applied to the sole of the foot or the anterior aspect of the leg (13). Along with the direct calf response, the quadriceps, hamstrings, adductors, and even the glutei may participate in the contraction (2,13).

Plantar flexor reflex—The plantar flexor reflex is most readily elicited following taps to the plantar surface of the toes. The response is a plantar flexion of the toes. When this reflex is brisk, it may be obtained from blows to other areas of the foot, and contraction of more proximal limb muscles may occur (13).

Table
Multiple Stretch Reflexes in Normal Subjects and Patients with Neurologic Lesions

Normal subjects		Symmetrical ipsilateral and contralateral multiple stretch reflexes
Patients with Central lesions: upper motor neuron		Enhanced ipsilateral and contralateral multiple stretch reflexes on involved side or sides
Peripheral lesions:	C5,C6	Inversion of brachioradialis reflex
	C7,C8	Paradoxic triceps jerk
		Other paradoxic phenomenon associated with absent reflexes, especially knee jerk

Discussion

Multiple stretch reflexes are encountered in several locations and observed in adjacent and remote muscles to the blow. The response may be limited to the ipsilateral side, and contralateral contractions may occur. These reflexes are dependent on brisk stretch mechanisms and are found in normal subjects as well as in patients with upper motor neuron and certain discrete peripheral lesions (Table). In normal subjects, multiple stretch reflexes are symmetrical, but in patients with lesions of the upper motor neuron, the reflexes are enhanced on the involved side or sides. Lesions of the peripheral nervous system may also be associated with abnormalities of these responses, which are listed in the Table. These pathological multiple stretch reflexes should be confirmed, however, by other abnormal neurological findings since their presence does not necessarily signify disease of the nervous system.

In 1944, Wartenberg (4) expressed the view that multiple stretch reflexes arise by independent stretch mechanisms from transmission of the blow to other muscles rather than from spread through intraspinal pathways. This opinion was derived from astute clinical observations.

The studies of Lance and DeGail (6) have been supportive of the mechanical hypothesis. By employing selective blocking techniques, Lance and DeGail demonstrated that it was possible to abolish the reflex contraction in those muscles while responses remained in intact muscles. Furthermore, when the blows were applied to an area more distant from the muscle, the increased latency corresponded to the time required for the vibratory wave to travel the greater distance. It was postulated that vibrations produced by the tap were transmitted along bone to muscles and stimulation of muscle spindles occurred, which was responsible for the multiple stretch reflexes.

Similar conclusions were reached by Teasdall and Magladery (10) in an electromyographic (EMG) study of the brachioradialis reflex. Latencies of brachioradialis reflex and accompanying contraction of forearm flexors as well as the finger flexor reflex were similar in any one subject. Moreover, latencies of the H reflex, which are unaltered by stimulus strength (37), were identical from brachioradialis and forearm flexor muscles. These observations suggested that the mechanically induced brachioradialis and finger flexor reflexes were subserved by reflex arcs having identical conduction times. The brachioradialis reflex

and accompanying contraction of forearm flexors must result from independent stretch mechanisms and not from an intraspinal spread.

It is well known that muscle spindles are stimulated by linear stretch (38), which is the appropriate stimulus for these clinically elicited reflexes. Activation of the gamma efferent system causes contraction of the intrafusal muscle fibers which increases the sensitivity of the muscle spindles to stretch (39). Echlin and Fessard (40) showed that muscle spindles also respond to vibrations transmitted from bone to muscle. Granit and Henatsch (41) demonstrated that the sensitivity of muscle spindles to vibrations was increased by activating the gamma system from the brain stem. Finally, Bianconi and Van der Meulen (42) found that spindle receptors responsive to vibrations were those associated with rapidly conducting afferent fibers, possibly from nuclear bag endings.

The findings reported by Lance and DeGail (6) and Teasdall and Magladery (10) are entirely consistent with the aforementioned hypothesis that percussion of bone initiates a vibratory wave that is propagated from bone to muscle and is capable of stimulating muscle spindles to produce reflex contraction of those muscles remote from the blow. Furthermore, certain reflexes such as the inversion of the brachioradialis, Hoffmann's sign, the paradoxic triceps jerk, and other paradoxic responses might well be similarly explained.

Wartenberg (4) offered the following explanation for the paradoxic triceps jerk: a blow to the triceps tendon passively extends the forearm and stretches the biceps muscle; a reflex contraction of the biceps muscle occurs, and the forearm flexes. Although stretch of the biceps muscle plays a role in the paradoxic triceps jerk, an additional mechanism is responsible. Contraction of the antagonist muscle usually occurs when the agonist reflex is tested (4). For example, contraction of the biceps muscle occurs when the triceps jerk is elicited. Similarly, the hamstring along with the knee jerk may contract, and the tibialis anterior and extensor hallucis muscles may participate when the Achilles tendon is tapped. Since these are multiple stretch reflexes, the contractions are attributed to the blow and the ensuing vibrations that stimulate muscle spindles.

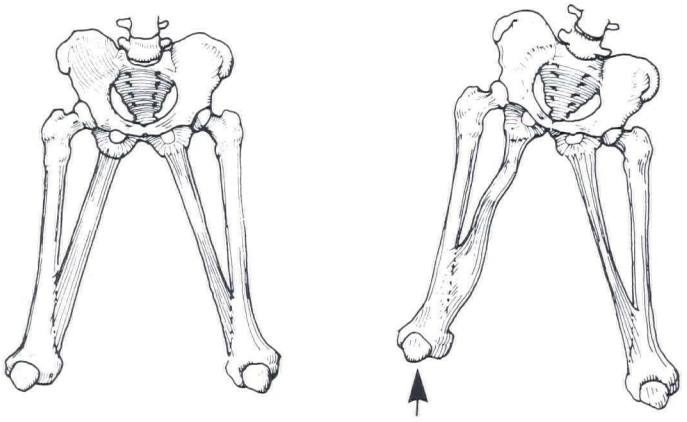

Fig 1—Diagrams of pelvis, femurs, and adductor magnus muscles before and after blow. Arrow designates direction of blow, which was applied to either patella or patellar ligament. Pelvis was tilted. Ipsilateral adductor muscle was shortened while contralateral adductor muscle was stretched. (From Teasdall RD, van den Ende H. The crossed adductor reflex in humans: An EMG study. Can J Neurol Sci 1981;8:84. Reprinted with permission.)

Furthermore, these contractions of antagonist muscles are enhanced when the corresponding reflex is absent. Accordingly, several factors are probably responsible for these paradoxic reflexes.

Multiple stretch reflexes are transmitted to the contralateral side. This may occur either by means of an intraspinal pathway or by a mechanism peripheral to the spinal cord.

Valobra and Bertolotti (8) stated that irritation of posterior roots is responsible for the crossed adductor reflex. Rasdolsky (9) described a crossed spino-adductor reflex, and Strümpell (7) mentioned crossed quadriceps reflexes in which radiation through the spinal cord was proposed. These latter reflexes, however, were probably associated with spinal automatism.

Considerable support exists for the hypothesis that postulates a pathway extrinsic to the spinal cord. In the spinal animal, Sherrington (43) demonstrated that the crossed adductor reflex persisted after midsagittal section of the lower spinal cord. He felt that the blow must be relayed mechanically across the pelvis to excite nerves in the opposite limb.

In human subjects, Schäffer (44) found similar latencies for the ipsilateral and contralateral adductor reflexes. This observation suggested that these reflexes were dependent on similar mechanisms that did not require conduction across the midline through the spinal cord. Wartenberg (13) offered the following clinical demonstration which indicates that the stimulus for the crossed adductor reflex was transmitted through the pelvis: with the patient seated, a crossed adductor reflex was elicited when the blows to the patella were directed toward the pelvis and along the axis of the femur; when these same blows were directed not toward the pelvis but rather vertically or downward, the crossed adductor reflex was not obtained.

Further support for this hypothesis was obtained from an EMG study of the crossed adductor reflex in humans by Teasdall and van den Ende (11). The mechanism postulated for the crossed adductor reflex following blows to the patella is shown in Fig 1. The left diagram illustrates the position of the limbs before the blow while the mechanical event occurring afterward is shown on the right. The blow to the patella, designated by the arrow, was directed along the axis of the femur which briefly tilted the pelvis. A shortening of the ipsilateral adductor muscle occurred along with a lengthening of the contralateral adductor muscle. Stretch induced in this manner was responsible for the crossed adductor reflex. With lesser degrees of stretch of the contralateral adductor muscle, which accompany blows to the medial epicondyle of the femur, a corresponding decrease occurred in the crossed adductor response. In addition, vibrations transmitted by bone through the pelvis may also play a role in these crossed reflexes, since Matthews and Stein (45) have reported excitation of muscle spindles following vibratory stimuli comparable to those employed in this study.

Bilateral contractions of the abdominal muscles occasionally occur when the deep abdominal reflexes are elicited. These

stretch reflexes were investigated electromyographically by Teasdall and van den Ende (46), who reported latencies in the range of 16.5 to 25 ms, which were usually identical from both sides of the abdomen. The discharges were synchronous. It was postulated that the blow to the abdominal muscles was transmitted over the entire abdominal wall. Muscle spindles were stimulated simultaneously on both sides of the abdomen, and separate stretch reflexes were produced. This accounted for the bilateral responses of equal latency. The events are shown schematically in Fig 2.

Although stretch reflexes cross the midline by a mechanism extrinsic to the spinal cord, cutaneous reflexes are mediated to the opposite side through a spinal pathway. In the experimental animal, the crossed extensor reflex is conducted via the spinal cord (47). In human subjects, the crossed component of cutaneous reflexes is probably conveyed by an intraspinal pathway (48).

Difficulties may be encountered in differentiating multiple stretch reflexes from those of spinal automatism. Reflexes of spinal automatism occur in patients with spinal cord lesions and consist of a reflex contraction usually of the lower limbs following a cutaneous stimulus. The EMG recordings comprise asynchronous discharges from various groups of muscles which have longer and more variable latencies than those of stretch reflexes. These responses are characteristic of polysynaptic reflexes. Multiple stretch reflexes may be found in normal subjects and are elicited by a mechanical stimulus. The response is a phasic contraction of muscles. The EMG recordings consist of synchronous discharges from muscles with latencies which are shorter and less variable than polysynaptic reflexes. These are features of monosynaptic reflexes. Occasionally, multiple stretch reflexes and reflexes of spinal automatism may coexist in patients with spinal cord lesions (49).

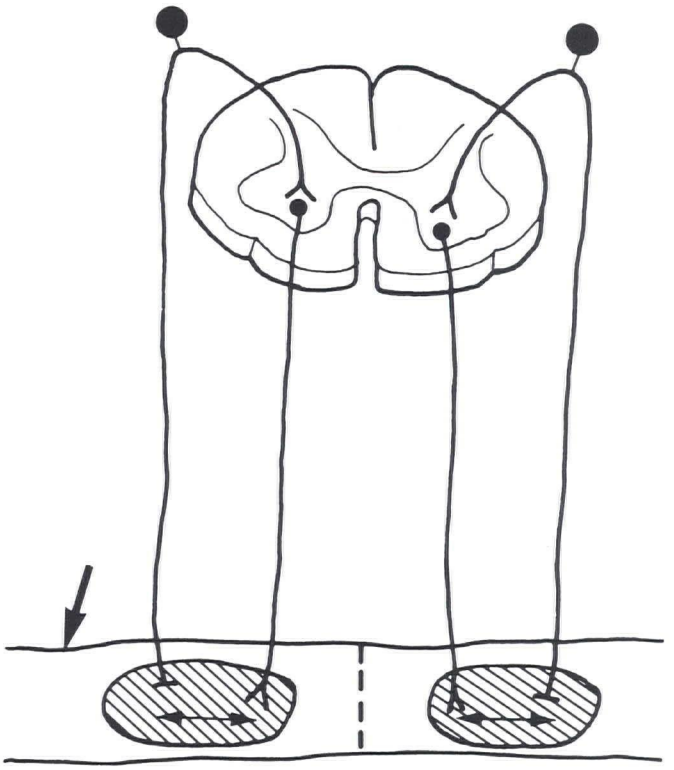

Fig 2—Diagrammatic representation of deep abdominal reflexes. Unilateral blow to abdominal surface, indicated by arrow, stretches abdominal muscles on both sides. Muscle spindles are stimulated, and reflex contractions of abdominal muscles occur bilaterally. (From Teasdall RD, van den Ende H. A note on the deep abdominal reflex. J Neurol Neurosurg Psychiatry 1982;45:383. Reprinted with permission.)

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