The Innervation of the Human Gallbladder

by

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Introduction

Very few reports can be found in the literature regarding the intramural innervation of the human gallbladder, while so many reports have been devoted to the subject of the intrinsic innervation of the enteric canal. Harting ('31) and Hermann ('52) introduced the works of Manz (1860), Lee (1862), Popoff (1872), Gerlach (1873), Variot (1882), Ranvier (1886) and Dogiel (1895a) who contributed to our knowledge of the intramural innervation of the extrahepatic biliary tract as the earlier investigators. Manz, Lee and Gerlach, according to Harting, seem to be the first three who have described the existence of ganglion cells in the plexus of the gallbladder.

Dogiel (1895a), using his methylene-blue method, studied the peripheral ganglia and plexuses of the gallbladder in the dog and cat. According to him, thick nerve bundles which enter the gallbladder along with blood vessels give rise to branches and form a plexus in the adventitia. He called this plexus "das Haupt- oder Grund-Geflecht", from which nerve bundles and fibers extend to blood vessels, the smooth-muscle layer and the mucosa. Dogiel (1896) also described two different types of ganglion cells, known as Dogiel's Types I and II, in the wall of the gallbladder.

Harting ('31) described three nerve plexuses in the wall of the gallbladder; one in each layer of the adventitia, the muscularis and the mucosa. Each plexus, according to him, includes ganglion cells which are in general aggregated in larger ganglia in the adventitia and in smaller ones in the muscularis. He seems to have observed only a small number of ganglion cells in the mucosa. He used the silver impregnation method and stated that the specimens
of the dog gave the best result.

Concerning the innervation of the human gallbladder, there are reports by Alexander ('40), Jabonero ('51a), Hermann ('52), and Zabosov and Maslov ('58).

Alexander ('40) reported the innervation essentially similar in structure and composition to that described by Harting. He observed the three intramural nerve plexuses; an adventitial, an intramuscular and a submucous plexus. Ganglia were present only in the first two, while only individual ganglion cells were found to be present in the tunica propria.

Jabonero ('51a) was particularly interested in the interstitial cells of Cajal (1893, 1894) and studied attentively the interrelation between these and intramural nervous elements. He seems to believe that interstitial cells form a nervous syncytium.

Hermann ('52) examined human gallbladders and described two nerve plexuses; one in the adventitia and the other in the mucosa. He proposed to term them Auerbach's and Meissner's plexuses of the gallbladder respectively. According to his account, nerve fibers in the muscularis are derived from both of them.

Zabosov and Maslov ('58) described the presence of two distinct nerve plexuses in the wall of the human gallbladder. One is located in the perimuscular layer (adventitia) and the other in the muscular layer. They advocate that each plexus contains ganglia comprising multipolar nerve cells. It is also claimed by them that the shape and arrangement of the ganglion in one plexus is entirely different from in the other.

It will thus be seen from the preceding that our knowledge of the intramural innervation of the human gallbladder is still poor and is not in complete agreement. Hence, it is clear that this problem deserves further close study. As being emphasized by Harting, the morphological study as well as the experimental and physiological research on this subject is requisite for investigation of the influence of the autonomic nervous system to the gallbladder.

Materials and Method

Forty human gallbladders obtained at cholecystectomy were used for this study. They were opened longitudinally and after the careful but swift macroscopic examination, were fixed in 10%
formalin for the period of more than six months. A piece of tissue was taken from both the region near the neck and the body of each gallbladder. The specimens were then frozen, cut 20 to 30μ in thickness, silver-impregnated (Kubo et al., '57) and mounted. Simultaneously, sections of gallbladders of rabbits, tongues of a pangolin (Kubo et al., '62) and an elephant, and other various organs were always silver-impregnated together to ascertain if the result was quite satisfactory for the examination or not.

Observations and Discussion

General histology of the gallbladder wall. The wall of the gallbladder consists of three distinct layers besides a serous layer which covers a part of this organ; they are, from the outer layer to the inner, (1) the adventitia, (2) the musculature, and (3) the mucosa (fig. 1).

(1) Adventitia. It consists of areolar tissue containing many collagenous fibers, varying numbers of fat cells, blood vessels, lymphatics and nerves. The blood vessels and lymphatics contained in this layer send branches into and through the muscular layer to the mucosa. When the wall is thickened, this layer is subject to most thickening.

(2) Musculature. This scanty layer is composed of an irregular network of longitudinal, transverse and oblique smooth muscle fibers, that is, the muscular layer of the human gallbladder does not comprise two fairly substantial layers of smooth muscle as in general does the gastro-intestinal tube. The musculature of the gallbladder is comparable in position, but not in thickness, to the muscularis externa of the intestine. In the spaces between the bundles of muscle are seen collagenous fibers with fibroblasts.

(3) Mucosa. It consists of a surface epithelium and a lamina propria, and is thrown into numerous folds. The lining epithelium is high columnar and rests on the lamina propria of areolar tissue. The lamina propria, as a rule, is thin, has lymphatic tendencies and contains an extensive vascular plexus. No lamina muscularis mucosae is observed, namely, the mucosa rests directly on a meager layer of smooth muscle. There is no gland in the mucosa but in the region of the neck where simple tubo-alveolar glands are present.

General innervation of the gallbladder wall.

(1) Adventitia. In this layer the thick nerve bundles, almost
always accompanied by the arteries, are observed rather close to the musculature. These bundles contain a dense crowd of fine nerve fibers and a few thicker ones which run parallel to each other and pursue more or less a zigzag course. They are wrapped tight by the perineurial sheath (fig. 2). Many Schwann cell nuclei are usually scattered in each bundle. It is scarcely recognized for these thick nerve bundles to give off branches on the microscopic examination. No ganglion cell appears to be present in or around them.

Closer to the muscular layer, almost attached to it at times, more bundles of nerve fibers, apparently different from ones just described, are found to be present. They give rise to branches occasionally after being traced for some distance. These bundles are not as dense with fibers as ones of the foregoing, but rather sparse and their perineuria are not so remarkable (fig. 3). Ganglia or isolated ganglion cells are seen occasionally at the same level, though whether they are located at the branching points or along the course of the nerve bundles has been unable to determine (fig. 4).

(2) Musculature. The bundles of nerve fibers just mentioned above enter the muscular layer between sheets or bundles of muscle fibers and gradually become thinner containing fewer Schwann cells. They are not always accompanied by blood vessels when they extend deeper in this layer. Nerve fibers in a bundle are characterized by crossing with each other rather frequently as well as bundles themselves. Aggregated and isolated ganglion cells are scattered in this layer, however, the anatomical relationship between them and fibers remains obscure since none of them has been impregnated enough to follow the processes which originate from it (fig. 5). On several occasions, strands of nerve fibers are observed to run towards some muscle sheets, however, their terminations are not clear.

(3) Mucosa. As soon as the bundles of nerve fibers enter the mucosa through the muscular layer, they disperse rather diffusely and break into finer strands which combine with one another to form a fine plexus of nerve fibers (figs. 6 and 7). In this plexus, nerve fibers contained in each strand are usually less than ten in number and they cross with each other more frequently than in the musculature. From this plexus, the terminal networks of very fine nerve fibers are seen to run in varied directions and sometimes very close to the base of the epithelium (fig. 8). In some instances,
a few thick nerve fibers like ones seen in the nerve bundles of the adventititia and the other are also present along or together with the terminal networks or independently (fig. 13). Many isolated ganglion cells and, now and then, smaller ganglia are found to be present in this layer; roughly six out of ten isolated ganglion cells found in the wall of the human gallbladder are located in this layer (fig. 9). Some of them are adjacent to the epithelium. Most ganglion cells are slightly smaller than those in the adventititia and the musculature. Once again, the direct connexion between them and fibers of the plexus or the terminal network even in this layer is not clear with the reason to be stated presently.

The autonomic ganglion cells are usually described to be multipolar neurons with variable numbers of cytoplasmic processes. Most ganglion cells observed in this study are oval in shape and indistinct in the peripheral zone, therefore, it is very rare to recognize the cytoplasmic processes which arise from the ganglion cell concerned because of poor affinity to silver. The nucleus is rounded in outline and impregnated with silver stronger than the cell body. In most instances the nucleus is eccentrically located and possesses one or more nucleoli (fig. 9).

More nervous elements are observed in the region near the neck than the body of the gallbladder as noted already by Dogiel (1895a), Alexander ('40) and others.

Unlike Hermann's observation, the author was unable to recognize ganglion cells of Dogiel's Type I and II in all the layers including the mucosa.

Architecture of the nerve plexus in the wall.

Most extrinsic nerves of the gallbladder, according to Harting ('31), derive from the celiac ganglion and follow the same course as the cystic artery; the parasympathetic nerve fibers originate chiefly from the right vagus nerve. There is another opinion that the right abdominal branch of the left vagus distributes the nerve fibers to the gallbladder (Kuntz, '53). Most investigators seem to agree that extrinsic nerves of the gallbladder is derived mainly from the celiac plexus and the vagus nerve though there are various opinions when they go into detail (Courtaude et Guyon, '04; Westphal, '23; Lütken, '26; Kondratjew, '29; Birch and Boyden, '30; Alexander, '40; Mallet-Guy et al., '52).
Extrinsic nerves give rise to branches which continue along the branches of the blood vessels in the adventitia, and form a plexus there, which was termed the main plexus (Haupt- oder Grund-Geflecht) by Dogiel (1895a). Harting (’31) observed the similar structure in the dog. According to his description, this plexus has an outlook of the network; the meshes are irregular, polygonal in shape and varied in size. Ganglion cells were found very seldom at the nodal points of meshes. Hermann (’52) described meshes of the main plexus (Grund-Geflecht) of the human gallbladder to have the form of the parallelogram. Zabosov and Maslov (’58) did not mention of this plexus in their paper on the nerves of the human gallbladder. The author’s observation supports the views of both Harting and Hermann. Since the nerve bundles of this plexus, as stated above, are wrapped tight by the perineurial sheath and scarcely give rise to branches on the microscopic study, they appear to form a network of larger meshes. No ganglion cell seems to be present in this plexus, though some ganglion cells were observed in the dog by Harting.

Around the blood vessels in the adventitia are observed the perivascular plexus (fig. 10), which clearly differs from the main plexus (Grund-Geflecht) from the anatomical points of view. This plexus is located in relation to the main plexus (Grund-Geflecht), however, the author has failed to determine its exact origin.

In addition to the main plexus (Grund-Geflecht), in the wall of the gallbladder, there are three nerve plexuses: the first one is situated very close to the musculature in the adventitia, the second in the musculature and the third in the mucosa adjacent to the musculature (figs. 3 and 6). The author terms these three the submuscular, the intramuscular and the epimuscular plexus respectively. Each of them is in very intimate connection with the neighbouring plexus as described above.

The submuscular plexus is a rather coarse structure. Its meshes are definitely larger than those of the remaining two. Bundles of it are, as a rule, as thick as ones of the main plexus (Grund-Geflecht) but consist of a fewer number of nerve fibers. Though the direct combination between these two plexuses has not been confirmed, judging from morphological evidences mentioned above, the submuscular plexus must be composed of nerve bundles branched off from the main plexus (Grund-Geflecht) like Harting’s observation in the dog (’31). He pointed out the striking resemblance
of it to Auerbach's plexus and Hermann ('52) suggested to call it Auerbach's plexus of the gallbladder. In this plexus are located ganglia, which consist of 4 to 10 or more ganglion cells (fig. 4). It is to be noted, however, that a small number of isolated ganglion cells are also found to be present in this plexus. The minute description of ganglia and ganglion cells has been given by Harting in the study of the gallbladder of the dog.

Characteristics of the intramuscular plexus are smaller meshes made up of more slender bundles of nerve fibers, fewer and smaller ganglia containing usually 2 to 5 ganglion cells, and more isolated ganglion cells (fig. 5). This plexus appears to give rise to branches which may terminate in the bundle of muscle fibers. Harting ('31) observed a terminal reticular network of the nerve fiber in the protoplasm of the muscle fiber, from which he presumed impulses to be transmitted to the muscle fiber.

The plexus of the mucosa (epimuscular plexus) consists of more slender bundles of nerve fibers than ones of the intramuscular plexus and forms a rather delicate meshwork. Harting ('31) described the similar structure in the mucosa. Hermann ('52) proposed to call the nerve plexus in the mucosa Meissner's plexus of the gallbladder. According to him, nerve bundles branched off from this plexus extend into the muscular layer to participate in forming the plexus in it. The author only could recognize the terminal networks of very delicate nerve fibers to extend towards the epithelium from this plexus (figs. 7 and 8). Ganglia found in this plexus are smaller than ones in the other two and usually comprise 2 to 3 ganglion cells. They are very few and majority of ganglion cells in the mucosa are found to be isolated (fig. 9). Very few Schwann cells can be noted in this plexus.

As briefly mentioned above, Hermann ('52) described the striking resemblance of the plexus outside the musculature, which corresponds to the submuscular plexus by the author, to Auerbach's plexus and suggested to designate it Auerbach's plexus of the gallbladder. He also suggested to call the plexus in the mucosa, which corresponds to the epimuscular plexus, Meissner's plexus of the gallbladder with the same topographical reason. He further states that the plexus in the musculature is derived from both Auerbach's and Meissner's plexuses of the gallbladder.

There is no unanimous description of the lamina muscularis mucosae in the mucosa of the human gallbladder. Most textbooks
omit any reference to it (Stöhr, Jr., '51; Elze, '56; Maximow and Bloom, '57), although there are both denial (Ham, '57) and approval (Bargmann, '56). The author failed to observe it in any one of preparations, therefore, the use of the term submucosa is in question and seems to be unsuitable for the gallbladder, especially in man. Furthermore, the muscle bundles of the gallbladder are arranged in the spiral form and construct the irregular latticework, and consequently are unable to be divided into two layers, longitudinal and circular, like the muscularis externa of the small intestine. The term myenteric plexus (Auerbach, 1864; Irwin, '31) should be used when the major portion of it is situated in the interspaces between the longitudinal and the circular muscle layers and the term submucous plexus (Meissner, 1857) is to be applied to the plexus situated in the submucosa. Therefore, strictly speaking from the only anatomical point of view, the nomenclature suggested by Hermann ('52) seems not to be applicable to the gallbladder.

The terminal networks of very fine nerve fibers branching off from the bundles of the epimuscular plexus are distributed in the subepithelial region. A considerable number of isolated ganglion cells are scattered here and there in the lamina propria, some of them are located very close to the epithelium.

Type of ganglion cells.

In every one of the submuscular, the intramuscular and the epimuscular plexuses and also in the terminal network, there are both isolated and aggregated ganglion cells (figs. 4, 5 and 9). Dogiel (1896) subdivided these ganglion cells into two different types, so-called Type I and II, mainly from the morphological and distributional difference of their protoplasmic processes (axon and dendrites). Subsequently, Hill ('27), van Esveld ('28), Stöhr, Jr. ('30), Jabonero ('51b), Greving ('52) and others recognized ganglion cells of Dogiel's Types I and II both in the myenteric ganglia and in the submucous ganglia of the stomach and intestine. Harting ('31) found more cells of Type I in the muscular layer of the gallbladder in the dog and Hermann ('52), on the contrary, observed majority of ganglion cells in the muscular layer of the human gallbladder to be of Type II. The author was unable to differentiate one from the other in this study because of poor affinity of ganglion cells to silver, probably due to degener-
Innervation of the Human Gallbladder

ation, especially in the peripheral area of them as had been stressed. The impregnating method used and the procedure followed are undoubtedly not responsible for this poor affinity to silver but the specimen itself is definitely ascribed to it. The evidence for it is given in the photomicrograph of the tongue of an elephant (fig. 11). Sections of the tongue were silver-impregnated together with the sections of the human gallbladder in every occasion. The ganglion cells demonstrated in the picture has many clear protoplasmic processes. It is indispensable to distinction between them to follow the dendrite and axon of each nerve cell. In only a few occasions, the author was able to observe cells which enclosed what appeared to be remnants of synaptic connections (see figs. 4, 5 and 12). Regrettably, it was impossible, however, to determine the type of them according to the classification of Dogiel. The problem of degeneration of the ganglion cells will be discussed in the author's next report which is to be published in the near future.

Effort was made to measure the size of ganglion cells. According to De Castro ('32), the autonomic ganglion cells naturally fall into three categories on the basis of the volumes of their cell bodies; large, medium-sized and small. In man the maximum diameters of the large ganglion cells vary from 35 to 55 or even 60 μ; those of the medium-sized ones from 25 to 34 μ, and those of the small ones from 15 to 24 μ. Most ganglion cells both in the submuscular and in the intramuscular layers of the human gallbladder appear to belong to the category of the large cell. They are ovoid or round in shape. The mean maximum diameter of them was 36 μ. The average diameter of their nuclei was 14 μ. A small number of cells, the mean maximum diameter of which was 24 μ, were also noted in these two layers. They were usually ovoid and had round nuclei of 10 μ diameter on an average. Most ganglion cells found in the mucosa were smaller ones like those noted in the submuscular and intramuscular plexuses as smaller cells. They were generally ovoid in shape. A few larger cells were also scattered among them. The measurement was more difficult in the mucosa than in others because of poorer affinity of cells to silver.

Zabusov ('58) studies the intramural nerve plexuses of mammalian gallbladders, mainly in the dog, and reported an existence of characteristic giant neurons and the interrelationship between them and other nervous elements. They are several times as large as ordinary ones and are located mostly in the ganglion. He regarded
them as primary neurons and classified under the cell of Dogiel's Type II. According to him, the giant neuron brings the entire gallbladder under control from the functional point of view. The author failed to observe such a large ganglion cell as this in the wall of the human gallbladder.

The author hesitates to find serious significance in the difference of the size of cells and to presume the cell of Dogiel's Type I or II for the present since this study has been done with diseased gallbladders and the thickness of preparations is 20 to 30 \( \mu \). So many factors obviously are involved concerning the size of cells that clear-cut physiological significance is hardly determinable. The existence of small cells may well be manifestation of pathological change of cells. In short, however, from the comparative morphological difference, the submuscular plexus contains ganglia which comprise 4 to 10 or more ganglion cells, and the intramuscular plexus 2 to 5 cells, whilst most cells in the lamina propria are isolated ganglion cells. Most ganglion cells in the submuscular and intramuscular plexuses are larger ones and most cells in the lamina propria are relatively smaller ones.

**Interstitial cells.**

Many interstitial cells of Cajal, described first by Cajal (1893) in the intestine, were also observed in the wall of the gallbladder, especially in the mucosa. It has been recognized by many investigators that they are particularly abundant in the wall of the enteric canal, however, the significance of them has been a subject of controversy ever since. Up to date, they have been variously interpreted as neural and as connective tissue elements. Cajal (1893, 1894) regarded them as nerve cells, however, Dogiel (1895b, 1896), after the careful examination of these cells, stated in opposition to Cajal's opinion as follows: they had neither any of morphological characteristics as nerve cells nor the direct connection with nervous elements. Boeke ('49) has pointed out that interstitial cells, which presumably form a syncytium, may be the connecting link between the postganglionic nerve fibers and the effector cells. Jabonero ('51a), on the basis of an extensive series of studies on the human gallbladder, has supported a point of view similar to that of Boeke. Kuntz ('53) has stated that the neuron theory, as a matter of fact, has played a more important role in the advancement of neurology than the doctrine of the continuity
of nerve cells, therefore, the neuron theory, which, in its classical form, obviously does not take adequate account of the more modern concepts, should be modified but not abandoned. Be the matter as it may, the problem of the interstitial cells and the synapse is of fundamental importance in future investigations in this field.

Afferent conduction of the gallbladder.

The author has noted a few thick, apparently myelinated nerve fibers in the main (Grund-Geflecht) and other three nerve plexuses. In the mucosa, they run in varied directions along or together with the terminal networks or independently (fig. 13). In general no specific sensory nerve ending seems to be present in the mucosa but the simple one (fig. 13). This observation supports the view of Inoue ('55). However, groups of entangled thick nerve fibers happened to be found in the mucosa near the tubo-alveolar glands in the region of the neck of the gallbladder. Judging from the morphological feature, they would well be a sort of sensory nerve ending (fig. 14).

Dogiel (1895a) has described thick myelinated nerve fibers which terminate in the ganglion of the gallbladder in the form of the intercellular plexus or of the pericellular. The latter is, according to him, derived from the cerebrospinal nervous system and thicker than the former. Shishido ('55) strongly suggested the close relation between biliary sensitivity and the phrenic nerve in addition to the thoracic sympathetic trunk.

The afferent conduction of impulses is a subject of particular interest to clinical investigators, which requires further extensive study for its elucidation.

Summary

Forty human gallbladders obtained at cholecystectomy have been examined for the intramural innervation with the silver impregnation method.

Nerves which innervate the wall of the gallbladder have been divided into the following five strata;

(1) The main plexus (Haupt- oder Grund-Geflecht nach Dogiel) in the adventitia. This plexus seems to include no ganglion cell.

(2) The submuscular plexus in the adventitia. In this plexus
are located ganglia which consist of 4 to 10 or more ganglion cells. A small number of isolated ganglion cells are also found to be present.

(3) The intramuscular plexus in the musculature. Fewer and smaller ganglia containing usually 2 to 5 ganglion cells and more isolated ones are characteristics of this plexus.

(4) The epimuscular plexus in the lamina propria. Ganglia found in this plexus are smaller than ones in the foregoing two and usually comprise 2 to 3 ganglion cells.

(5) The terminal networks in the lamina propria, which include isolated ganglion cells.

Majority of ganglion cells found in the lamina propria are isolated ones.

Characteristics of each nerve stratum relative to structure and composition have been also presented as well as ganglion cells contained.

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Literature Cited


Boeke, J., 1949. The sympathetic end formation, its synaptology, the interstitial cells, the periterminal network, and its bearing on the neurone theory. Discussion and Critique. Acta anat., 8: 18-61.


Innervation of the Human Gallbladder


——— 1951b. III. Innervation de l'estomac humain. Ibid., 11: 490-532.


Plates I–IV
Plate I

Explanation of Figures

1. Three layers of the gallbladder wall; (1) Adventitia, (2) Musculature, (3) Mucosa. Cholecystitis with stones in the common bile duct. 62-yr.-old male. Reduced to 6/7 from ×32.
2. One of nerve bundles of the main plexus (adventitia). A dense crowd of fine and thick nerve fibers. Clear perineurial sheath (at arrow). Cholecystitis, no stone. 45-yr.-old male. Reduced to 6/7 from ×450.
3. Bundles of submuscular and intramuscular plexuses. Perineuria are not remarkable. Cholecystitis, no stone. 45-yr.-old male. Reduced to 6/7 from ×140.
4. Ganglion in the submuscular plexus. Magnified picture of fig. 3. Reduced to 6/7 from ×450.

Abbreviations

a: artery  
m: muscle
bl: blood vessel  
smb: submuscular bundle
g: ganglion  
v: vein
imb: intramuscular bundle
Plate II

Explanation of Figures

5. Intramuscular plexus and an isolated ganglion cell. Anatomical relationship between the ganglion cell and nerve fibers is obscure. Cholecystitis, no stone. 45-yr.-old male. Reduced to 6/7 from ×450.

6. Intramuscular and epimuscular plexuses. Cholecystitis with stones in the bladder. 58-yr.-old male. Reduced to 6/7 from ×450.

7. Strand of the epimuscular plexus with Schwann cells (at arrow). Cholecystitis with stones in the bladder and common bile duct. 45-yr.-old female. Reduced to 6/7 from ×1000.

8. Terminal network of delicate nerve fibers just beneath the epithelium (at arrow). Cholecystitis with stones in the bladder. 29-yr.-old female. Reduced to 6/7 from ×1000.

Abbreviations

a: artery  
ep: epithelium
bl: blood vessel  
gc: ganglion cell
emp: epimuscular plexus  
im: intramuscular plexus
en: nucleus of epithelial cell  
m: muscle
Plate III

Explanation of Figures

9. Ganglion cells in the lamina propria and the terminal network (at arrow). Cholecystitis with stones in the bladder and common bile duct. 45-yr.-old female. Reduced to 6/7 from ×1000.

10. Bundle of the perivascular plexus in the adventitia. Cholecystitis, no stone. 45-yr.-old male. Reduced to 6/7 from ×700.

11. Ganglion cells in the tongue (lamina propria) of an elephant. Many clear protoplasmic processes (at arrow). Reduced to 6/7 from ×450.

12. Ganglion, composed of cells showing synaptic connections (speckles at arrow), in the submucosal plexus. Cholecystitis, no stone. 45-yr.-old male. Reduced to 6/7 from ×450.

Abbreviations

bl: blood vessel
ec: endothelial cell
gc: ganglion cell
m: muscle
n: nucleus
s: Schwann cell
sa: small artery
v: vein
Plate IV

Explanation of Figures

13. Sensory nerve fibers (at arrow) in the lamina propria. Cholecystitis with stones in the bladder. 57-yr.-old male. ×540.

14. Entangled thick nerve fibers found near the glands in the lamina propria. Specific sensory nerve ending. Cholecystitis with stones in the bladder. 46-yr.-old female. ×450.

Abbreviations

en: nucleus of epithelial cell  ep: epithelium
Plate IV

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