Human anal reflexes

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SUMMARY By perianal electrical stimulation and EMG recording from the external anal sphincter the anal reflex was constantly present in normal subjects. The latency decreased within certain limits with increasing stimulation to an average minimum latency of 50 ms (SD 10.5). There was no difference between the minimum latency in normal subjects and patients with suprasegmental lesions of the CNS. The latency may be prolonged in patients with lesion of the reflex arc. By stimulation over the posterior tibial nerve behind the medial malleolus a reflex reaction could be picked up constantly from the anal sphincter in normal subjects. This reflex had a longer latency but a lower threshold than the reflex reaction from the tibialis anterior muscle. The average minimum latency from the anal sphincter was 93 ms (SD 21.1) and from the tibialis anterior muscle 64 ms (SD 7.9). In the absence of the anal reflex it may be possible to localise the defect to the afferent or efferent parts of the reflex by using both types of stimulation. Preliminary studies of spinal shock revealed a perianally elicited anal reflex in all cases, but also a response to peripheral stimulation in some of the cases, more frequently found in the anal sphincter than in the tibialis anterior muscle.

The classical anal reflex is manifested by a contraction of the anus in response to pricking the anal mucosa or the perianal skin. The original description and designation of the reflex were given by Rossolimo (1891), who reported the constant appearance of the reflex in normal subjects. By experiments in dogs he was able to localise the anatomical spinal centre in the sacral part by transections of the spinal cord and the sacral nerve roots.

The reported constancy of the reflex in normal subjects was questioned by Müller (1902), who found it very inconstant, and later by Allert and Jelasic (1969, 1974). The sacral localisation of the segmental part of the reflex in man has been demonstrated in many clinical studies over the years, but the afferent and efferent limbs involved in the reflex have not been fully clarified.

A reflex reaction can also be elicited in the anal sphincter by the same stimulation on the legs as will provoke the flexor reflex (Mai and Pedersen, 1976), and this reaction in the anal sphincter has some features in common with the flexor reflex, but there are also differences.

Studies of the anal reflex by means of electromyography have so far been few. By using quantitative methods of stimulation and recording by EMG from the anal sphincter, we have tried further to characterise and quantitate the anal reflex and to investigate its relationship to the flexor reflex. The purpose of this paper is to present the results of these studies.

Methods

By the conventional method, the anal reflex is elicited by pinpricks in the mucosa or the perianal skin and the reaction in the anal sphincter can be observed visually or felt by a finger introduced into the rectum or recorded by EMG. A useful supplement to the technique is electrical stimulation perianally, and such electrical stimulation is necessary in the most accurate measurements of latencies.

In electrical stimulation and EMG recording of the reflex response the distance between the stimulating and recording electrodes was so short that the amplifier was saturated for several hundred milliseconds. This problem was, however,
solved by incorporating a relay in the input stages of the preamplifier. This relay was activated just before the electrical stimulation and a cut-off period of 10–20 ms was normally used.

In the routine set-up for the perianally elicited anal reflex the electrical stimulation was led to the patient by a digital programming unit of our own design and a modified constant current output unit, type Disa 15E07, and applied to the skin by a specially constructed pencil electrode with two metal tip electrodes of a diameter of 3 mm and a centre-to-centre spacing of 7.5 mm. A train of stimuli consisting of square-wave pulses of a duration of 1 ms separated by 1 ms was used; generally five pulses were included.

The EMG from the anal sphincter was obtained by bipolar intramuscular (Disa type 13K13) electrodes inserted through the skin just outside the anocutaneous junction into the external anal sphincter; the correct position of the electrode was checked by asking the patient to make a voluntary contraction.

In some of the cases simultaneous recording from the external urethral sphincter was performed by needle electrodes. In men, the electrode was introduced in front of the anus and the rectum, guided by a finger introduced into the rectum, until a position under the medial lobe of the prostate gland was reached. In women, a needle electrode was introduced through the vaginal mucosa beside the outer urethral orifice along the urethra and facilitated by an intraurethral catheter. The urethral sphincter is situated at a distance of approximately 15 mm from the orifice.

The reflex reaction in the anal sphincter in response to stimulation distally on the leg can be elicited in the same way as a flexor reflex, for example, by pinprick or electrical stimulation of the plantar skin, by electrical stimulation with intradermal electrodes in the sole of the foot, or by electrical stimulation of the posterior tibial nerve behind the medial malleolus. Stimulation over the posterior tibial nerve (Pedersen, 1954) was used in our routine method, and the stimuli consisted of square-wave pulses of a duration of 1 ms separated by 1 ms; generally five pulses were included. The stimuli were applied to surface electrodes placed over the posterior tibial nerve behind the medial malleolus, and the conventional flexor reflex was in all cases represented by the tibialis anterior muscle and recorded by EMG by surface electrodes placed approximately 5 cm apart longitudinally over the belly of the muscle. The stimuli were generally separated by intervals of at least 1 minute.

In order to elicit a reflex, the electrical stimulation was always given unexpectedly to the subject under investigation.

The signals from the electrodes were fed through amplifiers (Disa type 15C01) to data-recording equipment using videotape (Pedersen and Klemar, 1974).

**Results**

**ANAL REFLEX BY PERIANAL STIMULATION**

Studies of the constancy of the anal reflex were performed by a pinprick and electrical stimulation of the perianal skin and EMG recording from the external anal sphincter in more than 300 people, including normal volunteers and patients undergoing neurourological examination. The ages of individuals studied ranged from 6 months to 85 years, and the reflex could be elicited in all normal subjects and in the patients, apart from some in whom a lesion of the reflex arc was most likely to explain its absence. By mechanical stimulation alone the reflex was weak or absent in some cases, especially in the elderly, and could here be elicited only by electrical stimulation, and usually a much higher—for example, 10 times—intensity of stimulation than was normally required.

Standardised studies of the reflex by quantitative methods were performed in another 30 normal subjects. It appeared that the latency decreased within certain limits with increasing stimulus intensity (Fig. 1). The latency of the reflex was
studied from the threshold stimulus until minimum values were obtained; average latencies of 200 ms were obtained at a threshold stimulus; however, in some cases the latency was as high as 400 ms. The average minimum latency was 50 ms (Table).

By unilateral stimulation, the reflex reaction could be picked up by electrodes from both sides of the anal sphincter, but with a preponderance on the stimulated side. By perianal stimulation—whether mechanical or electrical—a simultaneous reflex reaction could be demonstrated in the external urethral sphincter in 10 patients investigated by neurourological examination, including both patients with lesions of the CNS and some without signs of neurological disorder.

Sixteen patients with lesions of the CNS, including multiple sclerosis, traumatic paraplegia, spinal tumours, all with spastic paraplegia of the legs, were studied. The ages of these patients ranged from 9 to 56 years, averaging 39 years (SD 12.6). By perianal electrical stimulation a minimum latency of 50 ms (SD 15.6) was found. This minimum latency did not differ from that observed in the normal group. The reaction of the reflex as demonstrated by EMG was variable, but generally, within certain limits, was more pronounced with increasing stimulation (Fig. 1). It was also more pronounced in the patients than in the normal subjects and with a greater tendency to separation into subfractions which, on more intense stimulation again disappeared and were replaced by an interference pattern of long duration.

In patients with lesions involving the reflex arc—such as lumbar disc protrusion, congenital lesions, neuropathies, sequelae of sacral blockades—the anal reflex may be absent, or a prolonged minimum latency may be recorded. This can be seen in a comparison with the normal series and in patients with lumbar disc lesions, also often as compared with the unaffected side. In a few patients with lumbar disc lesions leading to the cauda equina syndrome, repeat studies of the minimum latency revealed variations which seemed to be relevant to their clinical state. In one of these cases in which the cauda equina syndrome was caused by a protrusion of the fourth lumbar disc, the minimum latency of the anal reflex was 200 ms three days after operation, and 70 ms one week later. After recurrence of the cauda equina syndrome and re-operation, the anal reflex was absent, but during the next two weeks it returned and showed minimum latencies ranging from 70 ms to 46 ms.

**ANAL AND FLEXOR REFLEXES BY STIMULATION OVER THE POSTERIOR TIBIAL NERVE**

On electrical stimulation over the posterior tibial nerve behind the medial malleolus and on mechanical stimulation of the plantar skin in 50 normal subjects a reflex reaction could, in all cases, be recorded by EMG from the external anal sphincter.

In another 30 normal subjects, that is, those mentioned above (Table), the reaction on electrical stimulation over the posterior tibial nerve was studied simultaneously by EMG from the anal sphincter and from the tibialis anterior muscle. As recorded from both muscles, the latency of the reflex decreased within certain limits with increasing stimulus intensity (Fig. 2). Both the latency at the threshold stimulus and the minimum latency from the anal sphincter, 213 and 93 ms respectively, were longer than the corresponding values for the tibialis anterior muscle, 160 and 64 ms. This difference in the minimum latencies is significant (Table).

The threshold of the reflex from the anal sphincter was significantly lower than that from the tibialis anterior (Table and Fig. 2).

The 16 patients with lesions of the CNS were studied by the same technique, and the average minimum latency of the reflex from the anal sphincter was 100 ms (SD 42.8) and from the tibialis anterior muscle, 66 ms (SD 8.5). These values do not differ from those observed in the normal subjects. Wide variations were observed

| Table Measurements of the anal reflex by electrical stimulation of the perianal skin and recording by EMG from the anal sphincter, and of the reflex reaction in the anal sphincter and tibialis anterior muscle by electrical stimulation over the posterior tibial nerve in 30 normal subjects whose ages ranged from 9 to 60 years and averaged 34 years (SD 13.2) |
|---|---|---|---|---|
| Site of stimulation | Recording by EMG from | Threshold stimulation | Latency at threshold | Minimum latency |
| | | $\bar{x} \text{mA}$ | $\sigma$ | $\bar{x}$ ms | $\sigma$ | $\bar{x}$ ms | $\sigma$ |
| Perianal skin | Anal sphincter | 3.6 | 1.82 | 200 | 80 | 50 | 10.5 |
| Posterior tibial nerve | Anal sphincter | 4.1* | 1.57 | 213 | 52 | 93* | 21.1 |
| Posterior tibial nerve | Tibialis anterior muscle | 6.5* | 3.39 | 160 | 89 | 64* | 7.9 |

*Significantly different (P < 0.01)
†Significantly different (P < 0.001)
in the reflex response as recorded by EMG, but generally the EMG was more pronounced in patients with suprasegmental lesions of the CNS than in normal subjects (Figs 2 and 3), whereas in patients with lesions of the reflex arc the EMG response was less pronounced.

By peripheral stimulation on the leg, reflex reactions can be picked up not only from the anal sphincter, but also from the external urethral sphincter (Fig. 3), and this simultaneous reaction is independent of whether stimulation is applied to the plantar skin or over the posterior tibial nerve.

The average minimum latency of the reflex from the tibialis anterior muscle of 64 ms is not significantly different from that of 60 ms (SD 7.3) found in a larger series (Pedersen, 1954), in which investigation no significant difference in the minimum latency in normal subjects and in patients with supranuclear lesions was found.

**Fig. 2** Reflex in a normal subject from the anal sphincter recorded by EMG with needle electrode (upper trace) and from the tibialis anterior muscle by surface electrode (lower trace) elicited by electrical stimulation over the posterior tibial nerve behind the malleolus. Increasing stimulus intensity from (a) to (c).

**Fig. 3** Reflex from multiple sclerosis patient with spastic paresis of the legs and uninhibited neurogenic bladder. The reflex was elicited by electrical stimulation over the posterior tibial nerve behind the malleolus and the response recorded by EMG with needle electrode from the anal sphincter (upper trace), external urethral sphincter with needle electrode (middle trace), and from the tibialis anterior muscle with surface electrodes. $S =$ stimulation.

ANAL AND FLEXOR REFLEXES BY STIMULATION PERIANALLY AND OVER THE POSTERIOR TIBIAL NERVE
The possibility of eliciting a reflex reaction in the anal sphincter from two different sites gives in some cases an opportunity to perform a closer analysis of defects in the anal reflexes, since the two types of reflexes have the efferent, but not the afferent, pathway in common. This is illustrated in Fig. 4. In the patient concerned, a reflex reaction could not be elicited by perianal electrical stimulation, but by stimulation over the posterior tibial nerve. This indicates a lesion of the afferent sacral pathway involved in the anal reflex, in this patient caused by a traumatic lesion.

Recording of reflex reactions from the anal sphincter and the tibialis anterior muscle on stimulation perianally and peripherally on the leg was also used in the stage of spinal shock. So far, nine patients with spinal shock after a traumatic lesion of the spinal cord have been investi-
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![Fig. 4 EMG by needle electrode from the anal sphincter (upper traces) and by surface electrodes from the tibialis anterior muscle (lower trace to the right). To the left no reflex response is found after perianal stimulation, but to the right the reflex responses are shown in the anal sphincter and tibialis anterior muscle on stimulation over the posterior tibial nerve behind the malleolus. Patient with traumatic lesion. S = stimulation.](image)

gated. Of these, five were studied from the second to the sixth day after the onset of the spinal shock.

From these preliminary studies, it should be mentioned that in all cases the reflex reaction from the anal sphincter could be elicited by perianal stimulation and in some of the cases also by peripheral stimulation. In some, but fewer cases, weak reflex reaction was also obtained from the tibialis anterior muscle by stimulation over the posterior tibial nerve in the early phase of spinal shock. This reaction was found in one case as early as 36 hours after the onset of spinal shock. The reflex reaction was weak; the minimum latency was 150 ms, and a stimulus intensity of 24 mA was required.

**Discussion**

The constant appearance of the anal reflex in normal subjects originally reported by Rossolimo (1891) was later questioned by Müller (1902), who could demonstrate the anal reflex in only a quarter of normal healthy male subjects and in approximately half of normal healthy female subjects, and later by Allert and Jelasic (1969, 1974), who mentioned that individual anatomical variations may render it difficult to apply an adequate stimulus in many patients. With a technique including perianal electrical stimulation and EMG recording from the anal sphincter we found that the anal reflex was present in all normal subjects investigated and in patients in whom it was not very likely that a lesion of the reflex arc could explain its absence. However, the anal reflex was weak or absent in some cases, when mechanical stimulation was used. This applied, in particular, to elderly people in whom the reflex could be elicited only by electrical stimulation, and then often at a much higher stimulus intensity than normally required. Similarly, Bors and Comarr (1971) reported that the bulbocavernous reflex was weak or absent, especially in the elderly. Electrical application through our pencil electrode will often more readily elicit the anal reflex than mechanical stimulation by means of pinpricks, and EMG recording may be able to reveal reflexes which cannot otherwise be discerned.

The absence of the anal reflex thus provides strong circumstantial evidence of a lesion of the reflex arc, as does the presence of an increased minimum latency. In the absence of the anal reflex, stimulation perianally and peripherally on the leg may sometimes be of value in localising the defect to the afferent or efferent part of the reflex arc.

The demonstration that reflex reaction of the anal sphincter is constantly present in normal subjects on application of such stimulation on the leg as can elicit the flexor reflex, must imply that lumbar afferent roots are involved in the reflex, thus providing a parallel to the bulbocavernosus reflex, for which Bors and Comarr (1971) reported that the efferent limb is undoubtedly in the anterior sacral roots. The course of the afferent limb may or may not be in the posterior sacral roots because the bulbocavernosus reflex may survive a complete posterior rhizotomy below T10.

Both the perianally and peripherally elicited reflex of the anal sphincter has many features in common with the flexor reflex which in this study was represented by recording from the tibialis anterior muscle. Thus, the latency decreases within certain limits with increasing stimulation, and there is no difference in the minimum latencies in normal subjects and in patients with suprasegmental lesions of the CNS. However, the peripherally elicited reflex recorded from the anal sphincter has a longer latency and a lower threshold than the reflex recorded from the tibialis anterior muscle. Shahani and Young (1971) found the lowest threshold for the first component of the flexor reflex when intradermal electrical stimu-
lation on the sole of the foot was used. We observed longer latencies at threshold stimulation and shorter latencies at higher stimulus intensity by a method in which the stimulation was applied over the posterior tibial nerve.

In our preliminary study of spinal shock we were able to observe the well-known finding demonstrated by Riddoch as early as 1917—that the anal reflex is the first to return after spinal shock if, in fact, it had disappeared. The perianally elicited anal reflex was observed in all our cases. However, in some cases, reaction of the anal sphincter on peripheral stimulation also occurred, but weak reactions from the tibialis anterior muscle may also be seen on peripheral stimulation. This finding is in contrast with the classical concept of spinal shock, but in agreement with Shahani and Young (1971). They studied the flexor reflex in a single case during spinal shock until the return of the tendon jerks and found small and feeble flexor responses from the stage of severe spinal shock and no variation in minimum latency.

The anal sphincter is easily accessible for study by EMG and can, with some limitations, especially lesions of the reflex arc, be used as a representative of the activity of other parts of the pelvic floor, particularly the external urethral sphincter, in which a reaction simultaneous with that in the external anal sphincter was observed. Reflex reactions can be picked up from the external anal sphincter, not only by stimulation perianally and peripherally on the leg, but also accompanying the bulbocavernous reflex obtained by stimulation of glans penis or clitoris (Bors and Blinn, 1959). The constant appearance of the response of this reflex in the anal sphincter was demonstrated by Allert and Jelasic (1972, 1974) and in agreement with our experience (Pedersen, 1978), but not with Ertekin and Reel (1976), who found a very inconstant reaction in the anal sphincter.

The anal sphincter is also affected reflexly from the detrusor and the mucosa of the urethra and the bladder. By stimulation of the mucosa—for example, by a pull on a catheter—the effect is usually facilitation of the reflex activity, whereas anaesthesia in general gives rise to inhibition (Bors and Blinn, 1957; Rossier and Bors, 1962, 1969), which has been studied particularly in traumatic paraplegia.

References


