

A Case Having Abnormal Nerve Supply of the External Oblique Abdominal Muscle with Anomaly of the Intercostal Nerve

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An outline of this paper was presented at the 37th Kyushu Regional Scientific Meeting of the Japanese Association of Anatomists.

A very rare case was found in which the uppermost digitation of the external oblique abdominal muscle that took origin from the fifth rib had nerve supply by the Ramus muscularis externus of the fifth intercostal nerve, and further this fifth intercostal nerve did not have the Ramus cutaneus lateralis. Considerations from the standpoint of morphology and comparative anatomy with regard to the muscles of the thoracoabdominal region and the intercostal nerve suggested that the nerve fibers destined to supply the external oblique abdominal muscle had become included in the Ramus muscularis externus.

INTRODUCTION

The external oblique abdominal muscle in man usually takes origin by digitations from the fifth to twelfth ribs, and is innervated by branches from the Rami cutanei laterales of the ventral rami of the fifth to twelfth thoracic and first lumbar nerves.

During the course of anatomical dissections of cadavers, this author discovered a case in which the uppermost digitation of origin of the external oblique abdominal muscle was supplied by a slender branch from the Ramus muscularis externus of the intercostal nerve. Moreover, the intercostal nerve associated with this uppermost digitation in this case did not have the Ramus cutaneus lateralis.

A careful review was made of the literature dealing with the external oblique

abdominal muscle and the intercostal nerve, but no report was found that described a condition such as found by this author.

Therefore, the findings will be presented along with a review of the literature and discussion of the morphology.

FINDINGS

Cadaver number 2; Japanese male; age 77 years at time of death; cause of death due to cerebral hemorrhage.

External inspection of the external oblique abdominal muscle of the left side showed the origin (which is by digitations from the fifth to twelfth ribs), insertion, course of fasciculi, and relationship to adjacent muscles to be unremarkable and similar to the condition described in most anatomy textbooks.

Examination of the left thoraco-abdominal wall of this cadaver from the cutaneous side showed the presence of Ramus cutaneus lateralis of the intercostal nerve in each intercostal space, except in the fifth as well as the first intercostal space where this branch was absent. Near the lower margin of the uppermost muscular digitation that arose from the fifth rib, a slender branch from the Ramus muscularis externus of the fifth intercostal nerve emerged subcutaneously by penetrating the external intercostal muscle of the fifth intercostal space, and, after running for a short distance medialwards and downwards, it entered into this digitation from the outer surface. In addition to this branch from the Ramus muscularis externus, the external oblique abdominal muscle was supplied by slender branches from the Rami cutanei laterales of the ventral rami of the sixth and lower thoracic nerves and first lumbar nerve (Figures 1 and 2).

The findings of the fifth intercostal nerve will be described in accord with the nomenclature of Davies et al. (1931) for the main branches, while the nomenclature of Fujita (1963) will be used for the name of the nerve to the external intercostal muscle.

Examination of the left thoracic wall of this case from the pleural side showed, in the area near the dorsal edge of the internal intercostal muscle, the separation of the fifth intercostal nerve into the upper branch (main nerve) and lower branch (collateral branch), but there was no intermediate branch that normally penetrates the internal and external intercostal muscles to become the Ramus cutaneus lateralis. In the area near the mid-axillary line, the lower branch separated into two branches, one of which ran ventralwards and upwards to anastomose with the upper branch (main nerve) of the fifth intercostal nerve while the other ran ventralwards and downwards to extend beyond the sixth rib to anastomose with the upper branch (main nerve) of the sixth intercostal nerve (Figure 3).

Four Rami musculares externi were found to be given off from the fifth intercostal nerve in the paravertebral portion of the fifth intercostal space. The two distal rami united, in the region near the dorsal edge of the internal intercostal muscle, to form a single Ramus muscularis externus which, as it ran towards the sternum between the

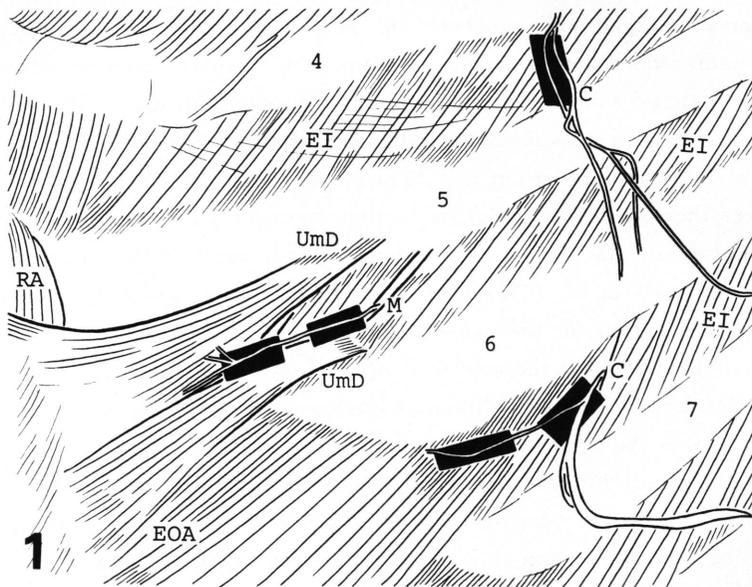


Fig. 1. Anterior view. The locations of the Rami cutanei laterales of the fourth and sixth intercostal nerves and the location of the slender branch from the Ramus muscularis externus of the fifth intercostal nerve are indicated by the small pieces of black paper.

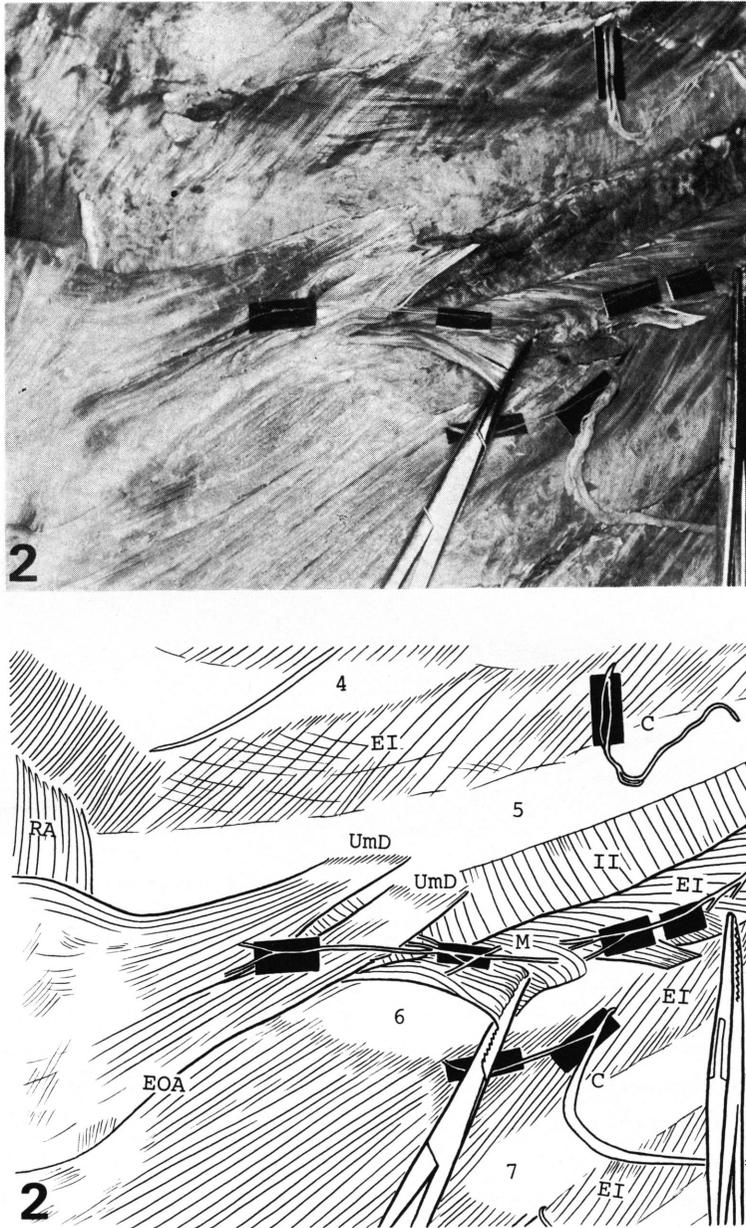


Fig. 2. Anterior view. The external intercostal muscle within the fifth intercostal space has been severed along the lower edge of the fifth rib and reflected caudalwards. The locations of the Rami cutanei laterales of the fourth and sixth intercostal nerves as well as the locations of the Ramus muscularis externus from the fifth intercostal nerve and of the slender branch supplying the uppermost digitation are indicated by the small pieces of black paper.

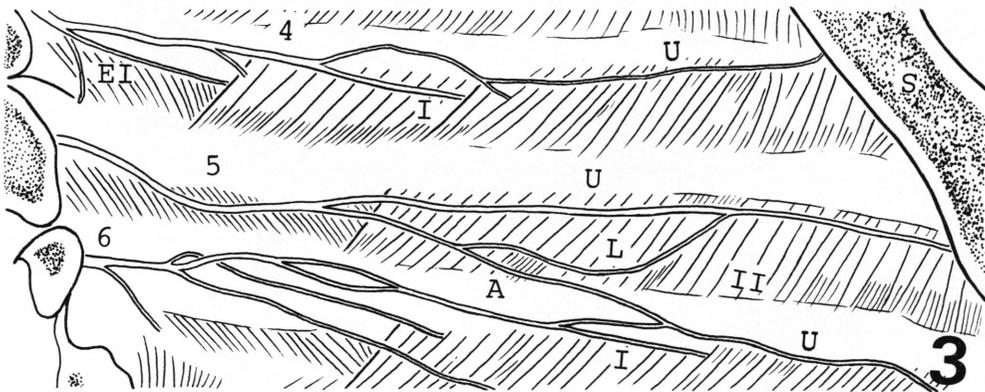


Fig. 3. View from pleural side. The subcostal and innermost muscles have been removed so as to expose the intercostal nerves. The fifth intercostal nerve does not have the Ramus cutaneus lateralis (intermediate branch).

internal and external intercostal muscles, sent off a slender twig to the external intercostal muscle. In the area near the lower edge of the uppermost digitation of origin of the external oblique abdominal muscle, this slender twig pierced the external intercostal muscle to appear on the outer surface of the digitation, and, after running a short distance medialwards and downwards, it entered into the uppermost digitation from its outer surface (Figure 4).

Stereomicroscopic examination of the intramuscular distribution of the slender nerve branch, which entered the uppermost digitation of origin of this muscle, confirmed that it was distributed to only this digitation (Figure 5).

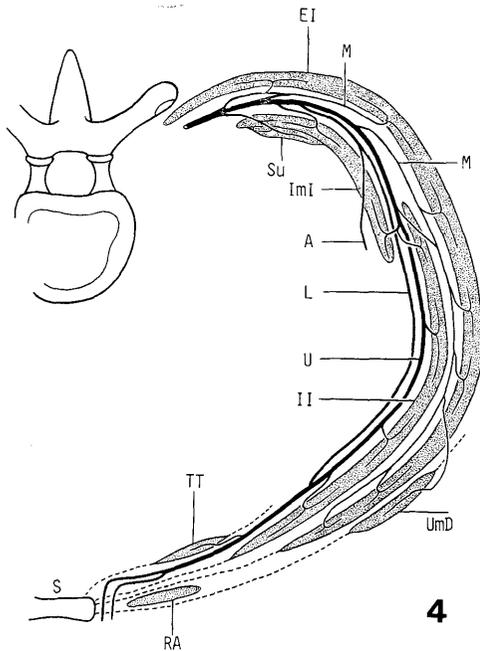


Fig. 4. Schematic illustration of horizontal section through the fifth intercostal space. The illustration shows the origins of the Rami musculares externi from the fifth intercostal nerve and the locational relationship between the slender branch from the Ramus muscularis externus and the uppermost digitation of the external oblique abdominal muscle.

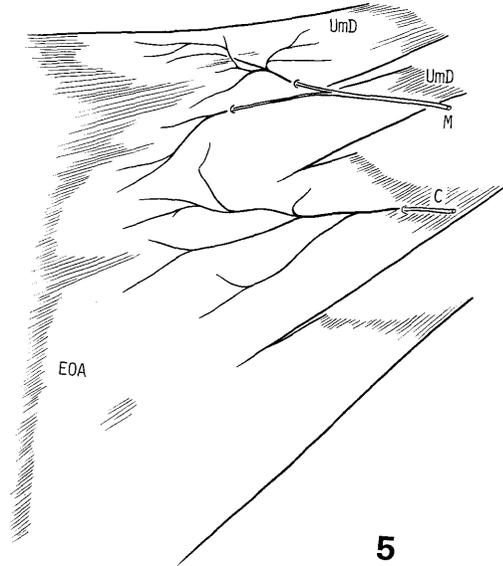


Fig. 5. Anterior view. Intramuscular distribution.

DISCUSSION

1. Nerve Supply of the External Oblique Abdominal Muscle in Man:

Descriptions of the nerve supply to the external oblique abdominal muscle in man are available in the reports on morphological studies that have been made of the thoraco-abdominal muscles by Seydel (1892), Bardeen (1902, 1903), Eisler (1912), Fujita (1963), Sato (1973), etc. All of these investigators, except Eisler, reported that this muscle is innervated by branches from the Rami cutanei laterales of the intercostal nerves as described in anatomy textbooks.

Macalister (1871), Knott (1883), and Eisler (1912) reported that the external oblique abdominal muscle occasionally had a separate second set of digitations of origin from the seventh to eleventh ribs in addition to the typical digitations that took origin from these ribs. These second digitations, after arising independently from the ribs at a site medial to the typical digitations, promptly fused with the deep layer of the external oblique abdominal muscle. According to the report of Eisler, the typical digitations of

origin of the external oblique abdominal muscle were innervated by branches from the Rami cutanei laterales, but this second set of digitations of origin were supplied by the Rami musculares externi.

The findings noted by the investigator for the uppermost digitation of origin of the external oblique abdominal muscle differ from the above-mentioned description by Eisler on the following points. That is, (1) the uppermost digitation of origin of this muscle in this investigator's case did not show a tendency of separation into two parts in the superficial and deep layers; (2) the uppermost digitation received the Ramus muscularis externus from its outer surface; and (3) the intercostal nerve, from which the above Ramus muscularis externus is sent off, did not have the Ramus cutaneus lateralis. Therefore, the condition of the external oblique abdominal muscle recently noted by this investigator seems to be very rare, and there has been no report of such a case to the knowledge of this investigator.

2. Association of the Ramus Muscularis Externus to the Muscles of the Anterior Abdominal Wall in Man:

Examination of the literature revealed hardly any description of innervation of the muscles of the anterior abdominal wall by the Rami musculares externi of the intercostal nerves, the only report being that of Eisler (1912) in which it is mentioned that there is nerve supply by the Rami musculares externi to the aforementioned second set of digitations that fuse into the deep layer of the external oblique abdominal muscle and to the Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott, 1883).

From the standpoint of phylogeny or comparative anatomy, the uppermost digitation of origin of the external oblique abdominal muscle arises from a higher rib in primitive vertebrates with shift of the attachment of the uppermost digitation to a lower rib in higher animals (Wood, 1870; Ruge, 1892; Kohlbrügge, 1897; Eisler, 1912; Cords, 1924; Nishi, 1938; Arikawa, 1960). The uppermost digitation of this muscle in man usually takes origin from the fifth rib. Its origin from the sixth rib, however, is also seen at a considerable frequency (32% reported by Loth, 1931; 32% by Wagenseil, 1937; 23% by Yonekura, 1954; 16.3% by Mori, 1964).

In view of the foregoing, the condition of the muscle noted by this investigator may be considered as follows. That is, the muscle taking origin from the fifth rib, i. e. the uppermost digitation, in this case noted by this investigator may be regarded to be homologous to the Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott), while the muscle which arises by digitations from the sixth to twelfth ribs may be considered to be external oblique abdominal muscle.

Eisler, in a comparison of the ventral trunk muscles of urodela among amphibians with those of man, reported that the "Obliq. ext. + Serrati postt. + Supracostales (Var.)" of man corresponds to the "Schicht des Obliq. ext. superficialis trunci" of urodela, and that the "Intercost. ext. + tiefe Zacken des Obliq. ext. abd." of man corresponds to the "Schicht des Obliq. ext. profundus" of urodela. Nishi (1938) also has expressed views almost identical to those of Eisler, stating that the differentiation of the ventral

trunk muscles of mammals may be explained based upon that in reptiles. Moreover, he mentioned that the *Obliq. ext. superf.* of reptiles corresponds to the *Obliq. ext. (abd.)* and *Obliq. thoracis (Sternocostalis superf.)* of mammals, and that the muscle corresponding of the *Obliq. ext. prof.* of reptiles may be observed on the chest of mammals as the *Levatores costarum* and *Intercostt. extt.*, but on the abdomen it usually is absent due to regression, with the *Obliq. ext. profundus* being observed only in rare cases. In view of these reports by Eisler and Nishi, the *intercostt. extt.* of the chest of mammals are a serial homologue with the *Obl. ext. profundus* of the abdominal region.

The nerve supply to the *Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott)* was reported by Eisler (1912) to be by a branch from the *Ramus muscularis externus* of the intercostal nerve, but Nakayama et al. (1952) has reported that the innervation is by a branch from the *Ramus cutaneus lateralis*. When the true nature of this muscle is considered from the standpoint of comparative anatomy, as done by Eisler (1912) and Nishi (1938), and from the viewpoint of nerve supply, the muscle reported by Nakayama et al. by the name of the *Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott)* should more appropriately be regarded to be an aberrant bundle of the external oblique abdominal muscle. Eisler reported that a branch from the *Ramus muscularis externus* entered into the *Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott)* from the inner surface. The external intercostal muscle is also generally known to receive the *Ramus muscularis externus* from its inner surface. Thus, even when considered from the pattern of nerve supply, the *Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott)* may be regarded as being a serial homologue with the external intercostal muscle. The uppermost digitation of origin of the muscle in the case of this author was supplied by a branch from the *Ramus muscularis externus*, but this digitation received the nerve branch from its outer surface. Therefore, the uppermost digitation of this case of the author can not be considered to be a serial homologue with the external intercostal muscle or to be homologous with the *Obliquus ext. secundus s. accessorius (Gruber) s. profundus s. minor (Knott)*. Rather, of great significance is the absence of the *Ramus cutaneus lateralis* of the intercostal nerve, to which the *Ramus muscularis externus* supplying the uppermost digitation is associated.

3. Intercostal Nerve :

Detailed studies have been made of the intercostal nerve by Davies et al. (1931), and some description of the intercostal nerve is seen in the reports by Walmsley (1916), Forster (1917), Fujita (1963), Sato (1971) and Sato (1973). Sato (1971) reported that the first intercostal nerve generally did not have the *Ramus cutaneus lateralis* and further that the second intercostal nerve may, in rare cases, not have the *Ramus cutaneus lateralis*, but there is no mention of any case such as recently discovered by this author in which the fifth intercostal nerve did not have the *Ramus cutaneus lateralis*.

According to the report of Davies et al. (1931), the intercostal nerve trunk, at between the intervertebral foramen and costal angle, gives off a branch to the external

intercostal muscle, and then it separates into its three main branches, that is, the upper branch, the intermediate branch, and the lower branch. The intermediate branch runs to the lateral thoracic wall, where it pierces the internal and external intercostal muscles to become the Ramus cutaneus lateralis.

The fifth intercostal nerve in the case examined by this author, after giving off the branches to the external intercostal muscle, separated into the upper branch and lower branch, but the intermediate branch that should penetrate the internal and external intercostal muscles was absent. The lower branch (collateral branch) of this nerve gave off an anastomosing branch to the upper branch of the sixth intercostal nerve, but this anastomosing branch did not have any association with the Ramus cutaneus lateralis of the sixth intercostal nerve. Therefore, the fifth intercostal nerve in the author's case can be considered to not have the Ramus cutaneus lateralis.

The Ramus muscularis externus was reported by Forster (1917) and Fujita (1963) to arise as a single nerve branch from the intercostal nerve, but Sato (1973) reported that it arose as three to six nerve branches. The reports by the former two differ from the description by Sato, but it is more appropriate to consider the report by Sato to be accurate since it was based upon the study of a large number of cases. The findings for the Ramus muscularis externus of this author's case are very similar to those of Sato. Therefore, the Ramus muscularis externus in this case can not be considered as having an exceptional morphology.

4. The Uppermost Digitation of the External Oblique Abdominal Muscle of this Author's Case:

The Obliquus ext. superficialis trunci of urodela among amphibians is segmented by tendinous intersections, which are said to indicate the boundary between adjacent metameres. The external oblique abdominal muscle of lower mammals also has tendinous intersections, but in higher mammals there is steplike interruption of the tendinous intersections or disappearance due to regression. Seydel (1892) and Ruge (1892) report that, although there may be change in the relationship of the location between metameres or loss of the boundary between metameres due to changes in the external shape of the tendinous intersections or due to their regression and disappearance, the boundary between metameres can be demonstrated by careful examination of the intramuscular distribution of the nerve supply. Therefore, in view of the relationship of the nerve supply, the external oblique abdominal muscle may be assumed as strongly maintaining its segmental structure.

Based upon the foregoing discussions, it seems to be reasonable for the uppermost digitation of the external oblique abdominal muscle in this author's case to be supplied by the fifth intercostal nerve. The fifth intercostal nerve in this case, however, did not have the Ramus cutaneus lateralis. Therefore, it is assumed that the nerve fibers destined to supply the uppermost digitation had become included in the Ramus muscularis externus of the fifth intercostal nerve.

SUMMARY

A very unusual case was found in which the uppermost digitation of origin of the external oblique abdominal muscle is supplied by the *Ramus muscularis externus* of the corresponding intercostal nerve, which lacked the *Ramus cutaneus lateralis*. The findings and discussions are as follows.

(1) The uppermost digitation of origin of the external oblique abdominal muscle from the fifth rib received a slender branch from the *Ramus muscularis externus* of the fifth intercostal nerve from its outer surface. The fifth intercostal nerve separated into the upper branch (main nerve) and lower branch (collateral branch), but did not have the intermediate branch (*Ramus cutaneus lateralis*).

(2) A review of literature dealing with the nerve supply of the external oblique abdominal muscle was made, and it was noted that there is no report of any case such as found by this author.

(3) The muscles of the anterior abdominal region which are supplied by the *Ramus muscularis externus* in man, that is, the second digitation reported by Eisler(1912) of the external oblique abdominal muscle and the *Obliquus ext. secundus s. accessorius* (Gruber) *s. profundus s. minor* (Knott, 1983), were reviewed from the standpoint of comparative anatomy and morphology. The results suggested that these two muscles are serial homologues with the external intercostal muscles. On the other hand, the uppermost digitation of this case, although it was supplied by the *Ramus muscularis externus*, is considered to be not a serial homologue with the external intercostal muscle in view of the pattern of nerve distribution, and it further is not homologous with the second digitation reported by Eisler of origin of the external oblique abdominal muscle or with the *Obliquus ext. secundus s. accessorius* (Gruber) *s. profundus s. minor* (Knott).

(4) A review of literature and consideration of morphology was made in connection with the situation of the fifth intercostal nerve in this author's case. It was confirmed that the fifth intercostal nerve of this author's case did not have the *Ramus cutaneus lateralis*.

(5) Considerations from the standpoint of phylogeny with regard to the external oblique abdominal muscle suggested that it strongly maintained its segmental structure based upon the relationship of its nerve supply. These results indicated that it is reasonable for the uppermost digitation of this author's case to be supplied by the fifth intercostal nerve and further that the nerve fibers destined to supply this digitation had become included in the *Ramus muscularis externus*.

Abreviation: A; anastomosing branch with the upper branch of the sixth intercostal nerve, C; Ramus cutaneus lateralis, EI; external intercostal muscle, EOA; external oblique abdominal muscle, I; intermediate branch, II; internal intercostal muscle, ImI; innermost intercostal muscle, L; lower branch, M; Ramus muscularis externus, RA; rectus abdominis muscle, S; sternum, Su; subcostal muscle, TT; transversus thoracic muscle, U; upper branch, UmD; uppermost digitation, 4-7; fourth-seventh ribs

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