THE CLINICAL CHARACTERS OF PAIN*

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Pain has been defined as a specific feeling that protects from noxious stimuli. Pain is, however, not a single feeling. It is rather a group of distinct feelings, each of which has clinical characters of its own. Thus pain of the skin is different from pain of the muscles. Each type is related to a definite group of tissues. Examination of this relation is of theoretical and diagnostic interest.

Severity

The general level of severity of a pain can be influenced so much by the patient's personality and surroundings that no reliable conclusions can be reached from its study. The examination of the relative sensitivity of tissues is more useful. Not all tissues are equally sensitive. Some, like the cornea, are exposed to injury, and yet the effects can be serious even though the injury be slight. These tissues, as may be expected, have a high degree of sensitivity; but the sensitivity of ordinary tissues is much lower. It would be very inconvenient if the sensitivity of all tissues were high. When the injury is so mild as not to be of any consequence it does not reach consciousness. On the other hand, if the stimulus, even though mild, persists too long or if the tissue is still suffering from the after-effects of a previous injury, further damage of any degree can be dangerous and the threshold of pain is then lowered. The sensitivity of a tissue is not a constant, but a variable that changes with the previous history of the injured tissue.

Thus if the skin is damaged in any way there develops after a short interval a diffuse area of tenderness which surrounds the site of injury. This area is hypersensitive to stimuli of heat, cold, pressure, etc., that from their degree would not normally be enough to produce pain. This hypersensitivity is limited specifically to the organs of pain; for example, the organs of touch are not affected, as can be tested by Fry's hairs. The central mechanism of this hyperalgesia is ultimately segmental, but the nerve distribution within the skin is such that the area of tenderness around the site of injury follows a geometrical, not a segmental pattern, being concentric around the injured spot. It is never referred to a distance.

In the deeper tissues hyperalgesia occurs also. When 2 c.cm. of a 6% hypertonic saline solution was injected deep in my triceps muscle, after five to six minutes there appeared definite tenderness even on slight pressure over the site of injection. After an interval the tenderness was more diffuse and was felt over a large part of the posterior aspect of the arm. The tenderness was not equally marked everywhere. Over the injury it was easy to elicit and to locate; at some distance it was present as hypersensitive spots which kept changing their place from time to time, especially after active exercise. These spots were not easily located, and were vaguely circumscribed. Active exercise of the arm re-exacerbated the tenderness when it had become milder after rest.

Similar tenderness is met with in numerous clinical conditions, and its presence in a diffuse form may mislead as to the real site of injury. It has the same distribution as with deep pain, it has not a geometrical but a segmental pattern, and

can even be referred to a distance. Thus deep tenderness in diaphragmatic pleurisy may accompany pain over the neck and shoulder.

Power of Discrimination

The tracing of the curve of a pain's intensity against time is called the curve of time-intensity of that pain. The type of curve is influenced by the activity of the stimulus, but depends upon the properties of the injured tissue. In fact, the same stimulus applied in the same manner produces different curves in different tissues.

When 0.5 c.cm. of a 6% hypertonic saline solution was injected intradermally into my forearm it caused pain that was felt very early and rose very rapidly to its maximal intensity. When an equal amount of the same solution was injected into my triceps muscle the pain took some seconds to appear and some seconds more to become maximal. Again, when a pin-point is applied to the cutaneous surface the pain is immediate and maximal from the very start; it fluctuates in intensity with the variations in pressure of the pin, and disappears as soon as the pin is taken away. When, however, the skin and the subcutaneous tissue of a zone over the triceps muscle were anaesthetized by 2% novocain solution and a needle was inserted through this area into the triceps, the pain was not immediate. It took several seconds to appear; it increased slowly in intensity, did not fluctuate with the movements of the needle within the muscle, and persisted long after the needle had been removed. While skin pain portrays in its intensity curve the activity of the stimulus, muscle pain is not a faithful index of this activity, and is in this sense non-discriminative.

In the deep tissues discrimination is also defective in the power to distinguish as separate two distinct stimuli. When the overlying skin was anaesthetized two separate injections of 0.5 c.cm. 6% saline into my triceps, four inches apart, were not felt as distinct sources of pain. This was noticed whether the injections were given simultaneously or at an interval of 30 seconds from each other. With two injections the distribution of pain was somewhat different from that with a single injection; but the pain from either injection was so diffuse and its distribution overlapped so much in the area of distribution of the other pain that it was impossible, even with an effort of will, to detect two separate foci.

Power to Locate.—The power to locate the site of the injury from the pain that is felt depends upon the type of tissue injured. It is perfect on the cutaneous surface, but gets progressively more defective the deeper the tissue, as will be discussed later on.

Quality

Quality is the distinctive character of a sensation; but it is a character that cannot be described. We can, for example, say what physical stimulus carries the feeling of green vision or which objects look green, but we cannot describe green itself. Similarly with pain. We can say which stimuli cause a certain type of pain or we can compare it with another familiar pain, but we cannot describe the pain itself (Lewis, 1938). We use as terms of comparison a familiar pain which is related to some part of the body, as when we say that the pain feels like a tummy-ache; or we compare pain with

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that which is related to a function, as when a mother compares her pain to a labour pain. Much more commonly we make comparison with a pain that is provoked by a familiar stimulus, as when we call a pain "burning" because the same type of pain is produced by a burn. This is reflected in our terminology of pain (Lewis, 1938).

This common method of comparison based on the stimulus too often conveys the false impression that the characters of a pain are a function of the stimulus. If the quality of a pain were a function of the stimulus we could not explain why the same stimulus applied in the same manner should give pain of a different quality in different types of tissue. Thus the injection of 0.5 c.cm. of 6% hypertonic saline produces burning in the skin, aching pain in the muscles, and pain of a different quality in the subcutaneous tissue of the forearm. The quality of a pain is a function of the injured tissue. The same tissue will always give pain of the same quality, whatever the stimulus (Lewis, 1938). To become convinced of this one must take every precaution to obtain the pain in as pure a quality as possible. It is necessary to avoid stimuli that excite more types of tissue at a time; to eliminate all concomitant modifying feelings of touch, pressure, stretch, and temperature; and to use stimuli that act for equal intervals of time when comparing two tissues.

Types of Somatic Pain

From the quality and from other characters of their pain it is possible to classify human tissues into groups. Neither anatomical structure nor physiological function determines to which group a tissue belongs. Thus the injection of hypertonic saline within the triceps muscle of a patient who had post-undulant arthritis of the hip-joint produced pain which he regarded as of the same quality as the pain in his thigh. Injection of 0.3 c.cm. of 6% hypertonic saline within the tendon of my flexor carpi ulnaris gave pain whose quality and characters resembled the pain from my triceps but was different from pain provoked by an equal dose of the same solution injected at the surface of my tendo Achillis about an inch above its insertion. At least three types of somatic pain can be distinguished: (1) Surface pain, from the cutaneous and mucosal surfaces. (2) Subsurface or intermediate pain, from the subcutaneous tissues (where these are thin), from the submucosae, and from some adjacent structures when the subcutaneous tissue is very thin. (3) Deep pain, from muscles and from all the other sensitive deep tissues in general.

Surface Pain

If pain from the skin is very short it is pricking, if prolonged it is burning; the difference between the two being only of duration, not of quality (Lewis, 1938). Pricking can be elicited from exactly the same spot and by the same stimuli that give burning when the injury is prolonged. Pricking and burning are the only sensations of pain from the normal skin. They are generally modified by concomitant subcutaneous pain or by touch, temperature sense, etc., but if these feelings are eliminated the skin is unable to respond to any sort of injury except by pricking or burning. Burning is the sensation which we associate with excessive heat, but it is definitely not the response of the temperature organs to the excess of heat. Excessive heat produces burning because it produces prolonged injury and stimulates the cutaneous organs of pain. Also cold, if intense enough to cause injury, produces burning, as can be evidenced by prolonged immersion of a finger in a freezing mixture, by a cold wind, or by chilblains. Pricking or burning is absent in injury to the skin only if the cutaneous organs of pain are not functioning on account of destruction or otherwise. On the other hand, if the lesion is only superficial, as in a mild burn, no other pain will be added.

Itching

Injury to the skin can also produce itching, but for itching to appear the stimulus must act on a skin that is hyperalgesic. Itching is not elicited from a normal skin. In a skin that has been already injured, as in dermatitis, it can be provoked even by very slight added injury, such as scratching, the application of ointments, changes of temperature, etc. The quality of itching cannot be distinguished from the pricking-like pain which is produced by droplets of strong acids or of other irritants if

they fall on the skin in size so minute as not to be felt. It is suggested that itching is only a variety of surface pain which is completely free from any other sensation and which occurs in skin that is hyperalgesic from a previous injury.

Other Characters of Cutaneous Pain

The functions of surface pain are obviously directed towards providing enough information about the offending stimulus to make adequate defensive reactions possible. In fact, all its characters tend to promote accuracy: the pain is very well located; it is localized and never referred to a distance; the power of discrimination is good. The protective reflexes provoked by the injury are all directed with considerable precision towards the elimination of the stimulus or towards the withdrawal of the injured part from danger. Typical are the scratch and the flexor reflexes. If the stimulus is adequate there is an added systemic reaction which invigorates the mind and the body and enables the individual to face the danger. Sympathetic activity is then increased; the mind is on the alert, and emotions of anger, rage, fear, etc., may appear. These reactions are sometimes provoked purposely by inducing surface pain. Thus they occur when we stimulate horses by whipping or during certain forms of treatment of a fainting fit.

Pain from the Mucosae

Not all the mucosae are sensitive. Those that are distant from injury of external origin are insensitive. When, however, a mucosa is sensitive its pain is pricking or burning, as can be expected when we consider that a mucosa is a surface. Itching, pricking, and burning are familiar results of injury to the stratified mucosae of the conjunctiva, mouth, throat, anal canal, urethra, labia, and lower vagina. Whatever the stimulus, the pain is always of the same quality. Thus burning in the mouth occurs whether the injury is due to hot food or to a chemical irritant, catarrhal inflammation, ulcer, or atrophy from a deficiency disease.

The oesophageal mucosa is normally insensitive to the presence of gastric juice, which regurgitates even during normal digestion. When, however, the mucosa is injured from any cause it becomes sensitive to further injury. Its pain is then burning. The pain occurs during the ingestion of irritants or during digestion when acid juice regurgitates. It is then spoken of as heartburn. It is diffuse, and is located vaguely behind the lower part of the sternum.

The pain of cervical erosion is not burning; but the mucosa of the cervix is so much adherent to the underlying tissues that the pain of cervical erosion is probably due to these subjacent tissues. The mucosa itself is probably insensitive; it does not respond to pin-prick. Equally the pain of the nasal mucosa, when provoked by ordinary stimuli, is due chiefly to the underlying periosteum to which the thin simple mucosa is adherent. If stimuli that act only very superficially are used, as in the inhalation of ammonia or on the instillation of hypertonic drops, the pain elicited is purely pricking or burning. The nasal sinuses and the middle ear are usually described as having a sensitive mucosa; but probably the mucosa is insensitive and the pain which is felt is periosteal. Pain from the larynx is pricking or burning.

The transitional mucosa of the urinary bladder also gives pricking or burning pain, but its behaviour is peculiar. The mucosa over the fundus is innervated from the lumbar segments, while that over the trigone is innervated from the sacral segments. The sensitivity varies accordingly. When cystostomy patients, under local analgesia, were examined in my presence it was shown convincingly that the mucosa of the fundus was completely insensitive and that pain from the fundus could be elicited only from the structures underlying the mucosa. In contrast to this the mucosa of the trigone was very sensitive. Crushing of a tiny fold between forceps produced pain whose quality was unmistakably burning. However, the pain was not located to the bladder but to the surface of the perineum. Pain of a different quality was obtained only if the stimulus also excited tissues that lie beneath the mucosa.

Subsurface or Intermediate Pain

The tissues that lie immediately beneath the skin or beneath the mucosae give pain whose characters differ from those of surface and of deep pain.

There seems to be a difference in the quality of the pain. Subcutaneous injury to a region where the subcutaneous tissues are thin, as over the forearm, gives pain of a quality which is distinct from pricking, burning, or aching. However, it is possible that this difference in quality from deep pain is felt only because it is modified by concomitant surface pain. When testing the subcutaneous tissues it is desirable to eliminate cutaneous pain, but it is not easy to do this convincingly without interfering with subcutaneous sensitivity. If unguentum anaesthesinae be rubbed over an area of lightly scarified skin till this feels numb to a pin-prick, or if an intradermal wheal be produced by a solution of novocain and adrenaline, a subsequent injection of hypertonic saline in the underlying subcutaneous tissue can be presumed to give pain that is unmodified by cutaneous pain. Its quality differs somewhat from deep pain; it is, if one may say so, of a higher tone.

Where the subcutaneous tissues are thick, as in the female mammary region, pain of the inner strata is not described as different in quality from deep pain. On the other hand, where the subcutaneous tissues are very thin, so that the skin is adherent to the deep fascia and underlying structures, the pain from these structures is also different from deep pain. Thus the periosteum over the tibia or over the knuckles, the outer fibres of the tendo Achillis, and the fibrous web between two fingers give pain whose quality differs from deep pain (Lewis, 1938).

Just beneath the body surface there is a second coating of tissues, pain in which is distinct in character from deep pain and complementary to surface pain in detecting injury of external origin. More than in quality, this intermediate type of pain differs from deep pain in its power to discriminate and to locate the injury. The pain is somewhat diffuse, but its diffusion is always limited to a narrow zone around the injury. It gets wider when the tissue is deep, but it is not referred to a distance. The reflexes provoked through it reinforce the surface reflexes in producing brisk movements, as can be evidenced by the technique adopted for the Babinski response.

The submucosae and some other structures to which the mucosa is adherent when the submucosa is very thin, as in the muco-periosteum of the nasal sinuses, are the seat of pain which is also distinct from deep pain. Thus pain from inflammation within a nasal sinus or within the middle ear is different in its quality from surface and deep pain. This pain, however, is not easily located. When the submucosa lies in a cavity that is at a distance from injury of external origin the pain is referred to an area over the surface which is innervated by the same segment.

Deep Pain

Pain from deep tissues has an aching quality. It is common to muscles and to all the other sensitive deep tissues in general.

Deep pain raises the alarm when injury reaches a deep locality, but it does not by itself furnish any useful information to help in eliminating the stimulus. It is non-discriminative. It is unable to disclose more sources of pain even if these are considerably distant from each other. It starts late, persists long, and does not portray the activity of the stimulus by fluctuations in its intensity. The pain is always very diffuse. It is impossible, from a deep tissue, to get pain which is felt only at the site of injury. The pain radiates to a distance, and this radiation is often extensive. There are several factors which determine whether the pain remains local or radiates extensively. The severity of the injury is important. A stronger concentration or a bigger dose of the hypertonic saline which was injected in my triceps determined different grades of diffusion. The time-interval after the injury is important, too. When adaptation to pain starts after a variable interval, the pain becomes restricted to a narrow area; but subsequent injury of any nature, or even active muscular exercise, can not only re-exacerbate the pain but also make it extend to some distance. A very important factor is the depth of the injured tissue. The deeper the tissue the greater is the tendency of the pain to radiate extensively (Kellgren, 1939). The relation of the injured tissue to structures of vital importance, as the spine, is perhaps also important. The nearer the tissue to such structures the more the pain is radiated.

The radiated pain can be as intensive at a distance as over the site of injury. Thus when 2 c.cm. of a 6% saline solution was injected into my triceps the pain in my elbow and forearm was as intense as the pain in the arm. Sometimes the pain is more intense at a distance than over the injury. When 1 c.cm. of hypertonic solution was injected into the upper margin of the trapezius muscle at an equal distance between the head and the shoulder the pain was felt most intensely at the angle of the jaw, so that one would locate the injury much higher than it actually was. In these circumstances one speaks more of the diffused pain than of the pain over the injury, and indeed can ignore the latter pain completely, unless an added factor directs attention to the real site of injury. If the pain is exacerbated by the movements of a joint or by the active contraction of a muscle of which the patient is fully aware, it will be easy for the injured individual to connect the pain with the region that causes the exacerbation. Equally, if deep injury is accompanied by injury to overlying subcutaneous tissues or skin and subcutaneous tissues, the power of these tissues to locate will direct the individual's attention to the site of injury. Thus when 2 c.cm. of hypertonic saline was injected into my triceps by means of a very wide-bored needle through a normal skin, the pain was felt in the arm, elbow, forearm, and even hand, but it could be made out that its source was in the arm. When, however, an intradermal wheal was produced by a solution of novocain and adrenaline and the injection was performed through this wheal with a very fine needle, which was inserted to the same depth as on the previous occasion, the pain had practically the same distribution as before; but, so long as the arm was kept at rest, not even with an effort of attention was it possible to be sure that the pain originated in the arm. When the triceps was made to contract, especially if it was made to contract isometrically against resistance at the wrist, the pain in the arm was exacerbated, and that made the source appear more manifest.

Possibly, pain that is referred from certain viscera is badly located for similar reasons. It has been determined that many viscera are connected by their pain afferents to the centres which subserve the deep somatic structures. These centres can therefore be stirred into activity from either source, so that pain from the viscus and pain from the somatic tissues cannot be distinguished from each other (Lewis and Kellgren, 1939). Thus stimulation of the first lumbar interspinous ligament evokes pain with the distribution and other characters of renal colic; including retraction of the testis; stimulation of the left seventh cervical or of the left first thoracic ligament evokes pain which extends down the arm and cannot be distinguished from angina of effort. In these instances the patient is unable to distinguish whether the pain is visceral or somatic, or to locate its source. In either case there is no added factor which can attract his attention to the injured somatic spot or to the disturbed viscus. The patient will hence speak only of a diffuse deep pain along the segment.

The reflexes that accompany deep pain, far from provoking brisk defensive movements, produce tonic contractions and quiescence. They aim more at resting the injured part and protecting it from subsequent injury than at eliminating the offending stimulus. The contraction is slow in onset and gets maximal only after a considerable interval. Sometimes the rigidity is slight and passes unobserved, the patient limiting his movements more from fear of exacerbating the pain than from inability to move on account of spasm. When, however, the injury is appropriately located as near a joint, near a cavity, or near a vital organ, the spasm may be such as to resist even deep anaesthesia and hamper operative intervention. It may be localized, but when severe it may form a definite barrier around the greater part or the whole of the injured segment, and may even occur at a distance from the injury. Thus the cremaster may contract when the injury is located in the spine.

The general reactions that are associated with deep pain tend equally to inhibit activity. Far from being invigorating, they cause mental and physical depression, with diminished knee-jerks, low blood pressure, etc. If the injury is severe, especially if it is diffuse and located within the trunk or very near to it, the full picture of "nervous" shock appears.

The Segment

However diffuse or referred deep pain may be, its distribution follows always a segmental pattern (Kellgren, 1938). The same pattern fits the deep tenderness as well as the muscular rigidity that accompanies the pain. If in embryonic life the injured tissue has migrated from its first relative position to another segment, the pain still extends along the segment from which the tissue has migrated and to which it has remained attached by its innervation. This is exemplified typically by the pain from a lesion to the central part of the diaphragm whose area of diffusion lies in the area of distribution of the third and fourth cervical nerves.

Within the affected segment the direction of the diffusion of deep pain is determined more by the level of the segment than by the situation of the injured spot in the segment. Thus in a thoracic segment the pain is felt anteriorly even if the injury is situated as far backwards as an interspinous ligament. In the last thoracic and in the upper two or three lumbar segments there is hardly any space anatomically for an anterior diffusion, and deep injury at this level causes backache. In the upper cervical segments the direction is predominantly posterior to the occiput; in the lower cervical it is predominantly anterior to the arms.

This extension of pain in an anterior or posterior direction occurs the same whether the pain is visceral or somatic in origin. As already stated, renal colic and interspinous injury give pain with identical distribution. Backache can be caused by a lesion in a pelvic viscus or in a somatic structure. With thoracic or abdominal pain there is a tendency to look for visceral lesions and to forget somatic causes; and, in lumbar pain, to look for somatic and forget about visceral lesions. This tendency probably arises from the greater frequency of visceral lesions in thoracic or abdominal pain and of somatic lesions in lumbar pain; but it is wise to be "segmentally minded" and to investigate all structures within the segment in every case.

Visceral Pain

The viscera lie, as a rule, so deep within the segments that they are well protected and do not therefore respond to the stimuli that provoke pain ordinarily in the somatic tissues. Many viscera are completely insensitive, and any pain that is associated with them is caused by an extension of the lesion to adjacent tissues, as to the parietal peritoneum or to the retroperitoneum. Other viscera are sensitive, but their stimuli must be appropriate to them, and their pain has the same characters and is probably furthered by the same mechanism as somatic pain. Embryologically these viscera are intimately connected with the somatic tissues. They arise entirely from the mesoderm, from each side of the segment; they are paired, or have been paired during some period of their embryonic life. Examples are the kidneys and the heart.

There is still another group of viscera. These are hollow organs which have never been paired, but have had always a mesial attachment and have included ectoderm in their cavities. Pain from these organs has distinct characters. It is exemplified typically by the pain of obstruction from a stenosing carcinoma of the colon. The appropriate stimulus is related to the spasm, which is a response to the stretching provoked by the obstacle. This pain, in quality, is not different from deep pain, and can be simulated by injecting hypertonic saline in the abdominal rectus muscles, but it is never accompanied by muscular rigidity or by tenderness of any kind; hence compression of the wall and active movements are not resented, and the patient may press his abdomen, bend, and writhe about restlessly in a vain attempt to obtain relief (Morley, 1937). The pain is diffuse, but even when maximal it remains always mesial and never extends beyond the abdominal wall to the limbs. Its distribution is segmental (Brown, 1942). It is referred to the level from which the viscus migrated in embryological development. It is epigastric for the stomach, duodenum, and gall-bladder; umbilical for the small intestine and appendix; hypogastric for the colon and urinary bladder. Pain from the rectum is felt vaguely about the site of the viscus.

Pain from Nervous Tissues

Before concluding it must be mentioned that clinically there is yet another type of pain derived from a lesion to the nervous

tissues, central or peripheral. In the sense that it is never meant to serve a defensive purpose this pain is not physiological, and therefore is not considered further here.

Conclusion

From their clinical characters we can distinguish types of pain each of which is related to a definite group of tissues. These tissues have in common their relation to the body surface.

There must be in each segment a complex mechanism which presides over the manifestations of deep pain in that segment. This mechanism can be set in motion by certain visceral as well as somatic afferents. Their connexions must be such that the whole or the greater part of the mechanism can be set in motion even by limited injury; hence the pain is distributed widely and lacks discrimination. More superficial tissues have connexions which are more limited, while the connexions of the hollow abdominal viscera which have a mesial attachment in their embryonic life are distinct.

The connexions from the skin must be entirely different, as the pain differs not only in discrimination, power of location, and type of reflexes provoked, but also in quality.

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SOME SOCIAL ASPECTS OF BURNS IN GLASGOW

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The Magnitude of the Problem

The present high incidence of accidental burns in the civilian population, causing incapacity often of long duration, is a problem of great importance to the community in a state of total war. The study of the factors related to the occurrence of these injuries is of immediate interest. It should reveal also whether or not the high incidence may be expected to continue with the resumption of more normal conditions.

The progressive increase in the numbers of cases of burns admitted to hospital in Glasgow over a period of 100 years has been shown clearly by Dunbar (1934); it is probable, as Dunbar himself suggests, that part of this increase was due to a greater liability or inclination of burned patients to be treated in hospital in the latter part of the period surveyed, but that can hardly be the only factor concerned. Thus at the beginning of the period—in the decade 1833–42—the maximum number of cases admitted to the Glasgow Royal Infirmary in 12 months was about 80. At that time the Royal Infirmary was the only Glasgow hospital to which patients with burns were admitted. In the last decade considered by Dunbar—1923–32—a level of about 320 admissions in 12 months was reached, in spite of the fact that by this time two other large voluntary hospitals were treating these injuries. In the 10-year period 1933–42 a maximum yearly admission of 327 cases was attained. In the 14 months from June, 1942, to Aug., 1943, 1,803 cases of burns were treated in the burns unit of the Glasgow Royal Infirmary, and, of these, 303 (16.8%) were admitted to the wards.

The following points should be noted as a preliminary to the considerations given later: (a) The Royal Infirmary, Glasgow, is situated in an industrial area and might therefore be expected to deal with a high proportion of industrial accidents. (b) The large numbers of infants and children treated for burns at the Infirmary do not represent all the

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